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# UNIVERZITET PIM BANJA LUKA

## XII INTERNATIONAL CONFERENCE ON SOCIAL AND TECHNOLOGICAL DEVELOPMENT - STED 2023

# PROCEEDINGS

## XII MEĐUNARODNA KONFERENCIJA O DRUŠTVENOM I TEHNOLOŠKOM RAZVOJU - STED 2023

# ZBORNIK RADOVA

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Trebinje, June 15th-18th, 2023

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# *INVITED LECTURE*
# *POZIVNO PREDAVANJE*

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# ZAŠTO JE OTISAK PRSTA NEPISMENIH LICA KOD OVJERE DOKUMENTA NEPOUZDAN ZA VJEŠTAČENJE

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## SAŽETAK

U praksi je da nepismene osobe umjesto potpisa u dokumentima, gdje je predviđena ovjera sa ličnim potpisom, izvode otisak kažiprsta desne ruke. To se izvodi uz pomoć lica u zakonom ovlašenim službama: u matičnim uredima opština, sudovima, policiji i kod notara. Postupak izvedbe ovjere otiskom prsta je zakonom definisan ali sam način izvedbe u praksi se izvodi na način da izvedeni otisak prsta je nekvalitetan i nije pouzdan kod vještačenja njegove autentičnosti. U praksi je da se obojenje prsta izvodi pritiskom prsta/kažiprsta na površinu tekstilnog jastučeta natopljenim sa tintom za pečata i poslije toga se pritiskom na papir vrši otiskivanje. Tako izveden otisak prsta zbog velike hrapavosti površine tekstilnog jastučena, obojena tinta se nije ravnomjerno adsorbirala na izbočene papilarne linije i minucije prsta i dobije se otisak prsta sa isprekidanim papilarnim linijama a minucije skoro da se uopšte ne vide.

Otisak prsta ako nije izveden sa jasnim papilarnim linijima i ako između papilarnih linija nema najmanje dvanaest vidljivih minucija, onda je takav otisak prsta nekvalitetan i nepouzdan za utvrđivanje njegove autentičnosti sa nespornim otiskom prsta u kome se jasno vide papilarne linije i prisutne minucije. Pravilo kod vještačenja autentičnosti spornog otiska prsta je da se grafičkom-komparativnom metodom istovjetnosti i neistovjetnosti utvrđiuje istovjetnost strukture papilarnih linija kod spornog i nespornog otiska prsta, da se utvrdi istovjetnost ili neistovjetnost najmanje dvanaest prisutnih minucija u spornom i nespornom otisku prsta. Ako je sporan otisak prsta u dokumentu izveden nekvalitetno i nestručno onda je takav otisak prsta neupotrebljiv za bilo kakvu komparaciju sa nespornim otiskom prsta određenog lica.

**Ključne riječi:** dokument, otisak prsta, tekstilno jastuče sa tintom za pečate i štambilje, papilarne linije i minucije, istovjetnost i neistovjetnost, grafička-komparativna metoda.

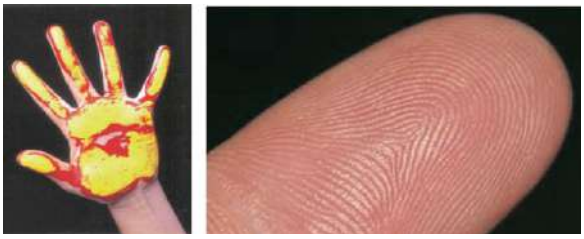
## UVOD

### Šta je daktiloskopija i kojoj stručnoj oblasti pripada?

Etimološko značenje riječi daktiloskopija potiče od grčke riječi *daktilos* = prst i *skopien* = posmatrati. Postoje saznanja da su se u Kini koristili otisci prstiju radi identifikacije lica, dva vijeka prije rođenja Hrista. U Svetom pismu, Knjiga o Jovanu, glava 37. piše: „On je udario pečat na ruku svakog čovjeka kako bi ljudi mogli upoznati njegovo djelo“

Talijanski ljekar Marčelo Malpigi 1664. godine otkrio je na prstima, dlanovima i tabanima ljudske kože, određene kvržice, koje je nazvao *papile* a papile na italijanskom jeziku znači bradavica, kvržica. Razvojem naučnih dostignuća te papile kao papilarne linije dale su mogućnost da se na osnovu njih utvrđuje identitet lica (Simonović, 2004; Sveučilište u Zagrebu, 2012).

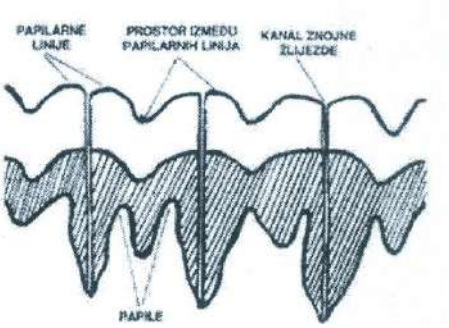
Na kraju jednog ugovora pisanog 782. godine naše ere, koji je pronašao engleski istraživač, Sir Aurel Stein, u istočnom dijelu Turkistana piše: „ Obje strane su saglasne da je ovo pravično i jasno su stavile otiske svojih prstiju kao znak raspoznavanja“.



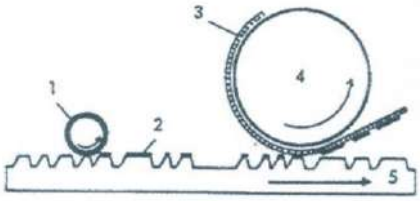
Slika 1. Izgled otvorene šake sa ispruženim prstima i dlanom na kojim se površinama najviše nalaze papilarne linije i izgled povećanih papilarnih linija na prstu (Branković i Branković, 2020).
Figure 1. Appearance of an open hand with outstretched fingers and palm, on which surfaces are the most papillary lines and the appearance of increased papillary lines on the finger (Branković, & Branković, 2020).

Ako se otisak prsta nalazi u dokumentu onda je to znak ovjere lica koje je nepismeno. Taj otisak prsta pripada grafičkim elementima toga dokumenta sa svojim individualnim specifičnostima kao što su nap. slova, potpisi, linije, otisci pečata, itd. Istovjetan je fizikalno-hemijski proces kod otiskivanja obojenog prsta na papir i otiskivanja pečata i štambilja na papir kao i otiskivanje štamparske forme za viskoku štampu na papir. Kod svih navedenih postupaka otisak se vrši sa izbočenih obojenih površina na papir sa određenim pritiskom.

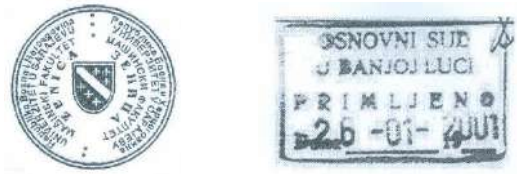
Zbog naprijed navedenog otisci prsta, tj. daktiloskopija pripada grafičkoj oblasti a ne pripada pedagogiji, psihologiji, pravu, mašinstvu, itd. Eksperti za vještačenje autentičnosti dokumenata i spornih grafičkih elemenata u dokumentima mogu biti samo odabrani najstručniji diplomirani inžinjeri grafičke tehnologije a ne nikakvi drugi obrazovni profili.



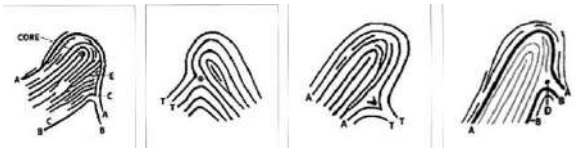

Slika 2. Povećana reprodukcija izgleda presjeka ljudske kože sa izgledom izbočenih papilarnih linija koje ostavljaju trag na otisku papira u dokumentima.
Figure 2. Magnified reproduction of the appearance of a cross-section of human skin with the appearance of protruding papillary lines that leave a mark on the paper impression in documents.



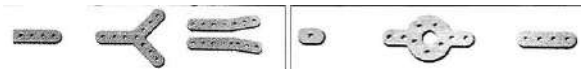

Slika 3. Šematski prikaz presjeka štamparske forme za visoku štampu: 1. valjak za nanošenje boje na izbočene površine sloga (linije, slova, klišeji), 2. nanešena boja, 3. arak papira, 4. štamparski cilindar mašine, 5. temeljna ploča sa slogom.
Figure 3. Schematic representation of the cross-section of the letterpress printing form: 1. roller for applying color to the protruding surfaces of the letter (lines, letters, clichés), 2. applied color, 3. sheet of paper, 4. printing cylinder of the machine, 5. foundation plate with a syllable.



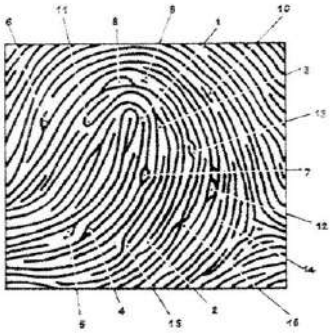

Slika 4. Reprodukcija otiska prikazanog pečata i štambilja.
Figure 4. Reproduction of the impression of the shown seal and stamp.




Slika 5. Povećana reprodukcija osnovnih oblika papilarnih linija: petljasti, lučni, spiralni i ostali oblik.
Figure 5. Enlarged reproduction of the basic shapes of papillary lines: loop, arc, spiral and other shapes.

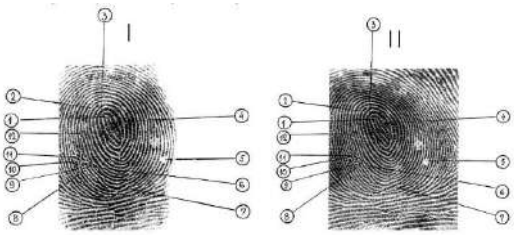


Slika 5. Povećani izgled različitih oblika minucija.
Figure 5. Magnified appearance of different forms of minutiae.

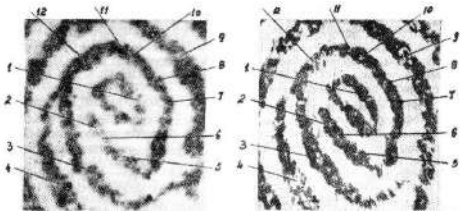


Slika 6. Povećana reprodukcija dijela otiska prsta sa identifikovanih 16. minucija.
Figure 6. Enlarged reproduction of part of the fingerprint with the identified 16 minutiae.

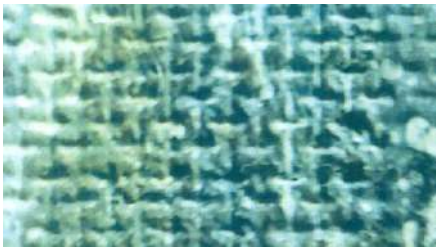
Znači, kod utvrđivanja jasne strukture papilarnih linija bilo kod spornog ili nespornog otiska prsta, potrebno je utvrditi i određen broj minucija u tim otiscima prsta. Može se komparacijom spornog i nespornog otiska prsta utvrditi istovjetnost strukture papilarnih linija ali ako se ne utvrdi istovjetnost najmanje dvanaest istovjetnih minucija u spornom i nespornom otisku pečata, onda sporni i nesporni otisci prsta nisu istovjetni i ne pripadaju istom licu.




Slika 7. Povećana reprodukcija spornog i nespornog otiska prsta sa identifikovanim istovjetnim minucijima.
Figure 7. Magnified reproduction of disputed and undisputed fingerprint with identical minutiae identified.

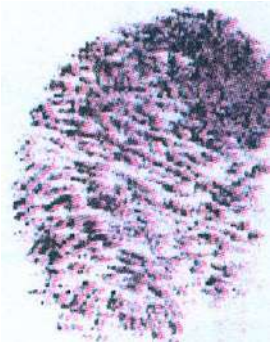


Slika 8. Reprodukcija dvadeset i pet puta povećanog dijela spornog i nespornog otiska prsta sa identifikacijom istovjetnih pora koje se nalaze u papilarnim linijama.
Figure 8. Reproduction of a twenty-five-fold enlarged portion of the disputed and undisputed fingerprint with identification of identical pores located in the papillary lines.



Slika 9. Povećan izgled hrapave površine različitih tekstilnih struktura jastučeta natopljenih tintom za pečte sa kojih se kontaktom kažiprsta uzima obojenje za otisak prsta na papir.
Figure 9. Magnified view of the rough surface of various textile structures of pads soaked in stamp ink from which fingerprint coloration is taken on paper by the contact of the index finger.

Kako izgleda nekvalitetno i nejasno izveden otisak prsta u dokumentu, prikazano je na sledećem prilogu. Ne vide se jasno papilarne linije otiska niti se mogu identifikovati prisutne minucije između papilarnih linija. A ako toga nema otisak je neupotrebljiv i pored njegovog izoštravanja, povećavanja kontrasta i sl. ali nekvalitno urađen otisak se ne može učiniti pouzanim za bilo kakvu komparaciju.



Slika 10. Hrapavost tekstilne površine neće jednolično prenijeti obojenje tinte na izbočene papilarne linije i minucije i tako izveden otisak prsta na papir je nekvalitetan i može se smatrati da nije nikakva ovjera dokumenta ni izvedena.
Figure 10. The roughness of the textile surface will not uniformly transfer the coloring of the ink to the raised papillary lines and minutiae, and the resulting fingerprint on the paper is of poor quality and can be considered that no authentication of the document has been performed.

**Kako je ispravno da se izvode otisci prsta nepismenih lica u dokumentima?**

U službama koje su ovlaštene da ovjeravaju razne vrste dokumenata (ugovore, testamente, punomoći, račune, itd.) sa otiscima kažiprsta desne ruke nepismenih lica potrebno je da imaju:

- neupojnu ravnu podlogu određene veličine,
- crnu boju za ofset štampu,
- ručni valjak za razribavanje boje na podlozi.

Neupoja ravna podloga može biti staklo, plastika, metal i sl. Na tu ravnu neupojnu podlogu se nanese i razriba ručnim valjkom tanki sloj crne ofset boje. Sloj nanesene boje treba da bude do 10 mikrona. Zašto crna ofset boja? Zato što ona ima sitne crne pigmene (koji su nosoci obojenja) i što su jednoločno dispergirani/raspoređeni u sloju boje. Debljina nanosa ofset boje na štamparskim ofset mašinama je od 4- 6 mikrona.

Slika 10. Kod izvedbe otiska prsta u dokument ovlašteno lice pomaže nepismenom licu da se to izvede na stručan način kako bi otisak prsta bio što kvalitetniji, tj. da su jasno vidljive papilarne linije i minucije između njih.
Figure 10. When fingerprinting a document, an authorized person helps an illiterate person to do it in a professional way so that the fingerprint is of the highest quality, i.e. that the papillary lines and the minutiae between them are clearly visible.

Kada je naprijed navedeno obezbjeđeno, ovlašteno lice uzima kažiprst nepismenol lica i pod uglom od $10^0$ (deset stepeni) lagano valja po razribanoj crno boji desni kažiprst lica od početka nokta do završetka nokta. Na taj način se dobije jasan i sa većom površinom otisak prsta. Na tom tako stručno izvedenom otisku prsta jasno se vide papilarne linije i municije između njih. U praksi se ne radi tako jer se obojenje uzima sa tekstilnog/hrapavog jastučeta koje je natopljeno sa (rijetkom) tintom za pečate, otisak se ne izvodi rotiranjem prsta i pod potrebnim uglom i zbog toga su otisci prsta nekvalitetni za bilo kakvo utvrđivanje njegove autentičnosti.

Stari način uzimanja otiska prsta na Kartonu lične karte se uzimao na stručan nači. Na starom Kartonu lične lica, prisutna su tri autentčna/originalna grafička elementa: originalna fotografija lica, nesporan i kvalitetan otisak prsta i nesporan svojeručno izveden potpis lica.

Danas se nesporan otisak prsta u MUP-a za identifikacione dokumente izvodi digitalno. Otisak prsta se izvede na digitalnoj ravnoj podlozi sa prodornim svjetlom i tako se memoriše izvedeni otisak prsta i pohrani u memoriju računara. Tako izveden otisak prsta je kvalitetan i on se može na komparatoru pozvati i komparirati sa nekim spornim otiskom prsta. Noviji programi mogu odmah identifikovati da li je sporni otisak prsta itovjetan sa nespornim otiskom prsta. Ako je sporan otisak prsta nekvalitetan onda se ne može utvrđivati njegova istovjetnost ili neistovjetnost sa nespornim otiskom prsta.

Slika 10. Računarski sistem SAFIS MORPHO za unošenje/memorisanje nespornih otisa prsta i uređaj za kompraciju nespornih i spornih otisaka prsta.
Slika 10. Računarski sistem SAFIS MORPHO za unošenje/memorisanje nespornih otisa prsta i uređaj za kompraciju nespornih i spornih otisaka prsta.

Kada se rješenjem ili naredbom traži od vještaka za dokumente da vještačenjem utvrdi autentičnost spornog otiska prsta, pravi se dodatna greška. Iz MUP-a postupajući sudija traženjem dobije nesporan otisak prsta određenog lica (izveden po CIPS projektu od 2003. godine) ali je nesporan otisak prsta dosta umanjem i još rastriran tj. prisutne su rasterske tačke koje su isprekidale papilarne linije a minucije su uništene (zavisno od rezolucije štampača). Na takvoj reprodukciji/fotokpiji i nesporan otisak prsta je učinjen nekvalitetnim i nije pouzdan za komparaciju sa spornim otiskom prsta. Zbog navedenog, vještačenje autentičnosti spornog otiska prsta treba povjeriti isključivo specijaliziranoj službi u MUP-a.

Slika 11. Povećani rastrirani izgled otiska prsta izveden po CIPS projektu i koji je reprodukovan na papir.
Figure 11. Enlarged rasterized view of a fingerprint produced by the CIPS project and reproduced on paper.

Vještak za dokumente može vještačiti autentičnost spornog otiska prsta ako ima na raspolaganju kvalitetan nesporan otisak prsta izveden na starom Kartonu lične karte i kad ima na raspolaganju kvalitetan otisak spornog otiska prsta u dokumentu.

Posebno treba u ovom području vještačenja razlikovati vještačenje autentosti spornog otiska prsta gdje se vrši komparacija papilarnih linija i minucija u spornom i nespornom otisku prsta. Posebna je tehnika i tehnologija za pronalaženje, fiksiranje i preuzimanje otisaka prstiju i dlanova u nekim urađenim krivičnim djelima. Tu aktivnost pronalaženja vidljivih i nevidljih otisaka na predmetima obavljaju posebno stručni izvršioci/kri-minalisti koji rade u policiji.

## ZAKLJUČCI

Kada se otiskom desnog kažiprsta nepismenog lica ovjerava određeni dokument, potrebno je da se taj otisak izvede kvalitetano, tj. da ima jasno vidljive papilarne linije i minucije. Ako je izvedeni otisak prsta u dokumentu nekvlitetan onda se može smatrati da on i ne postoji jer se njegov sadržaj ne može upoređivati sa nespornim otiskom prsta.

Kada je potrebno izvršiti utvrđivanje autentičnosti nekog spornog otiska prsta u dokumentu, preporučuje se da to uradi specijalizirana služba u policiji, zbog toga što u svojoj arhivi već ima

kvalitetan nesporan otisak prsta konkretnog lica a pomoću raspoloživih aparata i uređaja komparativno može nedvosmisleno utvrditi da li je sporni i nesporni otisak prsta istovjetan ili nije.

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# WHY IS THE FINGERPRINT OF ILLITERATES PERSONS WHEN VERIFYING DOCUMENTS UNRELIABLE FOR EXPERTISE

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## ABSTRACT

It is in practice that illiterate people, instead of signing documents, where a personal signature is required, make an impression of the index finger of their right hand. This is done with the help of persons in legally authorized services: in municipal registry offices, courts, police and notaries. The procedure for fingerprint authentication is defined by law, but the way it is performed in practice is performed in such a way that the fingerprint taken is of poor quality and is not reliable when examining its authenticity. In practice, the coloring of the finger is performed by pressing the finger/index finger on the surface of a textile pad soaked with stamp ink and after that the printing is done by pressing the paper. The resulting fingerprint, due to the high roughness of the surface of the textile cushion, the colored ink was not evenly adsorbed on the protruding papillary lines and minutiae of the finger, and a fingerprint with broken papillary lines is obtained, and the minutiae are almost not visible at all.

If the fingerprint is not made with clear papillary lines and if there are not at least twelve visible minutiae between the papillary lines, then such a fingerprint is of poor quality and unreliable for establishing its authenticity with an indisputable fingerprint in which papillary lines and present minutiae are clearly visible. The rule in the expert examination of the authenticity of a disputed fingerprint is to determine the identity of the structure of the papillary lines in the disputed and undisputed fingerprint using the graphic-comparative method of identity and non-identity, to determine the identity or non-identity of at least twelve minutiae present in the disputed and undisputed fingerprint. If the disputed fingerprint in the document was made in poor quality and unprofessionally, then such a fingerprint is unusable for any comparison with the undisputed fingerprint of a certain person.

**Keywords**: document, fingerprint, textile pad with ink for stamps and stamps, papillary lines and minutiae, identity and non-identity, graphic-comparative method.

# *ECOLOGY, ENERGETIC EFFICIENCY AND GREEN ENERGY*

# *EKOLOGIJA, ENERGETSKA EFIKASNOST I ZELENA ENERGIJA*

STRUČNI RAD – PROFESSIONAL PAPER DOI: 10.7251/PIMZ2301010R

# POVEĆANJE ENERGETSKE EFIKASNOSTI ZGRADA NA PODRUČJU GRADA BANJA LUKA U FUNKCIJI ADAPTACIJE NA KLIMATSKE PROMJENE

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## SAŽETAK

Negativni efekti klimatskih promjena koje se javljaju usljed prirodnih ciklusa i antropogenog djelovanja odražavaju se na sve aspekte životne sredine i života savremenog čovjeka: ljudsko zdravlje, ekosisteme, ekonomiju, socijalna pitanja i slično. Tome svjedoče ekstremne vrijednosti klimatskih parametara (visoke ljetne temperature, obilne padavine i poplave) koje su posljednjih nekoliko decenija sve učestalije. Usljed ugroženosti zdravlja i opstanka stanovništva u pojedinim sredinama, javlja se potreba da se preduzmu značajniji koraci po tom pitanju.

Prilagođavanje na izmijenjene klimatske uslove je postalo jedna od najbitnijih metoda koje lokalne zajednice koriste pri predviđanju budućih uticaja i rizika od klimatskih promjena. Jedan od načina u borbi protiv tih posljedica jeste povećanje energetske efikasnosti zgrada, što ima mnoge pozitivne efekte. Utopljavanje objekata (optimizacija omotača) utiče prvenstveno na smanjenje potreba za potrošnjom energije za grijanje i hlađenje objekata, što dugoročno ima za posljedicu smanjenje emisije $CO_2$, kao i ekonomske uštede.

Upotreba novih tehnologija gradnje i razvoj savremenog urbanizma u pravcu povećanja kvaliteta životnog prostora, a samim tim i kvaliteta života stanovništva gradskih sredina, uveliko bi uticali na energetsku efikasnost, očuvanje životne sredine, umanjenje negativnih efekata klimatskih promjena, a samim tim i ostvarivanje ciljeva održivog razvoja.

**Ključne riječi**: klimatske promjene, mjere adaptacije, energetska efikasnost, životna sredina, održivi razvoj.

## UVOD

Predmet istraživanja ovog rada su mjere adaptacije na klimatske promjene u vidu povećanja energetske efikasnosti zgrada. Grad Banja Luka je u radu prikazan kao model i predložene mjere mogu se primijeniti na sve lokalne zajednice u Bosni i Hecegovini sa sličnim mikroklimatskih obilježjima. Cilj istraživanja jeste da se utvrdi u kojoj mjeri povećanje energetske efikasnosti zgrada može da utiče na smanjenje negativnih posljedica klimatskih promjena sa posebnim osvrtom na smanjenje emisija gasova staklene bašte, a samim tim i na poboljšanje uslova života u gradovima, na zdravlje ljudi, odgovornu potrošnju i proizvodnju i ostvarivanje drugih ciljeva održivog razvoja.

Metodologija rada podrazumijeva analizu dosadašnjih istraživanja u ovoj oblasti, kao i sintezu svih zaključaka do kojih se došlo pri izvršenju postavljenih zadataka, kako bi se ostvario pomenuti cilj. Osim toga, uzeti su u obzir i određeni kvantitativni podaci koji govore o tome na koji način i u kojoj mjeri se ugrožava životna sredina u gradovima, kao i o mogućnostima umanjenja ili potpunog isključenja negativnih faktora. Prikazani su kvantitativni podaci o uticajima realizovanih projekata na području Grada Banja Luka i na osnovu toga date su preporuke i prijedlozi daljih mjera.

Dosadašnja istraživanja u ovoj oblasti pokazala su da postoje mnogobrojni pozitivni uticaji ovakvog vida adaptacije na klimatske promjene u gradskim sredinama i da je neophodno sprovoditi predložene aktivnosti na lokalnom nivou. Evropsku direktivu, strategije i sporazume (Direktiva 2010/31/EU o energetskim karakteristikama zgrada, Zelena agenda za Zapadni Balkan i

Evropski zeleni dogovor) i zakonske akte na nivou entiteta Republike Srpske (Zakon o energetskoj efikasnosti i Zakon o uređenju prostora i građenju) neophodno je prilagoditi specifičnostima lokalnih sredina, kako bi se na što bolji način odgovorilo na nastale posljedice, što ima značajan uticaj na ostvarivanje ciljeva održivog razvoja na globalnom nivou.

Zgrade, njihova okolina i prateći objekti proizvode više $CO_2$, stvaraju više zagađenja, troše više energije i prirodnih resursa nego bilo koje drugo preduzeće ili industrija (Sozer, 2010). Dosadašnjim istraživanjima dokazano je da sve navedene negativne posljedice klimatskih promjena izazvane ljudskim djelatnostima povećavaju učestalost i intenzitet svih ekstremnih vremenskih događaja: suša, padavina, poplava i slično. To može dovesti do velikih degradacija kvaliteta vode i smanjenja, pa čak i nestanka raspoloživih vodnih resursa u nekim regionima. Stoga, kao prioritetan zadatak na globalnom nivou postavlja se neophodnost rješavanja ovih problema, sprječavanja njihovog nastanka u potpunosti tamo gdje je to moguće ili smanjenja posljedica u što većoj mjeri. Tako su nastale dvije vrste mjera u borbi protiv klimatskih promjena: mjere mitigacije (sprječavanja štetnog djelovanja) i adaptacije (prilagođavanja) na nastale posljedice (Rosenzweig, 2011).

Postoji zajedničko shvatanje da su efikasnija upotreba energije i povećanje obnovljivih izvora energije najbolji načini da se uspori globalno zagrijavanje. S obzirom na činjenicu da sistemi grijanja i hlađenja predstavljaju veliki dio globalne potrošnje energije, od velikog je značaja poboljšanje performansi takvih sistema (Kharseh, & Altorkmany, 2012).

Ekološki uticaji, u vidu smanjenja emisija ugljen dioksida i smanjenja temperature, od velikog su značaja za umanjenje negativnih efekata klimatskih promjena. Poboljšanje energetske efikasnosti i upotreba obnovljivih izvora energije efikasni su načini za smanjenje ugljeničnog otiska, kao i veoma dobar način za finansijske uštede (Zhou, & Park, 2012).

## MATERIJAL I METODE RADA

Istraživanje pozitivnih uticaja povećanja energetske efikasnosti i prijedlog novih mjera u procesu adaptacije na klimatske promjene podrazumijeva analizu postojećih podataka u datim oblastima, na globalnom, državnom i lokalnom nivou, i to:

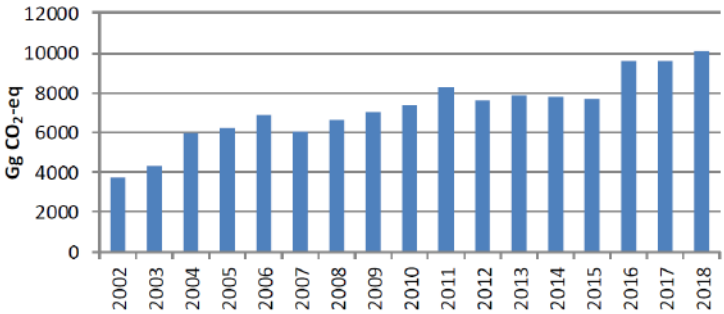
- Evropska direktiva (Direktiva 2010/31/EU o energetskim karakteristikama zgrada, Zelena agenda za Zapadni Balkan i Evropski zeleni dogovor),
- entitetski zakonski akti i akcioni planovi Republike Srpske (Zakon o energetskoj efikasnosti i Zakon o uređenju prostora i građenju, zatim Akcioni plan energetske efikasnosti Republike Srpske i Akcioni plan energetske efikasnosti jedinice lokalne samouprave),
- izvještaji relevantnih organa i javnih ustanova (Izvještaj o realizaciji Akcionog plana energetske efikasnosti Republike Srpske za 2015. godinu Ministartsva energetike i rudarstva i izvještaji i publikacije Fonda za zaštitu životne sredine i energetsku efikasnost koji je pod nadležnošću Ministartsva za prostorno uređenje, građevinarstvo i ekologiju),
- publikacije, naučni radovi i projekti (Zeleni poslovi – Analiza uticaja mjera energetske efikasnosti na zapošljavanje u BiH; GED projekat),
- strateška dokumentacija i projekti na lokalnom nivou (Akcioni plan za zeleni grad Banja Luka) (Grad Banja Luka, 2020) i
- statistički (kvantitativni) podaci od značaja za energetski sektor u zgradarstvu (publikacije Republičkog zavoda za statistiku Republike Srpske u oblasti energetike i životne sredine.

U ovom dijelu rada, predstavljeni su osnovni pojmovi koji se tiču klimatskih promjena, održivog razvoja i mjera energetske efikasnosti. Istražena je i prikazana relevantna Evropska direktiva, kao i načini njene implementacije na nivou Republike Srpske, kroz prethodno navedene zakonske akte, strateške i akcione planove. Zatim su u drugom dijelu rada prikazani rezultati istraživanja načina primjene mjera u oblasti energetske efikasnosti na lokalnom nivou, pri čemu je kao primjer uzeto područje Grada Banja Luka. Pozitivni efekti povećanjem energetske efikasnosti zgrada na području Grada proučeni su kroz dosadašnje primjere iz prakse i na osnovu toga dat je

prijedlog mjera za dalje aktivnosti u ovoj oblasti (GED projekat i njegovi efekti na području Grada Banja Luka).

Klimatske promjene podrazumijevaju spektar globalnih fenomena do kojih dolazi usljed različitih faktora izazvanih antropogenim djelovanjem, a posebno sagorijevanjem fosilnih goriva, što dovodi do povećanja emisije gasova sa efektom staklene bašte u atmosferu (vodena para, ugljen-dioksid, metan, azot-suboksid i hlorofluorokarbonati). Usljed toga, dolazi do povećanja temperature vazduha i globalnog zagrijavanja, što je posebno vidljivo na površini Zemlje od kraja 70-ih godina prošlog vijeka. Zabilježen je porast za oko 0,8°C od 1880. godine, u odnosu na vrijednosti sredinom XX vijeka (od 1950. do 1980. godine) (European Environment Agency, 2010).

Izvještaji Svjetske meteorološke organizacije prikazuju povećanje emisija gasova sa efektom staklene bašte od 1750. godine, izrazito kao posljedicu ljudskih aktivnosti. Koncentracija ugljen-dioksida je tokom 2016. godine prekoračila nivo od 400 ppm (dijelova na milion), koncentracija metana nivo od 1800 ppb i koncentracija azot-suboksida 320 ppb (dijelova na milijardu). U odnosu na period prije industrijskih revolucija, to je povećanje od preko 40% za ugljen-dioksid, 150% za metan i 20% za azot-suboksid (World Meteorological Organization, 2016). Prema Izvještaju o emisijama gasova sa efektom staklene bašte u Republici Srpskoj za period 2002-2018. godine, emisije ugljen-dioksida, metana i azot suboksida kontinuirano rastu. Najveće emisije $CO_2$ bile su u 2018. godini i iznosile su 10053.51 Gg $CO_2$-eq, što predstavlja porast od 4.7% u odnosu na 2017. godinu. Najveći uticaj na povećanje GHG emisija imaju energetski i poljoprivredni sektor.




Grafikon 1. Ukupne $CO_2$-eq emisije za Republiku Srpsku po godinama.
Chart 1. Total $CO_2$-eq annual emissions for Republika Srpska.

Zagađenje i degradacija svih oblasti životne sredine (voda, vazduh i zemljište) neminovno dovode u pitanje kvalitet života stanovnika takvih sredina, kao i njihovo zdravlje i opstanak. Negativan uticaj se odražava ne samo na čovjeka, nego i na ugrožavanje i uništavanje mnogih populacija biljnih i životinjskih vrsta. Usljed potrebe da se smanje negativni uticaji nastao je pojam očuvanja životne sredine, a u vezi s tim i pojam održivog razvoja koji podrazumijeva optimalno iskorištavanje resursa, na način da se ne dovodi u pitanje opstanak budućih generacija (Radulović, 1997).

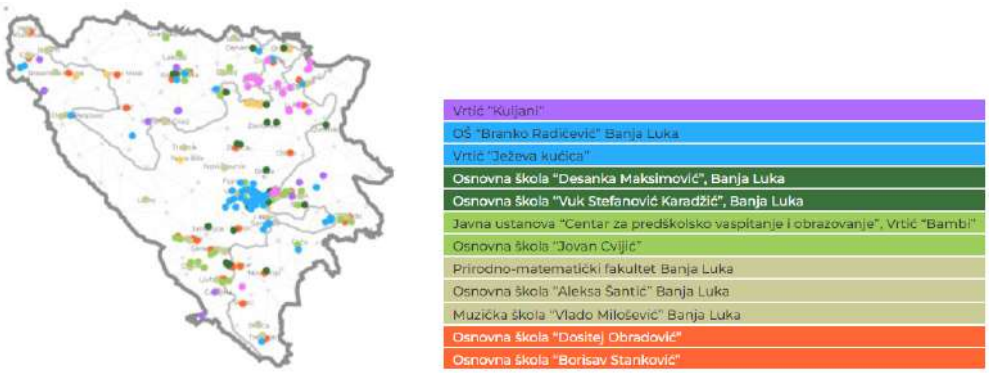
Energetska efikasnost u širem smislu podrazumijeva razvoj i primjenu tehnologija kojima se ostvaruje ekonomska ušteda, zaštita životne sredine i smanjuje potrošnja resursa, pri čemu se ne umanjuju životni standard društva, privredne aktivnosti i kvalitet usluga. U skladu sa definicijom pojma održivi razvoj, postizanjem energetske efikasnosti se ne ugrožavaju potrebe budućih generacija zadovoljavanjem potreba sadašnjih generacija za energijom. Pri tome se ostvaruje potreban kvalitet životne sredine jer se smanjuje potreba za korištenjem fosilnih goriva i potencira upotreba obnovljivih izvora energije i smanjenje gasova staklene bašte. Samim tim, smanjuje se i potreba za proizvodnjom energije i izgradnjom novih kapaciteta, a povećava se sigurnost snabdijevanja.

Jedan od ključnih pravnih akata kada je u pitanju energetska efikasnost zgrada jeste Direktiva 2010/31/EU (Energy performance of buildings directive - Direktiva o energetskim performansama

zgrada). Pored toga, značajnu ulogu ima i NZEB (Nearly zero-energy buildings – Zgrade približno nulte energije koje imaju vrlo visoke energetske performanse i niska količina energije koja im je potrebna dolazi uglavnom iz obnovljivih izvora). Nakon uvođenja pravila o energetskim performansama u državne građevinske zakone, zgrade danas troše 50% manje energije od tipičnih zgrada iz 1980-ih godina prošlog vijeka (Evropska komisija - energetska efikasnost zgrada, 2021).

Građevinski sektor je presudan za postizanje energetskih i ekoloških ciljeva Evropske unije. Istovremeno, bolje i energetski efikasnije zgrade poboljšavaju kvalitet života građana i donose dodatne koristi privredi i društvu. U vezi s tim, razvijeni su i standardi koji se tiču poboljšanja energetskih performansi zgrada (ISO standardi) koji definišu sve elemente zgrada: grijanje, hlađenje, ventilaciju, osvjetljenje, omotače i ostalo. S istim ciljem su nastale i najbolje raspoložive tehnike (BAT – Best Available Techniques) i referentni dokumenti, tzv. BREF dokumenti za pojedinačne oblasti. Referentni dokument o najboljoj dostupnoj tehnici za energetsku efikasnost (BREF 02.2009) opisuje razmjenu informacija o najboljim raspoloživim tehnikama, povezano praćenje i razvoj u njima, sprovedenu prema članu 17 (2) Direktive 2008/1/EC (IPPC direktiva). IPPC direktiva (Integrated Pollution Prevention and Control – Integrisano sprječavanje i kontrola zagađenja) zahtijeva da sve instalacije rade na takav način da se energija koristi efikasno, a jedno od pitanja koje treba uzeti u obzir pri određivanju najboljih raspoloživih tehnika za proces je njegova energetska efikasnost (International Plant Protection Convention [IPPC], 2007; European Commission, 2009).

U saradnji sa Zelenim klimatskim fondom (Green Climate Fund), na teritoriji Bosne i Hercegovine realizovani su mnogi značajni projekti u ovoj oblasti. To je novi globalni fond koji je uspostavljen kako bi pružio podršku naporima zemalja u razvoju da odgovore na izazov klimatskih promjena. Ovaj fond zemljama u razvoju pomaže u ograničavanju ili smanjenju emisija gasova staklene bašte i prilagođavanju klimatskim promjenama. Jedan od ciljeva Fonda jeste da podstiče prelazak na razvoj sa niskim emisijama i otporan na klimatske promjene, naročito vodeći računa o potrebama država koje su posebno ugrožene uticajem klimatskih promjena (Green Climate Fund, 2021).




Slika 1. Pregled lokacija objekata na kojima su realizovane mjere za povećanje energetske efikasnosti na području Bosne i Hercegovine.
Figure 1. Overview of locations of facilities where measures to increase energy efficiency have been implemented in Bosnia and Herzegovina.

Pomoću sredstava iz ovog Fonda i drugih međunarodnih organizacija (UNDP – Razvojni program Ujedinjenih Nacija), u Bosni i Hercegovini su realizovani ili su još uvijek u toku mnogobrojni projekti čiji je cilj povećanje energetske efikasnosti zgrada. Projekat GED finansira Švedska, a implementira Razvojni program Ujedinjenih nacija (UNDP), u saradnji sa Ministarstvom vanjske trgovine i ekonomskih odnosa Bosne i Hercegovine, Fondom za zaštitu okoliša Federacije BiH i Fondom za zaštitu životne sredine i energetsku efikasnost Republike Srpske, entitetskim ministarstvima prostornog uređenja, entitetskim ministarstvima za energiju,

kantonalnim ministarstvima, jedinicama lokalne samouprave i drugim partnerima (United Nations Development Programme [UNDP], 2021).

## REZULTATI I DISKUSIJA

Proučavanjem osnovnih pojmova, uzroka i mjera koje je neophodno primijeniti u oblasti smanjenja negativnih posljedica klimatskih promjena, došlo se do zaključka da je postojeću regulativu na nivou Evrope i entiteta Republike Srpske neophodno prilagoditi lokalnom nivou. To podrazumijeva usvajanje različitih mehanizama koje je potrebno realizovati na nivou jedinice lokalne samouprave kako bi predložene mjere dale što kvalitetnije rezultate.

Najznačajniji dokument kojim se reguliše oblast energetske efikasnosti na lokalnom nivou je SECAP (Sustainable Energy and Climate Action Plan – Akcioni plan za energetski održiv razvoj i klimatske promjene). Ovaj dokument definiše politike i mjere mitigacije i adaptacije i daje pregled finansijskih mehanizama za sprovođenje navedenih mjera. Fokusiran je na unapređenje energetske efikasnosti i smanjenje emisije gasova staklene bašte u gradovima (European Commission, 2018). SECAP definiše načine na koje će postavljeni ciljevi biti ostvareni. Primarno područje djelovanja predstavljaju programi i akcije uštede energije u javnim zgradama u vlasništvu lokalnih vlasti koje predstavljaju značajne potrošače energije – za zagrijavanje, hlađenje, osvjetljenje i slično. Bitno je naglasiti da ovdje ključnu ulogu ima sistem prostornog planiranja i organizacija javnih usluga, kao što je prevoz, odnosno sve što je u nadležnosti lokalnih i regionalnih vlasti. Strateško planiranje i uspostava energetskih standarda koji će se poštovati pri izgradnji novih zgrada mogu značajno da utiču na smanjenje korištenja energije. S tim u vezi, u nastavku rada, dat je pregled realizovanih projekata na području Grada Banja Luka i na osnovu dobijenih rezultata i komparativnih analiza, predložene su dalje mjere i aktivnosti. Ovaj dokument ima za cilj da podstakne redovan monitoring i izvještavanje u oblasti energetski održivog razvoja i klimatskih promjena na lokalnom nivou, što je jedna od obaveza preuzetih kroz entitetske zakonske akte usklađene sa Evroskom direktivom u datoj oblasti.

Grad Banja Luka je jedna od prvih lokalnih zajednica u Bosni i Hercegovini koja je pristupila inicijativi Evropske komisije potpisivanjem „Sporazuma gradonačelnika evropskih gradova“. Na taj način, između ostalog, obavezala se i na smanjenje emisije ugljen-dioksida za 20% do 2020. godine, što će biti rezultat povećanja energetske efikasnosti za 20% i 20% udjela obnovljivih izvora energije u kombinaciji sa drugim energijama (20:20:20). U skladu s tim, Grad je usvojio Održivi energetski akcioni plan Grada Banja Luka (SEAP), koji sadrži aktivnosti za sektor zgradarstva, saobraćaja, javne rasvjete, upravljanja otpadom, industrije i slično.

Banja Luka je bila jedna od lokalnih zajednica koje su učestvovale u projektu „Zeleni ekonomski razvoj“ koji od 2013. godine realizuje Razvojni program Ujedinjenih nacija (UNDP). U okviru ovog projekta u Gradu Banjoj Luci izvršena je rekonstrukcija ukupno 11 javnih objekata (osnovne škole, predškolske ustanove i fakultet). Unaprijeđena je energetska efikasnost objekata tako što su primijenjene različite termoenergetske mjere (termoizolacija, zamjena fasadne stolarije, ugradnja novih mašinskih instalacija, ugradnja kotlova na pelet i slično), što je doprinijelo smanjenju potrošnje energije, a samim tim i emisije $CO_2$ (UNDP, 2021a; Green Economic Development [GED], 2021).

Pregled realizovanih projekata i efekti svakog od njih dati su u Tabeli 1. iz koje su vidljivi svi pozitivni ekološki efekti (smanjenje potrošnje energije i emisije $CO_2$), povećanje komfora i finansijske uštede nakon izvedenih građevinskih radova na poboljšanju energetske efikasnosti predmetnih objekata. Na osnovu toga, dolazi se do zaključka da se uložena sredstva isplate i da je potrebno nastaviti u tom pravcu i ubuduće, na drugim objektima, kako javnim ustanovama, tako i na stambenim i poslovnim zgradama na području Grada Banja Luka. Prema dobijenim ukupnim podacima, vrijednost svih projekata je 1 176.631,00 KM, a godišnje uštede iznose 206.332,04 KM, dakle za manje od 6 godina, uložena finansijska sredstva se isplate. Pri tome treba napomenuti da je tokom ovih projekata otvoreno 65 novih radnih mjesta, tzv. „zelenih poslova“, odnosno poslova koji su u vezi sa očuvanjem životne sredine, što je takođe važan aspekt ovih projekata (Centar za razvoj i podršku, 2016).

Tabela 1. Pregled uticaja realizovanih projekata na području Grada Banja Luka u okviru projekta „Zeleni ekonomski razvoj“.
Table 1. Overview of the impact of implemented projects in the area of the City of Banja Luka within the "Green Economic Development" project.

| Vrsta i naziv objekta<br>Object name and type | Vrijednost projekta (KM)<br>Financial value of the project (BAM) | Očekivane godišnje finansijske uštede<br>Annual financial savings | Broj novih zelenih poslova<br>Number of new green jobs | Smanjenje emisije $CO_2$ (t/god)<br>$CO_2$ emission reduction (t/year) |
|---|---|---|---|---|
| OŠ Branko Radičević | 19.100,50 | 27.846,00 | 1 | 68 |
| Vrtić Ježeva kućica | 48.302,76 | 5.450,00 | 2 | 13 |
| JU Centar za predškolsko vaspitanje i obrazovanje i vrtić Bambi | 129.691,38 | 6.903,14 | 7 | 18 |
| OŠ Jovan Cvijić | 193.154,78 | 28.895,76 | 10 | 76 |
| Prirodno-matematički fakultet | 292.676,65 | 40.320,90 | 15 | 105 |
| OŠ Aleksa Šantić | 71.859,70 | 31.575,24 | 5 | 83 |
| Muzička škola Vlado Milošević | 180.298,82 | 7.308,00 | 10 | 73 |
| OŠ Dositej Obradović | 148.973,86 | 28.000,00 | 9 | 168 |
| OŠ Borisav Stanković | 92.572,55 | 30.033,00 | 6 | 172 |
| UKUPNO | 1 176.631,00 | 206.332,04 | 65 | 776 |

Banja Luka je 2020. godine usvojila Akcioni plan za zeleni grad, kao informativni dokument za Evropsku banku za obnovu i razvoj, za potrebe projekta Akcioni plan za zeleni grad Banja Luka, u sklopu Okvira za zelene gradove EBRD-a. Njegov cilj je unapređenje ekološke situacije na efikasan i finansijski održiv način, pri čemu je potrebno povećati koristi za privredu i društvo (Grad Banja Luka, 2020a). U skladu sa usvojenim Akcionim planom, u nastavku rada biće dat pregled novih prijedloga za poboljšanje energetske efikasnosti zgrada na području Grada koji su u vezi sa zelenom infrastrukturom i upotrebom biomaterijala u građevinarstvu, kako bi se ostvarili zadati ciljevi.

U skladu sa svim prethodno navedenim podacima o mjerama adaptacije na klimatske promjene sa posebnim osvrtom na mjere energetske efikasnosti u zgradarstvu koje su do sada sprovedene na području Grada Banja Luka, može se doći do zaključka da je u budućim aktivnostima prvenstveno potrebno realizovati sljedeće opšte korake:

Izraditi Akcioni plan energetski održivog razvoja i klimatskih promjena (SECAP) u skladu sa Evropskom direktivom (Direktiva 2010/31/EU o energetskim karakteristikama zgrada) i na primjerima drugih lokalnih zajednica u Bosni i Hercegovini koji će definisati konkretne mjere i korake za povećanje energetske efikasnosti u svim oblastima, a posebno u zgradarstvu, na osnovu referentnog inventara emisija gasova staklene bašte (Izvještaj o emisijama gasova sa efektom staklene bašte u Republici Srpskoj za period 2002-2018) i procjene rizika izloženosti klimatskim promjenama (Ministarstvo poljoprivrede, šumarstva i vodoprivrede, 2018);

Sprovoditi mjere koje su definisane u postojećoj zakonskoj regulativi (Zakon o energetskoj efikasnosti i Zakon o uređenju prostora i građenju) i u skladu sa specifičnostima lokalnog područja, redovno vršiti monitoring efekata realizovanih aktivnosti, pratiti stanje i izvještavati nadležne organe o istom;

Povećavati svijest svih građana o značaju mjera u ovim oblastima, a posebno učesnika u planiranju i građenju novih objekata, kroz razne seminare, radionice i pozitivne primjere iz Evrope i regiona sa sličnim mikroklimatskim obilježjima;

Na primjerima dosadašnjeg pozitivnog iskustva, redovno pratiti pozive za projekte međunarodnih organizacija koji su u vezi sa povećanjem energetske efikasnosti, učestvovati u njima i na taj način obezbijediti dio finansijskih sredstava za realizaciju istih;

Izraditi adekvatne mehanizme za podsticanje finansiranja privatnih kompanija, Zajednica etažnih vasnika i fizičkih lica koji realizuju mjere energetske efikasnosti i upotrebu obnovljivih izvora energije pri rekonstrukciji postojećih i izgradnji novih objekata;

Obezbijediti efikasnu dugoročnu saradnju između institucija na entitetskom i lokalnom nivou i kroz projekte poput do sada realizovanih (Zeleni ekonomski razvoj), nastaviti sa implementacijom mjera rekonstrukcije zgrada kroz finansiranje od strane nadležnih ministarstava i međunarodnih organizacija.

Kada je u pitanju realizacija građevinskih, mašinskih i elektroenergetskih mjera za povećanje energetske efikasnosti na području Grada Banja Luka, na osnovu dosadašnjih pozitivnih iskustava, preporučuju se sljedeće:

- rekonstrukcija ili zamjena krovnog pokrivača i termoizolacija krova;
- termoizolacija poda tavanskog prostora;
- toplotna izolacija vanjskog omotača zgrada;
- zamjena fasadne stolarije;
- ugradnja kotla na pelet;
- zamjena ekspanzionog sistema i ugradnja kalorimetra;
- instalacija solarnih kolektora na krovovima zgrada;
- upotreba obnovljivih izvora energije u sistemu daljinskog grijanja (biomasa);
- instalacija toplotnih pumpi u zgradama;
- zamjena rasvjete (klasičnih sijalica štednim LED sijalicama);
- zamjena kućanskih uređaja sa energetski efikasnijim uređajima.

Pored navedenog, dosadašnja istraživanja pokazala su mnogobrojne prednosti upotrebe specifičnih zelenih površina (krovno zelenilo i zelene fasade), kao i biomaterijala u građevinarstvu, u svrhu adaptacije na klimatske promjene i ostvarivanje ciljeva održivog razvoja. Usljed intenziviranja gradnje na području Grada posljednjih decenija, povećao se broj naselja, posebno u užem urbanom području, u kojima su mikroklimatski uslovi sve lošiji za život i zdravlje njihovih stanovnika. S druge strane, savremena arhitektura je upotrebom ravnih krovova na velikim stambenim i stambeno-poslovnim objektima pružila mogućnost oplemenjivanja gradskih sredina ozelenjavanjem ovakvih površina, bez obzira da li se radi o ekstenzivnim ili intenzivnim zelenim krovovima. Osim toga, tu mogućnost pružaju i krovovi podzemnih garaža i magacina, stepenasto izvedene terase i slične površine (Peck, 2008; Dunnet, & Kingsbury, 2004). Pored optimizacije omotača zgrada, vertikalne zelene površine (zelene fasade) efektno oplemenjuju fasade u estetskom smislu, čineći privlačnijim ukupan ambijent. Postoji širok spektar faktora koji utiču na povećanje osjenčenosti upotrebom vertikalnih vrtova i fasada (uključujući tip konstrukcije, orijentaciju fasade i vrstu vegetacije). Smanjenje temperature zida često može biti i 5 - 10°C (Perez et al. 2011).

Biomaterijali u građevinarstvu imaju veoma dugu istoriju upotrebe koja se ogleda u upotrebi drveta za uokvirivanje i pokrivanje krovova i upotrebi trske i slame za pokrivanje podova i krovova objekata. Biomaterijali pružaju mogućnost iskorištavanja njihovih svojstava koja se stalno unapređuju i imaju mnogobrojne prednosti, od ekonomskih i praktičnih, do ekoloških. Njihov osnovni potencijal može se okarakterisati kroz obezbjeđenje građevinskih materijala sa osnovnim prednostima, kao što su: skladištenje ugljenika u procesu fotosinteze ekstrahovanog iz atmosferskog $CO_2$, održiva proizvodnja, biorazgradivost (mogućnost dalje upotrebe kao materijal za proizvodnju biogoriva), niski ili nulti koeficijenti toplotnog širenja i visok specifični toplotni kapacitet i niska toplotna difuznost i slično (Khitab, 2021).

Na osnovu svega navedenog, dolazi se do zaključka da su očite veoma velike prednosti upotrebe biomaterijala u građevinarstvu sa aspekta očuvanja životne sredine, što se ogleda kroz: održivu potrošnju i proizvodnju, povećanje energetske efikasnosti zgrada, smanjenje negativnih uticaja klimatskih promjena, a samim tim i ostvarivanje ciljeva održivog razvoja. Takođe, drugi proizvodi od građevinskog materijala na biološkoj osnovi imaju prednost zbog znatno nižeg negativnog uticaja, u smislu emisije ugljen-dioksida, u odnosu na konvencionalne materijale, kao što su čelik, staklo ili beton. Shodno tome, biomaterijali su postali prepoznatljivi kao alternativna zamjena za tradicionalna građevinska rješenja.

## ZAKLJUČCI

Negativni uticaji na kvalitet životne sredine koji su izazvani dejstvom čovjeka zahtijevaju ozbiljan pristup i inovativna rješenja koja će obuhvatiti sve aspekte očuvanja okoline – ekološki, socijalni i ekonomski. Imajući u vidu neophodnost rješavanja negativnih posljedica izazvanih povećanim obimom ljudskih djelatnosti u svim sferama života, dolazi se do potrebe uvođenja noviteta, između ostalog, i u adekvatno planiranje i uređenje urbanih sredina i sektor građevinarstva. Gradovi, kao sredine koje su pretrpjele najveći negativan uticaj klimatskih promjena u vidu globalnog zagrijavanja, suočavaju se sa izazovom opstanka i nastajanja mjesta neadekvatnih za život čovjeka. Stoga, poboljšanje uslova u gradskim sredinama neophodan je i prioritetan zadatak za sve koji se bave uređenjem i planiranjem gradskih sredina, projektovanjem novih prostora i objekata, kao i realizacijom i održavanjem svih sastavnih dijelova jedne urbane sredine. Posebno se to odnosi na sektor zgradarstva koji predstavlja najveći uticajni faktor u potrošnji energije i emisiji $CO_2$. Adekvatan zajednički pristup rješavanju nastalih posljedica imao bi mnoge prednosti koje bi na višem nivou dovele do ostvarivanja ciljeva održivog razvoja.

U sektoru građevinarstva, jedan od načina ka ostvarivanju tih ciljeva, pored građevinskih, elektroenergetskih i mašinskih mjera koje su u dosadašnjoj praksi dale veoma dobre rezultate, jeste uvođenje specifičnih zelenih površina u kombinaciji sa biomaterijalima u proces građenja novih objekata ili rekonstrukciju postojećih, u slučajevima gdje trenutno stanje i tehničke karakteristike to dozvoljavaju. Dosadašnja istraživanja pokazala su da upotreba zelenih krovova, terasa i fasada, kao i materijala na biološkoj osnovi, imaju mnogobrojne prednosti. Prvenstveno, podržavaju odgovornu proizvodnju i potrošnju, čine gradove ekološkim i održivim, utiču na povećanje energetske efikasnosti objekata, umanjuju negativne efekte klimatskih promjena i poboljšavaju mikroklimatske uslove gradske sredine. Sve to takođe pozitivno utiče i na očuvanje ljudskog zdravlja, ne samo u smislu poboljšanja uslova života kroz poboljšanje kvaliteta vazduha i drugih aspekata, nego i povoljnim uticajem u psihološkom smislu, kroz upotrebu zelenih i prirodnih materijala u nekontrolisano građenim urbanim sredinama.

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# INCREASING THE ENERGY EFFICIENCY OF BUILDINGS IN THE AREA OF THE CITY OF BANJA LUKA AS A FUNCTION OF ADAPTATION TO CLIMATE CHANGES

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**ABSTRACT**

The negative effects of climate change that occur because of natural cycles and anthropogenic action are reflected in all aspects of the environment and life of modern man: human health, ecosystems, economy, social issues, and the like. This is evidenced by the extreme values of climate parameters (high summer temperatures, heavy rainfall, and floods), which have become more frequent in the last few decades. Due to the threat to the health and survival of the population in certain areas, there is a need to take significant steps regard to this. Adaptation to changed climate conditions has become one of the most important methods used by local communities in predicting the future impacts and risks of climate change. One way to combat these consequences is to increase the energy efficiency of buildings, which has many positive effects. Warming of buildings (envelope optimization) primarily affects the reduction of the need for energy consumption for heating and cooling of buildings, which in the long-term results in a reduction of CO2 emissions, as well as economic savings. The use of new construction technologies and the development of modern urbanism in the direction of increasing the quality of living space, and therefore the quality of life of the population of urban areas, would greatly affect energy efficiency, environmental protection, reduction of the negative effects of climate change, and thus the achievement of the goals of sustainable development.

**Keywords**: climate change, adaptation measures, energy efficiency, environment, sustainable development.

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# ORGANIC LIVESTOCK BREEDING AS A FUNCTION OF ENVIRONMENTAL PROTECTION AND SUSTAINABLE DEVELOPMENT

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## ABSTRACT

Conventional livestock production is still the dominant form of livestock production in the Republic of Serbia. However, there are also great opportunities for the development of organic livestock production. In order for a farm to pass the certification and receive the organic farm label, it is necessary for the farm to fulfil a number of conditions. First of all, it is necessary to harmonize all ecological and production conditions, as well as standards for animals raised in organic livestock systems in accordance with the legal regulations on organic production.

The aim of this paper is to present the possible forms of development of organic livestock production in accordance with the principles of environmental protection and sustainable development. For the development of organic animal husbandry, it is necessary to have the interest of consumers who will understand the importance and quality of organic products and appreciate their added value. The process of transforming a conventional farm to organic livestock production requires a certain period of time - the conversion period.

The social and ecological importance of organic livestock production compared to conventional farming is the production of sufficient quantities of high-quality food while minimizing all forms of pollution.

**Keywords:** organic livestock production, environmental protection, sustainable development.

## INTRODUCTION

Organic production is a sustainable agricultural system based on a high regard for ecological principles through the rational use of natural resources, the use of renewable energy sources, the preservation of natural diversity, and environmental protection. It aims to establish a closed system of plant and animal production.

Methods of organic production are based on the application of natural processes and substances with the limitation or complete elimination of the use of synthetic agents (Urošević et al., 2020).

From the very beginning of the development of organic farming systems, the preservation of biodiversity has been considered as important as maintaining soil fertility (Hass, 2012).

The basic principles of organic agriculture are based on the principles of sustainable agricultural development, which involve the management and preservation of natural resources and the direction of technological development towards meeting the needs of present and future generations. Such an approach can be successfully linked to the concept of multifunctional agriculture and sustainable development system, where the preservation of biodiversity and agrobiodiversity holds significant importance (Roljević et al., 2009; Đurić et al., 2019).

The Republic of Serbia and The Republic of Srpska (Bosnia and Herzegovina), like many other countries in the world, fulfill all the requirements for the organized development of high quality, safe, certified food that meets the consumers' needs and corresponds to export increase, making ecological and economic profit without jeopardizing the environment. As for the current state of legislation in the Republic of Serbia, our normative framework is completely harmonized with the EU directives. Enacted and implemented laws and regulations strictly follow the principle of "ecological welfare", facilitating the export of final organic products to the EU and third country

markets. This is the reason why organic production is described as a controlled way of production from field to table - it prevents a potential deterioration of ecosystem and human health. For the countries in the region, this is a very important type of production since they have always been agricultural countries with significant natural resources and a long production tradition (Milojević et al., 2022).

## ORGANIC LIVESTOCK PRODUCTION

In recent years, agricultural productivity has been affected dramatically by climate-related events such as drought. On the other hand, agricultural intensification is expected to satisfy the need for increased global food production. It is important to better understand the impact of multiple anthropogenic and global climate change stressors on agroecosystems since the cumulative effects and interaction between such disturbances can substantially decrease crop production (Azarbad, 2022).

Organic livestock production is based on the utilization of pasture areas and organic production of roughage and concentrated feed. The system of animal husbandry is free-range, which contributes to better health conditions and enables the expression of natural animal behavior. Transitioning to organic livestock production systems can significantly contribute to reducing environmental pollution and preserving ecological balance (Stojanović et al., 2004).

In organic livestock production, animal welfare is of high priority. It is necessary to provide animals with conditions for their growth and development in accordance with their natural genetic potential. This involves honouring the physiological and ethological needs of animals and creating conditions for the expression of natural functions and behaviors (Hovi, 2004; Drobnjak et al., 2013).

This production method is not extensive but rather intensive within the biological potential of the habitat (Rakonjac, 2017).

The social and environmental significance of organic livestock production compared to conventional production is the ability to produce sufficient quantities of high-quality food while minimizing all forms of pollution.

A sustainable food system is at the heart of the European Green Deal. Within the 'Farm to Fork Strategy' of the Green Deal, the European Commission has set a goal for at least 25% of agricultural land in the EU to be under organic farming and for organic aquaculture to be significantly increased by 2030 (Agricultural and rural development, 2023).

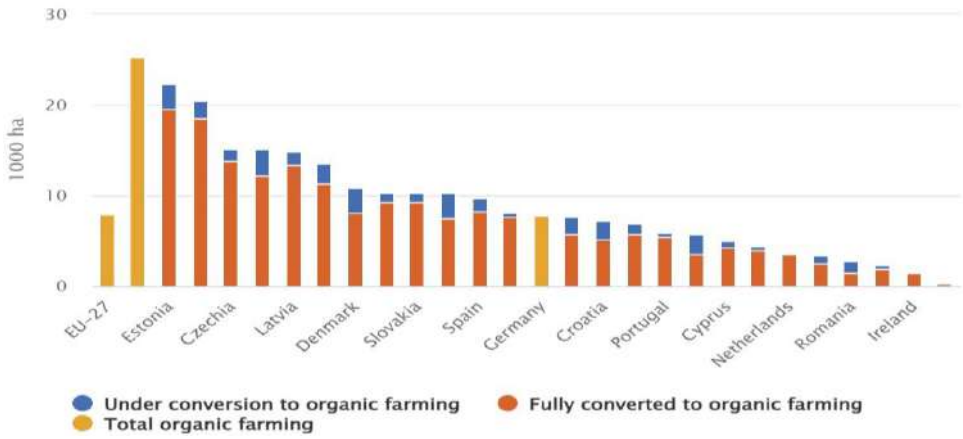



Figure 1. Share of organic area in total utilised agricultural area by country - 2019 (Eurostat online data, 2019).

**The rules of organic livestock production in the European Union**

Livestock breeders must meet specific requirements if they want to market their products as organic. These rules include respecting animal welfare and feeding animals according to their nutritional needs, and they are designed to protect animal health and the environment. In this way, it contributes to building public trust as the rules ensure that animals from organic farming are kept separate from animals in conventional farming.

The rules related to adherence to organic principles are as follows:

- Animals that are not organically raised must not be introduced onto the premises except for breeding purposes, and even then, they must comply with special rules.
- Farmers must provide their animals with 100% organic feed in order to market their products as organic.
- Food should primarily be sourced from the farm where the animals are kept or from farms in the same region.
- Cloning of animals and/or embryo transfer is strictly prohibited.
- Growth promoters and synthetic amino acids are prohibited.
- Mammals must be fed natural, preferably maternal, milk.
- Natural methods of reproduction must be used, although artificial insemination is allowed.
- Non-organic feed of plant origin, feed of animal and mineral origin, animal feed additives, certain products used in animal nutrition, and processing aids can be used only if they are explicitly approved for use in organic production.

The rules pertaining to animal welfare are as follows:

- Breeders must possess necessary basic knowledge and skills regarding animal health and welfare.
- Special attention should be given to housing conditions, breeding practices, adherence to prescribed stocking densities, and minimum surface areas for indoor and outdoor spaces.
- The number of livestock must be limited to minimize overgrazing, erosion, or pollution caused by animals or the spread of their manure.
- Animals should have access to open space or pasture whenever possible.
- Tethering or isolation of livestock is prohibited, except for individual animals for limited periods and only for reasons of welfare, safety, or veterinary purposes.
- Hormones or similar substances are not allowed, except as a form of veterinary therapeutic treatment for individual animals.
- When animals are sick, allopathic veterinary medicinal products, including antibiotics, can be used where necessary and under strict conditions. This is allowed only when the use of phytotherapeutic, homeopathic, and other products is inappropriate.
- The use of immunological veterinary drugs is permitted.

Statistical data on the number of organically raised animals in the European Union is incomplete and currently does not reflect the true state of the sector. However, based on the currently available information, the organic animal farming sector is rapidly developing in European countries (Trávníček et al., 2021). Table 1 provides an overview of European organic livestock in 2019, and it is observed that the majority of organic livestock farming is based on beef, lamb, and milk production. In Europe, there are approximately 5.1 million cattle, over 5.4 million sheep, and nearly 1.6 million pigs. From Table 1, it can be seen that over 62.3 million poultry are raised. Between 2010 and 2019, the highest increase was seen in poultry (110%). The number of cattle and dairy cows significantly increased in the same period (+81%), as well as the number of sheep (+55%) and pigs (+110%).

Table 1. Europe and the European Union: Organic livestock 2019 (Trávníček et al., 2021).

| | Europe | | | | European Union | |
|---|---|---|---|---|---|---|
| | Animals [head] | Organic share of total [%] | Change 2018-2019 [%] | Change 2010-2019 [%] | Animals [head] | Organic share of total [%] |
| Bovine animals | 5.079.962 | 4.0% | 4.1% | 80.9% | 4.852.303 | 6.0% |
| Sheep | 5.413.420 | 3.5% | -9.7% | 55.3% | 5.214.634 | 5.3% |
| Pigs* | 1.586.702 | 0.9% | 13.7% | 109.6% | 1.544.573 | 1.1% |
| Poultry** | 62.317.071 | 2.5% | 8% | 110% | 59.666.753 | 4.2% |

** Please note there is no consistent reporting in the official statistics, no clear distinction is made between the number of animals slaughtered, the places or average numbers of stock. Therefore, the data should be treated with caution.1*
*According to the Agricultural Market Information Company AMI, the average stock of fattening pigs was 621'000 in Europe, and 584'000 in the European Union.*
*** Also for poultry, there is no consistent reporting. According to the Agricultural Market Information Company (AMI), broilers' average stock was 15.1 million Europe and 14.6 million in the European Union. The average stock of laying hens was 27.3 million in Europe and 25.4 million in the European Union.*

**The state of organic livestock production in Serbia**

Conventional livestock production continues to be the dominant form of livestock production in the Republic of Serbia, and it is certain that it will remain dominant for a long time. According to data from the Statistical Office of the Republic of Serbia, comparing the status as of December 1, 2022, to the status as of December 1, 2021, there is a decrease in the total number of cattle (by 6.9%), pigs (by 7.0%), goats (by 1.7%), and poultry (by 3.5%), while there is an increase in the total number of sheep (by 1.5%) (RZS, 2023).

According to the data from the National Association for the Development of Organic Production *Serbia Organica* (2020), a smaller number of producers are engaged in organic livestock production compared to the number of producers involved in organic crop production. This can be explained by the fact that organic livestock production is more demanding in terms of meeting additional requirements for animal housing facilities, sourcing animals from other farms, and animal feeding and treatment. Intensive livestock production is closely related to intensive crop production, which relies on the use of significant amounts of chemicals and pesticides. It can be highly aggressive to the environment, especially if all prescribed technological procedures are not fully implemented. Within an organic farm, the circulation of mineral substances and nutrients comes to the fore, while maintaining soil fertility and satisfactory yield and production. By adhering to the basic standards prescribed for organic production, it is possible to achieve reduced environmental pollution and lower loss of nutrients at the farm level, which can directly impact production profitability (Bogdanović, 2015).

Furthermore, in order to market livestock products, it is necessary to meet the prescribed technological conditions for processing, as well as to provide conditions for storage and transportation in accordance with organic production regulations. However, livestock production in Serbia is experiencing a growth trend. In 2019, there was a significant increase in poultry (165%), bee colony (225%), sheep (18.7%), and pigs (10.7%), while the number of goats decreased (64%) compared to 2018 (Table 2).

A new development in organic livestock production in Serbia is the emergence of group production, which was previously characteristic only of organic crop production.

Table 2. Organic livestock production in Serbia 2012-2019 (Serbia Organica, 2020).

| Type of animal | Year | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 |
| Sheep | 2.837 | 4.031 | 3.153 | 4.848 | 4.378 | 4.665 | 5.138 | 6.099 |
| Pigs | 206 | 175 | 76 | 232 | 283 | 87 | 284 | 315 |
| Cattle | 1.428 | 2.176 | 2.726 | 2.746 | 2.895 | 3.094 | 3.594 | 3.556 |
| Goats | 211 | 946 | 1.154 | 1.686 | 1.406 | 2.048 | 1.486 | 536 |
| Poultry | 2.034 | 1.390 | 1.140 | 1.380 | 3.158 | 4.415 | 6.735 | 17.880 |
| Donkeys | 7 | 21 | 17 | 20 | 2 | 47 | - | - |
| Horses | 66 | 210 | 173 | 218 | 165 | 177 | 114 | 88 |
| Bee colony | 961 | 1.940 | 894 | 2.504 | 2.878 | 2.307 | 3.061 | 9.969 |

Research indicates that in the field of organic livestock production, there is faster development in those production branches where animal nutrition is based on grazing and roughage, particularly in the case of ruminants. The development of organic pig farming and organic poultry farming is significantly slower, considering that these domestic animal species require large quantities of protein feed in their diet (Rakonjac, 2016).

The state recognizes the importance of organic livestock production, and for subsidies in 2020, there was a planned increase of 40% compared to the amount of subsidies in conventional livestock production. Funds were allocated from the agricultural budget to co-finance the costs of control and certification of organic production, as well as the acquisition of machinery and equipment suitable for organic production (Đurić et al., 2021).

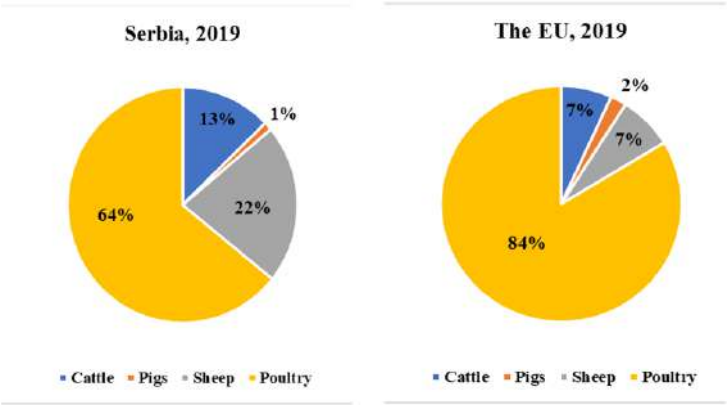
The transition from conventional to organic livestock production is demanding and involves a conversion period. Similar to conventional livestock production, there are differences in the quality of products resulting from the applied farming techniques or breed selection in organic livestock production as well (Bogdanović, 2015).

To obtain certified organic products, animals must be kept in accordance with the regulations, which specify the conversion period for transitioning from conventional to organic farming. The conversion period for different livestock species is prescribed as follows: for cattle and horses intended for meat production, a minimum period of 12 months is required; for small ruminants and pigs intended for meat production, a minimum of 6 months is required; for animals used for milk production, a minimum of 6 months is required; for fattening poultry, a period of 10 weeks is required; for poultry used for egg production, a period of 6 weeks is required (Bogdanović et al., 2004; Petrovic et al., 2016).

**Comparison of organic livestock production in the EU and in Serbia**

Comparison of organic livestock production in the EU and Serbia based on available data from 2019 can be made for four categories: cattle, pigs, sheep, and poultry (Graph 1).

From the graph, it can be observed that both in the EU and Serbia, poultry farming has the highest percentage, with 84% in the EU and 64% in Serbia. The least represented category is pig farming, with 2% in the EU and 1% in Serbia. In the EU, the percentage of sheep and cattle farming is equal at 7%, while in Serbia, sheep farming is higher at 22% compared to cattle farming at 13%.




Graph 1. Organic livestock production in the EU and Serbia in 2019.

## CONCLUSIONS

Organic livestock production, both in Europe and in Serbia, has a solid foundation and potential for further development. The connection between sustainable development and organic livestock farming is evident across all three dimensions - economic, social, and environmental. Although it requires significant initial investments, organic livestock production is becoming increasingly profitable.

However, organic livestock production cannot solve all the existing problems in animal husbandry, as it is still primarily targeted towards a selective and relatively small consumer group. Consumer interest and promotion of organic products are crucial factors.

The demand for certified organic products is growing among environmentally conscious consumers who understand the importance and quality of organic products and appreciate their added value. Farmers face numerous challenges, particularly during the conversion period from conventional to organic production. These challenges can be overcome through subsidies and support from relevant state institutions responsible for this field.

The social and environmental significance of organic livestock farming, compared to conventional production, lies in the production of sufficient quantities of highly quality food while minimizing all forms of pollution.

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# ENVIRONMENTAL BENEFITS AND ENERGY EFFICIENCY ARISING FROM OPTIMIZATION OF VESSEL'S VOYAGE

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## ABSTRACT

The number and size of vessels are increasing every day, and the maritime industry is becoming one of the leading factors of global pollution. This paper will present the basic methods and simulations which will show that significant environmental and energy efficiency benefits can be achieved by optimizing the vessel's route. A detailed description of the reduction of harmful gases emission, which is resulting from the reduction of the ship's speed, will also be presented. In addition to the presentation of the current existing results on this topic, the results obtained from the analysis carried out on the ship machine and engine simulator from the Maritime Faculty in Kotor, by the authors of the paper, will also be given. By optimization of the voyage, which comes from more effective tasks performing at all organizational levels, the vessel is able to adjust its speed in such a way to arrive at the port exactly on time for the berthing operations. This would allow the vessel to reduce its speed, which would lead to the ultimate goal of minimizing air pollution by reducing the emission of harmful gases from vessels.

**Keywords**: marine pollution, harmful gases emission, vessel's speed, vessel's voyage.

## INTRODUCTION

The implementation of environmentally sustainable practices in shipping is becoming increasingly important due to growing concerns for the environment and the need to reduce energy consumption (Watson et al., 2015.). This paper aims to study the environmental benefits and energy efficiency that arise from the optimization of a ship's voyage. Organization of ship's voyage presented in this paper consists of calculating a reduced speed which will affect harmful gases emission and will minimize or eliminate time spent at anchor while waiting for berthing operations. The calculated speed will allow the vessel to arrive at port precisely on time for berthing and cargo operations and will also lower the harmful gas emission (Heaver, 2021). Existing examples and results will be given through analysis of simulation performed on engine room simulator at the Maritime Faculty Kotor. Simulator exercises gave results of fuel consumption and harmful gas emission at different levels of speed performed on two types of vessels by using different speed adjustments. In addition to this method, this paper is based on a literature review of the application of different methods for optimizing a ship's voyage and their effects on the environment and energy consumption. Literature sources include scientific papers, conference papers, technical reports, and related publications published in the recent years. Figure 1 shows the increase in the capacity of container fleet ships over a period of 40 years (IHS, 2019).

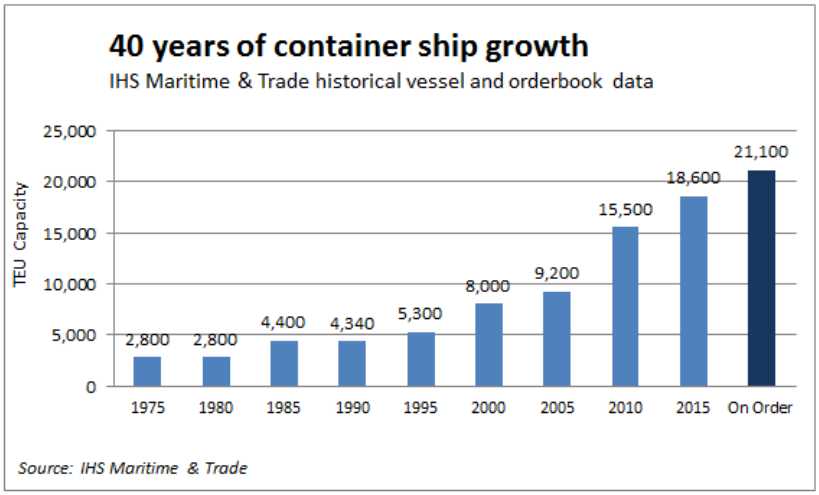


Figure 1. The increase in the capacity of container fleet ships over a period of 40 years (IHS, 2019).

## MATERIAL AND METHODS OF WORK

Nowadays, vessels spend a lot of time anchored in the areas in front of the port, waiting for the mooring and the start of the planned operations. In most cases, the ship's journey lasts several days or weeks, and ships spend a few hours or days at anchor. By optimizing the ship's journey, that is analyzed by the authors (Drašković, & Bošnjak, 2023), the conclusion is reached that with more effective and organized communication between all involved factors (ships, companies, ports, terminals, coastal stations), ship's journey could be optimized in such a way that ship arrives at the port exactly on time for mooring operations, which would avoid the negative impacts that anchoring brings with it. Also, from this comes the possibility of speed reduction, which significantly reduces fuel consumption and exhaust gas emissions, which is the main topic of this work. Table 1 shows a case study from the aforementioned paper, which presents the port of departure, time spent sailing to that port, as well as time spent at anchor, of vessel Agnes Victory (Call Sign:LAEM8, IMO: 9258600, Bergen, Norway, year 2021).

Table 1. Port of departure, time spent sailing to that port, as well as time spent at anchor.

| Port of Call | Time spent on anchorage | Length of voyage (full ahead) |
|---|---|---|
| Evyap Port, Izmit, Turkey | 16 hours | 4 days |
| Tartous, Syria | 8 bours | 2 days |
| Dneprobugskiy, Ukraine | 9 hours | 5 days |
| Kakinada, India | 1 hour 30 minutes | 7 days |
| Pasir Gudang, Malaysia | 18 hours | 6 days |

The table is taken from the case study of one of the authors of the paper (B. Drašković), during the time he spent working on the given ship.

## RESULTS AND DISCUSSION

Andersson, & Ivehammar, 2017 analyzed how it is possible to optimize the ship's voyage, in order to avoid anchoring, so that ships would arrive at the port exactly on time for mooring and commence of operations that were planned in specific port. Table 2 shows the fuel savings per 1000 kg on an annual basis, taking into account the percentage of speed reduction, as well as the time period in which this reduction was made. For example, if the speed is reduced by 25%, 12 hours before arriving at the port, the fuel savings will be 20979000 kg (annualy) (Andersson, & Ivehammar, 2017).

Table 2. The fuel savings per 1000 kg on an annual basis, taking into account the percentage of speed reduction, as well as the time period in which this reduction was made (Andersson and Ivehammar, 2017.)

| **Speed reduction** | **The time before arrival in which the necessary information is provided** | | | |
|---|---|---|---|---|
| | ***1h*** | ***4h*** | ***12h*** | ***24h*** |
| 5% | 402 | 1609 | 4826 | 9 640 |
| 10% | 784 | 3135 | 9376 | 18 638 |
| 25% | 1805 | 7163 | 20 979 | 41 249 |
| 50% | 3094 | 11 602 | 32 670 | 61 586 |

Table 3 shows the financial savings per 1000 kg on an annual basis, taking into account the percentage of speed reduction, as well as the time period in which this reduction was made. For example, if the speed is reduced by 10%, 12 hours before arriving at the port, the fuel savings will be 12089000 kg (annualy) (Andersson, & Ivehammar, 2017).

Table 3. The financial savings per 1000 kg on an annual basis, taking into account the percentage of speed reduction, as well as the time period in which this reduction was made (Andersson, & Ivehammar, 2017).

| **Speed reduction** | **The time before arrival in which the necessary information is provided** | | | |
|---|---|---|---|---|
| | ***1h*** | ***4h*** | ***12h*** | ***24h*** |
| 5% | 519 | 2074 | 6223 | 12 429 |
| 10% | 1011 | 4042 | 12 089 | 24 032 |
| 25% | 2327 | 9236 | 27 050 | 53 187 |
| 50% | 3989 | 14 959 | 42 127 | 79 418 |

Table 4 shows reduction of emissions of harmful gases ($CO_2$, $NO_x$, $SO_2$, $PM_{2.5}$) per 1000 kg on an annual basis, taking into account the percentage of speed reduction, as well as the time period in which this reduction was made. For example, if the speed is reduced by 10%, 12 hours before arriving at the port, the reduction of harmful gas emission ($NO_x$) will be 681000 kg (annualy) (Andersson, & Ivehammar, 2017).

Table 4. Reduction of emissions of harmful gases (CO2, NOx, SO2, PM2.5) per 1000 kg on an annual basis, taking into account the percentage of speed reduction, as well as the time period in which this reduction was made (Andersson, & Ivehammar, 2017).

| **Speed reduction** | **Emission** | **The time before arrival in which the necessary information is provided** | | | |
|---|---|---|---|---|---|
| | | ***1h*** | ***4h*** | ***12h*** | ***24h*** |
| 5% | $CO_2$ | 1259 | 5035 | 15 106 | 30 173 |
| | $NO_x$ | 29 | 117 | 351 | 700 |
| | $SO_2$ | 0.7 | 2.9 | 8.6 | 17 |
| | $PM_{2.5}$ | 0.5 | 2.0 | 5.9 | 12 |
| 10% | $CO_2$ | 2453 | 9812 | 29 346 | 58 338 |
| | $NO_x$ | 57 | 228 | 681 | 1354 |
| | $SO_2$ | 1.4 | 5.6 | 17 | 33 |
| | $PM_{2.5}$ | 1.0 | 3.8 | 11 | 23 |
| 25% | $CO_2$ | 5649 | 22 420 | 65 665 | 129 110 |
| | $NO_x$ | 131 | 520 | 1524 | 2996 |
| | $SO_2$ | 3.2 | 13 | 37 | 73 |
| | $PM_{2.5}$ | 2.2 | 8.7 | 25 | 50 |
| 50% | $CO_2$ | 9683 | 56 313 | 102 256 | 192 764 |
| | $NO_x$ | 225 | 843 | 2373 | 4475 |
| | $SO_2$ | 5.5 | 21 | 58 | 110 |
| | $PM_{2.5}$ | 3.8 | 14 | 40 | 75 |

Table 5 shows the emissions of $NO_x$, $SO_2$, and $PM_{2.5}$ per kg of fuel, assuming that all ships are powered by Marine Gas Oil (MGO) with a maximum sulfur content of 0.1%. (Andersson and Ivehammar, 2017.)

Table 5. The emissions of NOx, SO2, and PM2.5 per kg of fuel, assuming that all ships are powered by Marine Gas Oil (MGO) with a maximum sulfur content of 0.1% (Andersson, & Ivehammar, 2017).

| Type and size of vessel | $NO_x$ | $SO_2$ | $PM_{2.5}$ |
|---|---|---|---|
| Cargo small | 0.0731 | 0.00180 | 0.00119 |
| Bulk medium | 0.0728 | 0.00170 | 0.00115 |
| Bulk large | 0.0729 | 0.00172 | 0.00116 |
| RO-RO | 0.0661 | 0.00191 | 0.00125 |
| Container medium | 0.0733 | 0.00184 | 0.00122 |
| Container large | 0.0733 | 0.00184 | 0.00122 |
| Conteiner very large | 0.0722 | 0.00156 | 0.00108 |
| Tanker small | 0.0731 | 0.00180 | 0.00119 |
| Tanker medium | 0.0728 | 0.00170 | 0.00115 |
| Tanker large | 0.0734 | 0.00181 | 0.00134 |
| Tanker very large | 0.0734 | 0.00181 | 0.00134 |

The price of fuel largely depends on the current state of fuel market, which generally varies significantly. In addition to the spot price (settlement price, i.e. the market where goods are sold at the daily price), two alternatives were given with the average price during the three studied days (624 USD/ton), and a 50 percent higher spot price was also calculated. The results are shown in Table 6 (Andersson, & Ivehammar, 2017).

Table 6. Spot price (settlement price, i.e. the market where goods are sold at the daily price), two alternatives with the average price during the three studied days (624 USD/ton) and a 50 percent higher spot price (Andersson, & Ivehammar, 2017).

| | Spot price June 15 | Average spot price the 3 studied days | 50% higher spot price |
|---|---|---|---|
| Baltic Sea | 522.2 | 588.4 | 783.3 |
| North Sea | 418.3 | 471.4 | 627.5 |
| Total | 940.5 | 1059.8 | 1410.8 |

Tables 7 and 8 are showing the emission costs calculated with different unit values, as well as the average of their values (Andersson and Ivehammar, 2017.).

Table 7. Annual costs of CO2 emissions for traffic in the Baltic and North Sea areas, in millions of euros (Andersson, & Ivehammar, 2017).

| | ASEK | Stern low | Stern high | EU ETS | Average |
|---|---|---|---|---|---|
| Baltic Sea | 316.4 | 184.6 | 738.2 | 21.1 | 413.1 |
| North Sea | 253.5 | 147.9 | 591.4 | 16.9 | 330.9 |
| Total | 569.8 | 332.4 | 1329.7 | 38.0 | 744.0 |

Table 8. Annual costs for $NO_x$, $SO_2$ and $PM_{2.5}$ emissions for traffic in the Baltic and North Sea areas, in millions of euros (Andersson, & Ivehammar, 2017).

| | ASEK | CAFE 1 | CAFE 2 | CAFE 3 | CAFE 4 | Prosjek |
|---|---|---|---|---|---|---|
| Baltic Sea $NO_x$ | 549.6 | 194.6 | 299.3 | 366.4 | 538.8 | 390.8 |
| North Sea $NO_x$ | 431.7 | 296.6 | 459.9 | 552.9 | 815.0 | 511.2 |
| Total $NO_x$ | 981.3 | 491.2 | 759.2 | 919.3 | 1353.8 | 902.0 |
| Baltic Sea $SO_2$ | 4.6 | 6.8 | 10.7 | 13.6 | 20.2 | 11.2 |
| North Sea $SO_2$ | 3.7 | 10.2 | 16.2 | 20.7 | 28.3 | 15.8 |
| Total $SO_2$ | 8.3 | 17.0 | 26.9 | 34.3 | 48.5 | 27.0 |
| Baltic Sea $PM_{2.5}$ | - | 14.7 | 23.3 | 29.4 | 43.0 | 27.6 |
| North Sea $PM_{2.5}$ | - | 27.5 | 41.3 | 53.1 | 78.8 | 50.2 |
| Total $PM_{2.5}$ | - | 42.2 | 64.6 | 82.6 | 121.7 | 77.9 |

As a final result, research was conducted on the machine simulator of the Faculty of Maritime Studies in Kotor. Different degrees of speed were taken into consideration, combined with the emission of harmful gases at each of them, which is presented in Table 9.

Table 9. Different degrees of speed, combined with the emission of harmful gases at each of them

| Speed | Nav. Full Ahead | Full Ahead | Half Ahead | Slow Ahead | Dead Slow Ahead |
|---|---|---|---|---|---|
| $NO_X$ [ppm] | 1019 | 787 | 515 | 403 | 491 |
| CO [ppm] | 83 | 54 | 28 | 21 | 20 |
| $SO_X$ [ppm] | 67 | 61 | 62 | 33 | 30 |
| $CO_2$ [%] | 4 | 4 | 4 | 2 | 2 |
| C [mg/m$^3$] | 66 | 54 | 48 | 46 | 59 |
| Fuel consumption [%] | 76 | 48 | 30 | 14 | 6 |
| Speed [RPM] | 105 | 87 | 70 | 53 | 38 |

The table is also presented in detail in figure (diagram) 2, which shows the decrease in speed and emission of negative gases in a period of 30 minutes.

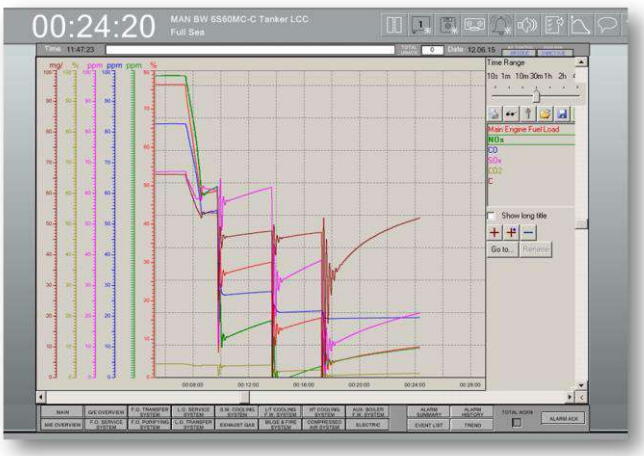


Figure 2. Diagram which shows the decrease in speed and emission of negative gases in a period of 30 minutes.

Figure 3 shows the increase in exhaust gas emissions ($NO_X$, CO, $SO_X$, $CO_2$, C) in three speed levels (Dead Slow Ahead, Half Ahead and Full Ahead).

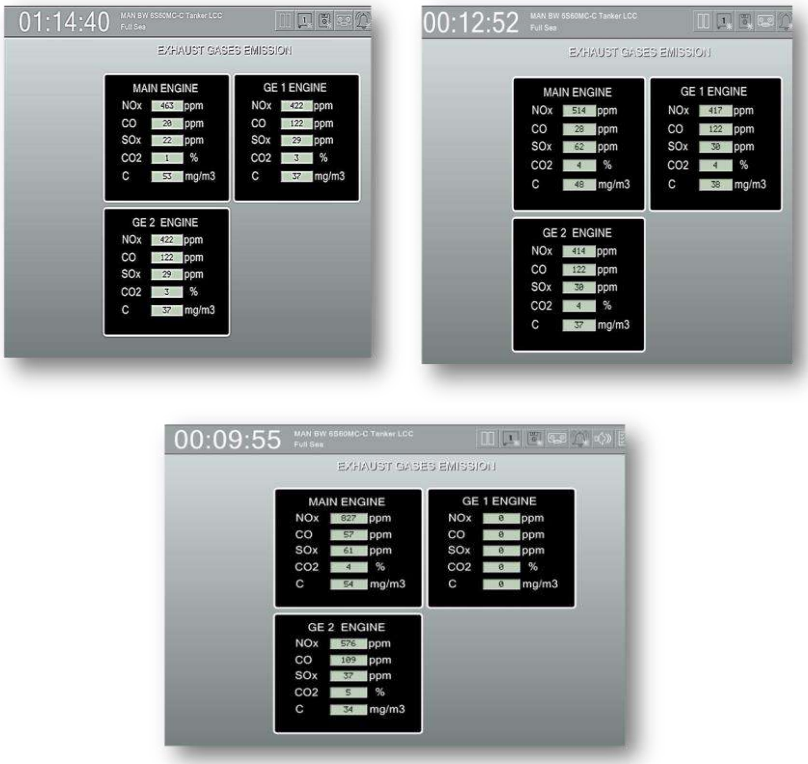


Figure 3. The increase in exhaust gas emissions (NOX, CO, SOX, CO2, C) in three speed levels (Dead Slow Ahead, Half Ahead and Full Ahead).

## CONCLUSIONS

In the end, based on the collected results of current research, as well as the test carried out on a machine simulator, the conclusion is reached that it is necessary to establish effective communication at all levels in maritime industry, in order to facilitate the optimization of the ship's journey. Quality optimization would bring a number of benefits, such as: avoiding the anchoring of the ship and its negative impacts, reducing the emission of harmful exhaust gases, reducing fuel consumption and significant financial savings

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# POREĐENJE FASADNIH SKLOPOVA SA ASPEKTA ENERGETSKE EFIKASNOSTI I EKONOMSKE ISPLATIVOSTI

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## SAŽETAK

Energetska sertifikacija objekata u Srbiji donela je brojne promene, koje se odnose na način projektovanja novih objekata, ali i značajnu potrebu za energetskom sanacijom postojećih objekata. Cilj ovog rada, jeste da ispita efikasnost najčešće korišćenih fasadnih sklopova, s obzirom na to da fasada jednog objekta predstavlja bitnu kariku u lancu elemenata koji čine jedan energetski efikasan objekat. U ovom radu, se analizira pet najčešće korišćenih fasadnih sklopova koji se primenjuju prilikom gradnje objekata višeporodičnog stanovanja u Republici Srbiji, sa materijalima koji se u njima upotrebljavaju. Analiziran je i njihov ekonomski aspekt, uz obavezni uporedni proračun energetske efikasnosti stambenog objekta i primenu programa URSA Građevinska fizika 2, u skladu sa Pravilnikom o energetskoj efikasnosti zgrada. Analiziran je fasadni sklop ventilisane fasade sa oblogom od prirodnog kamena, kao i kontaktne fasade sa različitim fasadnim oblogama. U tom kontekstu je analiziran i ekonomski aspekt primene različitih fasadnih sklopova. Uočeno je da za isti energetski razred fadasnog zida, investicija može biti značajno različita i biti 5,86 puta veća po metru kvadratnom površine fasadnog zida. Ovo istraživanje je značajno obzirom da se energetska sanacija postojećih objekata razmatra kao neophodan korak ka smanjenjenju energetskih potreba za zagrevanje objekata u Republici Srbiji, i da je potrebno preduzeti mere za smanjenje potrebne energije za zagrevanje objekata.

**Ključne reči**: ventilisana fasada, termoizolacija, energetska efikasnost.

## UVOD

U Srbiji je od 2012. godine obavezna energetska sertifikacija objekata, u tom smislu je usvojena regulativa kojom se propisuje metodologija proračuna, i sertifikacije objekata (Pravilnik o energetskoj efikasnosti zgrada [POEEZ], 2011; Pravilnik o uslovima, sadržaju i načinu izdavanja sertifikata o energetskim svojstvima zgrada [PUSNISESZ], 2012). I mada je stambeni fond Srbije relativno nov u poređenju sa fondom u zemljama EU, ugrubo 2/3 stambenog fonda je građeno u vreme socijalističkog perioda, a samo u periodu od 1971 do 1980 godine je sagrađeno oko 24% stambenih jedinica (Studija stambenog fonda Srbije 2006, str. 11 i 12) što je veći procenat nego u zemljama EU. Objekti koji su građeni u to vreme, su građeni prema propisima koji su važili u vreme njihove gradnje i zahtevaju energetsku sanaciju, pa je stoga ovo istraživanje koje je predmet rada još značajnije. Individualni stambeni objekti su dominantno zastuljeni tip gradnje u Srbiji sa 96,3% u odnosu na kolektivno stanovanje, koje je zastupljeno sa 3,7% (Jovanović Popović i sar., 2013). U Srbiji je prema Priručniku o Energetskoj efikasnosti u zgradama i kućama, prosečna potrošnja energije za zagrevanje objekata oko 200 [kWh/m2] (Priručnik o Energetskoj efikasnosti u zgradama i kućama [PEEZIK], 2018, str. 24), što je nekoliko puta više od dozvoljenih vrednosti za energetski razred C, kao prihvatljiv, prema propisima iz 2012. godine. Fasada jednog objekta sem estetskih svojstava igra vrlo važnu ulogu i može imati značajan uticaj u energetskim gubicima objekta ako nije adekvatno isprojektovana. Kroz uporedne analize i prikaze u monografiji Videti energiju autori (Jovanović Popović i Ignjatović, 2011) su dokumentovano prikazali veliki broj stambenih i poslovnih objekata u Beogradu, kroz termovizijske snimke fasada, kako bi pokazali koliko su objekti energetski neefikasni, odnosno koliki su potrošači energije. Njihovo istraživanje ukazuje, pre svega projektantima i izvođačima, na greške i zablude kada se projektuje i gradi objekat. Pravilnikom o energetskoj efikasnosti zgrada, propisane su maksimalne vrednosti

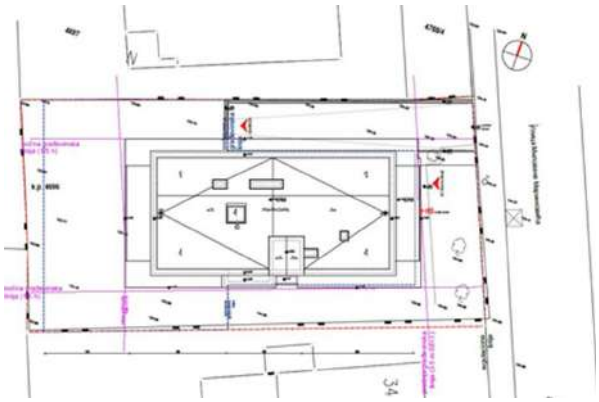
koeficijenta prolaza toplote građevinskog elementa Umax [W/m2K], koje su nekoliko puta niže od onih koji si važili u vreme masovne gradnje objekata u Srbiji. Ta značajna promena u vrednostima referentnih parametara koeficijenata prolaza toplote građevinskih elemenata, dovela je do povećanja debljine termoizolacionih materijala koji su neophodni u sklopu termičkog omotača objekta. O ulozi i značaju debljine termoizolacionog materijala u strukturi termičkog omotača rezultate istraživanja iznose mnogi autori (Prozuments i sar. 2023; Tucaković i sar., 2020; Šekularac i sar., 2018). Sa povećanjem debljine, povećavaju se i troškovi gradnje po metru kvadratnom termičkog omotača (Prozuments i sar., 2023; Onan, 2014).

Razvojem tehnologije građenja, nastale su velike mogućnosti izbora konstruktivnih rešenja, uz mogućnost izbora najrazličitijih materijala za izradu kako samog konstruktivnog sklopa, tako i za završnu obradu fasade. Poboljšanje termičkih karakteristika objekta se vrši primenom određenih materijala u njegovoj osnovnoj strukturi, primenom osnovnih elemenata sa poboljšanim termičkim karakteristikama. Sve češće se koriste konstruktivni elementi u vidu termo blokova ili betonskih blokova od gas betona, koji poseduju povoljne energetske karakteristika, čak i kada se ne primeni dodatni termoizolacioni sloj na objektu. Fasada predstavlja drugu po redu slabu tačku jednog objekta, odmah nakon stolarije. Iako delovi objekta poput tavanice, krova, kao i podne površine nemaju zanemarljive energetske gubitke, objekat koji je neizolovan može izgubiti i do 30% energije bez obzira na namenu koju on ima. To znači da jedan objekat izgubi gotovo trećinu energije u u periodu grejanja bez obzira da li je reč o novoizgrađenom objektu ili postojećem objektu kome je potrebna energetska sanacija (Mitrović, 2019a).

Izradom fasade na objektu ne samo da se smanjuje potrošnja energije, već se dobijaju i mnogi drugi propratni efekti koji su pozitivni, uključujući dobru zvučnu izolaciju, poboljšanje akustičke zaštite unutrašnjeg prostora od spoljašnje buke, viši komfor korišćenja prostora, kao i zaštitu od požara u zavisnosti od primenjenog termoizolacionog materijala. Ako objekat ima izvedenu toplotnu izolaciju i zamenjenu stolariju, ušteda energije, koja je potrebna za grejanje i hlađenje objekta bez obzira na njegovu namenu može iznositi čak 40-60%. (Mitrović, 2019b).

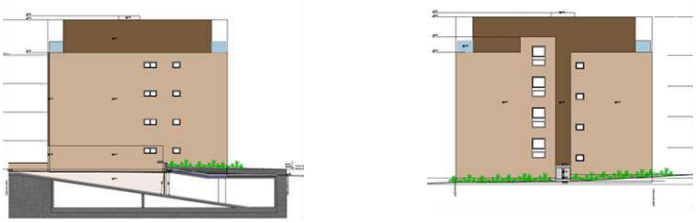
## MATERIJAL I METOD RADA

Fasada ima veliku ulogu u energetskim gubicima. Izbor fasadnog sistema, kao i materijala koji će se u njemu koristiti zavisi od mnogo faktora među kojima su namena objekta, konstruktivni sklop, dizajn i slično. Fasada jednog objekta ima i veliku investicionu vrednost, zavisno od izabranog fasadnog sistema, a s obzirom na to da se uglavnom izvodi jednom u životnom veku objekta, odabiru strukture i finalne izrade fasade treba posvetiti više pažnje. Zbog toga je potrebno napraviti dobar izbor fasadnog sklopa i sa energetskog i sa finansijskog aspekta. U radu su analizirani energetski gubici pet fasadnih sklopova, na jednom istom projektu višeporodičnog stambenog objekta, projektovanog u Beogradu. Objekat je projektovan kao samostojeći na građevinskoj parceli površine P = 385,30 m2, bruto površina prizemlja je P = 146,96 m2. Situacija objekta je prikazana na Slici 1.



Slika 1. Situacija objekta.
Figure 1. Situation of the facility.

Objekat je spratnosti Po+P+3+Pk, sa garažnim prostorom ispod nivoa terena. Osnova objekta je kompaktna, ulazom orjentisana prema ulici. Južna i severna fasada objekta su prikazane na Slici 2. To su bočne fasade objekta, orjentisane prema susednim parcelama na kojima se nalaze već izgrađeni objekti iz prethodnog perioda.



Slika 2. Južna fasada, Severna fasada objekta.
Picture 2. South facade, North facade of the building.

Zapadna fasada, orjentisana prema dvorišnom delu građevinske parcele i Istočna fasada objekta, orjentisana prema ulici je i fasada na kojoj se nalazi ulaz u objekat, su prikazane na Slici 3.

Slika 3. Zapadna fasada i Istočna fasada objekta.
Figure 3. West facade and East facade of the building.

Za potrebe ovog istraživanja je formirano pet modela, koji se razlikuju po fasadnom sklopu, dok su prozori, krov i izolacija poda u svim modelima isti. Za potrebe istraživanja, su urađeni proračuni, za svih pet formiranih modela u softveru URSA građevinska fizika 2, u skladu sa Pravilikom o energetskoj efikasnosti zgrada (POEEZ, 2011). Osnovne karakteristike analiziranih modela fasadnog sklopa su tabelarno prikazane u Tabeli 1.

Tabela 1. Fasadni sklopovi analiziranih modela U1,U2,U3,U4 i U5.
Table 1. Facade assemblies of the analyzed models U1, U2, U3, U4 and U5.

| Oznaka modela | Opis modela |
|---|---|
| U1 | Ventilisana fasada sa termoizolacionim slojem 12 cm mineralne vune i završnom oblogom od prirodnog kamena; |
| U2 | Kontaktna fasada sa termoizolacionim slojem od 12 cm mineralne vune i završnom oblogom od prirodnog kamena; |
| U3 | Kontaktna fasada sa termoizolacionim slojem od 12 cm ekstrudiranog polistirena i Etik fasadom; |
| U4 | Kontaktna fasada sa termoizolacionim slojem od 12 cm mineralne vune i Etik fasadom; |
| U5 | Kontaktna fasada sa termoizolacionim slojem od 12 cm ekstrudiranog polistirena i završnom oblogom od keramike. |

U istraživanju je analiziran i ekonomski aspekt, te su za proračun osim Normi i standarda rada u građevinarstvu (Mijatović, 2008), prikupljene ponude od izvođača za analizirane modele, što je urađeno u periodu krajem 2022. i početkom 2023. godine. Na takav način su dobijene cene za izradu celokupne fasade objekta u realnom vremenu i prema uslovima koji su u tom periodu postojali na tržištu građevinskih proizvoda i materijala za svih pet analiziranih modela. Obzirom da se tehnologija izrade fasade razlikuje, ukupna cena je podeljena sa površinom fasade da bi se dobila jedinična cena u dinarima po metru kvadratnom fasade objekta, kako bi se dobijene vrednosti mogle porediti. Treba naglasiti da u cenu nije ušlo projektovanje fasade, odnosno podkonstrukcije, popravke i održavanje tokom životnog ciklusa. Pribavljene cene se samo odnose na izradu fasade, za svaki od analiziranih modela.

## REZULTATI I DISKUSIJA

Da bi se mogli formirati modeli fasadnog sklopa bilo je potrebno pre svega uraditi proračune energetske efikasnosti, bez tog osnovnog uslova nije bilo moguće predložiti strukturu svake od pet analiziranih fasada. Prvi i osnovni uslov je morao biti zadovoljen u skladu sa važećom regulativom u Republici Srbiji (POEEZ, 2011; PUSNISESZ, 2012). Prvi uslov koji je morao nbiti zadovoljen je Koeficijent prolaza toplote građevinskog elementa, u ovom slučaju to je fasadni zid, za svaki od analiziranih pet modela  Oznaka koeficijenta prolaza toplote građevinskog elementa je U [W/m²K]. Metodologija za proračun parametara toplotne zaštite zgrade ili dela zgrade propisana je Pravilnikom o energetskoj efikasnosti zgrada (POEEZ, 2011) prema formuli (1).

$$U = \frac{1}{R_{si} + R + R_{se}}, \quad (1)$$

Kriterijum koji koeficijent prolaza toplote građevinskog elementa prema propisima mora zadovoljiti je:

$$U \leq U_{max}, \quad (2)$$

Maksimalna vrednosti koeficijenta prolaza toplote građevinskog elementa $U_{max}$ [W/(m$^2$·K)], je propisana Pravilnikom o energetskoj efikasnosti zgrada (POEEZ, 2011). Za nove zgrade, za spoljašnji zid je $U_{max}$ = 0,30 [W/(m$^2$·K)]. Za postojeće zgrade, kada se radi energetska sanacija istih, za spoljašnji zid je $U_{max}$ = 0,40 [W/(m$^2$·K)]. Istraživanje je rađeno za novu zgradu. Vrednosti koeficijenta prolaza toplote spoljašnjeg zida, proračunate prema važećoj metodologiji prema Pravilniku o energetskoj efikasnosti zgrada (POEEZ, 2011), prema formuli (1) za svih pet modela su prikazane u Tabeli 2.

Prema važećoj legislativi u Republici Srbiji, za energetsko rangiranje objekta potrebno je izračunati Godišnju potrebnu energiju za grejanje $Q_{H,nd}$ [kWh/a] prema SRPS EN ISO 13790. Formula za proračun Godišnje potrebne energije za grejanje je:

$$Q_{H,nd} = (Q_T + Q_v) - \eta_{H,gn} \cdot (Q_{int} + Q_{sol}), \quad (3)$$

Izračunate vrednosti Godišnje potrebne energije za grejanje se u skladu sa Pravilnikom o uslovima, sadržaju i načinu izdavanja sertifikata o energetskim svojstvima zgrada, (PUSNISESZ, 2012) radi energetskog rangiranja obračunavaju po metru kvadratnom površine objekta. Izračunate vrednosti Godišnje potrebne energije po metru kvadratnom površine objekta za svih pet analiziranih modela prikazane su u Tabeli 2.

Energetski razred objekata se iskazuje prema Pravilniku o uslovima, sadržaju i načinu izdavanja sertifikata o energetskim svojstvima zgrada, (PUSNISESZ, 2012). Svi novi objekti moraju zadovoljiti minimum energetski razred C. Rezultati energetskog rangiranja objekata prema analiziranim modelima prikazani su u Tabeli 2

Poređenje rezultata analize energetske efikasnosti objekata prema modelilima: U1, U2, U3, U4 i U5, prikazano je u Tabeli 2.

Analizirani model U1, fasadnog sklopa ventilisane fasade, sa termoizolacionim slojem od mineralne kamene vune od 12 cm i završnom oblogom od prirodnog kamena daje najbolje rezultate, kada su u pitanju energetske potrebe zgrade. Godišnja potrebna energija za grejanje po metru kvadratnom površine objekta je 18,23 [kWh/ m²]. Objekat sa ovakvim fasadnim sklopom svrstan je u energetski razred B. Pogodnost fasadnog sklopa je u tome što u konstrukciji ne dolazi do kondenzacije, što se može videti u delu proračuna difuzije vodene pare za ovaj fasadni sklop. Takođe, na unutrašnjoj površini ne dolazi do orošavanja i sve ostale karakteristike ovog sklopa su u pogledu energetske efikasnosti najbolje.

Tabela 2. Poređenje rezultata analize energetskih karakteristika analiziranih fasadnih sklopova modela U1,U2,U3,U4 i U5.
Table 2. Comparison of the results of the analysis of the energy characteristics of the analyzed facade assemblies of models U1, U2, U3, U4 and U5.

| **Oznaka modela** | **Karakteristike modela** | | | |
|---|---|---|---|---|
| | ***Opis modela i završna obloga*** | ***U* [W/m²K] *Za fasadni sklop*** | ***Qh,nd* [kWh/ m²] *Za objekat prema modelu*** | ***Energetski razred objekta*** |
| U1 | Ventilisana fasada-kamen | 0,229 | 18,23 | B |
| U2 | Kontaktna fasada-kamen | 0,241 | 18,70 | B |
| U3 | Kontaktna fasada-Etics | 0,283 | 20,44 | B |
| U4 | Kontaktna fasada-Etics | 0,242 | 18,74 | B |
| U5 | Kontaktna fasada-keramika | 0,281 | 20,36 | B |

Analizirani model U2, čiji je fasadni sklop sačinjen od kontaktne fasade sa termoizolacionim slojem od kamene mineralne vune u debljini od 12 cm i sa završnom oblogom od kamena. Godišnja potrebna energija za grejanje po metru kvadratnom površine objekta je 18,70 [kWh/m²], što je drugo mestu u odnosu na najbolje rangiran fasadni sklop U1. Model U2 se prema energetskim potrebama za zagrevanje objekta svrstava u energetski razred B. Rezultati proračuna difuzije vodene pare, za model U2 pokazuju da u konstrukciji dolazi do kondenzacije u zoni četiri, kao i da je vreme, koje je potrebno za isušenje konstrukcije oko 42 dana, što je prema važećoj legislativi dozvoljeno (POEEZ, 2011). Svi ostali parametri su zadovoljavajući i u granicama.

Analizirani model U3, čiji je fasadni sklop sačinjen od kontaktne fasade sa termoizolacionim slojem od ekstrudiranog polistirena od 12 cm sa završnom Etics fasadom proračun Godišnje potrebna energija za grejanje po metru kvadratnom površine objekta je 20,44 [kWh/ m²], što je peto mesto od analiziranih pet modela. Model U3 ima zadovoljavajuće parametre u pogledu energetske efikasnosti i svrstava objekat u energetski razred B. U fasadnom sklopu prema modelu U3, ne dolazi do kondenzacije u konstrukciji.

Kada se analitiraju rezultati za model U4 fasadni sklop kontaktna fasada sa termoizolacionim slojem od mineralne kamene vune od 12 cm sa završnom Etics fasadom, vrednosti Godišnje potrebna energija za grejanje po metru kvadratnom površine objekta je 18,74 [kWh/ m²] na trećem mestu. Za model U4 energetski razred objekta je B. Rezultati proračuna difuzije vodene pare za fasadu po modelu U4, pokazuju da dolazi do kondenzacije u konstrukciji u zoni četiri, međutim za isušenje je potrebno 0,47 dana, što je zanemarljivo.

Analizirani model U5 sa fasadnim sklopom kontaktne fasade sa termoizolacionim slojem od ekstrudiranog polistirena od 12 cm i završnom oblogom od keramike, vrednosti Godišnje potrebna

energija za grejanje po metru kvadratnom površine objekta su 20,36 [kWh/ m²] na četvrtpm mestu. Za model U5 energetski razred je B. U modelu U5 dolazi do kondenzacije u zoni četiri a potrebno vreme za isušenje konstrukcije je 19 dana.

Analizom rezultata proračuna energetske efikasnosti, možemo zaključiti da su svi analizirani modeli fasadnih sklopova u energetskom razredu B. Pojava kondenzacije u zoni četiri kod modela U2 i U5 iznosi 42 i 19 dana, preporučuje se povećanje debljine termoizolacionog sloja, kako bi se sprečila pojava kondenzacije. Ovo će naravno dovesti do povećanja investicije za izradu fasade u modelima U2 i U5. Kada je reč o modelu U4, kondenzacija u zoni četiri se može zanemariti s obzirom na to da je period isušenja konstrukcije manji od jednog dana.

Poređenje rezultata ekonomske analize predloženih modela je usledilo posle zaključka da su svi predloženi modeli fasade, sa energetskog aspekta u skladu sa savremenim propisima u toj oblasti. Na osnovu urađenih elaborata energetske efikasnosti i projekta urađen je predmer radova, u kome je bila izračunata za svaku od analiziranih fasada debljina i količina materijala i rada koji je potreban za izradu svake od pet analiziranih fasada.

Prikaz rezultata analize potrebne investicije po metru kvadratnom fasade, analiziranih modela: U1, U2, U3, U4 i U5 prikazano u Tabeli 2.

Tabela 2. Poređenje rezultata finansijske analize izrade fasade prikazano u dinarima/m$^2$ и €/m$^2$.
Table 2. Comparison of the results of the financial analysis of the facade construction shown in dinars/m2 and €/m2.

| **Oznaka modela** | **Tabelarni prikaz modela** | | |
|---|---|---|---|
| | ***Opis modela i završna obloga*** | ***Cena* [din/m²]** ***Za fasadni sklop*** | ***Cena* [€/m²]** ***Za fasadni sklop*** |
| U1 | Ventilisana fasada-kamen | 30.114,50 | 256,29 |
| U2 | Kontaktna fasada-kamen | 16.135,00 | 137,32 |
| U3 | Kontaktna fasada-Etics | 5.138,56 | 43,73 |
| U4 | Kontaktna fasada-Etics | 5.611,56 | 47,76 |
| U5 | Kontaktna fasada-keramika | 11.536,00 | 98,18 |

Iz prikazanih rezultata istraživanja, možemo zaključiti da model U1, ventilisana fasada sa oblogom od prirodnog kamena postavljena na podkonstrukciji, predstavlja najskuplje rešenje fasadnog sklopa. Nešto nižu cenu ima model U2, kontaktna fasada, takođe sa oblogom od prirodnog kamena, zatim U5 kontaktna fasada sa oblogom od keramike, pa U4 kontaktna fasada sa finalnom obradom Etics i na kraju kao najekonomičnije rešenje je model U3, takođe kontaktna fasada sa finalnom obradom Etics. U obračun potrebne investicije ušla je samo cena izrade fasade, bez investicije projektovanja i održavanja tokom životnog ciklusa objekta i da je cena prikazana po metru kvadratnom fasade u dinarima i evrima. Proračun finansijskih ulaganja se odnosi samo na investiciju za izgradnju samog fasadnog sklopa.

## ZAKLJUČCI

S obzirom na to da postoji široka potražnja za termoizolacionim materijalima usled ekspanzivne gradnje objekata, postoji i široka ponuda istih. Ukoliko se uzme u obzir da se fasada objekta, ako je dobro i kvalitetno urađena i održavana, radi jednom u životnom veku objekta koji je u Republicu Srbiji okvirno 50-60 godina, potrebno je dobro razmotriti koji je fasadni sklop najbolji izbor. Ovo bi trebalo biti određeno dizajnom, konstruktivnim sklopom, ali i elaboratom energetske efikasnosti objekta.

U skladu sa tim, sve je češća upotreba ventilisanih fasadnih sistema na novoizgrađenim objektima, i to sa završnom oblogom od prirodnog kamena, mada se koriste i drugi veštački materijali kao finalna obloga. Istraživanje pokazuje da ovaj sistem gradnje, podrazumeva veliku investiciju, koja u zavisnosti od željenog dizajna i izabranog kamena, može biti ekonomski

neopravdana. Proračunom energetske efikasnosti objekta sa sistemom ventilisane fasade, a prema modelu U1, pokazano je da objekat ima energetski razred B.

Proračunom energetske efikasnosti objekta sa kontaktnom fasadom prema modelima U2, U3, U4 i U5, dobijeni su takođe dobri rezultati, odnosno svi parametri se nalaze u okviru dozvoljenih granica, i takođe pripadaju energetskom razredu B. Razlika između ovih sistema, je u tome što se u sistemu sa kontaktnom fasadom modela U2, U4 i U5 javlja kondenzacija u ravni četiri pri čemu je period isušenja konstrukcije za model U2 iznosi 42 i U5 iznosi 19 dana, dok su proračuni za U1 i U3 pokazali da nema kondenzacije, a u modelu U4 je zanemarljiva kondenzacija, sa periodom isušenja od 0,47 dana.

Ako analiziramo investiciju za izradu ventilisane fasade u modelu U1, možemo zaključiti da je ona veća od svih ostalih analiziranih kontaktnih fasada, a od najjeftinije fasade U3 je veća 5,86 puta. U analizi cene kod sistema ventilisane fasade zanemaren je trošak projektovanja same fasade, što se mora uraditi s obzirom na to da se radi o teškoj završnoj oblozi na potkonstrukciji. Ventilisana fasada sa završnom oblogom od prirodnog kamena iziskuje dodatna investiciona održavanja radi impregnacije fasade koja se mora uraditi jednom godišnje, jer je reč o oblozi od prirodnog materijala. Dodatno, potrebno je uzeti u obzir i mogućnost podrhravanja ovakve obloge usled dejstva aseizmičkih talasa, različitih vibracija usled saobraćaja i slično, a to može dovesti do oštećenja fasadne obloge i do nesrećnih slučajeva. Ovo se ne može reći za model U2, s obzirom na to da je završna obloga ovog fasadnog sklopa prirodni kamen, koji zahteva dodatna održavanja tokom životnog veka objekta, zaštitni premaz jednom godišnje.

Sa druge strane, u slučaju kontaktne fasade analiziranih modela: U3, U4 i U5, dodatno investiciono održavanje nije potrebno raditi jednom godišnje, osim ukoliko dođe do oštećenja određenog dela fasade. Ciklusi održavanja fasade sa obradom Etics, mogu biti 5 do 7 godina. Svakako ova završna obloga je dosta lakša za sanaciju od prethodnog kamena, koji traži zaštitne premaze jednom godišnje. Za fasadu prema modelu U5, kod koje je završna obloga od keramičkih pločica, ako su radovi izvedeni kvalitetno i odabrana adekvatka keramika, životni vek ovih fasadnih obloga može biti vrlo dug, čak i 25-50 godina, bez obaveze dodatnih premaza. Analizirajući rezultate elaborata energetske efikasnosti, možemo zaključiti da uložena investicija u fasadni sistem ventilisane fasade modela U1 ne doprinosi energetskoj efikasnosti objekta u odnosu na model U3, s obzirom na to da je pri upotrebi oba pomenuta fasadna sklopa objekat u energetskom razredu B, ne postoji kondenzacija u slojevima, a svi ostali parametri su zadovoljavajući u oba slučaja.

Uzevši u obzir da se u pogledu energetske efikasnosti za modele U1 i U3 dobijaju slični rezultati, možemo zaključiti da je investicija za model U1 neopravdana u energetskom smislu, jer je 5,86 puta veća od potrebne investicije za model U3. Investicija za model U1 bi bila opravdana u pogledu estetike stambenog objekta, koja se sa aspekta primene prirodnog kamena kao finalne obloge kod nas smatra višim standardom i sa tog aspekta se može postići i viša cena kod prodaje nekretnine u objektu sa takvom materijalizaciom fasade.

Dalja istraživanja bi se mogla sprovesti u pravcu povećanja debljine termo izolacionog sloja u fasadama u kojima je uočen veći period potreban za vreme isušenja, da bi se eliminisali eventualni problemi od uticaja nagomilavanja vlage u konstrukciji fasadnog zida, a to su modeli U2 i U5, i shodno tome se izračunaju novi parametri energetske efikasnosti za te modele, kao i ekomski pokazatelji koji bi se poredili sa preostalim modelima. U sledećim istraživanjima bi se mogla prilikom ekonomskle analize uvrstiti i cena projektovanja ventilisane fasade modela U1, koja u ovom istraživanju nije ušla u proračun.

Istraživanje se prevashodno odnosi na gradnju novih objekata, odnosno energetsku i ekonomsku analizu koju treba imati u vidu kod izgradnje fasadnih sklopova novih objekata.

**Napomena**

Ovo istraživanje je deo master rada odbranjenog na studijskom programu Građevinsko inženjerstvo u visokogradnji na Akademiji tehničko umetničkih strukovnih studija Odsek građevinsko geodetski u Beogradu, Republika Srbija, na predmetu Energetska efikasnost i sertifikacija zgrada, maj 2023.

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# COMPARISON OF FACADE ASSEMBLIES FROM THE ASPECTS OF ENERGY EFFICIENCY AND ECONOMIC PROFITABILITY

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**ABSTRACT**

The energy certification of buildings in Serbia has brought numerous changes, related to the way new buildings are designed, but also a significant need for energy rehabilitation of existing buildings. The aim of this paper is to examine the effectiveness of the most commonly used facade assemblies, considering that the facade of a building is an essential link in the chain of elements that make up an energy-efficient building. In this paper, the five most commonly used facade assemblies, which are applied during the construction of multi-family residential buildings in Serbia, are analyzed, along with the materials used in them. Their economic aspect was also analyzed, along with the mandatory comparative calculation of the energy efficiency of the residential building and the application of the URSA-Building Physics 2 softver, in accordance with the Rulebook on Energy Efficiency of Buildings. The facade assembly of the ventilated facade with natural stone cladding, as well as the contact facade with distinct facade cladding, was analyzed. In this context, the economic aspect of the application of different facade assemblies was also analyzed. It was observed that for the same energy class of the facade wall, the investment can be significantly different and be 5.86 times higher per square meter of the surface of the facade wall. This research is significant considering that the energy rehabilitation of existing buildings is considered as a necessary step towards reducing the energy needs for heating buildings in the Republic of Serbia, and that it is necessary to take measures to reduce the energy required for heating buildings.

**Keywords:** ventilated facade, thermal insulation, energy efficiency.

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# EMISIJE I UKLANJANJE GASOVA STAKLENE BAŠTE KROZ DIMENZIJU DEKARBONIZACIJE

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## SAŽETAK

Osnovni cilj rada je opisivanje stanja, indikatora, ciljeva, politika i mjera u dimenziji dekarbonizacije, koja se odnosi na poddimenziju – emisija i uklanjanje gasova staklene bašte u Republici Srpskoj (BiH), na osnovu podataka iz još uvijek radnog Energetskog i klimatskog plana Republike Srpske. Ovim dokumentom date su preporuke, politike i mjera koje se odnose na dekarbonizaciju, energetsku efikasnost, sigurnost snabdijevanja unutrašnjeg tržišta i dr., u cilju ispunjavanja međunarodnih obaveza Republike Srpske (BiH) prihvaćenih Ugovorom o osnivanju Energetske zajednice jugoistočne Evrope i Sofijske deklaracija. Energetsko-klimatski plan Republike Srpske će nakon usvajanja zamijeniti Strategiju razvoja energetike Republike Srpske do 2035. Entitetski energetski i klimatski plan Republike Srpske i FBiH sastavni su dio Integrisanog energetsko-klimatskog plana Republike Srpske. BiH. Ciljevi postavljeni Energetskim i klimatskim planom Republike Srpske su veoma ambiciozni i izazovni za RS, posebno s obzirom na sektore energetske transformacije u kojima je planirano smanjenje emisije gasova staklene bašte.

**Ključne riječi:** dekarbonizacija, indikatori, gasovi staklene bašte, energetski i klimatski plan Republike Srpske, sektori energetske transformacije.

## UVOD

Međunarodni ugovor „Okvirna konvencija Ujedinjenih Naroda o klimatskim promjenama“ (UNFCCC) je usvojen maja 1992 godine. UNFCCC predstavlja odgovor međunarodne zajednice na svjetske klimatske promjene, uzrokovane povećanom koncentracijom gasova staklene bašte (GHG) u atmosferi (United Nations, 2009). Cilj UNFCCC je da se „osigura stabilizacija GHG na nivo koji bi sprečio negativne antropogene uticaje na klimatski sistem“. Kjoto protokol (KP) usvojen je decembra 1997.g. (Unation Nationa Climate Change, 1997) sa ciljem da pomogne u sprovođenju UNFCCC. Protokol obavezuje industrijalizovane zemlje da stabilizuju odnosno smanje emisije gasova sa efektom staklene bašte na osnovu načela iz UNFCCC. BiH je ratifikovala UNFCCC decembra 2000 godine (Predsjedništvo Bosne i Hercegovine, 2000), a Kjoto protokol aprila 2007 godine (Predsjedništvo Bosne i Hercegovine, 2008). BiH kao član UNFCCC, ali koja nije član Aneksa 1, nije imala obavezu da smanji GHG u okviru KP, ali se ohrabrivala da to uradi uz finansijsku podršku od razvijenih zemalja.

Međutim, potpisivanjem Ugovora o osnivanju Energetske zajednice (Evropska zajednica i Ugovorne stranke, 2006), Pariskog sporazuma (Evropska Unija, 2016) i Sofijske deklaracije o zelenom planu za Zapadni Balkan (Energy Community, 2020) do kraja 2022. g. zemlje Zapadnog Balkana, te i Republika Srpska i BiH su prihvatili da definišu ciljeve, politike i mjere dimenzije dekarbonizacije, poddimenzije emisija i uklanjanje GHG u RS, za njihovo smanjenje do 2030 godine. Integrisani energetski i klimatski planovi (NECP) uvedeni su Uredbom o upravljanju energetskom unijom i klimatskim akcijama 2018/1999 (Evropska Unija, 2018), dogovorenom kao dio paketa za čistu energiju za sve Evropljane. S obzirom na političku podjelu i strukturu vlasti u BiH, te da je oblast energetike prema Ustavu BiH u nadležnosti entiteta, osim integrisanog (NECP BiH), u izradi su i entitetski energetski i klimatski planovi (ECP RS i ECP FBiH), koji su sastavni dijelovi NECP BiH (Ministarstvo spoljne trgovine i ekonomskih odnosa BiH, 2022). Dimenzija ECP RS (Ministarstvo spoljne trgovine i ekonomskih odnosa Republike Srpske, 2022)

dekarbonizacija, ima dva ključna elementa: emisija GHG i obnovljivi izvori energije (OIE). U ovom radu je analizirana dimenzija dekarbonizacija, poddimenzija emisija i uklanjanje GHG u Republici Srpskoj (RS).

## STANJE-PREGLED INVENTARA (IZVJEŠTAJA) EMISIJA GASOVA SA EFEKTOM STAKLENE BAŠTE U REPUBLICI SRPSKOJ ZA PERIOD 2002-2018. G.

Evropska regulativa koja propisuje izradu Inventara GHG definisana je Uredbom 2013/525 (Evropska Unija, 2013) o mehanizmu za praćenje i izvještavanje o emisijama GHG i izvještavanju o drugim informacijama vezanim uz klimatske promjene.

Uredba 2018/841 (Evropska Unija, 2018a) utvrđuje obaveze u pogledu korištenja zemljišta, prenamjene zemljišta i šumarstva (LULUCF) kojima se doprinosi postizanju ciljeva iz Pariskog sporazuma i cilja smanjenja emisija GHG, EU za razdoblje od 2021.g. do 2030.g., kao i pravila za proračun emisija i uklanjanja iz sektora LULUCF i provjeru ispunjavanja tih obaveza.

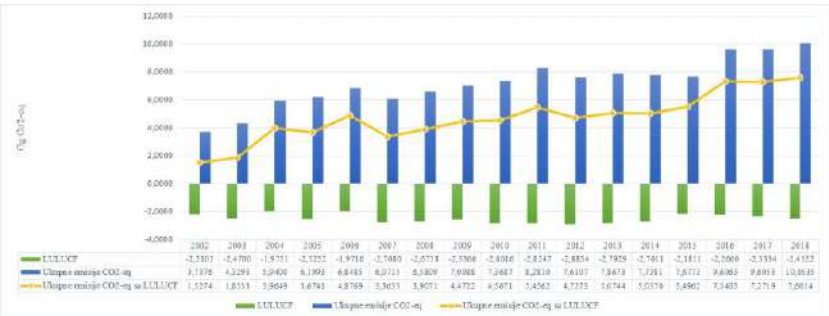
Uredba 2018/842 (EU, 2018b) utvrđuju obaveze u pogledu njihovih minimalnih doprinosa za razdoblje od 2021.g. do 2030.g. ispunjenju cilja EU o smanjenju njenih emisija GHG za 30 % u odnosu na nivo iz 2015.g. u 2030.g. u sektorima obuhvaćenim Uredbom, te utvrđuje pravila za određivanje godišnjih kvota emisija i ocjenjivanje napretka država EU u ostvarivanju njihovih minimalnih doprinosa.

Republika Srpska je donijela Zakon o zaštiti vazduha (Zakon o zaštiti vazduha [ZZV], 2017), kojim je propisana obaveza izrade Inventara GHG u RS. Inventar GHG za Republiku Srpsku (Republički hidrometeorološki zavod Republike Srpske, 2011) je izrađen u skladu sa Smjernicama o izvještavanju prema UNFCCC, za zemlje koje nisu članice Aneksa 1, Odluke 3/CP.5 (IPCC, 1999) i 17/CP.8 (IPCC, 2002).

Pregled stanja Inventara gasova sa efektom staklene bašte (GHG) za Republiku Srpsku urađen je za period 2002-2018. godine. Podaci korišteni za izradu ovog dokumenta su preuzeti iz baza podataka RHMZ RS, izvještaja i publikacija Republičkog zavoda za statistiku RS, stučnih i naučnih publikacija, kao i međunarodnih publikacija poput FAO (FAOSTAT, 2018), EIA, EUROSTAT.

Inventar je obuhvatio:

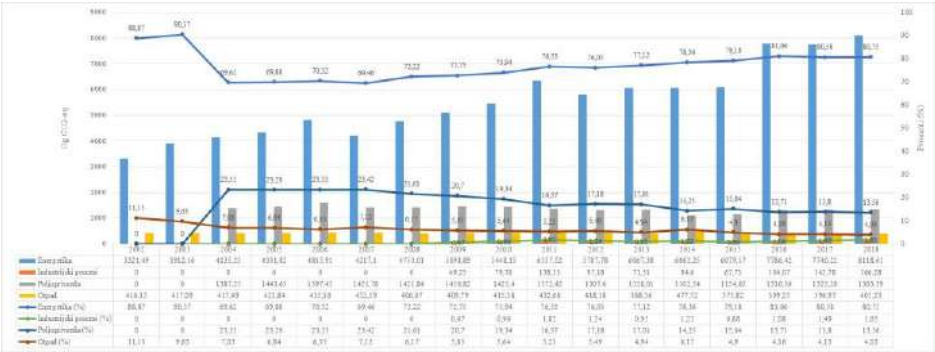
- Direktne gasove: $CO_2$ (ugljen dioksid), $CH_4$ (metan), $N_2O$ (azot suboksid) i
- Indirektne gasove: O (kiseonik), NOx (azotni oksid) NMVOC (nemetanska isparljiva organska jedinjenja), $SO_2$ (sumpor dioksid), $CF_4$ (tetrafluorugljenik), $C_2F_6$ (heksafluoretan), $SF_6$ (sumpor heksafluorid).
- Izvori emisija i ponori:
- Energetika,
- Industrijski procesi,
- Korištenje rastvarača i drugih proizvoda,
- Poljoprivreda,
- Promjena korištenja zemljišta i šumarstvo (LULUCF) i
- Otpad.




Grafikon 1. Inventar ukupnih emisija GHG u RS za period 2002-2018.
Chart 1. Inventory of total GHG emissions in RS for the period 2002-2018.

Na grafikonu 1 prikazan je Inventar ukupnih emisija GHG u Republici Srpskoj za period 2002-2018. g. izražena kao $CO_2$ - eq (Ministarstvo spoljne trgovine i ekonomskih odnosa Republike Srpske, 2022). Na grafikonu 1 je prikazan postepeni rast ukupnih emisija GHG u Republici Srpskoj.

Na grafikonu 2 je prikazano, da su najveće emisije GHG u posmatranom periodu bile u sektoru energetike (70-90%), a nastale su sagorijevanjem goriva za proizvodnju električne i toplotne energije, te pogona motornih vozila. Emisije $CO_2$ su bile najveće 2018. godine (10053.51 Gg $CO_2$-eq), zbog povećanja proizvodnje električne energije i potrošnje uglja u termoelektranama Republike Srpske. Iz sektora poljoprivrede u ovom periodu, poticalo je 11-23% emisija, sektora otpada 5-11%. Najmanje emisija $CO_2$ u posmatranom periodu poticalo je iz industrijskih procesa (do 2%).



Grafikon 2. Inventar ukupnih emisija GHG po sektorima u RS za period 2002-2018.
Chart 2. Inventory of total GHG emissions by sector in RS for the period 2002-2018.

## METODOLOGIJA

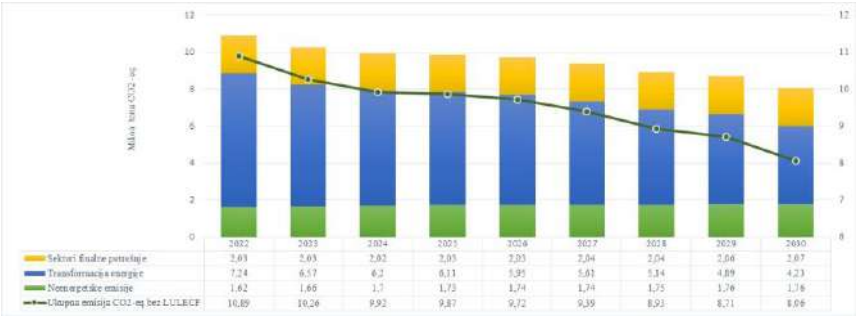
Za proračun emisija stanja korištena je metodologija Međuvladinog tijela za klimatske promjene (IPCC) propisana UNFCCC, na osnovu referentnog priručnika Revidirane smjernice IPCC-a za nacionalne inventare emisija GHG iz 1996. godine (IPCC/UNEP/ OECD/IEA (IPCC, 1996), IPCC/UNEP/OECD/IEA (IPCC/UNEP/OECD/IEA, 1997), Smjernica dobre prakse za upotrebu zemljišta i šumarstvo iz 2003. godine (IPCC, 2003), te Smjernica dobre prakse i upravljanje nesigurnostima u nacionalnim inventarima emisija gasova sa efektom staklene bašte iz 2000. godine (IPCC, 2000). Baza podataka je formirana u softveru IPCC (The NonAnnex I Inventory Software), koji je izradio UNFCCC Sekretarijat za zemlje koje nisu članice Aneksa 1 UNFCCC-a. Obzirom da metodologija zahtijeva određenu procjenu nesigurnosti proračuna i verifikaciju ulaznih podataka i rezultata, na taj način ona omogućava povećanje kvaliteta, tačnosti i unaprijeđenja pouzdanosti proračuna. Indikatori koji su se razmatrani u okviru poddimenzije emisije i uklanjanje GHG za smanjenje emisije GHG su: smanjenje emisija GHG, razlika između projekcija emisija GHG i cilja u 2020.godini, razlika između najnovije proxy liste emisija GHG i privremenih ciljeva u definisanim sektorima i intentitet GHG u oblasti ekonomije.

Low Emissions Analysis Platform (LEAP) je softverski alat koji se koristio za integrisano energetsko planiranje i procjenu ublažavanja klimatskih promjena, pri određivanju budućih ciljeva u 5 dimenzija definisanih u ECP RS. Modeliranje energetskih potreba je provedeno metodom; odozdo prema gore (*engl. bottom up*), kojom su rješavani manji dijelovi problema bitni za formiranje cjelokupnog rješenja. Ovom metodom prikazan je i proces dekarbonizacije energetskog sektora u dijelu OIE i emisija GHG ($CO_2$-eq), implementacijom mjera i preporuka, te se ista koristila unutar programa LEAP.

## CILJEVI

Cilj smanjenja ukupne emisije GHG u 2030. godini u Republici Srpskoj

Ciljna vrijednost ukupne emisija $CO_2$-eq bez LULUCF u Republici Srpskoj 2030.godine iznosi 8,06 $MtCO_2$. Ova vrijednosti je izračunata na osnovu planiranja razvoja energetskog sektora u Republici Srpskoj i indikatora definisanih u cilju postizanja karbonske neutralnosti 2050. godine. Na gafikonu 3 je prikazan trend smanjenja emisija $CO_2$-eq u periodu 2022-2030. godina.



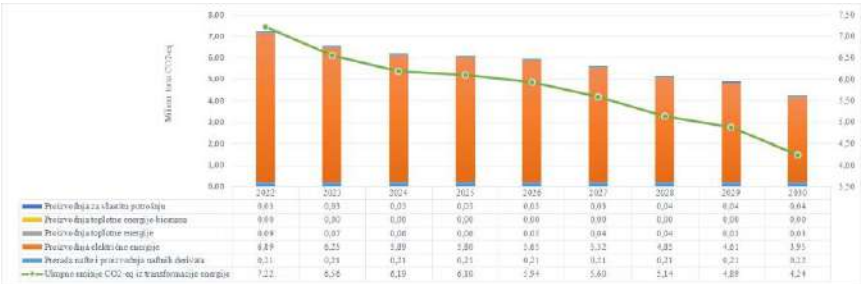

Grafikon 3. Trajektorija smanjenja emisije $CO_2$-eq bez LULUCF u RS u periodu 2022-2030, prema sektorima.

Chart 3. Trajectory of reduction of CO2-eq emissions without LULUCF in the RS in the period 2022-2030, according to sectors.

Smanjenje emisija GHG u RS do 2030.g. u sektorima tranformacije energije

Razmatrani sektori transformacije u RS: koksne peći, visoke peći, rafinerije nafte, proizvodnja električne energije, proizvodnja toplotne energije, proizvodnja toplotne energije iz biomase, samoproizvođači električne energije iz neobnovljivih izvora, kogeneracija iz biomase, prijenos i distribucija.

Ciljna vrijednost ukupne emisija $CO_2$-eq u sektoru transformacije energije 2030. godine u Republici Srpskoj iznosi 4,23 $MtCO_2$. Na grafikonu 4 prikazan je trend smanjenja emisije $CO_2$-eq u sektoru transformacije energije za period 2022-2030. godina u Republici Srpskoj.




Grafikon 4. Ukupno smanjenje emisije GHG-a u RS do 2030. u sektoru transformacije energije.

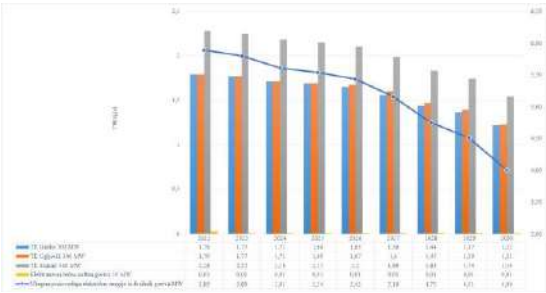
Graph 4. Total reduction of GHG emissions in the RS until 2030 in the energy transformation sector.

**Proizvodnja električne energije**

Ciljna vrijednost ukupne emisija $CO_2$-eq iz proizvodnje električne energije 2030. godine u Republici Srpskoj iznosi 3,95 $MtCO_2$. Izvori emisija GHG u RS pri proizvodnji električne energije su: TE (Gacko, Ugljevik, Stanari), elektrane na tečno naftno gorivo. U tabeli 1 su prikazani proizvodni kapaciteti za proizvodnju električne energije u RS u periodu 2022-2030. godina, koji su nepromijenjeni, što znači da nema gašenja ali ni izgradnje i puštanja u pogon novih postrojenja. Obzirom na ovu činjenicu, smanjenje emisije GHG se bazira na smanjenju proizvodnje elekrtične energije u ovim postrojenjima što je prikazano grafikonom 5.

Tabela 1. Kapacitet postrojenja za proizvodnju električne enerije u RS za period 2022-2030.
Table 1. Capacity of facilities for the production of electricity in the RS for the period 2022-2030.

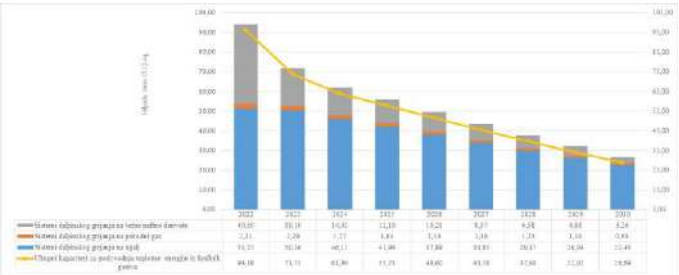
| Energetsko postrojenje / godina | 2022 | 2023 | 2024 | 2025 | 2026 | 2027 | 2028 | 2029 | 2030 |
|---|---|---|---|---|---|---|---|---|---|
| TE Gacko (MW) | 300 | 300 | 300 | 300 | 300 | 300 | 300 | 300 | 300 |
| TE Ugljevik (MW) | 300 | 300 | 300 | 300 | 300 | 300 | 300 | 300 | 300 |
| TE Stanari (MW) | 300 | 300 | 300 | 300 | 300 | 300 | 300 | 300 | 300 |
| Elektrane (MW) | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 |



Grafikon 5. Ukupna proizvodnja električne energije u proizvodnim postrojenjima RS za period 2022-2030.
Graph 5. Total production of electricity in production facilities of RS for the period 2022-2030.

**Proizvodnja toplotne energije**

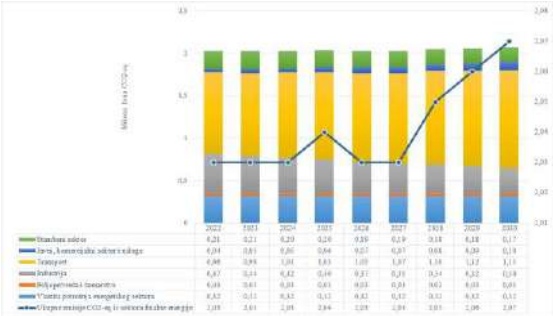
Ciljna vrijednost ukupne emisija $CO_2$-eq iz proizvodnje toplotne energije 2030. godine u Republici Srpskoj iznosi 26,69 $MtCO_2$. Izvori emisija GHG u RS pri proizvodnji toplotne energije su: sistemi daljinskog grijanja (SDG) na ugalj, SDG na prirodni gas i SDG na tečne naftne derivate. Na grafikonu 6. je prikazan raspored kapaciteta sistema daljinskog grijanja na fosilna goriva u RS u periodu 2022-2030. godina. Evidentno je, da se planira smanjanje SDG na ugalj i naftne derivate a povećanje proizvodnje toplotne energije na prirodni gas, ali u zbiru, smanjenje kapaciteta SDG je skoro za 25% u 2030. godini.



Grafikon 6. Raspored kapaciteta za proizvodnju toplotne energije u SDG u RS za period 2022-2030.
Chart 6. Capacity schedule for thermal energy production in SDG in RS for the period 2022-2030.

**Sektori potrošnje energije**

Ciljna vrijednost ukupne emisije $CO_2$-eq iz sektora finalne potrošnje energije u 2030. godine u Republici Srpskoj iznosi 2,07 $MtCO_2$. Sektori finalne potrošnje su: stambeni sektor, javni, komercijalni sektor i usluge, industrija, saobraćaj, vlastita potrošnja energije energetskog sektora i neenergetska potrošnja. Na grafikonu 7 je prikazana ukupna emisija $CO_2$-eq iz sektora finalne potrošnje energije u Republici Srpskoj za period 2022-2030.godina.



Grafikon 7. Ukupna emisija $CO_2$-eq iz sektora finalne potrošnje energije u RS u periodu 2022-2030.
Chart 7. Total CO2-eq emission from the sector of final energy consumption in RS in the period 2022-2030.

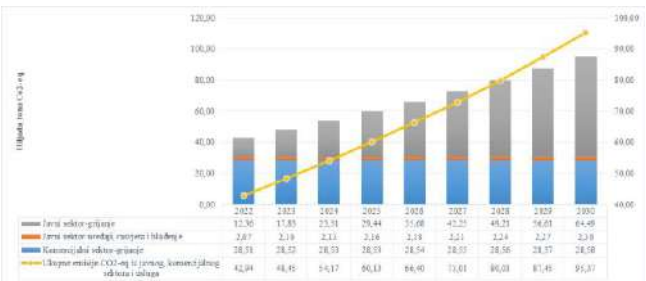
**Smanjenje emisija u stambenom sektoru**

Ciljna vrijednost ukupne emisije $CO_2$-eq stambenog sektora u 2030. godine u Republici Srpskoj iznosi 173,63 kt$CO_2$. Smanjenje emisije u ovom sektoru se očekuje implementacijom mjera obnove zgrada u RS.

Grafikon 8. Smanjenje emisije $CO_2$-eq u stambenom sektoru u RS u periodu 2022-2030.
Chart 8. Reduction of CO2-eq emissions in the housing sector in RS in the period 2022-2030.

**Smanjene emisija u javnom, komercijalnom sektoru i sektoru usluga**

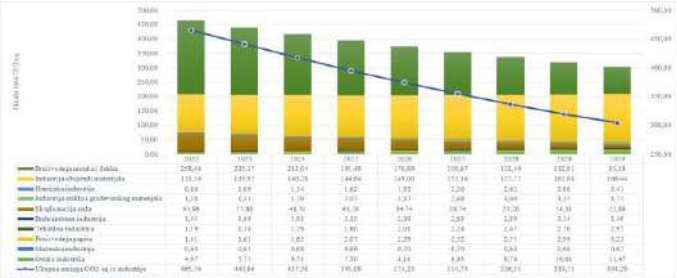
Cilj emisije $CO_2$-eq u javnom, komercijalnom sektoru i sektoru usluga, 2030. godine u Republici Srpskoj iznosi 95,36 kt$CO_2$.



Grafikon 9. Smanjenje emisije $CO_2$-eq u javnom, komercijalnom i sektoru usluga u RS u periodu 2022-2030.
Chart 9. Reduction of CO2-eq emissions in the public, commercial and service sectors in the RS in the period 2022-2030.

**Smanjene emisija u industriji**

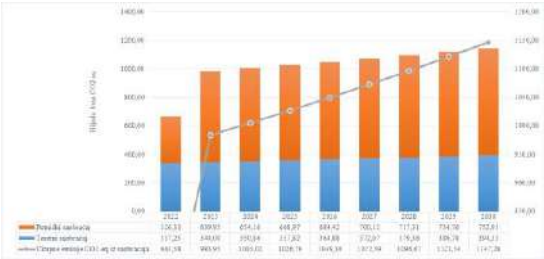
Cilj smanjenja emisije $CO_2$-eq u Republici Srpskoj iz industrije u 2030. godini iznosi 304,28 kt$CO_2$.



Grafikon 10. Smanjenje emisije $CO_2$-eq iz industrije u RS do 2030.
Chart 10. Reduction of CO2-eq emissions from industry in the RS until 2030.

**Smanjenje emisije $CO_2$-eq iz saobraćaja**

Cilj smanjenja emisije $CO_2$-eq u Republici Srpskoj iz saobraćaja u 2030. godini iznosi: 1.147,28 kt$CO_2$



Grafikon 11. Smanjenje emisije $CO_2$-eq iz saobraćaja u Republici Srpskoj do 2030.
Graph 11. Reduction of CO2-eq emissions from traffic in the Republic of Srpska until 2030.

## POLITIKE I MJERE DIMENZIJE DEKARBONIZACIJA – PODDIMENZIJA EMISIJE I UKLANJANJE GHG U RS

**Uspostaviti strateški i legislativni okvir za smanjenje emisije GHG**

Okvir za smanjenje emisija GHG uspostaviti usvajanjem strateških dokumenata i legislative o klimatskim promjenama.

*Smanjiti GHG emisije u skladu sa Uredbom 2018/842*

Smanjiti emisije GHG u sektoru saobraćaja kroz podsticanje smanjenja potrošnje energije u sektoru saobraćaja zamjenom postojećih motornih vozila i nabavkom novih i EE vozila. Uvesti posebnu naknadu za zaštitu životne sredine koja se plaća prilikom registrovanja vozila na motorni pogon.

*Smanjenje GHG emisije u skladu sa Uredbom 2018/841*

Smanjiti GHG emisije kroz:

Povećanje ponora u sektoru šumarstva kroz: povećanje prirasta i održivo gazdovanje šumama, osnivanje plantaža brzorastućih vrsta u cilju povećanja skladištenja ugljenika i energetskog iskorištavanja i unapređenje sistema zaštite šuma od požara.

Smanjenje emisija GHG iz otpada kroz: Sprječavanje nastajanja i smanjivanje količine krutog otpada, ponovnu upotrebu i recikliranje otpada poput (papira, metala, plastike, stakla iz domaćinstva), smanjena odloženog biorazgradivog otpada, korišćenja gasa sa odlagališta komunalnog otpada, korišćenja biogasa za proizvodnju biometana, električne i toplotne energije.

*Uspostaviti funkcionalni sistem trgovanja emisijama u RS (BiH)*

Neophodno je uspostaviti insititucionalni sistem za uvođenje sistema trgovanja emisijama GHG (ETS-a), zasnovanog na principu „cap and trade“. Usvojiti regulatorni okvir za uvođenje i funkcionisanje ETS-a u skladu sa ustavnim uređenjem BiH. Neophodno je provesti aktivnosti za uvođenje sistema trgovanja emisijskim jedinicama GHG, u cilju primjene troškovno efikasnog smanjenja emisija i niskokarbonskih investicija i registra obveznika (operatera postrojenja i

operatora avio-kompanija): ažuriranje planova praćenja emisija GHG, izraditi izvještaje o GHG, izraditi verifikacijske i izvještaje o poboljšanjima.

*Ukinuti energetske subvencije za korištenje fosilnih goriva*

Ukinuti direktne subvencije za električnu energiju iz TE za ugalj i grijanje. Ovo će dovesti do povećanja cijene električne energije, ali i uvođenja plaćanja usluge SDG na bazi potrošnje, suzbijanje ilegalne sječe drveta i ukidanje subvencija za energente. Istovremeno uraditi programe zaštite socijalno ugroženih građana sa jasnim kriterijumima za subvencionisanje troškova za grijanje i energente.

## GLAVNI IZAZOVI

Integrisanim energetskim i klimatskim planom RS u dimenziji dekarbonizacija, poddimenzija emisija i uklanjanje GHG u RS predložene su: strateške, regulatorne, informacijske i obrazovne politike i mjere. Između njih postoji interakcija, te vremenski period za njihovu realizaciju, tako da prolongiranje realizacije jedne može da utiče na realizaciju druge povezane mjere. Međutim ovim planom nisu uzeti u obzir izazovi, rizici, niti političke i geopolitičke mjere. Rizici su povezani s kašnjenjem u provođenju regulatornih mjera i nedovoljna sredstva za provođenje finansijskih mjera. Izvori sredstava su uopšteno nabrojanji (međunarodni izvori finansiranja, ali nisu naznačeni na koje se konkretno izvore misli), a finansijske vrijednosti za realizaciju planiranih preporuka i mjera nisu date. Takođe, treba imati u vidu da su strateški energetski dokumenti EU (Evropska Unija, 2016; Energy Community, 2020; Evropska zajednica i Ugovorne stranke, 2006; Evropska Unija, 2019), usvojeni prije ratnih dešavanja u Ukrajini i da su planirani za drugačije uslove. Sada realizacija tih dokumenata zavisi ne samo od unutarpolitičkih, političkih, nego i geopolitičkih okolnosti koje su vezane za ljude, energiju i resurse ne samo u RS (BiH), nego širom svijeta. U situacijama postojanja svjetske energetske krize, moraju postojati i drugi scenariji za realizaciju energetskog i klimatskog plana RS. Iako je sadržaj integrisnog energetskog i klimatskog plana propisan Uredbom 2018/1999 (Evropska Unija, 2018), neophodno je planirati procjenu rizika ne samo u dijelu energetske sigurnosti, nego u svim dimenzije ovog plana. Planiranje i sprovođenje politika i mjera treba se zasnivati na najkvalitetnijim dostupnim podacima, izradi modela i njihovoj analizi. To je veliki izazov s obzirom na teme povezane s energijom i klimatskim promjenama zbog njihove složenosti, kao i podataka koji mogu biti neprecizni i/ili nisu bili zasnovani na pouzdanim polaznim podacima.

Takođe, ciljevi mjera moraju biti dobro definisani a indikatori za mjerenje ostvarenja ciljeva moraju biti pouzdani. Pri izradi dokumenata NECP BiH (Ministarstvo spoljne trgovine i ekonomskih odnosa BiH, 2022) i ECP RS (Ministarstvo spoljne trgovine i ekonomskih odnosa RS, 2022), treba imati na umu, da se ciljevi koji su planirani u njima mogu odraziti na stanje u drugim državama, ali i na ciljeve EU. U pogledu dostizanja ciljnih vrijednosti smanjenja emisije GHG i praćenja napretka, ključnu ulogu ima Inventar GHG, čije utvrđivanje predstavlja složen proces. Proizvodnja i potrošnja energije uzrokuju preko 80% emisija GHG u RS. Period prelaska energetskog sektora RS (BiH) na energetske izvore s niskim nivoom ugljenika i dalje je izazovan. Ulaganja u infrastrukturu moraju se zasnivati na dugoročnom razumijevanju njihovih klimatskih i drugih uticaja. Naime, proračun emisija GHG u ECP RS je rađen na bazi postojećih termo i elektroenergetskih postrojenja. Ali, nije uzeta u obzir izgradnja gasne interkonekcije sa Republikom Srbijom i gasnih elektrana u RS, koje su planirane važećom Strategijom razvoja energetike Republike Srpske do 2035 (Ministarstvo energetike i rudarstva Republike Srpske, 2018). Unošenjem ovih energetskih objekata narušiće se proračun proizvodnje električne i toplotne energije urađen u softverskom programu LEAP, a samim tim i ciljne emisije GHG. Svjesni smo da na geopolitiku ne možemo da utičemo, ali moramo planirati i primarno uticati na svoju energetsku nezavisnost.

## PREPORUKE

U okviru ECP RS se moraju dobrovoljno predložiti ciljne vrijednosti smanjenja emisija GHG u kontekstu ostvarenja dugoročnog cilja njihovog smanjenja, prema potpisanim ugovorima i obavezama države kandidata (BiH). Koliko će se u tome zaista uspjeti prvenstveno zavisi od regulative i smanjenja administrativnih prepreka, cijena tehnologija, ali i ukidanja subvencija za

proizvodnju električne energije iz fosilnih goriva. U Republici Srpskoj postoji svijest da su neki ciljevi previsoko postavljeni za realizovanje u ovako kratkom vremenskom periodu, ali korak ka postizanju ovih ciljeva biće svakako iskorak naprijed ka krajnjem cilju.

## ZAKLJUČCI

Svedoci smo da je Evropa i njena energetska politika usmjerena na brojne mjere za uspostavljanje jedinstvenog energetskog tržišta, dekarbonizaciji energetskog sektora, kao i obezbjeđenju sigurnog snabdijevanja i održivog energetskog sektora. Izazovi s kojima se Republika Srpska (BIH) suočava u području energetike u periodu do 2030.g., odnose se i na područje dekarbonizacije u dijelu smanjenja emisija i uklanjanja GHG. Prema indikatoru "smanjenje emisija GHG" (Ministarstvo spoljne trgovine i ekonomskih odnosa RS, 2022) dekarbonizacija je moguća, ciljevi, mjere i preporuke su planirani do 2030. godine. Za uspješnu dekarbonizaciju energetike u RS (BiH) i realizaciju obaveza preuzetih dokumentima (Evropska Unija, 2016; Energy Community, 2020; Evropska zajednica i Ugovorne stranke, 2006; Evropska Unija, 2019), dostizanje planiranih ciljeva, prijeko potrebno je: istovremeno paralelno upravljati sa tranzicionim procesima i dimenzijama, imajući u vidu da svaki proces ima početne uslove - regulativu, izvore finansiranja, nosioce aktivnosti, način praćenja realizacije, te povezanost sa drugim procesima. Interakcijom ovih procesa, analizom rizika i primjenom mjera za njihovo smanjenje, smanjenjem rizika, moguće je pratiti EU u promjenama energetske politike, koje su postale neizbježne, ali pri tome primarno raditi na pronalaženju isplativih rješenja i unapređenju energetske nezavisnosti, održivosti i sigurnosti energetskog sistema RS (BiH).

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# EMISSIONS AND REMOVAL OF GREENHOUSE GAS THROUGH THE DECARBONIZATION DIMENSION

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**ABSTRACT**

The main goal of the work is to describe the state, indicators, goals, policies and measures in the dimension of decarbonization, which refers to the subdimension - emission and removal of greenhouse gases in the Republic of Srpska (B&H), based on data from the still working document Energy and Climate Plan of the Republic of Srpska. This document provides recommendations, policies and measures related to decarbonization, energy efficiency, security of supply to the internal market, etc., in order to fulfill the international obligations of the Republic of Srpska (BiH) accepted by the Treaty on the Establishment of the Energy Community of Southeast Europe and the Sofia Declaration. After its adoption, the Energy and Climate Plan of the Republic of Srpska will replace the Energy Development Strategy of the Republic of Srpska until 2035. The Entity Energy and Climate Plan of Republic of Srpska and FBiH are integral parts of the Integrated Energy and Climate Plan of BiH. The goals set in the Energy and Climate Plan of the Republic of Srpska are very ambitious and challenging for the Republic of Srpska, especially considering the energy transformation sectors in which the reduction of greenhouse gas emissions is planned.

**Keywords:** decarbonization, indicators, greenhouse gases, energy and climate plan of the Republic of Srpska, energy transformation sectors.

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# FULFILLING INTERNAL NEEDS FOR ELECTRIC ENERGY USING SOLAR PANELS ON PUBLIC BUILDINGS

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## ABSTRACT

The use of solar panels for the production of electric energy for one's own needs is at the beginning in Serbia. The adoption of the Law on Renewable Energy Sources and by-laws on the status of prosumer has initiated a greater interest of both households and business entities in greater use of energy produced in this way.In addition to simplified procedures, the increase in the price of electricity is another reason why citizens, the public and business sectors decide to build solar power plants on their roofs.

The paper shows how much it costs to cover one's own needs for electricity from a solar power plant installed on the roof of a public building. It is about the administrative building of a public utility company, in a city located in the south of Serbia- Pirot.

**Keywords**: solar energy, energy production from RES, prosumer.

## INTRODUCTION

By adopting a new Renewable Energy Law - Law on Renewable Energy Sources (Zakon o obnovljivim izvorima energije [ZOIE], 2021) in 2021 in Serbia is creating conditions for greater participation of citizens in the energy transition and, for the first time, allowing them to become "prosumer" status buyers - producers. The main advantages of using renewable energy sources are: reducing the use of fossil fuels, which contributes to environmental protection, reducing dependence on energy imports, as well as opening "green" jobs opportunities.

Transitioning to the use of renewable energy sources is also known as energy transition and it represents the transition to decentralized energy production from local renewable sources, in this case from solar energy. Ceasing the use of fossil fuels and maximum use of locally available renewable energy sources is a significant contribution in the fight against climate change.

Decentralized production and use of local renewable energy sources also result in greater energy supply security, increased resilience to crisis situations, the possibility of greater control over the overall energy price, and ultimately enabling citizens to actively participate in energy production and sales. Citizens are no longer passive buyers and consumers, but active buyers or "prosumers" and participants in the energy market and the energy transition.

Thus, this law recognizes citizens as "prosumers" or buyer-producers for the first time. According to this law, a buyer-producer is an end consumer who has connected their own renewable energy production facility to internal installations, where the produced electricity is used to supply their own consumption, and any excess electricity is fed into the transmission system, distribution system, or closed distribution system.

Local communities, as significant electricity consumers, are interested in using solar energy to reduce energy costs in their budgets, contribute to the fight against climate change, and protect the environment. Additionally, public buildings' roofs often have large and suitably oriented surfaces for installing photovoltaic panels. At the same time, by doing so, local government units become an example to their citizens for the use of solar energy.

In the paper "*Implementing Solar PV Projects on Historic Buildings and in Historic Districts*" (Kandt et al., 2023), it is shown that even buildings that are under state protection in the United States can have solar panels installed. This way, by preserving the historical heritage and

using solar energy, a common goal is achieved: preserving resources. Education of key stakeholders and monitoring project implementation is imperative for achieving success.

In study "*Application of Colored Solar Panels on Municipal buildings in Sweden*", (Aqel, 2021). it has been shown that the use of solar panels could be a factor contributing to the increased use of solar energy. Solar panels are the same as ordinary ones, only with a layer of color. This study clearly illustrates the advantages of installing solar panels on municipal buildings in Sweden. Not only is this a step in the right direction for society's renewable energy sources, but it can also be concluded that it would help buildings become energy independent, and people become more aware of solar panels when they can be seen in an architecturally pleasing perspective. This affects citizens' awareness, while the building itself becomes an inspiration for other buildings and municipalities.

The use of solar panels on municipal buildings can also make a significant contribution to these buildings becoming nearly zero-energy buildings, as envisaged by the EU Directive on the Energy Performance of Buildings (EPBD). In „*Optimal production and use of solar electricity in municipal nearly Zero Energy service buildings*" (Sankelo, 2016), the role of photovoltaic solar devices (PV) in improving the energy performance of buildings is investigated, with respect to the future nZEB regulations. Three case studies of municipal service buildings in Tampere, Finland were modeled and their energy performance was simulated. Simulation-based optimization is used to find optimal surface areas and angles of solar panels for each case study building.

Even in countries with abundant oil and gas resources, such as Iran, there are numerous initiatives for the use of renewable energy sources, particularly in municipal buildings, as shown in (Farahani et al., 2021).

On the other hand, regions that have unique advantages for the use of solar energy, such as the Tibetan plateau Qinghai, known as the "Roof of the World," which is the highest and largest plateau on Earth, represent ideal areas for research related to the use of solar energy. In study (Chen et al., 2021), eight potential solar energy system schemes were proposed to obtain an appropriate solar energy supply system and design an optimization method for public sanitation service buildings. The results show that the life cycle cost of an integrated solar hot water and heat storage system is 43% lower than that of a standalone solar hot air system and standalone photovoltaic system. The optimized integrated system consisting of photovoltaic, photothermal, thermal storage, and energy storage has the best overall performance. The annual energy savings ratio of the integrated system is ~85%, and the life cycle cost savings rate is around 50%. In addition, sensitivity analysis shows that electricity price is the most significant factor affecting the life cycle cost compared to the annual interest rate and inflation rate. The price of the solar collector and the air source heat pump has the most significant impact on the optimization results of the life cycle cost of the photovoltaic-photothermal-thermal and integrated energy storage systems.

When it comes to the importance of using solar panels in municipal utility systems, they can also be applied in waste management and disposal systems, as well as in decarbonizing the road transport sector. In (Calise et al.,2023), a technology based on an anaerobic digestion plant combined with a biogas upgrading unit for biogas production is proposed. Photovoltaic panels and solar thermal collectors are considered to match electrical and thermal demands, in order to achieve a fully renewable system. Results show that the plant is nearly self-sufficient thanks to the integration of thermal and electrical energy storage systems. The photovoltaic system is able to reduce energy dependency on the grid by 45%. Energy and environmental analyses show a primary energy savings of 126% and a $CO_2$ equivalent emission reduction of 112%. Economic feasibility analysis shows a promising payback period of 6 years.

## PROSUMERS IN SERBIA

In Serbia, the use of solar panels, both in households and public buildings, is still at a relatively low level. With the adoption of the Law on Renewable Energy Sources, the term "producer-consumer" was introduced for the first time. In addition to this law, other laws that define the term "producer-consumer" are the Law on Energy and the Law on Energy Efficiency and Rational Use of Energy, as well as the Regulation on Criteria, Conditions and Method of

Calculation of Claims and Obligations between the Producer-Consumer and Supplier. Based on this law, the producer-consumer is an end consumer who has connected their own facility for electricity production from renewable energy sources to their internal installations, whereby the produced electricity is used for their own consumption, and any excess electricity is delivered to the transmission system, distribution system, or closed distribution system. Every end consumer of electricity can become a producer-consumer. The following types of producer-consumers are distinguished:

- households,
- residential communities,
- other - business premises, industrial facilities, etc.

The customer-producer's production facility must be a facility for the production of electricity from renewable energy sources - solar power plant, wind power plant, hydro power plant, biomass power plant, etc. The minimum and maximum allowable power of the customer-producer's production facility are determined as follows: there is no minimum power requirement - it must be greater than zero kW if a production facility is installed, while the maximum power of the customer-producer's production facility in the "household" and "other" categories is equal to the approved power of the end customer's facility connection. The maximum power of the customer-producer's production facility in the "residential community" category is determined as the simultaneous power of the measuring points for common electricity consumption and the measuring points of individual members who build a common production facility. To acquire the status of a customer-producer for facilities that are not connected to the power system, it is not necessary to contact the operator of the distribution or transmission system. For all facilities that are connected to the power system in accordance with domestic regulations, it is necessary to contact the system operator to which the end customer's facility is connected in order for the connection to be possible. End customers in the process of acquiring the status of customer-producers in the categories of "household" regardless of the power of the production facility and "other" with a production facility of up to 10.8 kW are connected to the power system through a simplified procedure which includes:

- construction of the production facility,
- adjustment of the measuring point,
- conclusion of a full supply contract with net metering, or net settlement with the selected supplier.
- The production facility is connected to the end customer's internal installations.

The procedure for connecting customer-producers in the "other" category with a production facility with a power of 10.8 kW to 50 kW, in addition to everything previously mentioned, includes making a conceptual design, obtaining approval for connection from the system operator, conducting a trial run before permanent connection, and other requirements. To acquire the status of customer-producer in the "other" category with a production facility with a power greater than 50 kW, the end customer goes through the procedure for connecting power plants and finally connects their own production facility to their internal installation.

When it comes to residential communities, in order to become a buyer-producer, the community must first obtain approval for connection from the system operator, sign a full supply contract with net metering with the supplier, and more. The residential community's production facility is connected to the electricity distribution system via a special measuring point.

The buyer-producer meets a portion of their electricity needs from their own production facility and the remainder from the power grid (during periods when the production facility does not generate enough electricity to meet the buyer-producer's needs). During periods when the production facility generates more electricity than the buyer-producer requires for their own consumption, the electricity produced in the buyer-producer's production facility is primarily used for their own consumption. If production exceeds the buyer-producer's needs, they may supply the excess electricity to the power grid to which they are connected.

Net electric energy represents the difference between the total energy taken and the total energy delivered by the consumer-producer in the transmission, distribution, or closed distribution system during one month, measured in kWh based on the readings of the electricity meter that meet the prescribed metrological requirements, and is determined separately according to the tariff application times for active energy. The excess electric energy is the difference between the total energy delivered and the total energy taken by the consumer-producer at the end of the billing period, which has a positive value, and is determined according to the tariff application times for active energy.

Electricity is billed to the customer-producer using net metering and net settlement. Net metering is used for household and residential community customer-producers, while net settlement is used for other customer-producers. Net metering is a way of calculating net electricity consumption, whereby excess electricity supplied during one month is deducted from the amount of net electricity consumed during the next billing period. Net settlement is a way of calculating net electricity consumption whereby the value of excess electricity supplied during one month is calculated and billed based on the agreement between the customer-producer and the supplier. The period for settling claims and obligations between the customer-producer and the supplier is one year, from April 1 of the current year to March 31 of the following year. Due to the significant increase in the price of electricity on the electricity market, customer-producers in the "other" category can:

- Store excess electricity for use when needed,
- Manage consumption to increase their own consumption during periods when the production facility produces electricity and decrease it during other periods.

In the described way, the expensive kWh that the consumer-producer would buy from the supplier are replaced with the kWh they produced in their own production facility (Grujić, 2023).

## USE OF SOLAR ENERGY IN THE PUBLIC SECTOR IN SERBIA

Local self-government units from their budgets pay for the costs of electricity for all public buildings where administrative buildings, educational institutions, cultural institutions, sports facilities are located, and as such are faced with a constant increase in electricity consumption and higher expenses for these needs. In addition to this reason - reducing electricity costs, cities and municipalities should also be leaders in the fight against climate change, environmental protection, and reducing $CO_2$ emissions. This is the reason why cities are increasingly opting for the use of renewable energy sources, primarily solar energy as the most easily accessible.

### Case study: Solar power plant at the Public Utility Company "Komunalac" in Pirot

The city of Pirot is one of the cities in Serbia that has been at the forefront of using renewable energy sources for years through its energy policy, primarily biomass for heating its facilities, and in recent years, solar energy by building solar power plants on educational institutions and public utilities. In 2022, two solar power plants were built at the Economic School and the public utility company "Komunalac," while in 2023, the plan is to build one at the public utility company "Water Supply and Sewerage" and the Regional Landfill in Pirot. There are solar collectors for hot water at the General Hospital, indoor and outdoor swimming pools, sports hall, and central kindergarten.

The city of Pirot is located at an altitude of 368m, at a longitude of 22°36' east of Greenwich and at a latitude of 43°09' north of the Equator. The average maximum temperature is 18.42°C, the average minimum temperature is 5.95°C, while the average annual precipitation is 504.27mm.

The following pictures show that this part of the country is the most suitable for using solar energy (Zakon o obnovljivim izvorima energije [ZOIE], 2021).

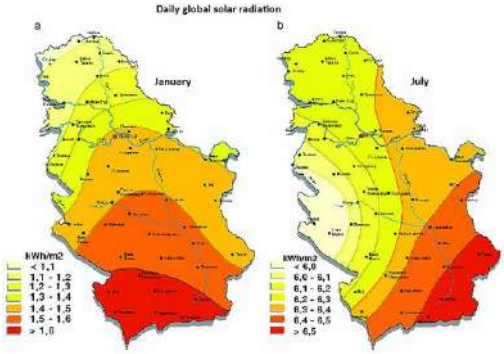


Figure 1. Global solar radiation on a horizontal plane in Serbia - Potential of renewable energy sources in Serbia.

The Figure 1 shows that the average daily global radiation energy on a horizontal surface for the area of the city of Pirot is the highest in Serbia and amounts to more than 6.5 kWh/m$^2$.

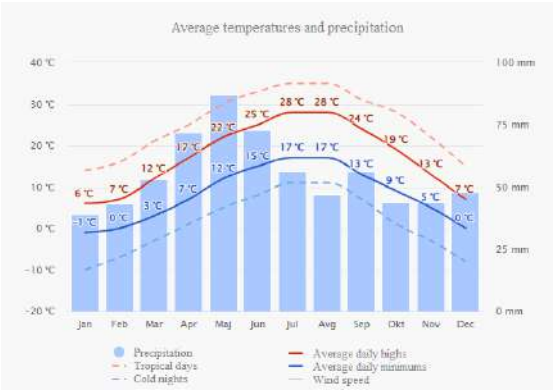


Figure 2. Average temperatures and precipitation in Pirot during one year.

"The average daily maximum" (solid red line) shows the average daily value for each month in Pirot. Similarly, "the average daily minimum" (solid blue line) shows the average daily minimum temperature. Tropical days or freezing nights (dashed red and blue lines) show the mean value of the hottest day and coldest night of each month in the last 30 years.

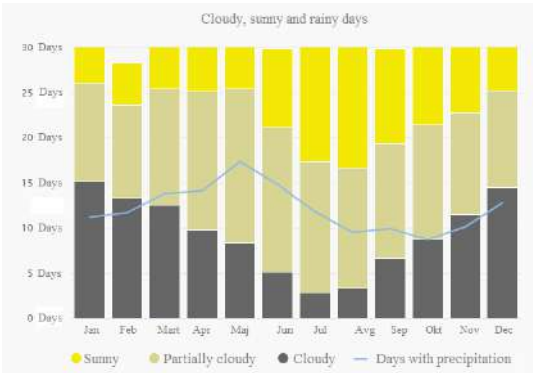


Figure 3. Cloudy, rainy, and sunny days in the city of Pirot during one year.

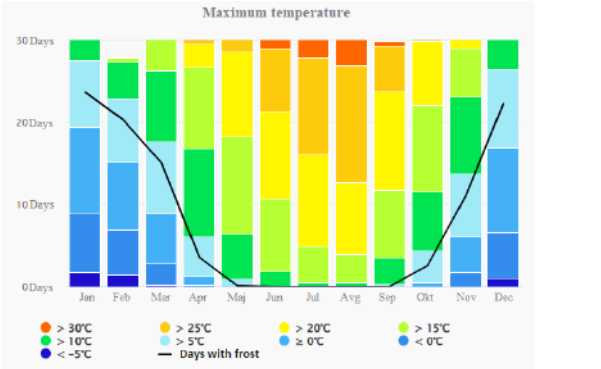


Figure 4. Maximum temperatures in the city of Pirot during one year.

From the previous image, it can be seen that Pirot is located in the part of Serbia with the highest solar energy potential.

The solar power plant at the Public Utility Company "Komunalac" in Pirot was installed in July 2021. Its power output is 30 kW, while the value of the completed works is around 3,600,000 dinars.

Figure 5. Solar power plant at the Public Utility Company "Komunalac" in Pirot.

The power plant was put into trial operation in July 2021, and the comparison of electricity consumption between the period of August-December 2021 and the same period in 2022 is presented below.

Table 1. Electricity consumption for the period August-December 2021 and August-December 2022.

| | Consumption [kWh] 2021 | Consumption [kWh] 2022 |
|---|---|---|
| January | 4168 | 3681 |
| February | 3810 | 1858 |
| March | 3713 | 2998 |
| April | 3174 | 2392 |
| May | 2001 | 1852 |
| June | 2178 | 3424 |
| July | 2574 | 2058 |
| August | 2401 | 891 |
| September | 2236 | 816 |
| October | 2265 | 893 |
| November | 3483 | 1745 |
| December | 2682 | 1160 |

Figure 6 graphically shows the difference in electricity consumption in 2021 and 2022.

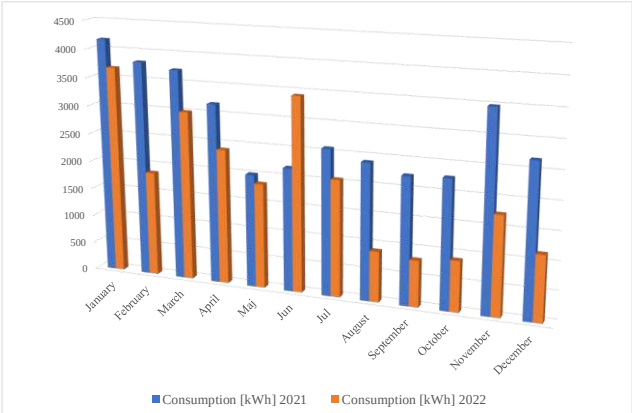


Figure 6. Comparison of electricity consumption in 2021 and 2022.

By comparing the electricity consumption before and after the installation of the solar power plant, it can be concluded that the reduction in electricity consumption for the period of August 2021 to December 2021, compared to the same period in 2022, was 58%, while the reduction in kWh was 7562 kWh.

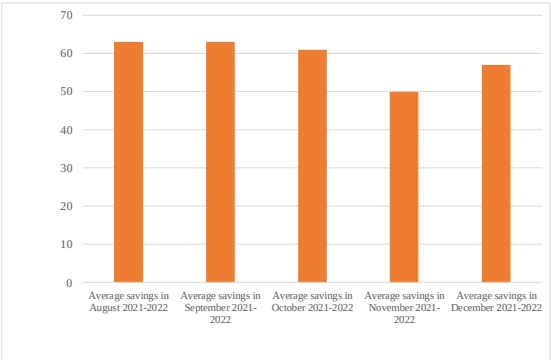


Figure 7. Average energy consumption reduction by month [%].

On figure  can be seen that the largest reduction in electricity consumption was in August and September, followed by October, December, and November.

## CONCLUSIONS

Local self-government units pay for the electricity costs of all public buildings from their budgets and, as such, they are faced with constant growth in electricity consumption and higher expenses for these needs. For this reason, more and more cities and municipalities are turning to the production of electricity from photovoltaic panels. In addition to this reason - reducing electricity costs, cities and municipalities should also be leaders in the fight against climate change, environmental protection, and reducing CO2 emissions. That is why cities are increasingly opting for the use of renewable energy sources, primarily solar energy as the most easily accessible.

This study analyzes the operation of a solar power plant on the administrative building of a public utility company in the city of Pirot. The solar power plant was built in July 2022 and was in trial operation until December 2022. During that period, consumption was reduced by 58%. For this reason (trial operation, it was not connected to the power system), the energy was used only to cover the current consumption without placing surpluses in the electricity distribution system. In the months of August, September, and October, the entire daily consumption was covered by its own production, while only nighttime consumption was covered from the grid. The reduction in

consumption in these months compared to last year is evident, and the largest reduction was in August at 63%, and the smallest in November at 50%. In the fall and winter months, due to the drop in production, in addition to the entire nighttime consumption, part of the daytime consumption was compensated from the system. Since December, the power plant has started operating in regular mode, and it is estimated that the coverage of annual needs will be at least 90%.

## ACKNOWLEDGEMENT

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PREGLEDNI NAUČNI RAD – REVIEW SCIENTIFIC ARTICLE DOI: 10.7251/PIMZ2301061P

# LOW-CARBON URBAN DEVELOPMENT INTEGRATION - DECARBONIZATION OF CITIES - A REVIEW

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## ABSTRACT

The global energy landscape is mired in persistent challenges characterized by the depletion of fossil fuel reserves and volatile, elevated energy prices. The extensive utilization of fossil fuels has engendered adverse environmental repercussions, substantially augmenting atmospheric carbon dioxide ($CO_2$) and other greenhouse gases. This has further intensified the greenhouse effect, culminating in global warming and the consequential phenomenon of climate change. Consequently, contemporary society faces the formidable imperative of embarking on a multifaceted spectrum of actions and commitments aimed at curtailing greenhouse gas emissions, with a particular emphasis on $CO_2$.

In the wake of the momentous Paris Agreement, national governments have undertaken the profound responsibility of conceiving and executing decarbonization strategies. The central objective of these strategies is to effectuate a substantial reduction in greenhouse gas emissions by 55% before the onset of 2030, ultimately culminating in the attainment of net-zero carbon emissions by 2050. The realization of these objectives is contingent upon the development of comprehensive, long-term decarbonization strategies buttressed by a roster of short- and medium-term actions. These strategies are envisioned to elucidate a trajectory towards an optimal future scenario, concurrently optimizing socio-economic dividends.

Empirical research has decisively ascertained that urban centers bear a substantial onus in this endeavor, as they account for an excess of 70% of global $CO_2$ and other greenhouse gas emissions. Consequently, urban locales are intrinsically poised for the deployment of meticulous decarbonization measures. This paper proffers an exhaustive scrutiny of research findings, with an explicit focus on the most efficacious systems and policies conducive to zero carbon emissions. It engages in an exhaustive examination of the classification and analysis of multifarious methodologies employed within the construction, industrial, and transportation sectors. Furthermore, the paper expounds upon the criteria that scholars have invoked to appraise global decarbonization trajectories, all in pursuit of achieving climate neutrality through the ubiquitous adoption of renewable energy sources.

This abstract accentuates the pressing exigency of confronting climate change, the pivotal role that urban centers assume in emissions abatement, and the systematic research approach employed to assess and advocate sustainable decarbonization strategies.

**Keywords**: climate change; greenhouse gas emissions; energy policy; decarburization.

## INTRODUCTION

Since the beginning of the industrial revolution, the concentration of carbon dioxide ($CO_2$) is on rise. For decades, the climate changes require a great attention within the sustainable development of the planet, as well as the reduction of carbon emissions to the environment, which became an ultimate imperative for the future of human civilization. Pursuant to the report of the latest Intergovernmental Panel for Climate Change (AR6 Synthesis Report, 2023) it is estimated that the global average temperature will rise by 1.4°C to 4.4°C by the end of the century. Based on the annual report, the value of global average carbon dioxide contained in the atmosphere was

417.06 parts per million (ppm) in 2022, setting a new record (National Oceanic and Atmospheric Administration, 2022).

Solving the issue of climate change at the global level began with an international agreement in 1992 with the establishment of the United Nations Framework Convention on Climate Change (UNFCCC). The ultimate objective of the Convention was the stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent risky interference with the climate system. The Kyoto Protocol, adopted in 1997, legally obliges countries to stabilize the emission of greenhouse gases based on the principle of Convection. The Paris Agreement, reached in 2016, sets out a global framework to avoid dangerous climate change by limiting global warming to far below 2°C and requires the transformation of national economies to meet net zero carbon dioxide emissions by mid-century. To accomplish that, the countries should define long-term decarbonisation strategies with short and mid-term actions to define their ideal future scenario, while maximizing socio-economic benefits. Key goal of the member states is the achievement of zero net emissions or climate neutrality by 2050.

The European Union is among the leading major economies when it comes to tackling greenhouse gas emissions. In line with the framework of the climate and energy policy, agreed on in 2014 prior to the Paris Agreement, the EU has committed itself to the following goals, to be reached by 2030: reduce GHG emissions by at least 55% below the level of 1990, increase energy efficiency by 32.5% and increase the share of renewable energy sources in final consumption to 32%. On 11 December, 2019, the European Commission presented the European Green Deal, an ambitious strategy of envisaged measures designed to help the EU attain carbon neutrality by 2050 (European Parliament, 2022).

The Paris Agreement requires all member states invest their best efforts and allocate financial resources, aimed at developing a long-term strategy that would enable a national and political framework for the fight against climate change. Recognizing new paths and encouraging a minimum or carbon neutral urban development pose a new challenge for the government, industry and the community. Within the strategy, priority measures to reduce GHG emissions and competent institutions for the implementation of certain options should be identified, as well as the time frame desired for the implementation in addition to the required financial resources.

This paper presents an overview of implemented policies and systems across the board with the goal of achieving zero carbon emissions and preserving our planet. Similarly, a brief overview of classifications and analysis of numerous methods used in the building and construction sector, the energy sector, the road transport sector and the industrial sector is presented, as well as the criteria by which the authors observed the path of decarbonization while achieving climate neutrality through the use of renewable energy sources.

Conclusively, the novelties in decarbonization will pose the vital source of wealth in the future. So far, it has been validated that the technologies are available, the principles of urban design for decarbonization are well understood, but the governance systems to facilitate and manage development at the municipal level are still largely lacking. This knowledge is significant, if we manage to advance such systems, processes and mechanisms that target the developed environment and prize positive behavior, we could begin to radically decarbonize our cities.

## CITIES' CONTRIBUTION TO CARBON EMISSIONS

Demographic estimates claim that in the next three decades the world will continue to urbanize. The urbanization rate, which was 56% in 2021, will be 68% in 2050, with urban areas absorbing almost all future growth in the world's population (World Cities Report, 2022). Research shows that cities are responsible for over 78% of global energy consumption and over 70% of GHG emissions (Climate Change, 2022).

Urban development, which characterizes modern cities, causes major economic, social and environmental issues, so the idea of sustainable urban development insists on a radical change of the very paradigm of urban development.

One of the definitions of sustainable urban development according to (Camagni, 1998) exemplifies it as a process of synergistic integration between city subsystems, which guarantees a long-term level of well-being for the city population, while reducing the negative effects of

development on the biosphere. Therefore, sustainable urban development represents an approach to planning and managing cities and settlements that strive to achieve a balance between social, ecological and economic needs of the present and future needs.

Cities, as hubs of activities, represent the key cause of climate change and as such can play a leading role in activities contributing to the decarbonization of our planet. It is of essence to develop urban plans and adopt a common approach to climate change mitigation and adaptation.

Sustainable urban strategies not only contribute to environmental protection, but also significantly influence the socio-economic aspects of cities. Here are some key points that highlight this connection:

- Job creation: Sustainable urban planning often requires investments in infrastructure, energy efficiency and renewable energy sources. It leads to the creation of new jobs within sectors such as construction, renewable energy and infrastructure maintenance.
- Increasing city attractiveness: The cities that invest in sustainability become more attractive to residents, tourists and business investors. Quality public infrastructure, parks and green spaces attract people and improve the overall experience of the city.
- Reducing costs for citizens: Sustainable strategies can reduce energy and transportation costs for citizens, which directly affects their economic well-being. For instance, a better public transport network can reduce the cost of driving.
- Enhancing the live quality: Sustainable urban planning can contribute to better air quality, noise reduction and greater access to green areas, which positively affects the health and well-being of residents.

In this chapter, several implemented urban plans and their impact on local communities are presented.

Copenhagen, Denmark: Copenhagen is often cited as an example of successful sustainable urbanism. The city has set ambitious goals for reducing $CO_2$ emissions and achieving climate neutrality by 2025. Investments in bike lanes, green roofs and renewable energy sources led to the better quality of life, reduced traffic congestion and the creation of new jobs (Dams et al., 2017).

Curitiba, Brazil: Curitiba is known for its innovative bus fast lane system and large parks. These strategies have reduced air pollution, improved the life quality and attracted investment (Miranda, & Rodrigues, 2012).

Vancouver, Canada: Vancouver is focuses on sustainable construction and high environmental standards for new buildings. It led to the reduction in energy consumption and $CO_2$ emissions, while citizens enjoyed a better quality of life and lower energy bills (Coleman, & Robinson, 2017).

The Blue Green (BG) Systems approach for innovative urban planning produces optimized urban solutions, hereafter referred to as Blue Green (BG) solutions. These harness the synergy benefits between urban components and ecosystem services, resulting in significantly more efficient and cost-effective, multifunctional urban solutions.

By optimizing the master plan through the BG Systems approach, nearly zero energy consumption was achieved for the Croatian capital Zagreb, with total energy savings of 68% for heating, 92% for cooling and 60% for electricity. Energy consumption within buildings decreased by 26%. While the investment return time was approximately 4.8 years (Bozovic et al., 2017).

The Blue Green (BG) system approach includes the following components:

- Urban Solutions. Building orientation and street orientation. Topography and urban amenities;
- Greenery. Grass, gardens, meadows, shrubs, trees and other vegetated areas including those on roofs and façades;
- Water Management (potentially integrated) of rainfall, drinking wastewater and treated effluent, ground (sub-surface) and surface water bodies;
- Building Solutions. Efficient building envelopes, energy systems, indoor water services;
- Energy. Locally available renewable energy, conventional energy and waste (heat) energy;
- Pollution. Thermal pollution, air pollution (quality), sound pollution and visual pollution;
- Climate Variability. Weather extremes: heat and cold waves, droughts, extreme rain, snow and storms (Bozovic et al., 2017).

The European Commission (EC) strategy points the way forward to a carbon-neutral economy by referring to the set of joint actions:

- improving energy efficiency within the buildings, which presently are responsible for 40% of energy consumption;
- maximizing the deployment of renewables and the use of electricity to fully decarbonize Europe's energy supply;
- embracing clean, safe and connected mobility, currently responsible for around a quarter of the GHG emissions in the EU;
- fostering circular economy as a key enabler to reduce GHG emissions, starting from reducing the input of materials through reuse and recycling, and significantly modernizing or replacing existing installations;
- developing an adequate and smart infrastructure ensuring optimal interconnection, especially to support the major developments framing the energy transmission and distribution landscape of tomorrow;
- reaping the full benefits of bio-economy enhancing capacity of agriculture and forestry to provide sufficient food, feed, and fibres as well as to support the energy sector and various industrial and construction sectors.
- enforcing carbon sinks, as important as reducing emissions, by maintaining and further increasing the natural sinks of forests, soils, and agricultural lands and coastal wetlands;
- tackling remaining $CO_2$ emissions with carbon capture and storage previously seen as a major decarbonization option for the power sector and energy-intensive industries (Pulselli et al., 2021).

## INTERNATIONAL CASE STUDIES

Since cities are held accountable for over than 70% of greenhouse gas emissions, it is needed to develop modern urban policies that would contribute to decarbonisation. A new model of urban planning, Concept '15-Minute City', which is already applied in large European cities, was developed by (Alam et al., 2022). This concept can serve as an influential solution for reorganizing cities for greater sustainability and economic equity, through the mechanisms applicable at the local level.

As a signatory to the Paris Agreement, Singapore has committed itself to achieving net zero carbon emissions. Singapore's decarbonization strategy was developed by (Lau et al., 2021) which envisages achieving climate neutrality before 2100. The decarbonization strategy unites four main components: using post-combustion carbon capture technology and its storage in underground reservoirs, production of hydrogen from natural gas (CCS) by existing and integrating carbon capture facilities, modernization of the processing sector with the introduction of biorefineries and transition to the practice of electric cars, biofuels in aviation and hydrogen for running ships in the transport sector.

In order to identify effective carbon reduction policies (Wei et al., 2021), was conducted the energy-related GHG emission inventories for 167 globally distributed cities with information from different sectors, and assessed the city-scale near-term, mid-term, and long -term goals carbon mitigation targets from 2020 to 2050. On this basis, a strategy was developed for achieving local and global targets that includes the following sectors: construction, industry, transport, agriculture and waste disposal.

An analysis of in-depth decarbonization plan for eight cities, Bridgewater, Park City, Guelph, Lahti, Vancouver, Oslo, Toronto, New York was presented (Lintom et al., 2021). The decarbonization plan of these cities starts with a series of actions in the following sectors: energy, construction, transport, waste disposal and carbon storage, aimed at reducing GHG emissions by 80-100% by 2050 or earlier.

(Nerini al., 2019) described how Research and Innovation (R&I) can play a key role in decarbonizing European cities and the role that research and educational institutions can play in that regard. The paper highlights critical Research and Innovation activities in cities based on three pillars: innovative technology and integration, governance innovation and social innovation.

Expansion of Malaysia's city population accelerated the increase in carbon emissions of urban cities, the value of which reaches 200 million $tCO_2e$ per year. The Malaysian government has set a goal of reducing carbon emissions by 33% by 2030 and becoming climate neutral by 2050. Carbon neutrality can be achieved using The digital twin concept, which can practically represent any physical system, including an entire city in relation to its real-world counterpart. The simulation of the Bertam digital twin city showed the possibility of achieving energy savings of 49.25% and reducing carbon emissions after the optimization (Zaidi, & Haw, 2023).

The study developed by (Harris et al., 2020) comprised ten European cities that have a diverse population of several tens of thousands and up to several million, with the aim of implying a sustainability strategy by comparing two scenarios for the year 2050. A combination of qualitative and quantitative methods evaluates the effectiveness of the scenarios: a business-as-usual (BAU) and a post-carbon/sustainability scenario (PC2050). The assessment analysis of: sustainability indicators, energy consumption, GHG emissions, economic costs, shows that the PC2050 strategy can be profitable in the long term.

For the city of Guangzhou in China, a study was developed by (Xie et al., 2022) that focuses on establishing a multi-objective model that includes energy savings and $CO_2$ emission (MCEE) estimates. Sustainable development measures are divided into three categories: energy saving, demand optimization and environmental protection. The studies reveal that the energy saving measure offers the best results in energy conservation and $CO_2$ emission reduction. The implementation of demand optimization measures and energy saving measures can achieve energy savings and $CO_2$ emission reductions of up to 80%, respectively.

Human activities are progressively becoming agents of increasing GHG levels, leading to global warming. In order to avoid changes in the climate system, it is necessary to take urgent mitigation measures. Moreover, we are faced with a continuous rate of population growth in urban areas, which makes cities one of the main consumers of energy. But as such, they can play an important role in reducing GHGs. (Sani et al., 2022) propose a model based on open source optimization called the Energy–Technology–Environment Model (ETEM) and analyze the energy transition paths of the Greater Montreal region in Canada in the period 2020 to 2050. The results show that with emission reductions of 6.9, 1.6, and 1 million tons of $CO_2$ compared to the 2020 level, the transport, commercial, and residential sectors have great potential for deep decarbonization.

To reduce GHG emissions needed to be mitigated by 2050, (Linton et al., 2021) developed a study that examines the best practices of cities that can achieve deep decarbonization. The study provides insight into the strategies and management structures used to develop and implement profound decarbonization plans in eight cities in four different countries (USA, Canada, Finland, Norway) whose population ranges from a few thousand to several million. Best practice examples of deep urban decarbonization use key strategies of stakeholder engagement, nurturing a green economy, policy making and providing financial incentives.

## RELEVANT CASES OF THE KEY SECTORS LIABLE FOR GHG EMISSIONS

In this section are presented the implemented examples and cases of good practice aimed at achieving net-zero emissions in the four main sectors.

### Building sector

The building and construction sector in 2021 was responsible for 37% (Figure 1) of $CO_2$ emissions, whereas global energy demand in this sector was 34%. Energy-related emissions in the building sector for 2021 reached a record value of about 10 $GtCO_2$, an increase that exceeds the 2020 level by about 5%. Though the demand for energy in structures reached the highest level of 135 EJ, which is an increase of about 4% compared to the period of 2020 (Global Alliance for Buildings and Construction, 2022). Based on this information, it can be concluded that the demand for energy in the building and construction sector will continue to grow in the coming years. In this high-demand scenario, if appropriate measures are not taken instantly, the buildings constructed in the current way and the use of inefficient technologies will block GHG reduction trajectories for decades to come and leave the world vulnerable to environmental impact (Bandyopadhyay, &

Banerjee, 2022). In the building sector, there is great potential for a series of measures and actions that would lead to solving the problem of carbon emissions in the future.

Figure 1. Global share of buildings and construction operational and process $CO_2$ emissions, 2021 (Global Alliance for Buildings and Construction, 2022).

Zero-emission buildings or zero-carbon buildings are those that are energy efficient and do not produce any GHG or carbon dioxide emissions during the construction, either on-site or off-site. Zero net energy buildings are an important component of the movement towards decarbonization of the building sector as reducing the overall energy demand also facilitates decarbonization (Jeffery et al., 2022).

The researches have shown that the most effective way to decarbonize a building includes three components:

- Improving the performance of the building envelope, with the aim of reducing energy needs
- Transition to the use of devices in a building with a high energy class;
- Utilizing energy through a decarbonized grid or installing systems for using renewable energy sources on site.

This section presents the outcomes of studies and modern methods that have been created and implemented around the world with the aim of achieving zero carbon emissions in the building and construction sector.

Buildings are characterized by high energy consumption and GHG emissions, so this problem triggered a need to develop a series of methods and strategies aimed at reducing energy consumption and switching to renewable energy sources (RES). A study developed by (Zhang et al., 2021) shows the energy, carbon and investment payback period for buildings refurbished with a new precast concrete element (PCE) system. The results showed that the energy payback periods for Spain, the Netherlands and Sweden are 20.45 years, 17.60 years, 19.95 years, respectively, and the carbon payback period is 23.33 years, 16.78 years and 8.58 years, respectively. While, the investment cost recovery time exceeds the lifetime of the building, less than 100 years. Based on new analyzes with the reusing (PCE2), the payback period is significantly reduced to 29.30 years in Sweden, 42.97 years in the Netherlands and 85.68 years in Spain, respectively.

A study developed by (Al-Yasiri et al., 2023) shows simulation results generated in Iran for the city of Al Almara. The main goal is to achieve an energy-efficient building with almost zero energy consumption, through the construction of a building envelope that uses expanded polystyrene (EPS) and phase change composite material (PCM) as thermal insulation.

By the transition to the utilization of RES, the practice of heat pumps started, which transfers heat energy from one environment to another. In order to achieve climate neutrality by 2050, (Rumsey et al., 2021) used the heat pump system as one of the means to achieve building decarbonization through HVAC transformation.

China's construction sector needs to be deeply decarbonized in order to meet the obligations stipulated by the Paris Agreement. A national bottom-up energy technology model for the building sector (NET-Building) was developed by (Tang et al., 2021), with the goal of constraining global warming to far below 2°C and 1.5°C compared to pre-industrial levels. To achieve this goal, it is

required to significantly reduce the use of devices of the entire construction sector that consume conventional fuels and switch to the use of RES-based devices, as well as the use of heat pumps, solar thermal water heaters and photo panels.

For Japan, (Shimoda et al., 2021) was developed a study with the aim of decarbonizing the building sector, in which, as in the previous work, the bottom-up energy end-use method was applied. The decarbonization scenario includes the expansion of highly insulated buildings, the use of greatly efficient equipment and devices, as well as the integration of heat pumps and photovoltaic systems in buildings. By implementing this scenario, compared to 2013, a 61% reduction in total primary energy was accomplished.

In order to reduce the energy used for heating (Abdollah et al., 2021) developed a study targeting three cities: Cairo, Hurgada and Asuan, aimed at achieving the best method taking into account the effects of global warming. It was set up that double walls with air vents and the outside insulation proved to be the best solution for all areas of the city, achieving cooling energy savings of 40%, making the maximum return on investment time 6.3 years.

The study initiated in three European cities Madrid, Berlin and Helsinki estimates the potential of renewable energy sources' system applied to multi-family houses with the goal of its implementation for the mass decarbonization of the existing and future construction fund. The main components of the system developed by (Palomba et al., 2020) are: solar thermal collectors with thermoelectric generators; a sorption module; a reversible heat pump/ORC and a biomass boiler, arranged in a flexible configuration. The results in (Figure 2) show that in multi-family houses (in Madrid) it is possible to obtain 100% of cooling and hot water (DHW) from RES (in all climates), and more than 80% of heating from RES (with the only exception of Madrid in SB, that's 80%).

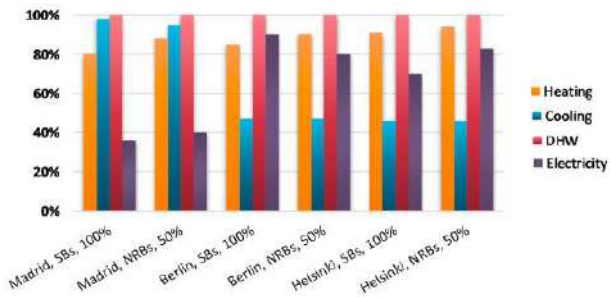


Figure 2. Overall share of renewables, 2020 (Palomba et al., 2020).

On the path to decarbonisation, aimed at limiting global warming, the application of solar energy makes a significant contribution. (Fu et al., 2023) developed a study analyzing energy production and quantify the impact of thermoelectric coupling in BIPV façade systems. The structural composition of the BIPV facade consists of a BIPV module and an insulating building envelope. An air channel is formed between the integrated BIPV module and the insulation envelope of the building, which enables natural ventilation. The findings illustrate that during the solar radiation and increase in the distance of the air channel, the growth in heat energy production by 53.22% is achieved. That is, the share of heat increased by approximately 15%, while the share of electricity decreased by 15%.

The state of New York, as well as at least 15 other states in the northeastern part of the USA, has great potential for decarbonizing the construction sector, due to high seasonal demand for heating. Due to the icy winter climate, space heating accounts for 56% of the total energy consumption in buildings (Durga et al., 2021) developed a system Using Borehole Thermal Energy Storage (BTES) to seasonally store excess thermal energy in the subsurface for later heating use. As an example, the heating of the 6855 $m^2$ Snee Hall building with unused summer steam from Cornell's combined heat and power plant is shown. A standard 2-D transient subsurface conductive heat transfer model is coupled to a high temperature heat pump that can supply Snee Hall's

existing radiators. The results showed that the utilization of this system provided 94% of the heating demands of Snee Hall, while saving 250 MT $CO_2$ emissions annually. The system implemented on this building can be applied to other buildings as well.

**Energy sector**

With the European Green Deal (EGD), the EU set itself a goal of becoming the first climate-neutral continent by 2050. In order to meet its climate commitments, the EU must make its energy sector climate neutral. The production and use of energy in all relevant sectors releases more than 75% of GHG emissions in the EU (Requested by the ITRE committee, 2021). As such, the energy system has great potential for implementing strategies and methods aimed at decarbonization.

A study initiated in the United States and developed by (Stock, & Stuart, 2021) singles out two extremely successful policies of deep decarbonization of the energy sector. By applying the tradeable performance standard (TPS) and a hybrid Clean Electricity Standard (CES) policy, 80% decarbonization can be achieved by 2035. These two policies do not meet the main objective; the energy sector should become 100% clean by 2030. To achieve profounder decarbonization, it is necessary to work on new technologies.

The study developed by (Borasio, & Moret, 2022) aims to achieve zero emission of hazardous gases in the energy sector using an extended version of the EnergyScope model. This model was applied in Italy and covers all energy sectors. The results of the analysis show the possibility of achieving almost zero $CO_2$ emissions by 2050, reaching 9.5 $MtCO_2/y$, which is 97% less compared to 1990 levels, by means of the electrification of the energy system in combination with the use of renewable energy sources and the use of new highly efficient technologies.

Great potential for decarbonization of the European energy system is seen in the production of low-carbon hydrogen and renewable hydrogen. In the study developed by (Seck et al., 2022), the used modeling framework combines three models: detailed European energy system optimization model (TIMES-type), an aggregated optimization model for the European energy system, (Integrate Europe) and a dedicated model for calculating hydrogen import options for Europe (HyPE). The findings show that hydrogen is a cost-effective solution and a versatile response to the limitation of deep electrification and energy efficiency improvements. Also, the use of hydrogen in the decarbonization of the energy sector reduces emissions by 55% by 2030 compared to 1990, though it is planned to achieve zero emissions by 2050.

(Wang et al., 2023) studied the implementation path and $CO_2$ reduction of electrolytic hydrogen in the decarbonisation of smart cities in China. Electrolytic hydrogen could transform additional renewable energy into hydrogen that can be stored and used subsequently. This way of storing renewable energy is helping to construct future low-carbon energy systems (FCES).

Energy conversion with negative $CO_2$ emissions can be achieved through the process of biomass gasification with $CO_2$ capture. A study developed by (Cormos, 2023) assesses the techno-economic and environmental implications of decarbonized green hydrogen generation using the biomass gasification. The used decarbonization technologies are: conventional chemical and physical scrubbing (using MDEA and Selexol™), membrane and hybrid membrane – absorption systems. The results show that all technologies used for biomass gasification yield an amount of hydrogen of 300 MB (corresponding to 100,000 Nm3/h hydrogen with purity above 99.95% vol.) with a carbon capture rate of 90%.

The study they conducted (Bonilla et al., 2022) aims towards complete decarbonization of the Spanish power system by using renewable energy sources. The methodology used in this paper is based on historical data and artificial intelligence. The presented methodology enables the calculation of the optimal mix of electricity that meets predefined criteria related to demand coverage while simultaneously minimizing electricity costs and reducing $CO_2$ emissions. The results obtained in this study show that an 70% reduction in $CO_2$ emissions can be achieved in the Spanish electricity system by 2030. This reduction requires obtaining 79,70% of energy from renewable sources, PV (20%), wind (37,2%) and Concentrated Solar Power plants (CSP) (5,37%), mainly (Figure 3).

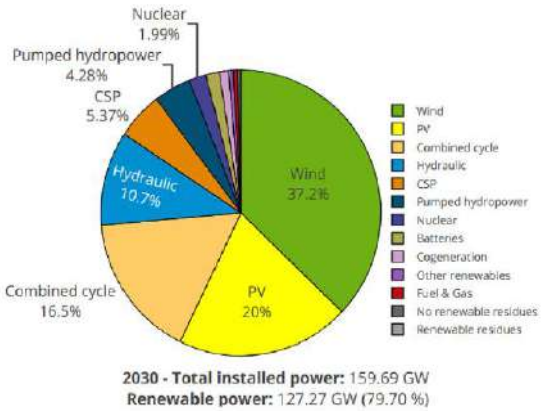


Figure 3. Optimization results for 2030 and 70% $CO_2$ emissions reduction, 2022 (Bonilla et al., 2022)

In this study (Zhang et al., 2022) examine the decarbonization of three coupled energy sectors: electricity, transport and heating/industry. The sector coupling includes the production of hydrogen from each of electricity via electrolysis, the gasification of coal and the reforming of natural gas. The combination of these three sectors gives significant results: hydrogen obtained from coal gasification or by reforming natural gas with CCS can have a significant presence in energy systems with reduced costs by 80%, as well as a reduction in $CO_2$ emissions.

**Road traffic sector**

$CO_2$ emission in road transport originates from the exhaust gases of vehicles that burn fossil fuels. Research has proven that the use of public transport reduces gas emissions caused by combustion, the reason for this comes from the reduction in the use of cars, i.e. the reduced use of energy sources. With an average occupancy rate of 1.6 people per car in Europe for 2018, they represent the key polluters with 60.7% of total road traffic $CO_2$ emissions (Figure 4) (European Parliament, 2019). According to data on the amount of $CO_2$ emissions in road traffic, it is required to differentiate the measures that can be used to reduce $CO_2$ emissions and define a strategy by which the energy needed for the operation of vehicles will be obtained from renewable sources.

With the aim of achieving carbon neutrality and fully utilizing the potential of decarbonization in the transport and energy sector (Wang et al., 2022) developed a new concept (Vehicle-to-Micro-Grid (V2μG) network). This concept includes an off-grid building energy system with flexible power storage/supply provided by battery EVs (BEVs) and fuel cell EVs (FCEVs). The results show that the optimal V2μG network can reduce carbon dioxide emissions by 515.56 tons per year compared to the conventional off-grid building energy system.

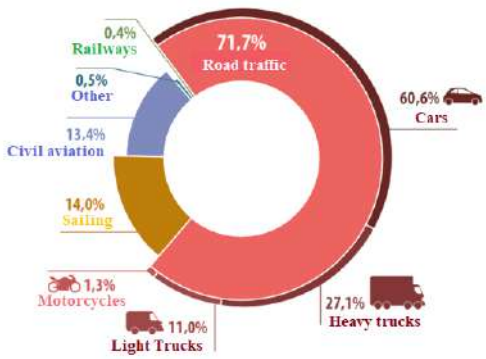


Figure 4. Analysis of greenhouse gas emissions by mode of transportation

Photovoltaic devices (PV) integrated with electric vehicles (EV) are increasingly being used as a solution for reducing $CO_2$ emissions in city traffic. A study developed by (Kobashi et al., 2022) presented the SolarEV city concept and performed techno-economic analyzes for rooftop photovoltaic systems integrated with stand-alone batteries or electric vehicles in residential and commercial districts in Japan for the period from 2020 to 2040. The findings reveal that residential "PV+EV" systems are a potential source for significant production and storage of renewable energy and that is feasible to achieve a $CO_2$ emission reduction of 88%.

Cities are characterized by large unused roof surfaces that are suitable for the installation of photovoltaic systems. The South Korean government committed itself of achieving carbon neutrality by 2050. The SolarEV City concept can help the government realize its goal. The possibility of potential decarbonization for four cities and one province by combining photovoltaic devices on the roof (PV) and electric vehicles (EV) was examined. The results of the analysis shown in (Figure 5) show that by 2030, the combination of (PV+EV) systems can save energy costs by 47.1%, while $CO_2$ emissions would be reduced by 65.7% (Chang et al., 2022).

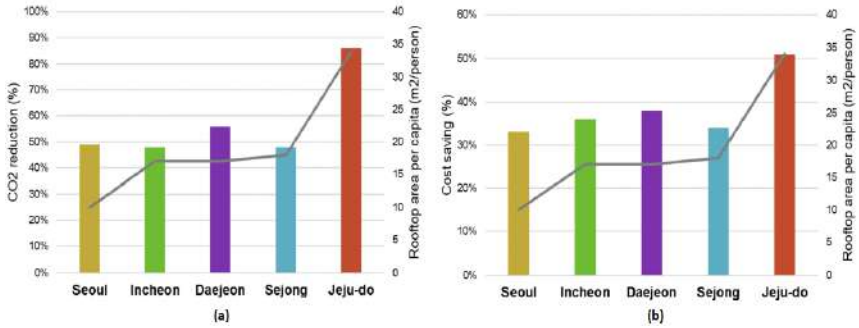


Figure 5. (a) $CO_2$ emission reduction (%) of different urban settings ("PV + EV" 2030); (b) Cost saving (%) of different urban settings ("PV + EV" 2030), (Chang et al., 2022)

**Industrial sector**

The industrial sector has a significant share in global $CO_2$ emissions. Annual energy demand in industry reaches 24.4% (Emissions by sector, 2019), while global $CO_2$ emissions for 2021 amounted to 36.3 gigatons (Gt) (Global Energy Review, 2021). For the sake of achieving climate neutrality by 2050, it is crucial to undertake measures and actions that can reduce $CO_2$ emissions in the industrial sector.

One of the likely means to decarbonize the industrial sector includes demand-side measures, energy efficiency improvements, fuel and raw material substitution, and carbon capture. Decarbonization options for the four focus sectors can be clustered into the following categories (Figure 6):

- Demand-side measures. Decreasing the demand for an industrial product should lead to lower production and $CO_2$ emissions
- Energy-efficiency improvements. Increases in energy efficiency can economically cut fuel consumption for energy use by 15 to 20 percent across sectors.17 Potential gains in energy
- efficiency will differ between sectors and facilities. Using less fossil energy to make industrial products will lower $CO_2$ emissions.
- Electrification of heat. Emissions from the use of fossil fuels to generate heat can be abated by switching to furnaces, boilers, and heat pumps that run on zero-carbon electricity.
- Hydrogen usage. Emissions from the consumption of fossil fuel for heat and emissions from certain feedstocks can be abated by changing them for zero-carbon hydrogen
- Biomass usage. Like hydrogen, sustainably produced biomass can be used in place of some fuels and feedstocks. Depending on the fuel or feedstock required, biomass in a solid (wood, charcoal), liquid (biodiesel, bioethanol), or gaseous (biogas) form can be used.

- Carbon capture. With carbon-capture technology, $CO_2$ can be collected from the exhaust gases produced by an industrial process and prevented from entering the atmosphere. The $CO_2$ can be stored underground (CCS) or used as a feedstock in other processes through carbon capture and usage (CCU).
- Other innovations. Besides the decarbonization options listed above, other techniques for carrying out industrial processes could lead to $CO_2$ emission reductions. For example, alternatives to limestone feedstock could reduce process emissions in cement production. High-temperature chemical processes can also be replaced by electrochemical processes, in which electricity, rather than heat, drives reduction and oxidation reactions (Pe, 2018.).

Figure 6. Decarbonization of industry through the options leading to significant reductions in $CO_2$ emissions (Pe, 2018).

The researches proved that the cement industry in China is responsible for a large amount of air pollution and that it contributes 8% of global $CO_2$ emissions, so as such it can take a significant impact on the path of decarbonization. An integrated assessment framework developed by (Ren et al., 2023) combining a top-down computable general equilibrium model, a bottom-up technology selection model, and a life-cycle assessment was developed to explore the cement industry's carbon–neutral pathways and associated environmental impact. The results show that energy-efficient technologies are key to changing $CO_2$ emissions in the short term. Achieving net zero carbon emissions in the long term requires the application of bioenergy for carbon capture and storage (BECCS), as well as the application of demand-side mitigation measures.

In order to decarbonize heavy industry, carbon capture and utilization (CCU) is considered the most efficient technology. A study developed by (Kawai et al., 2022) investigates the possibilities of decarbonization using the Carbon capture and utilization (CCU) model in Japan, the influencing features (CCU) and how the increase in the number of zero-emission vehicles (ZEV) on the market may affect the application (CCU). Study indicates that CCU has the potential to reduce the use of fossil fuel-based energy required by the petrochemical industry by 32%, thus, substantially contributing to Japan's 2050 $CO_2$ emissions target.

## CONCLUSIONS

Cities are accountable for over 78% of global energy consumption and more than 70% of greenhouse gas (GHG) emissions. This makes them the primary drivers of climate change and positions them to play a leading role in endeavors contributing to the decarbonization of our planet.

Our analysis has shown that we can move closer to achieving the goal of low-carbon cities through the decarbonization of four crucial sectors: construction, energy, transport, and industry.

The development of urban policies and the adoption of a unified approach to climate change mitigation and adaptation are of paramount importance.

There are various possibilities for reducing $CO_2$ emissions, the most prevalent greenhouse gas produced by human activities. These include improving energy efficiency in buildings, which currently account for 40% of energy consumption, increasing the use of renewable energy sources, maintaining mobility, as transportation is responsible for approximately one-quarter of GHG emissions in the EU, embracing the concept of smart cities, enhancing the capacity of the bio-economy, agriculture, and forestry, as well as implementing carbon sinks.

This paper provides an overview of implemented policies and systems, along with an analysis of various methods that lead to climate change mitigation, with the primary goal being zero carbon emissions. The results obtained from already implemented systems and methods demonstrate that by decarbonizing the construction, energy, transport, and industry sectors, we can reduce $CO_2$ emissions by approximately 60% by 2030, with the potential to achieve nearly zero $CO_2$ emissions by 2050.

This conclusion reaffirms the significance of cities in the global fight against climate change and highlights concrete pathways to achieving greenhouse gas emissions reduction targets.

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# *ECONOMY AND MANAGEMENT*
# *EKONOMIJA I MENADŽMENT*

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# ZAPADNI BALKAN U RALJAMA TRANSNACIONALIZMA I INDIVIDUALIZMA

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**SAŽETAK**

U radu autori problematizuju proces približavanja zemalja regiona Zapadni Balkan članstvu u Evropskoj uniji [EU] kroz analizu procesa stabilizacije i pridruživanja sa aspekta ispunjenosti kriterijuma za članstvo u EU. Zapravo, osnovni cilj rada je utvrditi da li ova transnacionalna zajednica vodi isti proces približavanja članstvu u EU za sve zemlje regiona Zapadni Balkan s obzirom da se pojedine zemlje regiona nalaze u različitim fazama razvoja i zahtjevaju individualni pristup prilikom ispunjavanja kriterijuma za članstvo u EU. Istraživački fokus je usmjeren prevashodno na interese zemalja regiona Zapadni Balkan (Albanija, BiH, Crna Gora, Kosovo, Sjeverna Makedonija, Srbija) za pridruživanje EU, odnosno na izazove kojima su navedene zemlje izložene na tom putu integracija kao i na potencijalne posljedice ovakvih pristupnih procesa po dotične zemlje. Drugi cilj je analizirati zajedničke spoljne politike EU prema zemljama regiona Zapadni Balkan da bi se saznalo u čemu je njihov interes za pristupanje EU (i obratno) i koliko se brzo može očekivati proširenje članstva u EU i na ove prostore Balkana.

**Ključne riječi**: Zapadni Balkan, EU, spoljne politike EU.

## UVOD

Proces "približavanja" zemalja regiona Zapadni Balkan članstvu u Evropsku uniju, vrlo je "inspirativan" različitim profilima istraživača, geopolitičkim, geoekonomskim i drugim ekspertima pa je i autore ovog rada ovaj "fenomen" motivisao da, kroz anlitički okvir stabilizacije i pridruživanja, sagledaju stepen ispunjenosti kriterijuma za članstvo i utvrde da li ova transnacionalna zajednica isporučuje istovjetne uslove svim zemljama u regionu Zapadni Balkan, odnosno da li ima prema njima isti tretman. Takođe, u radu se analiziraju integracioni procesi na relaciji Evropka unija - zemlje regiona Zapadni Balkan od 1990.godine (oružana previranja na prostoru ex Jugoslavije), osnovni interesi zemalja regiona Zapadni Balkan za ispunjavanje uslova i eventualnu integraciju u Evropsku uniju kao i neki modaliteti pomoći Evropske unije. Bez respekta u radu autori posebno apostrofiraju "grešku" koju Evropska unija neracionalno i netaktično pravi, tretirajući region Zapadnog Balkana kao homogenu cjelinu, odnosno zanemarujući činjenicu da se zemlje ovog regiona nalaze u različitim političkim i ekonomskim fazama razvoja koje po svojoj prirodi zahtjevaju individualan tretman kod ispunjavanja kriterijuma za članstvo u Evropsku uniju. Autori u sadržaju ovog rada u fokusu imaju prije svega, interese zemalja regiona Zapadni Balkan (BiH, Crna Gora, Srbija, Makedonija, Kosovo i Albanija) u pogledu pridruživanja Evropskoj uniji i obrnuto, kao i izazove sa kojima će se nabrojane zemlje suočiti do konačnog cilja - da budu dio Evropske unije. Na samom početku determinisan je metodološki okvir pisanja rada (opredjeljenje autora za kvalitativne metode istraživanja), potom kratka analiza odnosa Evropske unije i zemalja Zapadnog Balkana. U središnjem (analitičkom) dijelu rada predstavljena je kolekcija izazova sa kojima se zemlje regona Zapadni Balkan suočavaju na svom putu ka evropskim integracijama. S tim u vezi, značajan prostor u radu je posvećen definisanju pojma "integracije". I na kraju, autori iznose svoj sud o tome da li je potvrđena ili opovrgnuta hipoteza – da Evropska unija koristi istu strategiju u procesima stabilizacije i pridruživanja u svim zemljama regiona Zapadni Balkan. Da bi kompletirali sadržaj ovog rada, autori su iskoristili kao primarne izvore mnogobrojna dokumenta, sporazume,programe, deklaracije i ugovore a koji su se odnosili na Evropsku uniju i zemlje regiona Zapadni Balkan.

## DEFIICIJA POJMA "ZAPADNI BALKAN"

Pažljivom istraživaču neće promaći činjenica da postoji više definicija pojma "Zapadni Balkan" ali je za potrebe ovog rada uzeta savremena definicija Evropske unije prema kojoj su zemlje regiona Zapadni Balkan: BiH, Crna Gora, Srbija, Makedonija, Kosovo i Albanija. Obzirom da je navedeno da postoji više definicija i pristupa objašnjenju pojma Zapadni Balkan, onda je pristojno neke i navesti. Evropska unija je kao Zapadni Balkan, krajem 1990-ih, definisala sljedeće zemlje: Albaniju, Bosnu i Hercegovinu, Hrvatsku, Makedoniju i Saveznu Republiku Jugoslaviju. Međutim, politička nestabilnost u regionu je na početku XXI vijeka stvorila 3 države od Savezne Republike Jugoslavije, odnosno Savezna Republika Jugoslavija je preimenovana u Državnu zajednicu Srbija i Crna Gora, da bi Crna Gora stekla nezavisnost 2006. godine. Od 2008. godine, Evropska unija definiše: Albaniju, Bosnu i Hercegovinu, Crnu Goru, Hrvatsku, Makedoniju i Srbiju kao Zapadni Balkan. Naredna promjena kad je u pitanju definicija pojma Zapadni Balkan od strane Evropske unije dogodila se 2013. godine sa ulaskom Hrvatske u Evropsku uniju (Evropska komisija, 2023). U sadržaju koji slijedi, pod pojmom „Zapadni Balkan" podrazumijevaće se zemlje – kako ih je definisala Evropska komisija 2013. godine: Bosna i Hercegovina, Crna Gora, Srbija, Makedonija, Kosovo i Albanija (Vesnić Alujević, 2012).

Slika 1. EU i Zapadni Balkan (European Commission, 2023).
Figure 1. The EU and the Western Balkans (European Commission, 2023).

Danas je svakoj zemlji koja pretenduje na članstvu u Evropsku uniju jasno da postoje kriterijumi koje treba da ispuni ako želi da postane punopravna članica Evropske unije, odnosno kriterijumi za pristupanje, koji su uglavnom poznati kao kriterijumi iz Kopenhagena. Ovi kriterijumi su (European Commission, 2023):

- Politički – stabilnost institucija u zemlji koje konkurišu za članstvo, koje moraju garantovati demokratiju, vladavinu prava, poštovanje ljudskih prava i zaštitu manjina;
- Ekonomski – zemlja koja aplicira za članstvo mora da obezbedi postojanje funkcionalne tržišne ekonomije, sposobne da se nosi sa konkurencijom i tržišnim silama unutar EU; i
- Pravni – zemlja mora imati kapacitet da preuzme obaveze članstva, uključujući pridržavanje ciljeva političke, ekonomske i monetarne unije

Kad su u pitanju zemlje regiona Zapadni Balkan onda treba konstatovati da je Evropska unija isporučila i dodatne uslove svakoj zemlji koje ove moraju da ispune u okviru Procesa stabilizacije i pridruživanja i Sporazuma o stabilizaciji i pridruživanju. Većina ovih uslova odnosi se na saradnju zemalja u regionu Zapadni Balkan i na modalitete uspostavljanje i održavanje dobrosusjedskih odnosa među državama. Početak pristupanja zemalja regiona Zapadni Balkan Evropskoj uniji u osnovi je počeo njihovim posebnim tretmanom u okviru procesa stabilizacije i pridruživanja, a kasnije i potpisivanjem Sporazuma o stabilizaciji i pridruživanju (sve zemlje su ga već potpisale). U slučaju ispunjavanja obaveza u procesu stabilizacije i pridruživanja, svaka zemlja postepeno ide ka članstvu u EU, dok Evropska komisija u godišnjim izvještajima ocjenjuje postignuti napredak za svaku zemlju pojedinačno.

## PROCES INTEGRACIJE ZEMALJA REGIONA ZAPADNI BALKAN

U trećoj deceniji po okončanju oružanih sukoba na prostoru Balkana, društveno-politička situacija u zemljama regiona Zapadni Balkan je konfuzna, jednom riječju - teška. Bosna i Hercegovina je u značajnoj mjeri paralizovana zemlja i još uvijek se traga za jedinstvenim Ustavom (u sadašnjim okolnostima na snazi su tri Ustava i Dejtonski sporazum) koji treba da omogući jedinstven pristup funkcionisanju zemlje. S druge strane Republika Srbija se već godinama suočava sa problemom uspostavljanja međunarodno prihvatljivih granica. Makedonija se suočava sa nepriznavanjem imena zemlje u međunarodnim krugovima kao i tinjajućim sukobima između makedonske većine i albanske manjine. Crna Gora je na razmeđu između Evrope i Rusije što znači da se na njenom tlu ukrštaju interesi navedenih zemalja i međunarodnih organizacija. Od zajedničkih karakteristika koje se mogu pripisati svakoj zemlji regiona Zapadni Balkan, treba istaći: neuspješna borba protiv korupcije, loši ekonomski pokazatelji, visoka nezaposlenost, masovne ilegalne migracije migranata u posljednjih godinu-dvije, masovni odlazak obrazovanih mladih ljudi u inostranstvo i politička nestabilnost. Činom potpisivanja Sporazuma o stabilizaciji i pridruživanju sve zemlje regiona Zapadni Balkan načinile su prvi korak ka pridruživanju Evropskoj uniji. Gledano istorijski, uticaj stranih sila (Otomanskog carstva, Habzburške monarhije, kasnije Austrougarske i Ruske imperije) je uvijek bio prisutan na Balkanu. Drugim riječima, ovakvo stanje proizvodilo je vrlo često političku nestabilnost i cikličnu integraciju zemalja regiona Zapadni Balkan. Mnogo ranije nego što se Sarajevo "proslavilo" kao grad u kome je izvršen atentat na austrougarskog prestolonaslednika Franca Ferdinanda, Balkan je bio podijeljen između Osmanskog Carstva i Habzburške monarhije. Balkanski ratovi početkom XX vijeka nisu doprinijela stabilizaciji regiona, Po završetku I svjetskog rata i raspada Austrougarske, jedan broj zemalja se ujedinilo u Kraljevinu Jugoslaviju (u Kraljevina Jugoslavija se zvala Kraljevina Srba, Hrvata i Slovenaca). Drugi svjetski rat, definitivno je uticao na ukidanje kraljevine, jer su se balkanske zemlje koje su iz rata izašle kao pobjednici ujedinile u novu Jugoslaviju, u kojoj je bio prisutan novi politički sistem – socijalizam. Trenutno sve zemlje iz regiona Zapadni Balkan pokazuju želju za integracijom u EU, što predstavlja važnu promjenu, jer su prije samo 25 godina sve zemlje izrazile snažnu želju za nezavisnošću.

## INTEGRACIJA I TRANSNACIONALNOST

U savremenim pristupima razumijevanja ova dva pojma polazi se od utvrđene činjenice da transnacionalne tvorevine nastaju (ili preživljavaju transformacione procese) usljed nemogućnosti da dvije ili više zemalja, međusobno razviju normalnu, odnosno nekonfliktnu saradnju. Mnogobrojne teorijske definicije koje su dostupne u relevantnoj literaturi najčešće povezuju integraciju pojedinih zemalja u transnacionalnu tvorevinu (organizaciju, strukturu i sl) s namjerom da riješe nagomilane probleme koje same nisu u stanju riješiti ili, češće, da smanje transakcione troškove i druge prepreke međusobnoj trgovini. Ovakvim opredjeljenjem zemlje članice obezbjeđuju veći prosperitet (Eilstrup, & Verdier, 2005).

Međutim, u praksi se dešava da je dosta teško razgraničiti gdje počinje a gdje se završava ekonomska, odnosno politička integracija imajući u vidu da, recimo, ekonomska integracija nije utemeljena isključivo na trgovinskim i/ili ekonomskim efektima nego u sebi objedinjava i mnogobrojne političke motive. Drugim riječima, ukoliko ekonomsku integraciju ne prate i uspostavljene institucije i njihove politike onda je vrlo vjerovatno da neće doći do političke integracije. Na primjer, uspostavljanje slobodne zone za trgovanje ne znači da je automatski došlo i do političke integracije. S druge strane, ukoliko se kao posljedica ekonomske integracije uspostave određene zajedničke (centralne) institucije i specifične politike onda je politička integracija neizbježna (Haas Ernst, 1958.). Eilstrup i Verdier (2005) predstavili su model u kojem tvrde da integracija može poslužiti kao kredibilna obaveza koja onemogućava ili čak uklanja rizik od budućeg sukoba između zemalja koje nisu podjednako moćne. Ovde su autori uglavnom želeli da ukažu da je integracija pojedinih država u nadnacionalne zajednice alternativa za sprečavanje rata drugim sredstvima, odnosno da je ova vrsta integracije sredstvo za zaustavljanje rasta revizionističkih moći u uspostavljanju regionalne dominacije (Eilstrup, &Verdier, 2005).

## ODNOSI EVROPSKE UNIJE PREMA ZEMLJAMA REGIONA ZAPADNI BALKAN

Uspostavljanje odnosa između Evropske unije i zemalja Jugoistočne Evrope ima u vidokrugu vise ciljeva ali nekoliko se izdvajaju: na političkom planu, uspostavljanje demokratskih institucija državne uprave i civilnog društva dok na ekonomskom cilj se prevashodno odnosio na revitalizaciju ekonomskih aktivnosti uspostavljanjem tržišnih mehanizama funkcionisanja privrede i, uporedo obnova oštećene infrastrukture. Potrebno je kao primjer, istaći da je Evropska unija poslije ratnih sukupa na prostoru nekadašnjih jugoslovenskih republika, pružila sukobljenim stranama humanitarnu pomoć, da je 1999.godina inicirala, na temelju regionalne saradnje, stvaranje Pakta stabilnosti za Jugoistočnu Evropu. Međutim, ova inicijativa nije uspjela iz vrlo jednostavnog razloga – zemlje jugoistočne Evrope su ovu inicijativu shvatile kao alternativu članstvu Evropskoj uniji a to nisu priželjkivale. Da ova inicijativa ne bi doživjela potpuni fijasko, iste godine Evropska unija započinje sprovođenje procesa stabilizacije i pridruživanja za koji su dale svoj pristanak i zemlje regiona Zapadni Balkan vjerujući da im kao nagrada neminovno pripada članstvo u Evropskoj uniji. U vezi sa ovom aktivnošću pokrenut je 2000.godine Program pomoći Evropske unije za rekonstrukciju, za razvoj i stabilizaciju (CARDS). Program se bazirao na tehničkoj i finansijskoj pomoći zemljama regiona Zapadni Balkan. Ovaj program je trajao sve do 2007.godine kada je zamijenjen instrumentom pretpristupne pomoći – IPA (Eur lex, 2023). Kroz ovaj program od 2007.godine pa na ovamo, Evropska unija zemljama kandidatima i zemljama potencijalnim kandidatima, pruža finansijsku podršku radi sprovođenja neophodnih reformi. Da bi jasnije razumjeli ovu vrstu podrške treba još jednom osmotriti proces stabilizacije, odnosno Sporazum o stabilizaciji i pridruživanju i ciljeve koje predviđa (Eur lex, 2023):

- promocija tranzicije privrede ka tržišnoj ekonomiji i politička stabilizacija zemlje,
- podsticanje i unapređenje regionalne saradnje i
- članstvo u EU.

Po svojoj prirodi sam proces stabilizacije i pridruživanja zamišljen je da bude od koristi zemljama potpisnicama prevashodno u usvajanju i primjeni pravne stečevine Evropske unije i usvajanju međunarodnih standarda. Uspostavljeno partnerstvo zemalja regiona Zapadni Balkan i Evropske unije u krajnjem treba da omogući:

- slobodan pristup tržištima Evropske unije,
- finansijsku (ekonomsku) pomoć zemljama potpisnicama, za obnovu, razvoj i stabilizaciju

Uopšteno, prilika koju je Evropska unija pružila zemljama regiona Zapadni Balkan, izgleda idealno jer im kao ključni benefit nudi političku i ekonomsku stabilnost pod uslovom da ispune ključne ciljeve koje je pred njih postavila Evropska unija. Međutim, ispunjavanje ciljeva je daleko od ispunjavanja neophodnih uslova za članstvo u Evropsku uniju što na neke zemlje regiona čitav proces djeluje frustrirajuće i nedostižno. U kontekstu, naslova ovog rada ovaj proces se može umjesto prilike shvatiti kao uslov(ljavanje) imajući u vidu da zemlje prolaze kroz najmanje tri imperative bliska koraka: potpisivanje sporazuma o stabilizaciji i pridruživanju, ispunjavanju ciljeva koji proizilaze iz tog sporazuma i ispunjavanje uslova koji se direktno tiče članstva zemalja u Evropskoj uniji.

## NEKE SLABOSTI MEHANIZMA PRISTUPANJA ZEMALJA ZAPADNOG BALKANA EVROPSKOJ UNIJI

Pristup Evropskoj uniji nije unificiran, odnosno ne postoji nekakva univerzalna matrica prema kojoj se ulazi u članstvo Evropske unije. Od svih faktora, najvažnije je da zemlja želi da uđe u članstvo Evropske unije, da potpiše Sporazum o stabilizaciji i pridruživanju i isti primjeni prije nego što se pokrene mehanizam pregovora za članstvo i podnošenja zahtjeva za učlanjenje i dobijanje statusa kandidata – mada ovakav redosled aktivnosti nije nigdje preciziran. Kad se u fokus dovedu želje i interes zemalja u regionu Zapadni Balkan za članstvo u Evropskoj uniji, onda se može konstatovati da manje - više (barem deklarativno to tako izgleda) sve zemlje imaju nedvosmisleno opredjeljenje da idu u tom pravcu. Ovakav stav nije iznenađenje budući da su sve redom u procesu tranzicije, da je nezaposlenost velika a privredni rast nizak za razliku od zemalja

članica Evropske unije kod kojih je obrnuta situacija. Jedan značajan broj autora koji prate proces pridruživanja Evropskoj uniji ukazuju na "grešku" institucija Evropske unije sadržanu u tome što na makro nivou ima isti tretman za sve zemlje kandidate bez obzira na njihove individualne specifičnosti i prepreke na putu integracija.

S druge strane i prilike u Evropskoj uniji su se promijenile. Nezaposlenost je porasla jer je došlo do stagnacije privrednog rasta. Dogodila se ekonomska kriza i recesija od koje se jedan broj zemalja EU nije oporavio ili se teško oporavlja, dogodio se Bregzit kao svojevrsni šok, Evropska unija očekuje i dalje priliv migrnata sa Bliskog istoka pa zbog tog zemlje u graničnim zonama podižu ograde i žice na svoje granice, javljaju se masovni (po nekima opravdani) protesti protiv TTIP-a i CETA itd. U značajnom broju zemalja članica Evropske unije aktuelizovana je dilema: da li da se pravi presedan i u člnstvo EU prime zemlje sa nestabilnim političkim prilikama i oslabljenoj ekonomiji. Dogodio se svojevrsni paradoks – do samo nekoliko godina unazad Zapadni Balkan nije bio spreman za Evropsku uniju s jedne strane a sada Evropska unija nije spremna za Zapadni Balkan s druge strane.

Teorija domina takođe dolazi iz ekonomske osnove integracije, koja objašnjava da preferencijalno smanjenje trgovinskih barijera u nadnacionalnoj strukturi kakva je EU stvara pritisak za „autsajdere" (zemlje koje nisu članice) i kako ova struktura raste, pritisak da se pridruživanje povećava (Baldwin et al., 1995). Kako to izgleda u praksi najbolje se može razumjeti na sljedećem primjeru: ako uzmemo jednostavan model od 3 zemlje - matične zemlje, zemlje partnera i zemlje ostatka svijeta, gdje matična država iznenada uspostavlja carinsku uniju sa zemljom partnerom. Carinska unija znači da postoji slobodna trgovina između dvije zemlje (carine se ukidaju i necarinske barijere uz istovremeno uspostavljanje zajedničkih carina za ostatak svijeta). Pozitivne ekonomske posljedice po zemlje u takvoj uniji prema Baldwin, R., i Wyplosz C. su sljedeće (Baldwin, & Wyplosz, 2012):

- dolazi do smanjenje cijena proizvoda na domaćem tržištu,
- dolazi do povećanja cijene na granici za zemlju partnera,
- dolazi do povećanja uvoza iz partnera zemlje i
- dolazi do povećanja domaćeg uvoza.

Istovremeno, tvrde isti autori, takvo „partnerstvo" ostavlja negativne posljedice po zemlje ostatka svijeta:

- uzrokuje smanjenje cijena proizvoda na granici,
- uzrokuje smanjenje uvoza iz zemalja ostatka svijeta i
- trgovina i uvoz se premiještaju u zemlju partnera

Navedeni primjer s velikom pouzdnošću dokazuje da ekonomske i političke integracije ne idu ruku pod ruku iz prostog razloga što ekonomska integracija nije zasnovana isključivo na trgovinskim i ekonomskim benefitima, odnosno efektima jer joj po pravilu prethodi ili slijedi politički dogovor zainteresovanih strana – politička integracija. Po prirodi stvari od ishoda tih dogovora i uspostavljanja centralnih institucija i usaglašenih politika zavisi i stepen ekonomske integracije. Međutim, prema Haas i Ernst B., ukoliko je situacija obrnuta pa se tokom ekonomske integracije uspostave određena tijela, institucije i zajedničke politike onda je i politička integracija sasvim izvjesna (Haas Ernst, 1958).

## ZAKLJUČCI

Bez obzira što Evropska unija ima svojevrstan interes (ili višestruke interese) za integraciju zemalja regiona Zapadni Balkan, proces integracije teče sporo i neizvjestan je rok do koga će se čitav proces okončati. S druge strane, zemlje regiona Zapadni Balkan zatičemo u različitim pripremnim fazama u procesu pridruživanja – neke zemlje su tek prihvatile Sporazum o stabilizaciji i pridruživanju koji je osnova za procese integracije, neke su podnijele zahtjev za članstvo ali proces miruje (na primjer BiH), neke imaju status kandidata (Makedonija, Srbija, Crna Gora), neke su započele pregovore (Srbija i Crna Gora). Hrvatska je jedina zemlja iz „paketa" zemalja regiona Zapadni Balkan koja je postala članica Evropske unije.

Analize pokazuju da sve zemlje koje iskažu želju za integracijom u Evropsku uniju prolaze istim putem, odnosno ispunjavaju iste uslove. Međutim, na tom putu ekonomske i političke okolnosti diktiraju tempo napretka pa je normalno da neke zemlje brže napreduju a neke zaostaju. Upravo iz navedenih razloga varira i period od podnošenja zahtjeva do sticanja statusa kandidata zemalja regiona Zapadni Balkan. Na primjer, Makedonija je dobila status kandidata samo godinu dana nakon podnošenja zahtjeva dok je Albanija „čekala“ na odgovor pet godina. Prema praksi u procesu integracija zemalja kandidata u članstvo Evropske unije, od statusa kandidata do početka pregovora u prosjeku treba da prođe najmanje dvije godine. U međuvremenu, Evropska unija je uvela i praksu „odlaganje pregovora“ što je samo demotivisalo ostale zemlje da ubrzaju reforme radi integracija. Razlozi za ovakvu „novu“ praksu koja se odnosi na odlaganje pregovora su mnogobrojni ali se, prema mišljenju poznavaoca prilika, mogu svrstati u nekakve četiri grupe:

- veto članica EU,
- specifičnost situacije u zemlji kandidatu, što izaziva zabrinutost za EU,
- nedoslednost zahteva EU i
- problematičnost zemlje u međunarodnom okruženju.

Pažljivom promatraču je vidljivo iz nabrojanih “grupa” razloga koji su usporili, odnosno doveli do odlaganja pregovaračkog procesa sa zemljama regiona Zapadni Balkan, da je ispunjavanje opštih kriterijuma i s tim u vezi promocija opštih vrijednosti Evropske unije prioritet svih prioriteta. Slab “plasman” Bosne i Hercegovine na tom putu je u najmanju ruku začuđujući imajući u vidu da je EU neposredni “graditelj” Bosne i Hercegovine poslije okončanja ratnih sukoba 1995. godine. S druge strane Hrvatska je za “samo” dvanaest godina uspjela da postane punopravna članica Evropske unije dok je Srbija tek u fazi ispunjavanja uslova za predpristupne pregovore. Od svih zemalja regiona Zapadni Balkan najbolju poziciju u procesu integracija ima Crna Gora. Makedoniju muči pitanje granice sa Grčkom. Albanija će, prema mišljenju poznavaoca prilika na Zapadnom Balkanu, proći najteži put ka evropskim integracijama jer zemlja ima specifičan put razvoja koji nije donio mnogo toga zajedničkog sa ostalim zemljama regiona.

Na kraju, zaključna konstatacija bi bila da ne postoji univerzalni pristup Evropskoj uniji. Postoji samo redosled koraka (sporazum o pridruživanju i stabilizaciji, pregovori za članstvo, podnošenje zahtjeva za članstvo, dobijanje statusa kandidata itd) ali oni u praksi nisu potvrđeni što potvrđuje hipotezu rada da Evropska unija koristi istu strategiju u procesima integracija pa i u procesu integracija zemalja regiona Zapadni Balkan ali “zbunjuje” to što strategijama ne korespondiraju prakse Evropske unije tokom tih procesa (na primjer: iznenadno odlaganje pregovora) koje mogu biti različite od zemlje do zemlje.

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# THE WESTERN BALKANS IN THE ERA OF TRANSNATIONALISM AND INDIVIDUALISM

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**ABSTRACT**

In the paper, the authors problematize the process of approaching the Western Balkan countries to membership in the European Union through the analysis of the process of stabilization and association from the aspect of fulfilling the criteria for membership in the European Union. In fact, the main goal of the paper is to determine whether this transnational community leads the same process of approaching membership in the European Union for all Western Balkans countries, given that some countries in the region are in different stages of development and require an individual approach when fulfilling the criteria for membership in the European Union. The research focus is primarily on the interests of the Western Balkan countries (Albania, Bosnia and Herzegovina, Montenegro, Kosovo, North Macedonia, Serbia) for joining the EU, that is, on the challenges to which the mentioned countries are exposed on the path of integration, as well as on the potential consequences of such accession processes by respective countries. The second goal is to analyze the common foreign policies of the European Union towards the Western Balkans in order to find out what the interest of the Western Balkans countries for joining the European Union (and vice versa) and how quickly we can expect the expansion of membership in the European Union and these areas of the Balkans.

**Keywords:** Western Balkans, EU, EU foreign policy.

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# KONCEPT KONKURENTNOSTI PRIVREDE GRADA

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## SAŽETAK

U radu se prezentuje koncept konkurentnosti privrede grada. Ističe se njegova rastuća važnost u teoriji i politici konkurentnosti pojedinih urbanih prostora. Koncept konkurentnosti grada treba sagledavati u svetlu svojevrsnog teorijskog i metodološkog objedinjavanja opštih i lokalnih dimenzija višeslojne kategorije konkurentnosti. Time se višestruko šire mogućnosti sagledavanja relacija između ekonomskih aktera na određenom prostoru. Autori konstatuju rastući interes istraživača različitih vokacija za proučavanje koncepta konkurentnosti grada.

Za ekonomske analitičare koncepta konkurentnosi grada posebno su značajni pokretači unapređenja konkurentnosti grada koji se odnose na dinamične promene strukture privrede, gibanja na tržištima rada, pojave novih društvenih potreba, a u poslednje vreme na značaju dobija sve veći broj faktora povezanih sa pitanjima bezbednosti (energetske, prehrambene itd.). Sve veći broj gradova prepoznaje potrebu za jačanjem svoje konkurentske pozicije primenjujući preduzetnički i marketinški pristup. Pored tzv. „tvrdih“ pokretača konkurentnosti grada (mogućnosti zaposlenja, lakoće poslovanja, turistička atraktivnost), na značaju dobijaju „meki“ faktori poput percepcije kvaliteta življenja, imidža grada i tome slično. Redukujući kategoriju konkurentnosti privrede grada u Republici Srbiji na pokazatelj ekonomski agregat, u radu se na osnovu vlastitog izračunavanja prezentuje komparativni pregled indikatora konkurentnosti privrede gradova Beograd, Novi Sad, Niš i Kragujevac u periodu 2005-2021. godine.

**Ključne reči**: konkurentnost grada, pokretači unapređenja konkurentnosti grada, ekonomski agregat.

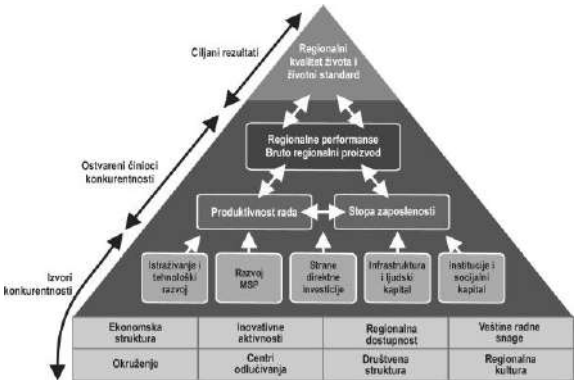
## UVOD

Analiza ključnih determinanti konkurentnosti grada u savremenim uslovima privređivanja važna je dimenzija politike održivog razvoja na nacionalnom i regionalnom nivou. Kategorija konkurentnosti grada suštinski se povezuje sa njegovim ključnim ekonomskim performansama. Međutim, činjenica je da se o mestu može govori isključivo sagledavajući njegovu relativnu poziciju prema drugim gradskim sredinama, a daleko manje prema njegovoj akumuliranoj imovini. „Napredak savremenog društva sve se više usmerava kroz razvoj različitih nivoa mesta, te različitog dostignutog stepena iskorišćenosti potencijala (Toli, & Murtagh, 2020; Yigitcanlar, et al., 2019). Jačanje konkurentnosti i ostvarenje punog potencijala mesta, stoga postaje imperativ dugoročno održivog ekonomskog razvoja. Pritom mesta primenjuju ili pripremaju primenu različitih organizaciono-razvojnih koncepcija u upravljanju mestima“ (Širola i Zrilić, 2013).

## KONKURENTNOST MESTA

Konkurentnost mesta, u konkretnom slučaju grada, govori o njegovoj sposobnosti da raste zahvaljujući unapređenju svojih relativnih pozicija u nacionalnoj i međunarodnoj podeli rada. Radi se o području ekonomske teorije posvećenom analizi činjenica i politika koje oblikuju sposobnost grada da stvori i održi sredinu, pogodnu za stvaranje veće vrednosti u preduzećima koja posluju na konkretnoj teritoriji i prosperitet njenim stanovnicima (Garelli, 2009).

Nivo konkurentnosti grada dobrim delom određuje stope prinosa na investicije u ljudski, inovacioni i fizički kapital. Više stope prinosa na ulaganja utiču na ubrzanje ekonomskog rasta na nivou grada. Prioriteti politike konkurentnosti menjaju se prelaskom iz jedne u drugu razvojnu fazu. U početnim fazama, privreda konkretnog mesta može da se nadmeće na bazi relativnog obilja faktora proizvodnje. U narednoj fazi ekonomskog a samim tim i urbanog razvoja, odlučujući faktori konkurentnosti su efikasnost proizvodnje i kvalitet proizvoda i usluga, dok u današnjim uslovima privređivanja ekonomski najrazvijenija mesta mogu omogućiti održivi rast životnog stanadarda stanovništva isključivo zahvaljujući obrazovnom i intelektualnom kapitalu (Slika 1).




Slika 1. Izvori, činioci i ciljani rezultati konkurentnosti mesta (Brettel, 2005).
Figure 1. Sources, factors and target results of place competitiveness (Brettel, 2005).

Poruka Slike1 je da mesto treba da se orijentiše na prepoznavanje i optimalno korišćenje vlastitih konkurentskih snaga u čijem se ishodištu nalaze izvori konkurentnosti: okruženje, centri odlučivanja, društvena struktura, regionalna kultura, ekonomska struktura, inovativne aktivnosti, regionalna dostupnost, veštine radne snage.

U osnovi, ono što razlikuje konkurentnost zemlje, regiona, grada, lokalne zajednice, s jedne, od konkurentnosti preduzeća, s druge strane, je mesto koje ovi entiteti imaju u stvaranju ekonomske vrednosti u društvu (Cvetanović et al., 2022). Ekonomsku vrednost stvaraju samo preduzeća, dok administrativne oblasti pored kreiranja okruženja koje podržava ili ometa aktivnosti preduzeća, u novije vreme obavljaju i veliki broj preduzetničkih funkcija (Mazzucato, 2014). Afirmaciji koncepta konkurentnosti mesta umogome je doprinela pojava nove, odnosno endogene teorije rasta tokom osamdesetih i devedesetih godina prethodnog veka. U ovom kontekstu, ekonomisti naglašavaju da endogena teorija ostavlja prostor za delovanje države na različitim nivoima njene administrativne organizovanosti u cilju podržavanja konkurentskog potencijala slabije razvijenih područja.

## KONKURENTNOST ČETIRI NAJVEĆA GRADA U REPUBLICI SRBIJI

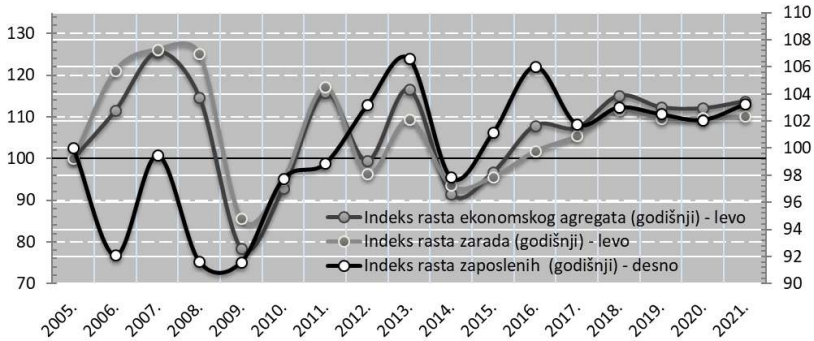
Početkom ovoga veka u Republici Srbiji je prepoznata potreba da se u sklopu sagledavanja regionalnog aspekta konkurentnosti sagleda konkurentnost pojedinih gradova. U tu svrhu, od 2005. godine u Republici Srbiji se za iskazivanje konkurentnosti gradova koristi pokazatelj *ekonomski agregat*. Najkraće, vrednost ekonomskog agregata se dobija kao proizvod ukupnog broja zaposlenih i prosečnih bruto zarada po zaposlenom na sagledavanoj teritoriji. Dakle, radi se o zbirnom indikatoru koji reprezentuje ekonomsku aktivnost grada iskazanu u evrima.

Kao i svi ostali zbirni indikatori, i ekonomski agregat ima svojih dobrih, ali takođe i manje dobrih strana. Njegova ključna dobra strana je jasnoća i lakoća izračunavanja, takođe pružanje uporedivosti prilikom sagledvanja atraktivnosti mesta za investiciona ulaganja potencijalnih preduzeća. Slabosti ovog pokazatelja proizilaze iz činjenice da se on temelji na prosečnim vrednostima, usled čega je neprecizniji u odnosu na bruto domaći proizvod po stanovnku koji predstavlja proizvedenu i tržišno realizovanu proizvodnju roba i usluga po stanovniku.

U cilju sticanja realne slike o dostignutim nivoima četiri najveća grada u Republici Srbiji analizirani su podaci o kretanju veličina ekonomskog agregata, bruto zarada preračunatih u evrima i nezaposlenosti u vremenskom intervalu od 2005. do 2021. godine. U cilju izbegavanja navođenja velikog broja tri prethodna indikatora konkurentnosti mesta u radu su date grafičke eksplikacije njihovog kretanja u periodu 2001–2021. Pri tom ne treba gubiti iz vida činenicu da pitanje konkurentnosti privrede grada u savremenim uslovima podrazumeva analizu daleko većeg broja indikatora u odnosu na tri apostrofirana pokazatelja (Despotović, 2014). Međutim, imajući u vidu kompleksnost ovih pokazatelja, a posebno veličine ekonomskog agregata, mišljenja smo da je na osnovu iskazanih podataka moguće steći globalnu sliku o relativnoj konkurentnosti četiri najveća grada po broju stanovnika i ekonomskom potencijalu u Republici Srbiji.

Konkurentnost Kragujevca

Rast zarada na području grada Kragujevca pratio je vrednosti ekonomskog agregata u celokupnom posmatranom periodu sa nešto blažim oscilacijama. Međutim, u periodu 2015–2020. zarade su rasle nešto brže u poređenju sa kretanjem vrednosti ekonomskog agregata. Indeks promene broja zaposlenih pokazuje značajnije variranje u periodu od 2005. do 2016. godine i reflektuje ne samo globalne već i lokalne ekonomske promene grada Kragujevca (Slika 2).

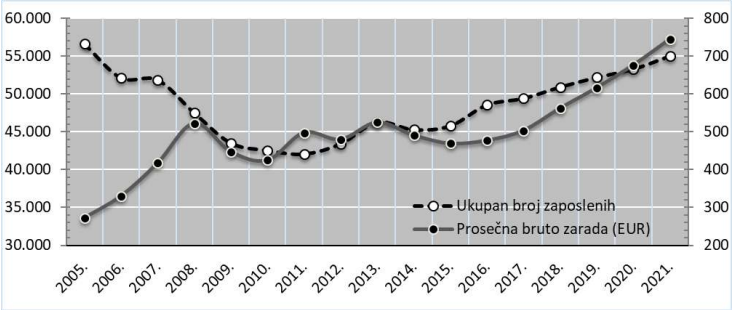



Slika 2. Uporedni prikaz indeksa promene ekonomskog agregata, bruto zarada i broja zaposlenih za Kragujevac (Republički zavod za statistiku [RZS], 2023).

Figure 2. Comparative presentation of the index of changes in the economic aggregate, gross wages and the number of employees for Kragujevac (Republički zavod za statistiku [RZS], 2023).

Ključni ekonomski problem grada Kragujevca u vremenskom intervalu od 2005. do 2011. godine bio je rast nezaposlenosti. Uočava se da od 2008. do 2011. godine nezaposlenost na području grada Kragujevac iskazuje trend rasta (opada ukupan broj zaposlenih), dok u periodu 2011–2021 neazaposlenost počinje da se smanjuje (osim blagog pada u 2014. godini koja je zbog poplava bila krizna na nivou cele RS). Ovaj trend je u prvom delu povezan sa dolaskom italijanske kompanije FIAT (i njenih partnerskih firmi) i otvaranjem fabrike automobila FAS (Fiat Automobili Srbija). Međutim, tek od 2011. godine veći broj stranih direktnih investicija dovode do preokreta trenda i rasta zaposlenosti. U periodu od 2017. godine ovaj trend rasta broja zaposlenih pokazuje stabilnu rastuću tendenciju.

Iznos prosečnih bruto zarada predstavlja najvažniji parametar socijalne dimenzije konkurentnosti grada. Uporedni prikaz kretanja broja zaposlenih i prosečnih bruto zarada grada Kragujevca dat je na Slici 3.

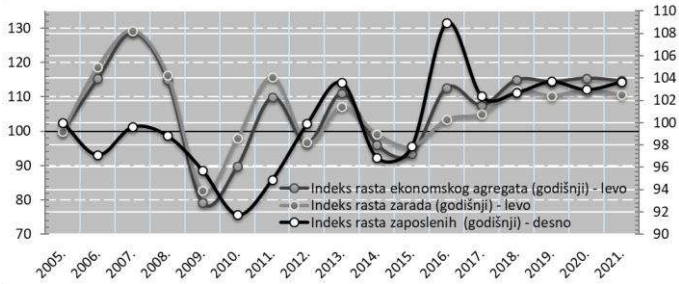



Slika 3. Uporedni prikaz broja zaposlenih i bruto zarada za Kragujevac.
Figure 3. Comparative view of the number of employees and gross earnings for Kragujevac.

Evidentno da su prosečne bruto zarade grada Kragujevca od 2008. godine pratile trend kretanja zaposlenosti, osim u početnom periodu od 2005. do 2008. godine, kada je dolazak FIAT-a ublažio pad zaposlenosti u ovom mestu usled svetske ekonomske krize. Zarade su imale kasnije fluktuacije 2012. (sušna godina), 2014. i 2015. godine usled poplava, ali je srednjoročni trend rastući sve do 2021. godine.

Konkurentnost Niša

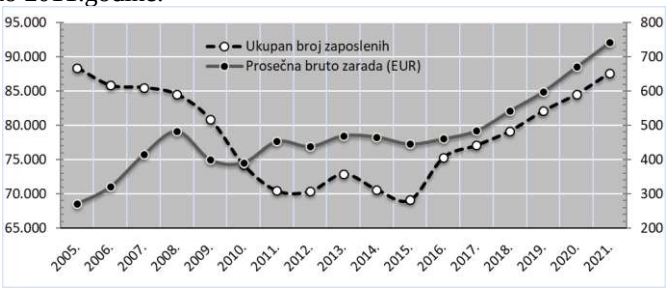
Ekonomski agregat grada Niša iznosio je 65.050.522 evra u 2021. godini (nešto više od 1,5 puta veći od kragujevačkog i po tome su ova dva grada najpribližnija) što se može zapaziti na Slici 4.




Slika 4. Uporedni prikaz indeksa promene ekonomskog agregata, bruto zarada i broja zaposlenih za Niš.
Figure 4. Comparative presentation of the index of change in the economic aggregate, gross wages and the number of employees for Niš.

Od 2016. pa do 2021. godine grad Niš pokazuje stalni trend apsolutnog rasta kako zaposlenosti tako i prosečnih bruto zarada. Detektuje se blaga varijacija indeksa promene zaposlenosti usled pandemije u 2020. godini, ali je ona na nivou 1 procentnog poena i nadoknadjena je već u 2021. godini.

Na Slici 5 je predstavljeno kretanje broja zaposlenih i prosečnih bruto zarada grada Niša u periodu od 2005. do 2011.godine.

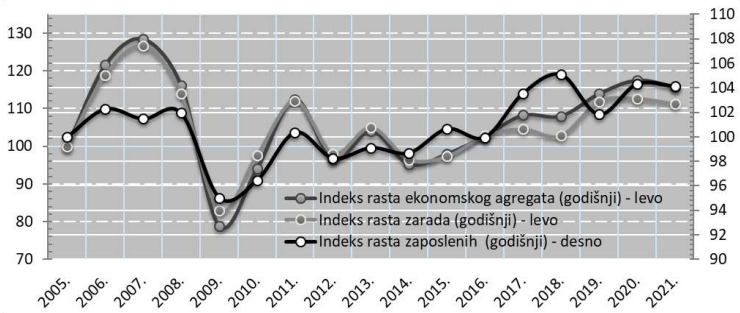



Slika 5. Uporedni prikaz broja zaposlenih i bruto zarada za Niš.
Figure 5. Comparative presentation of the number of employees and gross earnings for Niš.

Uočljiv je vrlo izražen trend povećanja ukupnog broja zaposlenih i prosečnih bruto zarada izraženih u evrima u periodu 2016–2021 na području Niša.

Konkurentnost Novog Sada

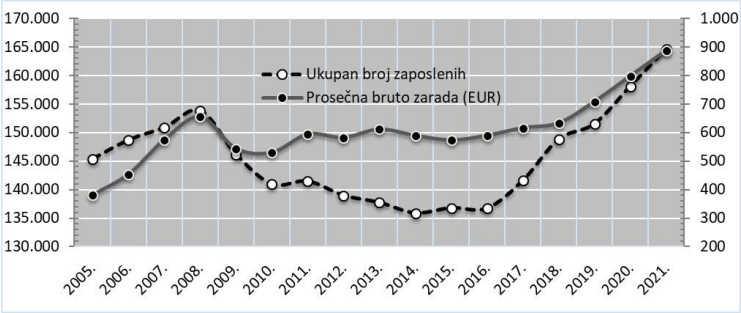
Ekonomski agregat grada Novog Sada iznosio je 146.019.458 evra u 2021. godini.




Slika 6. Uporedni prikaz indeksa promene ekonomskog agregata, bruto zarada i broja zaposlenih za Novi Sad.
Figure 6. Comparative presentation of the index of changes in the economic aggregate, gross wages and the number of employees for Novi Sad.

Slika 6 pokazuje u posmatranom periodu slične varijacije sva tri posmatrana parametara, ali i znatno manje pikove (i negativne i pozitivne) u odnosu na grad Kragujevac. Naročito je izražena značajno veća stabilnost privrede Novog Sada u periodu globalne ekonomske krize od 2008. godine. Takođe, indeks broja zaposlenih je značajno manje oscilovao i tokom suše 2012. godine i tokom poplava 2014. godine. U periodu posle 2015. godine, Novi Sad je kao i Kragujevac stabilizovao pozitivne trendove posmatranih ekonomskih indikatora.

Za razliku od Kragujevca koji je pad indeksa zaposlenosti ublažio baš tokom postkrizne 2009. (i ponašao se delimično kontraciklično ostatku zemlje) Novi Sad je zabeležio znatan pad indeksa zaposlenosti 2009. godine, da bi se tek 2011. godine vratio na nivo iz 2005. godine (Slika 7).

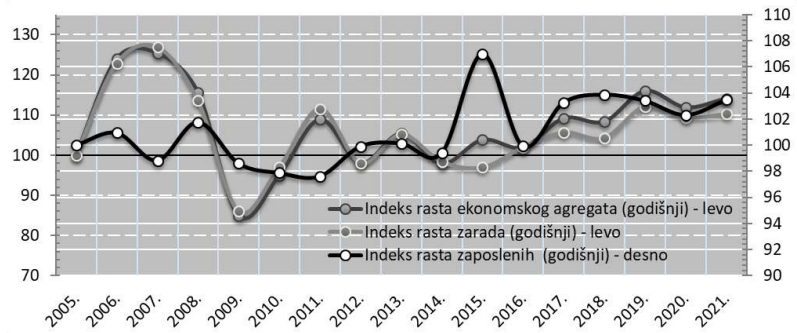



Slika 7. Uporedni prikaz broja zaposlenih i bruto zarada za Novi Sad.
Figure 7. Comparative view of the number of employees and gross earnings for Novi Sad.

Slično kao i Kragujevac 2016. godine, ali sa pomakom od 2 godine, Novi Sad dostiže snažan pik rasta indeksa zaposlenosti usled značajnijeg priliva stranih investicija. U 2019. godini ovaj indeks beleži rast da bi u epidemijskoj 2020. godini zabeležio blagi pad i 2021. godini povratak na nivo od 2019. godine. Međutim, kada se indeks prevede u apsolutni broj zaposlenih, Novi Sad je pad usled globalne ekonomske krize iz 2008. godine uspeo da nadoknadi tek u 2019. godini. Prosečne bruto zarade su i po indeksu promena i u apsolutnom iznosu većinom imale iste trendove, i takodje su tek 2019. godine dostigle predkrizni period iz 2008. godine.

Konkurentnost Beograda

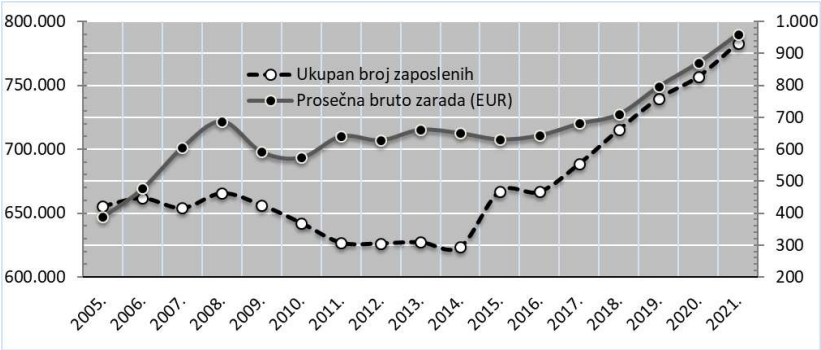
Ekonomski agregat grada Beograda u 2021. godini iznosio je 751.978.206 evra. Ovo je nešto više od 18 puta veće od kragujevačkog, više od 11,5 veće od niškog i više od 5 puta veće od ekonomskog novosadskog agregata. Region Beograda je u apsolutnim brojevima neuporediv sa ostalim posmatranim gradovima ali dosta slikovito pokazuje stepen centralizacije u Republici Srbiji (Slika 8).




Slika 8. Uporedni prikaz indeksa promene ekonomskog agregata, bruto zarada i broja zaposlenih za Beograd.
Figure 8. Comparative display of the index of change in the economic aggregate, gross wages and the number of employees for Belgrade.

Uporedni prikaz kretanja vrednosti ekonomskog agregata, zarada i zaposlenosti Beograda na Slici 8 pokazuje da je u posmatranom periodu Beograd imao slična kretanja indeksa ekonomskog agregata i zarada kao i tri sagledavana srpska grada. Ali, na osnovu kretanja broja zaposlenih i zarada po zaposlenom moguće je zaključiti da je srpska prestonica lakše prebrodila ekonomsku krizu iz 2008. godine u odnosu na ostala tri najveća grada u zemlji.

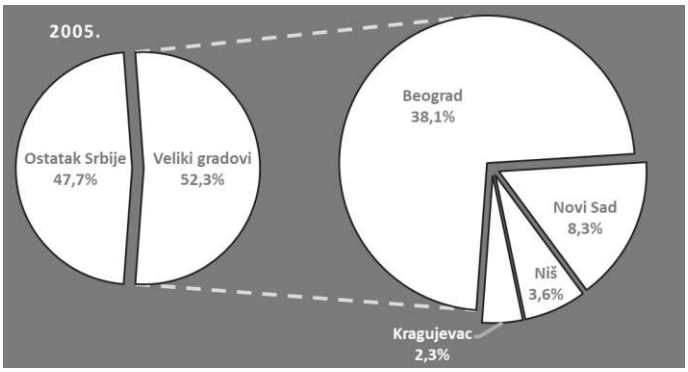
Prosečne bruto zarade su tokom celog posmatranog perioda očekivano bile najveće u Beogradu i u 2021. godini su prešle 950 evra (Slika 9).




Slika 9. Uporedni prikaz broja zaposlenih i bruto zarada za Beograd.
Figure 9. Comparative view of the number of employees and gross earnings for Belgrade.

## KRETANJE EKONOMSKOG AGREGATA ČETIRI NAJVEĆA GRADA U REPUBLICI SRBIJI

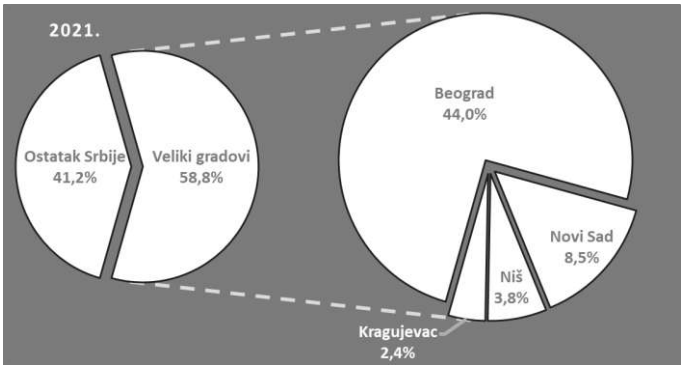
U cilju sticanja što realnije predstave o regionalnim neravnomernostima u Republici Srbiji bice prikazan uporedni pregled veličine ekonomskog agregata četiri najveća grada u Republici Srbiji u 2005. (Slika 10) i 2021. godini (Slika 11).




Slika 10. Uporedni pregled ekonomskog agregata Srbije i velikih gradova za 2005.
Figure 10. Comparative overview of the economic aggregate of Serbia and large cities for 2005.

U 2005.godini privreda grada Beograda je učestvovala sa 38,1% u ukupnom ekonomskom agregatu Republike Srbije.

Na Slici 11. prikazana je veličina ekonomskog agregata pomenutih gradova. Učešće grada Beograda se u 2021. godini povećalo na 44%.




Slika 11. Uporedni pregled ekonomskog agregata Srbije i velikih gradova za 2021.
Figure 11. Comparative overview of the economic aggregate of Serbia and large cities for 2021.

Kod ostalih velikih gradova takođe postoji trend blage ekonomske centralizacije (izražene kao rast procentualnog učešća njihovih ekonomskih agregata u ukupnom agregatu Republike Srbije) u odnosu na 2005. godinu, ali je on značajno blaži nego na primeru Beograda.

## ZAKLJUČCI

Pregledom kretanja veličine ekonomskog agregata za gradove Beograd, Novi Sad, Niš i Kragujevac kao četiri najveća grada u Republici Srbiji u vremenskom intervalu 2005–2021. godine, zaključujemo da privreda grada Kragujevca ima slabiji intenzitet ekonomskog razvoja u odnosu na privredu gradova Novi Sad i Beograd. Privreda grada Kragujevca je trenutno na veoma sličnom nivou sa privredom grada Niša. Medjutim, zapaža se da je posle snažnijeg ekonomoskog razvoja grada Kragujevca u periodu od 2008. do 2018. godine došlo do svojevrsnog zamora i relativnog gubitka razvojnog trenda u odnosu i na grad Niš i na republički prosek u periodu od 2018. do 2021. godine.

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# CONCEPT OF COMPETITIVENESS OF THE CITY'S ECONOMY

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**ABSTRACT**

The paper presents the concept of competitiveness of the city's economy. Its growing importance in the theory and policy of the competitiveness of certain urban areas is highlighted. The concept of city competitiveness means a kind of theoretical and methodological unification of the general and local dimensions of the multi-level category of competitiveness. This multiplies the possibilities of viewing relations between economic actors in a certain area. The authors note the growing interest of researchers of various vocations in studying the concept of city competitiveness. For economic analysts of the concept of competitiveness of the city, particularly significant drivers of the improvement of the city's competitiveness are related to dynamic changes in the structure of the economy, movements in the labor markets, the emergence of new social needs, and recently an increasing number of factors related to security issues (infrastructural, energy, food, etc.). An increasing number of cities recognize the need to strengthen their competitive position by applying an entrepreneurial and marketing approach. In addition to the so-called "hard" drivers of the city's competitiveness (job opportunities, ease of doing business, tourist attractiveness), "soft" factors such as the perception of the quality of life, the image of the city, the availability of specific offers, and the like are gaining importance. Reducing the category of city economy competitiveness in the Republic of Serbia to an economic aggregate indicator, the paper presents, based on its own calculations, a comparative overview of the economic competitiveness indicators of the cities of Belgrade, Novi Sad, Niš and Kragujevac in the period 2005-2021.

**Keywords:** competitiveness of the city, drivers of improving the competitiveness of the city, economic aggregate.

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# UPRAVLJANJE EKSTERNOM SOLVENTNOŠĆU SELEKTOVANIH BALKANSKIH ZEMALJA

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## SAŽETAK

Autori istražuju eksternu solventnost kao važnu dimenziju eksterne pozicije tri balkanske zemlje, od kojih su dve zapadnobalkanske države tzv. zakasnele tranzicije (Bosna i Hercegovina i Srbija), dok je Bugarska zemlja koja je je završila tranzicju i od 2007. godine je članica Evropske unije. Analiziraju se dva indikatora eksterne solventnosti: *eksterni dug/bruto nacionalni dohodak* (BND) i *eksterni dug/izvoz roba i usluga* u periodu 1997–2021. Konstatovana je umerena eksterna zaduženost ovih zemalja na kraju 2021. godine. Konkretno, racio *eksterni dug/BND* za BiH je na kraju sagledavanog vremenskog intervala iznosio 58,08%, za Srbiju 67,83%, a za Bugarsku 57,52%. I drugi pokazatelj eksterne solventnosti koji se odnosi na racio *eksterni dug/izvoz roba i usluga* je na kraju 2021. bio u granicama dozvoljenog, odnosno ispod 220% vrednosti koeficijenta koju je Svetska banka označila gornjom granicom zaduženosti. Došlo se do zaključka da je Srbija od početka druge decenije ovog veka bila mnogo uspešnija u privlačenju stranih direktnih investicija u odnosu na ostale dve balkanske zemlje. Takođe, istraživanje korelacione veze rasta bruto domaćeg proizvoda i stranih direktnih investicija kao udela bruto domaćeg proizvoda za Srbiju pokazuje daleko pozitivniju vezu u odnosu na Bosnu i Hercegovinu i Bugarsku tokom prethodnih desetak godina.

**Ključne reči**: eksterna pozicija, eksterna solventnost, eksterni dug, izvoz roba i usluga, strane direktne investicije.

## UVOD

Pored domaćih, značajni izvor finansiranja ekonomskog razvoja zemalja predstavljaju strana sredstva. Alokacija domaćih i stranih izvora u najprofitabilnije projekte je jedna od ključnih pretpostavki dugoročnog ekonomskog rasta.

Značaj strane štednje u politici ekonomskog razvoja je time značajniji što je bruto domaći proizvod po stanovniku u posmatranoj zemlji na nižem nivou. Drugačije kazano, što je niži nivo bruto domaćeg proizvoda po stanovniku teže je finansirati privredni razvoj bez stranog zaduživanja.

Velika eksterna zaduženost je obeležje najvećeg broja manje razvijenih zemalja savremenog sveta. Jedan broj ekonomista nepovoljnu eksternu poziciju nedovoljno ekonomski razvijenih zemalja vidi kao jedan od najvećih problema međunarodnog ekonomskog i finansijskog sistema. Indikatore eksterne pozicije zemalja čine indikatori međunarodne likvidnosti i solventnosti, kao i indikatori izloženosti finansijskom riziku i stepenu otvorenosti ekonomije (Vuković, 2006).

Eksterna solventnost, pored eksterne likvidnosti pokazuje kratkoročne mogućnosti i dugoročne sposobnosti zemlje da izmiruje dugove prema inostranim poveriocima, kao i devizne

obaveze u celini. Na osnovu ovih indikatora međunarodne finansijske organizacije rangiraju zemlje prema stepenu zaduženosti (Dugalić i sar., 2022).

Nivo eksterne solventnosti kvantifikuje se brojnim pokazateljima (Madžar, 2019). Dva najpoznataija indikatora eksterne pozicije zemalja jesu koeficijenti *Spoljni dug/BDP* i *Spoljni dug/Izvoz robe i usluga*. Ukupan spoljni dug je dug prema nerezidentima koji se može otplatiti u valuti, robi ili uslugama. Ukupan spoljni dug je zbir javnog, javno garantovanog i privatnog negarantovanog dugoročnog duga, kredita MMF-a i kratkoročnog duga. Kratkoročni dug uključuje sve dugove sa prvobitnim rokom dospeća od godinu dana ili kraćim i kamate na dugoročni dug. Izvoz dobara i usluga obuhvata sve transakcije između rezidenata jedne zemlje i ostatka sveta koje uključuju promenu vlasništva sa rezidenata na nerezidente opšte robe, neto izvoz robe u prometu, nemonetarnog zlata i usluga.

Prema metodologiji Svetske banke granična vrednost koeficijenata *Spoljni dug/BDP* je 80% i *Spoljni dug/Izvoz robe i usluga* 220% (Tabela 1). Prekoračivanje ovih vrednosti nagoveštava problem urednog servisiranja javnog duga u nastupajućem periodu (Ćosović, 2020).

Tabela 1. Kriterijumi za ocenu stepena zaduženosti (World Bank, 2023).
Table 1. Criteria for assessing the degree of indebtedness (World Bank, 2023).

| **Indikator** | **Nisko zadužene zemlje** | **Umereno zadužene zemlje** | **Visoko zadužene zemlje** |
|---|---|---|---|
| Spoljni dug/BDP | manje od 48% | između 48 i 80% | više od 80% |
| Spoljni dug/Izvoz roba i usluga | manje od 132% | između 132 i 220 % | više od 220% |

Načelno govoreći, racio *Eksterni dug/BDP* će biti veći ako je kamatna stopa na dug veća u odnosu na stopu ekonomskog rasta i ako bilans tekućih transakcija teži ka deficitu. U slučaju da je bilans na računu tekućih transakcija u ravnoteži, koeficijent spoljne zaduženosti će rasti kada je kamatna stopa veća od stope ekonomskog rasta zemlje domaćina i obratno.

Smatra se da je više od 50% dužničkih kriza nastalo kada je spoljni dug dostigao 60% BDP-a, dok je 70% dužničkih kriza nastalo kada je nivo spoljnog duga dostigao oko 80% BDP-a. Drugi indikator, odnosno *odnos spoljnog duga prema izvozu*, pokazuje mogućnost otplate duga kroz izvoz roba i usluga. Praktično, nema rizika od dužničke krize ako je izvoz veći od uvoza, odnosno neće biti rizika ako dug ne pređe granicu od 220% u odnosu na izvoz.

## KOEFICIJENT EKSTERNE ZADUŽENOSTI (SPOLJNI DUG/BND)

Kretanje indikatora *Eksterni dug/BND* (BND = BDP + dohodak od nerezidenata – dohodak plaćen nerezidentima) za Bosnu i Hercegovinu, Bugarsku i Srbiju u periodu 1997–2021. prezentovano je u Tabeli 2.

Primećuje se da je Srbija u 2021. imala najveći racio *Spoljni dug/BND* (67,83%). Za Bosnu i Hercegovinu ovaj racio je bio 58,08%, a za Bugarsku 57,52%. Proizlazi da prema kriterijumima Svetske Banke nijedna od selektovanih balkanskih zemalja nije bila u zoni visoko zaduženih zemalja u 2021. godini. Kretanje ovog indikatora eksterne solventnosti za tri balkanske zemlje grafički je predstavljeno na Slici 1.

Tabela 2. Indikator Spoljni dug/BND (World Bank, 2023).
Table 2. External debt/GNI indicator (World Bank, 2023).

| Godina | Bosna i Hercegovina | Bugarska | Srbija |
|---|---|---|---|
| 1997. | | 101,28 | 41,30 |
| 1998. | | 77,33 | 55,98 |
| 1999. | 44,49 | 87,74 | 56,58 |
| 2000. | 45,79 | 92,93 | 168,32 |
| 2001. | 42,45 | 79,35 | 96,24 |
| 2002. | 44,23 | 73,53 | 66,86 |
| 2003. | 50,37 | 66,36 | 63,81 |
| 2004. | 49,70 | 62,80 | 56,17 |
| 2005. | 59,94 | 61,79 | 59,74 |
| 2006. | 65,00 | 83,53 | 63,08 |
| 2007. | 71,20 | 106,47 | 62,66 |
| 2008. | 66,14 | 102,35 | 60,07 |
| 2009. | 76,57 | 110,58 | 75,98 |
| 2010. | 81,86 | 102,16 | 80,40 |
| 2011. | 65,68 | 85,44 | 66,84 |
| 2012. | 74,89 | 95,99 | 82,05 |
| 2013. | 74,83 | 94,63 | 76,64 |
| 2014. | 69,91 | 83,19 | 70,94 |
| 2015. | 71,12 | 82,07 | 80,03 |
| 2016. | 68,67 | 76,50 | 72,60 |
| 2017. | 72,67 | 70,83 | 74,87 |
| 2018. | 64,49 | 62,45 | 64,62 |
| 2019. | 63,09 | 60,48 | 65,89 |
| 2020. | 70,09 | 68,42 | 73,54 |
| 2021. | 58,08 | 57,52 | 67,83 |

Slika 1. Kretanje indikatora Spoljni dug/BND za Bosnu i Hercegovinu, Bugarsku i Srbiju u periodu 1997–2021 (World Bank, 2023).
Figure 1. Movement of the indicator External debt/GNI for Bosnia and Herzegovina, Bulgaria and Serbia in the period 1997–2021 (World Bank, 2023).

U svetlu sagledavanja uticaja eksternog duga na kretanje ekonomskog rasta, svojim značajem se nameću pitanja u vezi sa mogućnostima redovnog servisiranja velikog spoljnog duga, gubitkom efikasnosti privređivanja zbog neminovnog rastućeg oporezivanja svih vidova potrošnje u cilju vraćanja dospelih anuiteta eksternog duga, usporavanjem ekonomskog rasta kao posledice istiskivanja kapitala prouzrokovanog velikim eksternim dugom.

Uredno servisiranje obaveza po osnovu eksternog duga, tj. uredno plaćanje kamata i glavnica uzetih zajmova od stranih poverilaca, podrazumeva korišćenje velikog dela novostvorenog proizvoda nacije. U nedavnoj prošlosti mnoge privrede su postale u pravom smislu dužničke zemlje. Otplata prispelih kamata po osnovu javnog duga po pravilu podrazumeva neophodnost smanjivanja tekuće potrošnje u dužničkoj zemlji.

Isplata eksternog duga podrazumeva plaćanje kamata poveriocima. Da bi se prikupila sredstva za plaćanje kamata moraju se nametnuti porezi. Uvećani porezi logično umanjuju raspoloživi dohodak i destimulativno deluju na preduzetničke aktivnosti u dužničkoj zemlji.

Najozbiljnija negativna posledica visoke spoljne zaduženosti na privredni razvoj je činjenica da on deluje na smanjenje nacionalnih investicija. Posledica je usporeni ekonomski rast i pad životnog standarda stanovništva u dužničkoj zemlji.

Rast eksterne zaduženosti takođe može uticati na opadanje sklonosti ka štednji sektora stanovništva, budući da podrazumeva rast poreza za servisiranje dospelih obaveza. Posebno značajno pitanje je da li finansiranje eksternog duga pomoću dodatnog pozajmivanja predstavlja veće opterećenje za buduće generacije u poređenju sa porezima koji predstavljaju finansijski namet sadašnjim generacijama.

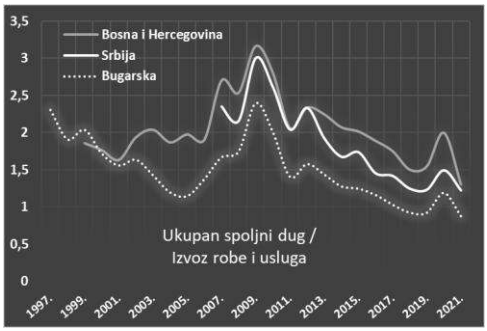
## POKRIVENOST SPOLJNOG DUGA VREDNOŠĆU IZVOZA ROBA I USLUGA (SPOLJNI DUG/IZVOZ ROBA I USLUGA)

U Tabeli 3 prikazano je kretanje indikatora *Spoljni dug/Izvoz roba i usluga* kao drugog važnog pokazatelja eksterne sloventnosti zemalja (Shabbir, 2013). Rastom spoljnog duga i smanjenjem vrednosti izvoza roba i usluga povećava se koeficijent *Spoljni dug/Izvoz roba i usluga*. Kritična granica ovog indikatora prema Svetskoj banci je 220%. Na kraju 2021. vrednost ovog parametra za BiH je bila 131%, za Srbiju 122%, a za Bugarsku 87%.

Tabela 3. Odnos indikatora Spoljni dug/Izvoz roba i usluga (World Bank, 2023).
Table 3. Ratio of indicators External debt/Export of goods and services (World Bank, 2023).

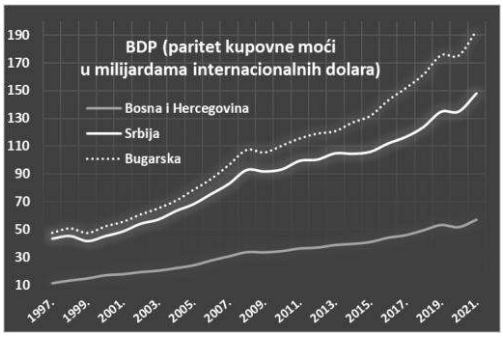
| Godina | Bosna i Hercegovina | Bugarska | Srbija |
|---|---|---|---|
| *1997.* | | 230% | |
| *1998.* | | 191% | |
| *1999.* | 186% | 204% | |
| *2000.* | 177% | 172% | |
| *2001.* | 163% | 156% | |
| *2002.* | 194% | 163% | |
| *2003.* | 204% | 142% | |
| *2004.* | 187% | 119% | |
| *2005.* | 198% | 115% | |
| *2006.* | 191% | 137% | |
| *2007.* | 270% | 167% | 235% |
| *2008.* | 254% | 174% | 216% |
| *2009.* | 316% | 239% | 301% |
| *2010.* | 280% | 200% | 261% |
| *2011.* | 206% | 140% | 204% |
| *2012.* | 234% | 157% | 233% |
| *2013.* | 225% | 144% | 192% |
| *2014.* | 207% | 128% | 167% |
| *2015.* | 202% | 124% | 173% |
| *2016.* | 189% | 116% | 145% |
| *2017.* | 175% | 103% | 142% |
| *2018.* | 151% | 92% | 124% |
| *2019.* | 155% | 92% | 123% |
| *2020.* | 200% | 119% | 149% |
| *2021.* | 131% | 87% | 122% |

Eksterna solventnost zemalja se pogoršava porastom eksternog duga, a poboljšava rastom bruto nacionalnog proizvoda i rastom vrednosti izvoza roba i usluga. U tom smislu, na Slici 2 su prikazani trendovi rasta BDP-a izraženog u paritetu kupovne moći u internacionalnim dolarima tri selektovane balkanske zemlje u periodu 1997–2021. godine.




Slika 2. Kratanje koeficijenta Spoljni dug/Izvoz roba i usluga za Bosnu i Hercegovinu, Bugarsku i Srbiju u periodu 1997–2021 (World Bank, 2023).
Figure 2. Shortening of the External Debt/Export of Goods and Services ratio for Bosnia and Herzegovina, Bulgaria and Serbia in the period 1997–2021 (World Bank, 2023).

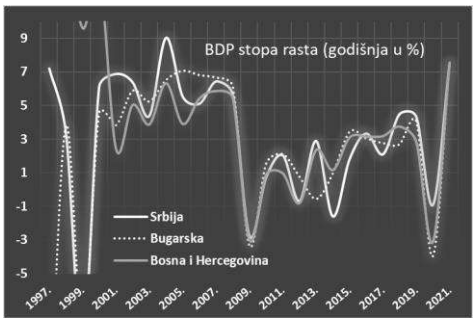
Postavlja se fundamentalno pitanje da li spoljno zaduživanje dovodi do ekonomskog rasta zemalja dužnika ili negativno utiče na njega (Timuș-Iordachi, & Ciobu, 2019). Na dijagramskoj prezentaciji (Slika 3) dato je kretanje BDP-a iskazanog u dolarima po paritetu kupovne moći analiziranih balkanskih zemalja u periodu 1997-2021.




Slika 3. Kretanje GDP tri balkanske zemlje (World Bank, 2023).
Figure 3. Movement of GDP of three Balkan countries (World Bank, 2023).

Evidentna je superiornost privrede Bugarske u povećanju BDP-a u odnosu na Srbiju, a pogotovo u odnosu na BiH.

Na dijagramskoj prezentaciji (Slika 4) su prikazane prosečne godišnje stope rasta BDP-a sagledavane tri balkanske zemlje.




Slika 4. Prosečne godišnje stope rasta GDP sagledavane tri balkanske zemlje (World Bank, 2023).
Figure 4. Average annual GDP growth rates of the three Balkan countries considered (World Bank, 2023).

Sve tri balkanske zemlje su bile pogođene ekonomskim krizom sa kraja prethodnog veka, a takođe i finansijskom krizom iz 2008–2009. i tzv. Kovid krizom iz 2019–2020. godine. Nepobitna je činjenica da njihovo nastojanje da smanje razvojno zaostajanje za većinom evropskih država podrazumeva daleko izraženiju stopu privrednog rasta kontinuirano u dužem vremenskom periodu u budućnosti. Istini za volju, trenutna energetska i sirovinska kriza i poremećaji ekonomskih tokova kao posledice ratnih dešavanja na ukrajinskom tlu ne daju mnogo nade za takva očekivanja.

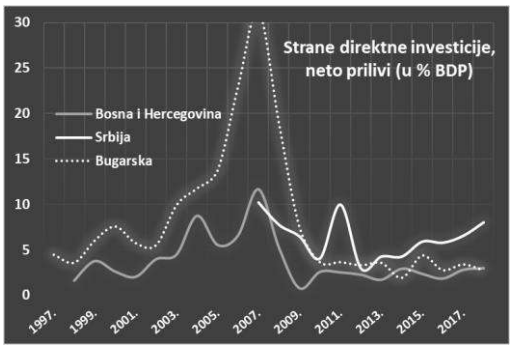
## STRANE DIREKTNE INVESTICIJE I NJIHOV UTICAJ NA BDP

Jedan od faktora poboljšanja platnobilansne pozicije zemlje su strane direktne investicije (SDI). SDI treba da stimulišu ekonomski rast zemalja domaćina kreirajući nove poslove i angažovanjem nove radne snage. Zemlje u koje dolaze strane investicije mogu imati koristi od njih, zahvaljujući novim poslovima, transferu nove tehnologije i savremenim menadžerskim veštinama. Razumljivo, broj novih poslova koje direktno stvaraju strane investicije determinisane su prirodom industrije u koje je strano investiranje ostvareno. Sposobnost stranih firmi da koriste savremenu tehnologiju u zemlji domaćinu dobrim značajnim delom zavisi od obučenosti njene radne snage. Zemlje koje imaju dovoljan broj tehničkih kadrova su po pravilu zemlje u kojima se nova tehnologija brže usvaja i komercijalno valorizuje.

Posmatrjući neto prilive po osnovu stranih direktnih investicija u godinama druge decenije ovoga veka u tri analizirane balkanske zemlje, evidentna je dobra relativna pozicija Srbije u odnosu na druge dve države (Slika 5).

Takodje, i kod veze rasta BDP-a i SDI kao udela u bruto domaćem proizvodu, Srbija pokazuje najjaču pozitivnu vezu.

SDI mogu imati pozitivan uticaj na rast bruto domaćeg proizvoda u zemljama primaocima, jer mogu povećati formiranje kapitala, stvoriti nove mogućnosti za zapošljavanje i doprineti prenosu tehnologije i razmeni znanja. Drugim rečima, one mogu pomoći u povećanju dostupnosti kapitala za finanansiranje investicija u fizičku infrastrukturu kao što su putevi, luke i telekomunikacione mreže, a takođe i u aktivnosti obrazovanja i obuke. Ovo može poboljšati produktivnost, što u krajnjoj instanci dovodi do intenziviranja ekonomskog rasta.

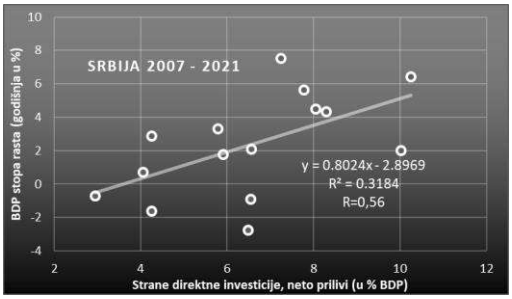



Slika 5. Neto prilivi kao % BDP-a (World Bank, 2023).
Figure 5. Net inflows as % of GDP (World Bank, 2023).

Kapitalno intenzivne SDI zahtevaju napredne veštine i znanja. Takođe, one mogu doneti nove tehnologije i nove tehnike upravljanja.

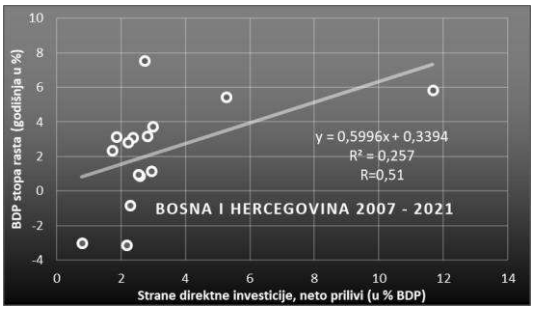
Ukupno gledano, SDI mogu imati pozitivan uticaj na rast BDP-a u zemljama primaocima povećanjem kapitala, stvaranjem novih mogućnosti za zapošljavanje i pojednostavljenim transferom tehnologije i razmenom znanja. Međutim, obim tog uticaja zavisi od različitih faktora, kao što su dostignuti nivo razvijenosti zemlje, kvalitet institucija i regulative. Mnoge skorije studije koje analiziraju direktne strane investicije i rast pokazale su pozitivnu povezanost između SDI i BDP-a (Agrawal, & Khan 2011; Sengupta, & Puri, 2020). Neka od pomenutih istraživanja (npr. Hansen, & Rand, 2006) detektuju nesigurnost u pogledu mehanizma uzročnosti, ali se kod

posmatranih zemalja u ovom istraživanju sa velikom iskustvenom sigurošću, pa čak i intuicijom, može pretpostaviti da SDI utiči na rast BDP-a, a ne obrnuto.



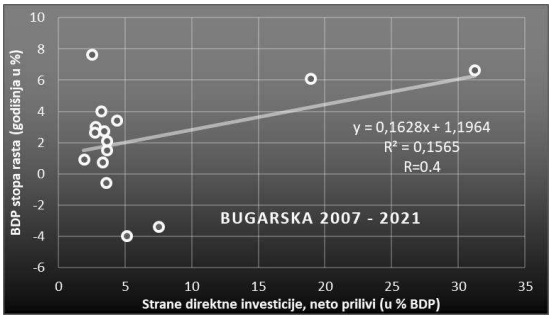

Slika 6. Korelacija između stope rasta BDP-a i SDI (kao udela u BDP-u) za Srbiju (World Bank, 2023).
Figure 6. Correlation between GDP growth rate and FDI (as a share of GDP) for Serbia (World Bank, 2023).

Na Slici 6 vidimo da je gore pomenuti uticaj SDI na rast BDP-a u slučaju Srbije za period od 2007. do 2021. pozitivan i statistički signifikantan (granični Pirsonov koeficijent za nivo signifikantnosti od 99% iznosi 0,537).




Slika 7. Korelacija između stope rasta BDP-a i SDI (kao udela u BDP-u) za Bosnu i Hercegovinu (World Bank, 2023).
Figure 7. Correlation between GDP growth rate and FDI (as a share of GDP) for Bosnia and Herzegovina (World Bank, 2023).

Slike 7 i 8 pokazuju da je uticaj SDI na rast BDP-a u slučaju Bosne i Hercegovine i Bugarske takođe pozitivan, ali nešto slabijeg intenziteta i to respektivno. Statistička signifikantnost korelacije kod Bosne i Hercegovine je na nivou od 98%, dok je kod Bugarske na nivou od 90%.




Slika 8. Korelacija između stope rasta BDP-a i SDI (kao udela u BDP-u) za Bugarsku (World Bank, 2023).
Figure 8. Correlation between GDP growth rate and FDI (as a share of GDP) for Bulgaria (World Bank, 2023).

Značajno precizniji uvid uticaja SDI na dinamiku BDP-a se u daljim istraživanjima može analizirati primenom Panel regresione analize i to na dužoj vremenskoj seriji. Međutim, autori

smatraju da je vremenska serija podataka ograničena na period od 2000. godine i smatraju da su podaci pre 2000. godine isuviše distorzični (usled činjenice da su Srbija i Bosna i Hercegovina imale veoma izražen diskontinuitet ekonomskih tokova u periodu od 1990. do 2000. izazvan dubokom i sveobuhvatnom krizom na području bivše Jugoslavije).

## ZAKLJUČCI

Eksterna solventnost pretstavlja važnu dimenziju eksterne pozicije zemalja.

Komparativna analiza eksterne solventnosti tri balkanske zemlje, Bosne i Hercegovine, Bugarske i Srbije pomoću indikatora eksterne solventnosti: eksterni dug/bruto nacionalni dohodak (BND) i eksterni dug/izvoz roba i usluga u periodu 1997–2021. je ilustrovala umerenu eksternu zaduženost ovih zemalja na kraju 2021.godine.

Racio eksterni dug/BND za BiH je na kraju sagledavanog vremenskog intervala iznosio 58,08%, za Srbiju, 67,83%, a za Bugarsku 57,52%.

Racio eksterni dug/izvoz roba i usluga je na kraju 2021. bio u granicama dozvoljenog, odnosno bio ispod 220% vrednosti koeficijenta koju je Svetska banka označila gornjom granicom zaduženosti.

Srbija je od početka druge decenije ovog veka bila mnogo uspešnija u privlačenju stranih direktnih investicija u odnosu na druge dve balkanske zemlje.

Istraživanje korelacione veze rasta bruto domaćeg proizvoda i stranih direktnih investicija, kao udela bruto domaćeg proizvoda za Srbiju, pokazuje značajno pozitivniju i statistički signifikatniju vezu u odnosu na Bosnu i Hercegovinu i Bugarsku, posmatrano tokom perioda od prethodnih petnaestak godina.

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# EXTERNAL SOLVENCY MANAGEMENT OF SELECTED BALKAN COUNTRIES

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## ABSTRACT

The authors investigate the external solvency of three Balkan countries, two of which are so-called late transition countries (Bosnia and Herzegovina and Serbia), while Bulgaria is a country that has completed the transition and become a member of the European Union since 2007. Two indicators of external solvency are analysed: External debt/gross national income (GNI) and External debt/export of goods and services in the period 1997-2021. Moderate external indebtedness of these countries at the end of 2021 was established. Specifically, the external debt/GNI ratio for Bosnia and Herzegovina was 58.08%, for Serbia, 67.83%, and for Bulgaria, 57.52%. At the end of 2021, the second indicator of external solvency was within the permissible limits, i.e., it was well below 220%, which the World Bank marked as the upper limit of indebtedness. The value of this parameter was quite high for BiH (131%) and Serbia (122%), while for Bulgaria was incomparably lower (87%). An important factor of a country's external solvency is the Net inflow of foreign direct investments (FDI). The available data indicate that since 2010, Serbia has been much more successful in attracting FDI compared to the other two Balkan countries. Also, research on the correlation between GDP growth rate and FDI (as a share of GDP) for Serbia shows a statistically more significant positive relationship compared to Bosnia and Herzegovina and Bulgaria.

**Keywords**: external debt, external solvency, export of goods and services, foreign direct investments.

KRATKO SAOPŠTENJE – SHORT OR PRELIMINARY COMMUNICATION
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# SOME RESULTS IN THE APPLICATION OF THE PRINCIPLES OF CIRCULAR ECONOMY IN THE PRODUCTION OF CARDBOARD PACKAGING

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## ABSTRACT

The dominant model of the economy, in the world and in our country, is still a linear model, that is, a linear economy based on the assumptions that natural resources are available in abundance, easy to obtain and cheap to dispose of. In contrast to the aforementioned, the circular economy represents a regenerative economic system within which production resources, waste, waste emissions and energy outflow are significantly reduced by slowing down, rounding off and extending energy and material cycles (life cycles) in production. The paper will present the basic principles of the circular economy and the results of their application on the example of a company for the production of cardboard packaging in the Republic of Serbia. Through responsible business operations, the company managed to achieve a significant shift in the optimization of production processes and thus reduce the negative impact on the environment by minimizing the emission of harmful gases, reducing energy and water consumption. The company also cultivates a B2B2C model, according to which it collects information on how users use packaging and thus proactively participates in the eco-design of packaging, which consists mostly of recycled and ecological materials, paints and varnishes.

**Keywords**: circular economy, sustainable development, cardboard packaging, eco-design.

## INTRODUCTION

The circular economy is an economic model that aims to maximize resource efficiency, minimize waste generation, and promote sustainability. It offers an alternative to the traditional linear economy, where resources are extracted, transformed into products, and eventually disposed of as waste. In contrast, the circular economy seeks to close the loop by keeping materials and products in use for as long as possible through strategies such as recycling, reusing, and refurbishing. The concept of a circular economy gained traction in response to the growing recognition of environmental challenges, resource scarcity, and the impacts of traditional consumption and production patterns. It emphasizes the need to shift from the linear "take-make-dispose" model to a more regenerative and restorative approach. The following are the key principles of a circular economy:

*Design out waste and pollution:* The circular economy emphasizes the importance of designing products and systems with the intention of reducing waste and pollution. This involves adopting *eco-design principles, considering the entire lifecycle of a product, and utilizing materials and processes* that are environmentally friendly and can be easily recycled or repurposed.

*Keep products and materials in use:* Instead of following the traditional linear model of "take-make-dispose," a circular economy promotes the concept of keeping products and materials in use for as long as possible. This includes *strategies such as repair, refurbishment, and*

*remanufacturing* to extend the lifespan of products, *as well as promoting sharing, leasing, and product-as-a-service models.*

*Preserve and enhance natural capital:* The circular economy recognizes the finite nature of natural resources and aims to preserve and enhance them. This *involves responsible resource management, minimizing extraction, promoting renewable energy sources, and prioritizing the use of sustainable and bio-based materials*.

*Foster collaboration and create circular value chains:* Collaboration among various stakeholders, including businesses, governments, and consumers, is essential in a circular economy. By creating circular value chains, where materials and resources flow in closed loops, waste is minimized, and opportunities for resource recovery and recycling are maximized.

*Rethink business models and incentives:* The circular economy encourages businesses to shift from selling products as standalone items to offering integrated solutions and focusing on delivering value and services. This requires *rethinking business models, developing new revenue streams, and aligning incentives to promote circular practices, such as rewarding resource efficiency and recycling*.

*Empower consumers and raise awareness:* Engaging and empowering consumers is crucial for the success of a circular economy. By *raising awareness, educating consumers about the environmental impact of their choices, and providing information on sustainable alternatives*, consumers can make more informed decisions and actively participate in the transition to a circular economy.

Circular economy principles play a significant role in sustainable development by offering a transformative approach to economic activity that addresses environmental challenges and promotes long-term prosperity. Here are some key reasons why circular economy principles are important for sustainable development:

- Resource Efficiency;
- Waste Reduction and Pollution Prevention;
- Climate Change Mitigation;
- Economic Opportunities and Job Creation;
- Resilience and Security;
- Social Benefits;
- International Cooperation and Sustainable Consumption.

By integrating circular economy principles into policies, business strategies, and individual practices, sustainable development can be achieved by balancing economic growth, environmental protection, and social well-being. The circular economy provides a holistic framework that enables the transition to a more sustainable and resilient future for present and future generations (Demko-Rihter et al., 2023).

## CIRCULAR ECONOMY IN SERBIA

The Circular Economy Program was adopted by the government of the Republic of Serbia on 1st December 2022. General objective is to create a stimulating environment for the development of circular economy in order to support green transition in the Republic of Serbia, that will be reached through 5 specific goals (Mihajlov et al., 2019; Kamberović et al., 2020):

- support to economy in transforming towards circular business models;
- support to local self-governments in creating circular communities;
- improve the waste management system through more efficient use of waste in circular economy;
- support the green public procurements and voluntary instruments in the area of environmental protection;
- raising awareness at interested public and educational institutions about the circular economy concept.

Research on the topic of the circular economy conducted among companies in Serbia provided a more detailed insight into the level of business awareness regarding the circular economy, but also into the real needs for the transition from linear to circular production, awareness of the points where companies can get advisory, financial or technological support, awareness of the economic profitability of the circular model, awareness of the necessity of introducing a circular economy due to the changed business environment and EU legislation relating, for example, to $CO_2$ footprint standards when exporting to the EU starting in 2026, i.e. the implementation of Carbon Border Tax changes , the awareness that the circularity and sustainability of the production model can determine the customer for a specific product with an increase in their environmental awareness. The industries on which the research primarily focuses are defined in the Roadmap for the circular economy in Serbia (Privredna komora Srbije 2022):

- manufacturing industry,
- agriculture and food (surplus food and food waste),
- plastics and packaging,
- construction.

## CASE STUDY OF THE BOSIS COMPANY, VALJEVO

The family company "Bosis" was founded in 1982 as a small craft shop for screen printing, and today it is a leading manufacturer of printed and laminated cardboard packaging and blister cardboard with 143 employees (Pantelić, & Pantelić, 2021). Assortment consists of both printed and laminated cardboard packaging and blister cardboard, for nearly 200 satisfied clients. Company uses resources responsibly to reduce energy, water, and electricity consumption, and other materials, too. Company develops awareness of employees through various actions which remind them to behave responsibly and manage resources at the workplace.

Compliance with the principles of social responsibility is necessity if company tends to be participant in the global supply chains. EU and multinational companies usually choose suppliers from the global supplier basis, such as EcoVadis. Bosis company has a label of Platinum supplier, which means that is among the top 1% of companies in all categories that meet high social responsibility requirements, which means that we are among the top 1% of a total of over 100,000 companies that have passed the EcoVadis "check". An increasing number of companies join this platform and connect through their network, which shows a positive trend in respecting the principles of the environment, labor and human rights, sustainable procurement and ethics.

The impact of Bosis on the environment is characterised with the following principles:

- Reducing the amount of material used by applying "smart" and Eco design
- Focus on making products that can be recycled
- Use of materials obtained through recycling
- ISO 14001 & 9001 standards FSC standard
- Automatic selection and collection of waste in production
- Recycling of all generated waste paper
- Recycling island
- Careful selection of material types and cardboard weights
- Procurement of materials from environmentally responsible suppliers

Hereinafter will be presented one recent example of production process' optimization which has resulted in responsible consumption of energy and water, reduction of GHG emission, followed by improved efficiency and effectiveness of the production process and increased production volume. During the production of printed and laminated cardboard packaging and blister cardboard, a large amount of paper and cardboard waste is generated. For many years we have been baling this paper and cardboard waste and delivering it in the form of bales to a paper and cardboard factory where it is recycled and a new material is made from it, which we also often buy and later reuse in production. (Table 1) Due to the growth of our business the existing production capacity became too small to handle our physical volume of production, which resulted in frequent congestion and stoppages of machines that depend on the continuous removal of paper

and cardboard waste. Those stoppages, in addition to a great loss of time, also caused large unnecessary GHG emissions, resulting from the necessity of maintaining the conditions for the machines to work until the stoppage is removed (example: constant maintenance of temperature and steam pressure in the rollers for wave production). At the beginning of 2022, we expanded the system for the automatic removal of paper and cardboard waste from production, as well as the installation of a baling press with a larger capacity, which will be able to meet the growth of our production capacity for the next period.

Table 1. Results of the production system improvement.

| **Average hours of downtime per month:** | **Old system:** | **New system:** |
|---|---|---|
| Lamination | 17.6329 | 6.304 |
| Stamping | 132.283 | 23.134 |
| total | 149.916 | 29.438 |
| **Average cost of downtime per month (EUR approx.):** | **Old system:** | **New system:** |
| Lamination | 3,174 | 1,135 |
| Stamping | 13,228 | 2,313 |
| total | 16,402 | 3,448 |
| **Average GHG emissions per month at downtime (t CO2e):** | **Old system:** | **New system:** |
| Lamination CNG | 6.78 | 2.43 |
| **Average water consumption per month at downtime (m3)** | **Old system:** | **New system:** |
| Lamination | 4.76087 | 1.70208 |

Company Bosis try to make products (packaging) responsible. By reducing spending of renewable and non-renewable materials we produce more and thus save resources and reduce emissions of GHG. Responsible consumption of energy and water

**ENERGY**

The means of internal transport with gas and diesel engines were replaced and invested in means of internal transport powered by electricity

- Gas emissions by using the full capacity of trucks through collective transport were reduced
- Third parties for product transportation were hired
- Public transport services is used for employees
- Implementation of the new technologies that reduce GHG emission
- Solid fuel (coal) heating was replaced with pellet heating which reduced the emission of GHG.
- LPG was replaced with CNG in the production of steam

Reduction of energy consumption through more efficient equipment:

- The old fluorescent lighting were replaced with LED lighting and achieved significant savings
- A control system with frequency regulators was introduced for the main engines great forces
- The system for expulsion waste of paper and cardboard was replaced with a new system that consumes 4 times less energy
- The compensation system for losses caused by the occurrence of reactive energy was improved
- Automated press control
- All buildings have 6 cm of styrofoam in their walls as insulation, which saves money and energy

- Intelligent heating and air conditioning were instaled
- Sensors for turning on/off the lighting and reduced consumption electric energy were installed.

This year we also conducted a study on supplementation of existing heating system using wood chips from waste wooden pallets. Chromocardboard, our primary production material, comes to us on wooden pallets of non-standard sizes, which disables their further use in logistics. By grinding those pallets and using the obtained wood chips for heating, we would cover about 45% of our current need for energy for heating buildings in winter, which would result in savings of about 30,000 EUR per year (at the price of the wood pellets we currently use for heating).

Table 2. Energy Performance Indicators (EPI) in the Bosis Copmany.

| BOSIS COMPANY Energy performance indicators (EPI) | | | 2017 | 2018 | Change 2018 to 2017 | 2019 | Change 2019 to 2018 | 2020 | Change 2020 to 2019 | 2021 | Change 2021 to 2020 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| FSC materials | | % of total materials that could be FSC certficated | 94.3 | 85.9 | | 74.9 | | 80 | | 76.3 | |
| Raw material (RM) of recycled materials | | % of total quantity | 93.3 | 92.3 | | 91.1 | | 93.1 | | 92.32 | |
| FSC products | Number of new FSC products | | | | | 71 | | 146 | 105.63 | 142 | -2.74 |
| Pellet | Share of FSC products in final product | % | | 4.84 | | 10.42 | | 13.4 | | 13.91 | 3.81 |
| | Consumption | t | 348 | 270 | -22.41 | 242 | -10.37 | 234.4 | -3.14 | 268 | 14.33 |
| | Consumption per tone of RM | t | 0.046 | 0.03 | -34.59 | 0.025 | -16.49 | 0.022 | -12.97 | 0.021 | -3.11 |
| Water | hydrant | m3 | 1.07 | 88 | -91.78 | 76 | -13.64 | 33 | -56.58 | 148 | 348.48 |
| | industrial | m3 | 3,664,000 | 2,985,000 | -18.08 | 4,893,000 | 64 | 5,364 | 9.63 | 7,222 | 34.64 |
| | total | m3 | 4,714 | 3,073 | -34.81 | 4,969 | 61.7 | 5,364 | 7.95 | 7,370 | 37.4 |
| | water consumption per tone of RM | m3 | 0.627 | 0.344 | 45.04 | 0.519 | 50.65 | 0.503 | -3.00 | 0.586 | 16.44 |
| Electricity | consumption per processed tone of RM | kWh | 208.28 | 189.72 | 8.91 | 177.92 | -6.22 | 168.57 | 5.26 | 163 | -3.31 |
| Cost of energents | | % of total costs | 2.8 | 2.25 | | 2.33 | | 2.33 | | 2.41 | |
| | | % of total realization | 2.4 | 1.96 | | 2.02 | | 2.09 | | 2.06 | |
| Recycling share of total waste | | % | 93.06 | 96.26 | | 64.64 | | 92.63 | | 93.62 | |
| Disposal to landfill | | % | 6.94 | 3.74 | | 5.36 | | 7.37 | | 6.38 | |

## WATER

Ba responsible waste water management we eliminate possibility of pollution of the flowing waters that surround us, we provide water recycling and its reuse.

Education of employees for rationally usage of water (drinking and technological)

- Implementation of innovative systems for automatic equipment washing and cleaning
- Systems for reduction of water consumption was introduced
- The usage of water dispersion materials which do not pollute the water
- The usage of chemistry for developing an offset plate with a minimum using of water
- Installation of equipment for chemical preparation of water which reduces water consumption
- Installation of efficient equipment with a CNG gas burner for production of water steam

## CONCLUSIONS

In this sense, procedures and technologies are being improved in order to reduce the consumption of raw materials and enable their recycling. Waste management is carried out responsibly with the active participation of all employees. The complete supply chain is monitored and the product life cycle is analysed. We work with customers and suppliers to reuse packaging. By modifying the product, the weight of the packaging is reduced (by reducing the thickness or amount of material), with the use of more sustainable materials that can be recycled. Products are labeled in accordance with international standards PAP 20 and PAP 21 so that all users of the product, from the manufacturer to the end customer, can easily manage packaging and waste. Employees, clients and their consumers, as well as other interested parties are educated about waste management.

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# CILJEVI REFORME FINANSIJSKOG IZVEŠTAVANJA U JAVNOM SEKTORU

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## SAŽETAK

Aktuelne reforme javnog sektora, usmerene na unapređenje njegove efikasnosti i efektivnosti, zahtevaju finansijske informacije koje odražavaju efekte poslovnih aktivnosti ne samo na angažovane finansijske već na ukupne ekonomske resurse. Uvek postoji dilema koji od računovodstvenih modela se može primeniti u javnom sektoru kako bi se najkvalitetnije zadovoljile informacione potrebe svih zainteresovanih korisnika. Finansijsko izveštavanje u javnom sektoru se zasniva na gotovinskom modelu računovodstva koji je zbog informativnosti u odredjenom broju slučajeva potrebno dopuniti obračunskim modelom.

**Ključne reči:** reforma, javni sektor, računovodstvo, finansijsko izveštavanje.

## UVOD

Savremene reforme javnog sektora nužno sa sobom donose znatan uticaj na računovodstvo i finansijsko izveštavanje. Primarni ciljevi koji se reformama žele postići su pre svega racionalizacija i unapređenje efikasnosti, efektivnosti i transparentnosti svih funkcija javnog sektora.Na ovaj način definisani ciljevi reformi neminovno su doneli i promene u našinu upravljanju subjektima javnog sektora. Administrativni pristup upravljanju i kontroli aktivnosti subjekata javnog sektora korigovan je i unapredjen novim upravljačkim konceptima koji se tradicionalno koristi u poslovanju subjekata privatnog sektora. Navedena promena i uvodjenje upravljačkog koncepta u javnom sektoru zahteva nove oblike analize ukupnih troškova izazvanih njihovim aktivnostima, kontinuelne i periodične analize postignutih rezultata i poveđanje odgovornosti menadžera za korišćenje poverenih im javnih resursa. Za sprovodjenje navedenih promena u javnom sektoru polaznu osnovu predstavlja kvalitetna podloga finansijskih informacija na osnovu koje će se donositi optimalne odluke o alokaciji resursa i vrednovati performanse svakog pojedinačnog subjekta ili grupe subjekata javnog sektora. Iz tih razloga finansijske informacije prikazane u eksternim i internim finansijskim izveštajima subjekata javnog sektora treba da omoguće precizno definisanje finansijskog položaja, uspešnosti upravljanja poverenim resursima i održivosti finansiranja poslovnih aktivnosti. Finansijski izveštaji subjekata javnog sektora moraju biti pripremljeni i prezentovani u skladu sa zahtevima različitih korisnika koji su zainteresovani za funkcionisanje odredjenih subjekata a ne samo upravljačkih struktura.

Kritički pristup i kvalitetna analiza efekata primene različitih računovodstvih načela i politika na vrstu i informacioni obuhvat finansijskih izveštaja subjekata javnog sektora dovodi do opredeljenja za onu osnovu računovodstva koja će omogućiti adekvatno prikazivanje finansijskih informacija neophodnih za primenu savremenog upravljačkog koncepta. Ovakvim pristupom omogućava se identifikovanje mogućih nedostataka u normativnoj regulativi i sistemu finansijskog izveštavanja subjekata javnog sektora kao i nalaženje rešenja za njihovo umanjenje ili potpuno eliminisanje.

## DEFINISANJE CILJEVA FINANSIJSKOG IZVEŠTAVANJA

Analiza podataka dobijenih od mnogih nacionalnih tela za donošenje računovodstvenih standarda i drugih autoritativnih tela koja su nadležna za definisanje standarda za finansijsko izveštavanje entiteta javnog sektora pokazala je da se najčešće kao korisnici finansijskih izveštaja opšte namene subjekata javnog sektora navode:

- poreski obveznici i druge strane koje na "nedobrovoljnoj" osnovi subjekta javnog sektora obezbeđuju resurse,
- građani i drugi korisnici usluga od subjekata javnog sektora,
- zakonodavna i nadzorna tela,
- političkim procesima izabrani ili postavljeni zvaničnici i njihovo osoblje,
- donatori (uključujući i međunarodne organizacije) i druge strane koje na dobrovoljnoj osnovi subjekta javnog sektora obezbeđuju resurse, nacionalne statističke institucije,
- aktuelni i potencijalni institucionalni i individualni kreditori i kupci državnih obveznica i drugih instrumenata dužničkog kapitala,
- korisnici usluga subjekta javnog sektora koji za te usluge plaćaju nadoknade,
- dobavljači i zaposleni,
- mediji i
- predstavnici ili savetnici prethodno nabrojanih grupa korisnika (Handbook of International Public Sector Accounting Pronouncements [IPSASB], 2008).

Po važećem Konceptualnom okviru, strane koje entitetima javnog sektora obezbeđuju resurse i njihovi predstavnici, pored prethodno navedenih informacionih zahteva, imaju i zahteve za dodatnim informacijama koje će im omogućiti da ocene ( IPSASB, 2015):

- stepen ostvarenja ciljeva za čije postizanje su resursi prikupljeni (obezbeđeni),
- način finansiranja tekućih aktivnosti, odnosno da li su tekuće aktivnosti finansirane iz resursa koji su obezbeđeni u tekućem periodu po osnovu oporezivanja ili iz pozajmljenih izvora i
- verovatnoću nastanka potrebe za dodatnim resursima za finansiranje aktivnosti izveštajnog entiteta u budućnosti kao i mogućnost pribavljanja tih resursa iz različitih izvora.

Ciljevi finansijskog izveštavanja subjekata privatnog sektora su se vremenom postepeno menjali, te su promene najčešće bile izazvane promenama nastalim u nekom od brojnih oblika privredne aktivnosti koje su u najvećem broju slučajeva bile sinhronizovane sa promenama u računovodstvenom okruženju. Ciljevi finansijskih izveštaja opšte namene su da obezbede informacije o finansijskoj poziciji, performansama i novčanim tokovima subjekta koje su korisne za donošenje ekonomskih odluka značajnog broja korisnika koji nisu u poziciji da zahtevaju izveštaje koji su prilagođeni tako da zadovoljavaju njihove specifične potrebe za informacijama.

U stručnoj literaturi se kao korisnici finansijskih izveštaja opšte namene za subjekte privatnog sektora najčešće navode: investitori, kreditori, dobavljači, zaposleni, kupci, država i javnost u opštem smislu reči. U naučnim krugovima postoji gotovo potpuna saglasnost da finansijsko izveštavanje opšte namene za subjekte javnog sektora ima za cilj obezbeđivanje informacija o finansijskom položaju, finansijskim performansama i novčanim tokovima subjekata koje su korisne širokom spektru korisnika u procesima donošenja i vrednovanja odluka o alokaciji resursa.Širokom spektru korisnika treba obezbediti informacije kojima se precizira odgovornost subjekta u korišćenju resursa koji su mu povereni. Razlika u određivanju cilja finansijskog izveštavanja opšte namene za subjekte privatnog u odnosu na subjekte javnog sektora je posledica različitih primarnih korisnika finansijskih izveštaja i njihovih informacionih potreba. Iako je princip finansijskog izveštavanje za subjekte javnog i privatnog sektora u suštini isti među njima postoje i određene značajne razlike. Javni sektora sredstva

prikupljena od poreskih obveznika, donatora, kreditora i iz ostalih izvora i koristi ih za finansiranje raznorodnih aktivnosti koje su primarno usmerene na pružanje usluga stanovnicima i drugim korisnicima,dok privatni sector funkcioniše na tržišnim principima.

## NUŽNOST REFORMI JAVNOG SEKTORA

Reforme javnog sektora i u sklopu njih reforme računovodsta javnog sektora su jedna od retkih zajedničkih zadataka gotovo svih zemalja sveta.Za potrebe reforme upravljanja javnim sektorom aktuelan je sledeći stav: "Ako postoji ijedna konstanta u globalizovanom svetu, to je ubrzan tempo promena države.Gotovo svaka nacija se bori da svoju državu učini jačom kroz povećanje efikasnosti njenih administrativnih procesa i unapređenje performansi.Pokretači svih reformskih procesa javnog sektora, iako se međusobno razlikuju u zavisnosti od toga da li je reč o razvijenim industrijskim zemljama ili zemljama u razvoju, proistiše iz sledeće četiri sfere (Kettl, 2005):

- političke,
- socijalne,
- ekonomske i
- institucionalne.

Politički pokretači reformi u zemljama u razvoju rezultat su uticaja građana na državu, odnosno njihovih očekivanja da država nađe način da podstakne i ubrza ekonomski razvoj kako bi se dostigao nivo razvijenih ekonomskih zemalja.Uprkos činjenici, da su i zemlje u razvoju imale za cilj dostizanje nivoa ekonomske razvijenosti razvijenih zemalja to ne znači da i vlade razvijenih zemalja nisu bile izložene reformskom pritisku čija je osnova politička.Vlade razvijenih tržišnih ekonomija su se tako našle pred problemom kako istovremeno odgovoriti na opasnost od terorizma i obezbediti visok nivo ne samo nacionalne sigurnosti već i ostalih javnih usluga, a s druge strane smanjiti veličinu javnog sektora i visinu izdataka povezanih sa njim.

U većini zemalja odigravale su se i korenite promene socijalnih struktura koje su, naravno, imale svoje specifičnosti s obzirom na njihove istorijske i kulturološke razlike. U zemljama u razvoju, zbog višedecenijskih tradicionalističkih društvenih podela osnovni problem u socijalnoj sferi je bilo ustanovljavanje društva na principima jednakih prava za sve građane. Stanovnici razvijenih zemljama izloženi su sve većim ograničenjima i izazovima koji otežavaju očuvanje dostignutog nivoa životnog standarda.Zajednička karakteristika za sve zemlje je izloženost njihovih stanovnika i ekonomija konstantno rastućim ekonomskim zahtevima.

Na ekonomskom polju u dvadesetom veku dogodio se čitav niz kriza koje su imale i dalje imaju dalekosežne ekonomske, socijalne i političke posledice. Niz je započet sa Prvom i Drugom naftnom krizom, kada je cena za jedan barel sirove nafte višestruko porasle. Drastičan rast cena zemlje uvoznice nafte nisu mogle finansirati bez značajne upotrebe budžetskih sredstava zbog čega su dospele u stanje izuzetno visokih budžetskih deficita. U poslednjoj deceniji dvadesetog veka nastavljen je niz finansijskih kriza koje su izazvane problemima u bankarskom sektoru. Početak ovog veka obeležili su veliki korporativni skandali zbog kojih su milioni radnika ostali bez posla i bez svojih penzionih fondova. Sva navedena turbulentna ekonomska događanja zahtevala su snažno uplitanje države u prevazilaženje krize i pronalaženje načina da se izbegne ekonomska stagnacija i ubrza ekonomski rast.

Reformske procese u javnom sektoru različitih država čine i promene nastale u institucionalnoj sferi. Formiran je niz supranacionalnih struktura koje preuzimaju odredjene funkcije koji su se do tada nalazili u isključivoj nadležnosti suverenih država.

Dominantniju ulogu u definisanju i oblikovanju državnih zajednica u ekonomskom i političkom smislu zauzima značajan broj međunarodneih organizacija. Takodje, formiran je i veliki broj nacionalnih i internacionalnih nevladinih organizacija čije aktivnosti su postale izuzetno značajni u svim političkim i socijalnim sverama.

Zemlje u kojima su sprovođene reforme javnog sekora razlikuju se po stepenu ekonomske razvijenosti, po konkretnim pojavnim oblicima reformskih stimulansa kao i po odabranim strategijama sprovođenja reformi.

## REFORMA FINANSIJSKOG IZVEŠTAVANJA JAVNOG SEKTORA

Reforme javnog sektora i uporedo sa tim reforme računovodsta javnog sektora zajedničke su karakteristika gotovo svih zemalja u svetu.Iako su reforme zasnovana na razlikama u primenjenim strategijama i taktikama, poslednjih godina se, ipak, uočava određeni stepen konvergencije u ovom domenu.Zajednička je karakteristika jačanje napora usmerenih ka koordinaciji različitih programa javnog sektora i njihovu kontrolu kroz primenu procesa vrednovanja performansi zasnovanog na vrednovanju krajnjih efekata aktivnosti javnog sektora. Davanje prioriteta vrednovanju performansi je izraz cilja da se javni sektor, odnosno njegove upravljačke strukture, učine odgovornim za njihove rezultate, a aktuelna vladajuća elita za rezultate njihovog liderstva (Potter, 2005). Accounting as a social and institutional practice: Perspectives to enrich our understanding of accounting change (Potter, 2005). Iz tih razloga su zahtevi za većim stepenom odgovornosti i boljim performansama postali osnovni pokretači reformi.

Primenjene strategije i taktike u reformama javnog sektora, postavili su i određene zahteve u odnosu na računovodstvene informacije koje su neophodne za praćenje i kontrolu kako aktivnosti javnog sektora tako i efekata reformi. Ovo je doprinelo iniciranju i intenziviranju istraživanja na područjima finansijskog izveštavanja i revizije javnog sektora koja su, do tada, bila u senci istraživanja finansijskog izveštavanja i revizije privatnog sektora. Osnovna idejom je bila da se opišu karakteristike računovodstvnih sistema javnog sektora u pojedinim zemljama. Klaus Lüder je medju prvima pokušao da objasni poreklo uočenih razlika u funkcionisanju i karakteristikama računovodstvenih sistema javnog sektora u šest razvijenih industrijskih zemlja kao i njihove međusobne sličnosti i razlike. Rezultat njegovog istraživanja je formulacija Modela kontingencije (Lüder, 1992) (Contingency model) koji određuje osnovne objašnjavajuće varijable koje bitno utiču kako na karakteristike računovodstvenog sistema javnog sektora tako i na karakter, dinamiku i rezultate njegovih reformi, odnosno na implementaciju računovodstvenih inovacija.Početni model kontingencije obuhvatao je četiri osnovne varijable: socijalno strukturalne karakteristike zemlje, karakteristike njenog političko-administrativnog sistema, podsticajne mehanizme reformskih procesa i barijere za primenu reformi.

Istraživanja i praktična iskustvo doveli su do značajnih modifikacija i proširenja ovog modela. Prvo proširenje izvršio je sam Lüder uvođenjem uticaja bihejviorističkih varijabli koje opisuju ponašanje korisnika i onih koji produkuju finansijske informacije. Naknadna proširenja odnose se na uvođenje uticaja međunarodnih organizacija i donatorskih agencija, uticaja akademske i stručne javnosti, povratnog uticaja efekata i posledica inovacionih procesa u javnom sektoru i uticaja izmena u sistemu upravljanja i rukovođenja.

Stimulansi inovacija u računovodstvenom sistemu javnog sektora, odnosno pokretači reformskih procesa, su egzogene varijable nezavisne od računovodstvenog sistema: kao što su fiskalni pritisak, finansijski skandali, finansijska kriza ili potreba da se stekne, unapredi ili očuva pozitivna međunarodna reputacija. Ovi stumulansi utiču na bihejviorističke varijable, odnosno na formiranje očekivanja i način ponašanja učesnika u procesu finansijskog izveštavanja, odnosno korisnika finansijskih izveštaja - političkih aktera i javnosti - i računovodstveno-administrativne funkcije entiteta koji se bave pripremanjem i prezentovanjem finansijskih izveštaja. Bihejviorističke varijable su dvostruko uslovljene, kako reformskim stimulansima tako i onim što se naziva kontekst reformi, odnosno karakteristikama i strukturom socijalnog, političkog i administrativnog okruženja koji predstavljaju okvir u kome egzistiraju i funkcionišu akteri procesa finansijskog izveštavanja. Ponašanje korisnika finansijskih izveštaja može biti uslovljeno opštim kulturološkim nivoom društvene zajednice, razvijenošću tržišta kapitala i vrstom i intezitetom medijskih aktivnosti promotera reformskih procesa. Kada je reč o političkim akterima, njihovo ponašanje zavisi od nivoa razvijenosti demokatije,

karakteristika političkog sistema, nivoa političke kulture i stepena korupcije. Ponašanje računovodstveno-administrativnih aktera uslovljeno je njihovom organizacionom strukturom, nivoom administrativne kulture, standardizacijom računovodstvenog procesa i aktivnostima profesionalnih organizacija. I konačno, uspeh i rezultati definisanih i započetih reformi mogu biti usporeni i ugroženi zbog negativnog delovanja endogenih varijabli, odnosno zbog karakteristika samog javnog sektora i postojećeg računovodstvenog sistema, a pre svega stručne osposobljenosti računovođa.

Aktuelne reforme javnog sektora usmerene na unapređenje njegove efikasnosti i efektivnosti zahtevaju finansijske informacije koje odražavaju efekte aktivnosti javnog sektora ne samo na angažovane finansijske već na ukupne ekonomske resurse. Uvek postoji dilema koji od računovodstvenih modela se može primeniti u javnom sektoru i najkvalitetnije zadovoljiti informacione potrebe.

## ZAKLJUČCI

Nedvosmisleno je da postoje značajne razlike u karakteristikama subjekata javnog i privatnog sektora i razlike u pogledu primarnih korisnika njihovih finansijskih izveštaja i iz njih proistekle razlike u ciljevima njihovog finansijskog izveštavanja. Reforma javnog sektora zahteva formiranje specifičnog koncepta relevantnog za finansijsko izveštavanje subjekata javnog sektora u skladu sa faktorima koji uslovljavaju savremene reforme. Finansijsko izvešatavnje subjekata javnog sektora koje se po svom osnovnom cilju ne razlikuje u odnosu na finansijsko izveštavanje subjekata privatnog sektora odnosno, zajednički posmatrano i jedan i drugi subjekt imaju isti osnovni cilj pružanje adekvatnih informacija korisnicima finansijskih izveštaja opšte namene. Konkretizacija cilja finansijskog izveštavanja određena je prvenstveno informacionim potrebama korisnika finansijskih izveštaja opšte namene. U finansijskim izveštajima opšte namene prikazane su informacije o finansijskom položaju, finansijskim performansama i novčanim tokovima subjekata koje su korisne širokom spektru korisnika u procesima donošenja i vrednovanja odluka o alokaciji resursa. Za korisnike finansijskih izveštaja opšte namene ovi izveštaji predstavljaju osnovni izvor informacija. Obračunski računovodstvo model zasnovan je na obračunskoj osnovi koje efekte transakcija i događaja priznaje u trenutku njihovog nastanka nezavisno od toga da li su novac ili novčani ekvivalenti primljeni ili isplaćeni. Finansijske informacije koje prezentuje računovodstvo zasnovano na obračunskoj osnovi omogućavaju: vrednovanje ukupne imovine koju subjekt kontroliše, ocenu svrsishodnosti načina upotrebe imovine, vrednovanje performansi, finansijskog položaja i novčanih tokova subjekta i donošenje odluka o budućim načinima pružanja usluga i njihovog finansiranja. Gotovinski model računovodstva se zasniva isključivo na prilivima i odlivima gotovine planirane budžetom. Iz navedenih razloga reforme javnog sektora, moraju biti praćene i reformama računovodstva javnog sektora koje po svojoj suštini predstavljaju tranziciju sa računovodstva zasnovanog na gotovinskoj osnovi na računovodstvo zasnovano na obračunskoj osnovi.

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# OBJECTIVES OF FINANCIAL REPORTING IN THE PUBLIC SECTOR

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**ABSTRACT**

Current public sector reforms, aimed at improving its efficiency and effectiveness, require financial information that reflects the effects of business activities no only on engaged financial but on total economic resources. There is always a dilemma which of accounting models can be applied in the public sector to best meet the requirements information needs of all interested users. Financial reporting in the public sector is based on the cash model of accountants, which for the sake of information in a number of cases needs to be supplemented by the accounting model.

**Keywords**: reform, public sector, accounting, financial reporting.

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# UTICAJ KRETANJA CENE ZLATA NA PRINOSE OD AKTIVNOSTI INVESTIRANJA

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## SAŽETAK

Usled posledica izazvanih krizom pandemije virusa COVID-19 (poremećeni/prekinuti lanci snabdevanja), energetske krize, geopolitičke krize (ratni sukobi između Rusije i Ukrajine) gde za posledicu imamo pojavu visoke inflacije, u radu se analizira, testira i kvantifikuje uticaj kretanja cene zlata na dnevne stope prinosa od aktivnosti investiranja na posmatranim finansijskim tržištima Amerike, Evrope i Kine. Cilj rada jeste dolaženje do konkretnih, u praksi testiranih i kvantifikovanih saznanja putem primene multivarijantnih GARCH modela u funkciji kvantifikacije uticaja cene zlata na stope prinosa posmatranih finansijskih tržišta. Investiranje u zlato predstavlja alternativu investiranju u valute (valutne parove) i finansijske instrumente na finansijskim tržištima. Vremenski period istraživanja je od 2012. do 2023. godine, gde se testira uspešnost primene multivarijantne GARCH metodologije u periodu pre COVID-19 krize, za vreme, kao i nakon krize. Metodologija istraživanja uključuje upotrebu SIC (*Schwarz*) informacionih kriterijuma za odabir optimalnih modela. Rezultati rada potvrđuju značaj primene prilagođenih ekonometrijskih multivarijantnih modela GARCH u smislu kvantifikacije uticaja cene zlata na dnevne stope prinosa od aktivnosti investiranja na posmatranim finansijskim tržištima. Dobijeni rezultati istraživanja će biti korisni kako akademskoj zajednici za dalja istraživanja u oblasti, tako i stručnoj javnosti u smislu donošenja optimalnih odluka o investiranju.

**Ključne reči:** cena zlata, prinosi na finansijskim tržištima, GARCH modeli, rizik, investiranje.

## UVOD

Skup kvaliteta koji čine zlato, učinio ga je željenim "objektom" u gotovo svakoj civilizaciji, a aktivna tržišta zlata postoje više od 6000 godina. Zlato kao novac, zlato kao investicija, zlato kao čuvar i izvor vrednosti, gotovo na stotine naučnih radova napisano je o zlatu. Duga i isprepletena istorija zlata, finansijskih tržišta i novca su rezultirali redovnom prisutnošću zlata u ulaganjima i monetarnim raspravama. Zlato je zapravo jedan od najstarijih načina čuvanja bogatstva. Procjenjuje se da je ukupno iskopano 209.000 tona zlata. Vrednost ukupne količine zlata je 2013. godine iznosilo 6 biliona dolara, dok se danas procenjuje na cca 12 biliona dolara. Prema određenim istraživanjima do 1933. godine zlatni i srebrni novčići smatrali su se novcem. Najpoznatija uloga zlata je bila tokom perioda zlatnog standarda. Zlatni standard postoji kad monetarne vlasti poseduju dovoljno zlatnih rezervi da sav novac koji je pušten u opticaj konvertuju u zlato. Zlatni standard ograničava moć vlada za inflacijom cena kroz prekomerno izdavanje (štampanje) papirne valute. Nakon Drugog svetskog rata, dogovorima postignutim na Konferenciji u Bretton Woods-u 1944. godine, stupio je na snagu poslednji Zlatni standard po kojem su mnoge zemlje vezale kurs svojih valuta za američki dolar. SAD su tada obećale fiksnu cenu zlata od 35 dolara po unci. Posledično, sve valute vezane za kurs dolara su time dobile fiksnu vrednost u zlatnom smislu. Francuska je za vreme predsednika Charles de Gaullea, do 70-ih godina prošlog veka, smanjila rezerve dolara kupujući za njih zlato od vlade SAD-a, smanjujući time američki ekonomski uticaj u svetu. Na kraju, u avgustu 1971., predsednik Richard Nixon suspendovao je Zlatni standard na neodređeno vreme, kako bi sprečio dalji odliv zlata iz SAD-a. Odluka je stupila na snagu 15.08.1971. godine. Nakon toga, Federalne rezerve više nisu smele dolare menjati za zlato. To je u narednih nekoliko desetina godina dovelo do rasta stope inflacije i ogromnog porasta cene zlata.

Napuštanjem zlatnog standarda onemogućen je proces menjanja dolara u zlato što je nekoliko desetina godina kasnije dovelo do rasta stope inflacije i ogromnog porasta cene zlata.

Danas se zlatom trguje na sedam finansijskih tržišta uključujući London OTC tržište, COMEX (New York), tri šangajske berze, TOCOM (Tokio), MCX (Indija), Dubai i Istanbul. Što se tiče prometa, dva glavna tržišta zlata su londonsko OTC tržište i njujorško sa dnevnim volumenima preko 34,5 milijardi američkih dolara. Iako naizgled, trgovina zlatom ima velike volumene, ona zapravo predstavlja oko 1% ukupnih svetskih ulaganja u finansijsku imovinu.

Finansijska tržišta beleže najveću volatilnost tokom razdoblja finansijskih kriza, bilo da su one prouzrokovane ekonomskim, geopolitičkim, energetskim ili zdrvstvenim činiocima. Svedoci smo pojava izazvanih krizom pandemije virusa COVID-19 (poremećeni/prekinuti lanci snabdevanja), energetske krize, geopolitičke krize (ratni sukobi između Rusije i Ukrajine) gde za posledicu imamo pojavu visoke inflacije globalno.

Ulaganje u finansijsku imovinu i cena zlata imaju negativnu korelaciju. To znači da kada na berzama tržište akcija raste, cene zlata obično padaju. Kada tržište akcija ili ulaganja u HoV ima rastuću putanju, tražnja se dalje prebacuje na ostala tržišta. Međutim, istorija nam pokazuje, da tokom perioda finansijskih kriza, cene rizične finansijske imovine padaju prenoseći gubitke gotovo istovremeno na druga finansijska tržišta, dok istovremeno postoji i "*flight to quality*" (beg u kvalitet) što rezultira povećanjem cena sigurnije imovine (isključivo zlata u poređenju s drugom imovinom).

Sa druge strane, berze se smatraju važnom institucijom finansijskog sistema iz razloga što podstiču rast svih sektora privrede alokacijom štednje iz štedno-suficitarnih subjekata ka finansiranju deficitarnih jedinica i omogućavaju optimalnu raspodelu i korišćenje oskudnih kapitalnih resursa, čime se obezbeđuje osnova za dugoročni održivi ekonomski rast i razvoj. Ulaganje u zlato zapravo predstavlja aalternativu ulaganjima u finansijske instrumente na finansijskim tržištima. Kako se berza smatra ključnom za ekonomski napredak i predstvlja jedan od najvažnijih indikatora stanja u kome se ekonomija određene zemlje nalazi u radu je fokus na definisanju uticaja kretanja cene zlata na stope prinosa na finansijskim tržištima.

Prilikom investiranja u akcije ili donošenja finansijskih odluka o investiranju moraju se uzeti u obzir trenutna stanja ekonomije, kako bi se donela odluka o daljim ulaganjima. Stoga, investitori imaju zadatak da predvide faktore koji utiču na performanse portfolia i u skladu sa time da donose odluke na temelju sopstvenih očekivanja, a cena zlata jeste jedan od onih faktora koji utiče na portfolio. Tržišna cena zlata predstavlja indikator koji odslikava stanje u kom se ekonomija nalazi, prediktor je finansijskih kriza i kao takva za investitore predstavlja pokazatelj sigurnosti ulaganja na finansijskim tržištima. Zbog toga je za investitore na finansijskom tržištu veoma važno da pre donošenja odluka o investiranju pristupe podrobnoj finansijskoj analizi za procenu vrednosti cena akcija u koje imaju nameru investirati, kao i da kvantifikuju uticaj faktora finansijskog rizika, poput recimo cene zlata.

Cilj istraživanja jeste dolaženje do konkretnih, u praksi testiranih i kvantifikovanih saznanja o mogućnostima i efikasnosti primene multivarijantnih GARCH modela u funkciji kvantifikacije uticaja kretanja cene zlata na stope prinosa posmatranih finansijskih tržišta Amerike, Evrope i Kine. Vremenski period istraživanja je od 2012. do 2023. godine, gde se omogućava testiranje uspešnosti primene GARCH metodologije u periodu pre COVID-19 krize, za vreme, kao i nakon krize. Tako da su sledeće hipoteze testirane u ovom istraživanju:

Osnovna hipoteza H0: Multivarijantni GARCH modeli uspešno testiraju postojanje uticaja cene zlata na stope prinosa posmatranih finansijskih tržišta Amerike, Evrope i Kine.

Takođe, u istraživanju su testirane i dodatne (izvedene) hipoteze i to:

- H1: Kretanje cene zlata negativno utiče na stope prinosa posmatranih finansijskih tržišta Amerike, Evrope i Kine.
- H2: Primenom GARCH metodologije se uočavaju različiti uticaji cene zlata na stope prinosa posmatranih finansijskih tržišta Amerike, Evrope i Kine u pred kriznom (pred Covid-19) i kriznom periodu (za vreme Covid-19).

Rad je struktuiran na sledeći način. Pored prvog uvodnog dela, nalazi se drugi deo u kome je dat pregled relevantne literature iz oblasti. Treći deo rada je vezan za podatke i primenjenu

metodologiju. U četvrtom delu prikazani su dobijeni rezultati istraživanja, dok su u petom delu predstavljeni najvažniji zaključci, ukazano je na limite i predloge za dalja istraživanja. Reference su derivirane iz vodećih međunarodnih naučnih časopisa.

## PREGLED LITERATURE

Efekat pandemije u pogledu ekonomskog uticaja COVID 19 na volatilnost berzi jeste upravo prisustvo rasta cena (inflacije). Neizvesnosti izazvane pandemijom još uvek traju i nastavljaju se u vidu negativnih signala investitora i inflacije koja će imati uticaje na dugoročne investicione odluke (Jelilov i dr., 2020). Za razliku od prethodne velike ekonomsko-finansijske krize (2007) koja je nastala u hipotekarnom sektoru, potom se prenela na finansijsko tržište, a zatim i u realni sektor ekonomije, ekonomska kriza prouzrokovana pandemijom virusa COVID-19 je nastala kao posledica zdravstvenog globalnog problema koji se „momentalno“ odrazio na pad ekonomske aktivnosti. Pandemija COVID-19, pored toga što negativno utiče na ekonomije mnogih država, negativno utiče na životni stil, zdravlje i egzistenciju nekoliko milijardi ljudi u celom svetu. Dosadašnje prognoze i simulacije pokazuju da, pored ozbiljnih zdravstvenih posledica, pandemija virusa COVID-19 će gotovo sigurno usporiti globalni ekonomski rast, povećati globalno siromaštvo i nezaposlenost (Sumner i sar., 2020).

Nepovljna ekonomska (trgovinski sukobi), zdravstvena (pandemija COVID-19) i politička (ratni sukobi) situacija se usled globalizacije odslikala gotovo na sva finansijska tržišta. Ovakav globalni trend imao je efekte na investicione poduhvate, gde usled pojave nepredvidivih kretanja na tržištima investitori reaguju radikalno, stvarajući različite tipove rizika (pojava tkzv. volatilnosti) (Adekoya et al., 2021; Yi et al., 2021; Mensi et al., 2022). Volatilnost se može posmatrati kao merilo i instrument za upravljanje rizikom.

U radu predmet posmatranja jeste volatilnost prinosa berzanskih indeksa i kretanja cene zlata od uticaja na isti. Prilikom posmatranja volatilnost finansijske aktive mnogi autori su izveli određene karakteristike koje se vezuju za nju (Bai et al., 2003; Sichoongwe, 2016): grupisanje (velike ili male promene u cenama); volatilnost predstavlja srednju vrednost osciliranja (ukazuje na činjenicu da li je nestabilnost prisutna ili ne); nove informacije na tržištu mogu imati asimetričan uticaj na volatilnost (asimetrija pod efektom leveridža ili premije rizika); uticaj egzogenih varijabli na volatilnost; pojava “repova“ (bezuslovni rasporedi povrata finansijske aktive dovode do pojave ovog fenomena); “moć“ predviđanja (efikasnost moći predviđanja nije moguće tačno utvrditi). Za procenu uticaja cene zlata na volatilnost berzanskih indeksa koristiće se ekonometrijski prilagođeni GARCH (*Generalized Autoregressive Conditionally Heteroscedastic*) modeli.

Zlato u svakom trenutku predstavlja adekvatnu alternativu za investitora i na većini finansijskih tržišta koristi se kao instrument za investiranje, odnosno hedžing od promene stope inflacije. Shodno tome, javlja se potreba za analiziranjem uticaja cene zlata. Veliki broj autora je kroz svoje istraživačke poduhvate utvrdilo postajanost korelacione veze između cena zlata i prinosa na berzanske indekse (Mishra et al., 2010; Smith, 2001; Akar, 2011; Monjazeb, & Shakerian, 2014).

U istraživanju (Thapa, & Shah, 2020) imali su za cilj da procene različite faktore koji utiču odluke o investiranju u zlato. Proučavali su šest uticajnih faktora i njihov odnos sa investicionim odlukama, kao što su: cena zlata, sigurnost investicije, potreba za likvidnošću, socijalni status, reklama i drugi uticaji i potražnja za zlatom. Došli su do zaključka da su među svim uticajnim varijablama, potreba za likvidnošću i socijalni status pokazali najveću srednju vrednost što ukazuje na jak razlog za ulaganje u zlato, dok reklama i drugi uticaji imaju najmanje uticaja.

Istraživački rad (Choudhry et al., 2015) istraživao je nelinearne dinamičke veze između prinosa na zlato, prinosa na berzi i volatilnosti tržišta akcija tokom nedavne globalne finansijske krize za UK (FTSE 100), SAD (S&P 500) i Japan (Nikkei 225). U rezultatima rada su pokazali da korelacioni integrali zasnovani na bivarijantnom modelu pokazuju značajne dokaze o nelinearnom povratnom efektu između varijabli tokom perioda finansijske krize za sve zemlje koje su predmet istraživanja. Dobili su veoma ograničene dokaze o značajnim vezama između posmatranih faktora pre krize. Rezultati dobijeni istraživanjem impliciraju da zlato možda neće imati dobre rezultate kao sigurno utočište tokom perioda finansijske krize zbog dvosmerne međuzavisnosti između

prinosa na zlato i prinosa na akcije, kao i volatilnosti na berzi. Međutim, zlato se može koristiti kao zaštita od prinosa na berzi i volatilnosti u stabilnim finansijskim uslovima.

Rezultati istraživanja (Syahri, & Robiyanto, 2020) su pokazali da promene cene zlata imaju značajan uticaj na volatilnost cena akcija, gde se beleži prisustvo pozitivne dinamike korelacija između CSPI (*Composite Stock Price index*) i zlata i negativne dinamičke korelacije između CSPI i deviznih kurseva.

Mnoštvo je literature na temu zlata kao finansijske aktive i ulaganja u isto, međutim na osnovu kratkog gore navedenog pregleda relevantne literature iz oblasti u istraživanju će se putem GARCH metodologije doći do konkretnih i testiranih saznanja u funkciji kvantifikacije uticaja kretanja cene zlata na stope prinosa posmatranih finansijskih tržišta Amerike, Evrope i Kine.

## PODACI I PRIMENJENA METODOLOGIJA

Uzorak istraživanja uključuje dnevne vrednosti berzanskih indeksa, kao i izračunate stope prinosa na posmatranim finansijskim tržištima Amerike (NYSE Composite berzanski indeks) Evrope (Londonski FTSE 100 berzanski indeks) i Kine (Shanghai Composite berzanski indeks). Vremenski period obuhvaćen istraživanjem je od 01.01.2012. do 31.03.2023. godine. Širina vremenskog horizonta istraživanja omogućava testiranje efekata modela u periodu pre, kao i za vreme COVID-19 krize. Uticaj cene zlata je posmatran u datom periodu od 2012-2023.te godine i baziran je na procentualnoj dnevnoj promeni cene.

Prema (Brooks, 2008) stopa prinosa berzanskih indeksa može biti prikazana:

$$r_t = (lnP_t \,/\, P_{t-1}) * 100 \qquad (3.1)$$

gde je $r_t$ logaritmovana stopa prinosa posmatranih berzanskih indeksa u vremenu *t*, dok su $P_t \; i \; P_{t-1}$ empirijske vrednosti berzanskih indeksa posmatrane serije u periodu *t* i u prethodnom periodu, odnosno u periodu prve docnje.

U radu je korišćena odgovarajuća metodologija za modelovanje volatilnosti i testiranje istraživačkih hipoteza. Primena GARCH (*Generalized Autoregressive conditional heteroskedasticity*) modela je korišćena kako bi se potvrdila osnovna H0 i pomoćne H1 i H2 hipoteze u istraživanju, gde se za svako posmatrano finansijsko tržište i za period posmatranja birao optimalniji GARCH model koji je pokazivao signifikantnost uticaja cene zlata.

GARCH model opisuje procese u kojima se promene volatilnosti predstavljaju na sledeći način (Brooks, 2008). U radu na pomenutom uzorku koristimo GARCH (1,1) model za vremensku seriju *Yt*

$$y_t = \varepsilon_t \qquad (3.2)$$

$$\varepsilon_t = \sqrt{h_t \eta_t},\; \eta_t \xrightarrow{IID} N(0,1) \qquad (3.3)$$

$$h_t = a_0 + \sum_{i=1}^{q} a_i \varepsilon^2{}_{t-i} + \sum_{j=1}^{p} b_j h_{t-j} \qquad (3.4)$$

$$h_t = C_0 + C_1 h_{t-1} + C_2 \varepsilon^2{}_{t-1} \qquad (3.5)$$

$$Y_t = \alpha_0 + \alpha_1 Y_{t-1} + \cdots + \alpha_q Y_{t-q+} \varepsilon_t \qquad (3.6)$$

gde je $h_t$ uslovna varijansa ili odstupanje od $\varepsilon_t$ prema informacijama koje su dostupne u vremenu *t*. Tako da GARCH(1,1) model povezuje uslovnu varijansu $h_t$ sa prošlom funkcijom kvadriranih grešaka i prošlim uslovnim varijansama. Na osnovnu verziju GARCH (1,1) modela uključujemo stopu promene cene zlata kako bi izmerili uticaj, tako da model GARCH (1,1) sada glasi:

$$Y_t = C_0 + C_1 Y_{t-1} + \cdots + C_q Y_{t-q} + Pgold + \varepsilon_t \qquad (3.7)$$

Kako bi se izvršio izbor najboljih varijacija GARCH modela u radu koristimo i sledeće tipove GARCH modela: EGARCH model koji ima sledeću formu:

$$\log(h_t) = a_0 + \sum_{i=1}^{q} a_i g(\eta_{t-1}) + \sum_{i=1}^{p} b_i \log(h_{t-i}) \quad (3.8)$$

gde je $\varepsilon_t = \sqrt{h_t \eta_t}$ i $\boldsymbol{g(\eta_t) = \theta\eta_t + \gamma[|\eta_t| - \mathbf{E}|\eta_t|]}$ koji predstavljaju ponderisane vrednosti inovacija u modelu koje sa asimetričnim efektom između pozitivnih i negativnih povrata finansijske imovine, dok su $\theta$ i $\gamma$ konstantne. Na osnovnu verziju EGARCH modela uključujemo stopu promene cene zlata kako bi izmerili uticaj, tako da model EGARCH sada glasi:

$$log\ h_t^{\ 2} = C + \beta \ln\left(h_{t-1}^{\ 2}\right) + \alpha(\varepsilon_{t-1}) + C_1 Pgold \quad (3.9)$$

Zatim TGARCH ili GJR GARCH koji ima sledeću formu:

$$h_t^{\ 2} = w + \sum_{i=1}^{p} \alpha_i \varepsilon_t^{\ 2} + \sum_{j=1}^{q} \beta_j h_{t-j}^{\ 2} + \sum_{i=1}^{p} \gamma_i I_{t-i} \varepsilon_{t-i}^{\ 2} \quad (3.10)$$

gde je $I_{t-i} = \begin{cases} 1\ ako\ je\ \varepsilon_{t-i} < 0 \\ 0\ ako\ je\ \varepsilon_{t-i} \geq 0 \end{cases}$

gde je indikator funkcije $I_{t-i}$, dok α i β predstavljaju nenegativne parametre koji zadovoljavaju uslov $\alpha + \beta < 1$. Takođe, u TGARCH modelu, uslovna volatilnost $h_t^{\ 2}$ je pozitivna ako je $\alpha + \gamma \geq 1$, dok je proces stacionaran u kovarijansi, ako i samo ako je $\left(\alpha + \frac{\gamma}{2}\right) + \beta < 1$. Parametar γ meri asimetrični ili leveridž efekat u smislu da veštačka promenljiva uzima vrednost 1 ako su reziduali negativni, odnosno vrednost 0 ako su reziduali nenegativni. Na osnovnu verziju TGARCH modela uključujemo stopu promene cene zlata kako bi izmerili uticaj, tako da model TGARCH sada glasi:

$$h_t^{\ 2} = C_0 + (\alpha + \gamma I_{t-1})\ \varepsilon^2{}_{t-1} + \beta h_{t-1}^{\ 2} + C_1 Pgold \quad (3.11)$$

gde α i β predstavljaju nenegativne parametre koji zadovoljavaju uslov $\alpha + \beta < 1$. Takođe, u prilagođenom TGARCH modelu, uslovna volatilnost $h_t^{\ 2}$ je pozitivna ako je $\alpha + \gamma \geq 1$, dok je proces stacionaran u kovarijansi ako i samo ako je $\alpha + \left(\frac{\gamma}{2}\right) + \beta < 1$. Parametar γ meri asimetrični ili leveridž efekat u smislu da veštačka promenljiva uzima vrednost 1 ako su reziduali negativni, odnosno vrednost 0 ako su reziduali nenegativni.

Asimetrija modeliranja dovela je do uvođenja brojnih specifikacija procesa uslovne volatilnosti. Među njima, popularna i veoma opšta klasa modela je asimetrična moć GARCH modela *Asymmetric Power GARCH* (PGARCH*p,q* formulisan od strane (Ding et al., 1993), a koji se definiše:

$$\varepsilon_t = \sigma\eta_t;$$

$$\sigma_t^{\delta} = \omega + \sum_{i=1}^{q} \omega > 0\ ;\ \alpha_i |\varepsilon_{t-1}|\delta\ 1\varepsilon_{t-1} \geq 0 +\ \alpha_i |\varepsilon_{t-1}|\delta\ 1\ \varepsilon_{t-1} < 0 + \sum_{j=1}^{p} \beta_j \sigma_{t-j}^{\ \delta} \quad (3.12)$$

gde su koeficijenti nenegativne konstante, a $\delta$ predstavlja pozitivnu konstantu.

Svi modeli u istraživačkom delu rada ocenjeni su pomoću softverskog paketa EViews, uz primenu Marquardt algoritma optimizacije i Bolerslev-Vuldridžovog metoda korekcije standardnih grešaka ocena. Parametri prilagođenih GARCH modela ocenjeni su metodom maksimalne

verodostojnosti. Izbor adekvatnosti modela u istraživanju se vršio na osnovu SIC (*Schwarz information criterion*) informacionih kriterijuma koji su korićeni za odabir najoptimalnijih modela i potvrđivanje hipoteza istraživanja. Prema (Gujarati, 2010) korišćeni kriterijum se računa:

$$SIC = \mathrm{l_n}(\hat{\sigma}^2) + \frac{\mathrm{k}}{\mathrm{T}}\mathrm{l_n T} \qquad (3.13)$$

gde je $\hat{\sigma}^2$ rezidualna varijansa, što je ekvivalentno rezidualnoj sumi kvadrata podeljeno sa brojem opservacija u seriji, k=p+q+1 je ukupan broj ocenjenih parametara, a T je veličina uzorka. SIC kriterijum nameće najstrožije penale. Iako se prema (Brooks, 2008) ne može tvrditi koji kriterijum je najbolji, u istraživanju su birani najoptimalniji modeli prema najnižoj vrednosti SIC informacionog kriterijuma.

Za sve prinose na posmatranim finansijskim tržištima Amerike (NYSE Composite berzanski indeks) Evrope (Londonski FTSE 100 berzanski indeks) i Kine (Shanghai Composite berzanski indeks) u periodu posmatranja, a kako bi se kvantifikovao uticaj procentualne promene cene zlata, primeniće se PARCH, GARCH 1,1, TGARCH/GJR-GARCH i EGARCH modeli koji uključuju kretanje cene zlata. Potom će se putem SIC informacionih kriterijuma birati najoptimalniji GARCH model između PARCH, GARCH 1,1, TGARCH/GJR-GARCH-a i EGARCH-a za period posmatranja i zasebno za svako finansijsko tržište čiji prinosi se posmatraju. Na kraju se prezentuje poređenje rezultata izabranih najoptimalnijih multivarijantnih GARCH modela u cilju kvantifikacije uticaja procentualne promene cene zlata i testiranja hipoteza.

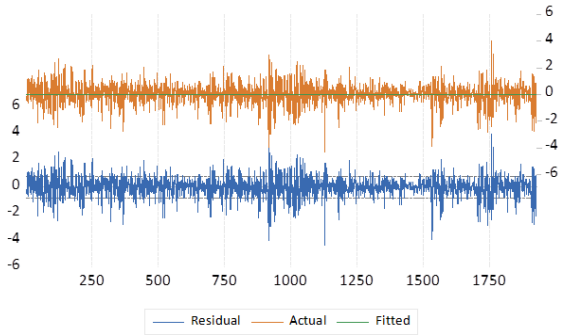
## REZULTATI I DISKUSIJA

U ovom delu studije biće predstavljeni rezultati istraživanja na multivarijantnim prilagođenim GARCH modelima, kao i analiza, testiranje i kvantifikacija uticaja procentualne promene cene zlata na prinose od investicionih aktivnosti na finansijskim tržištima Amerike, Evrope i Kine. U ovom delu studije za svaku posmatranu zemlju ponaosob, prvo će se izvršiti izbor najboljih ekonometrijskih modela u periodu pre Covid-19 krize, kao i za vreme Covid-19 krize, a zatim će se grafički prikazati kretanje reziduala. Naredne tabele će se odnositi na predstavljanje dobijenih najboljih modela, kao i na prikaz normalnosti distribucije uzorka. U narednom odeljku predstaviće se rezultati studije slučaja - AMERIKA.

Na osnovu SIC kriterijuma u tabeli 4.1 izabrani su najoptimalniji multivarijantni GARCH modeli u periodu posmatranja. Što su niže vrednosti SIC kriterijuma, to se smatra da je model optimalniji. Rezultati primene kriterijuma za optimalni izbor GARCH modela su pokazali da je za merenje uticaja cene zlata na dnevne stope prinosa berzanskog indeksa finansijskog tržišta Amerike (NYSE Composite berzanski indeks) najoptimalniji PGARCH model za ceo period i Covid-19 period, dok je za pred-krizni COVID-19 period najoptimalniji EGARCH model.

Tabela 4.1 – Reprezentativni kriterijumi za odabir optimalnih modela.
Table 4.1 - Representative criteria for selecting optimal models.

| Period posmatranja | PGARCH | | TGARCH / GJR GARCH | | EGARCH | | FIGARCH | |
|---|---|---|---|---|---|---|---|---|
| | AIC | SIC | AIC | SIC | AIC | SIC | AIC | SIC |
| CEO PERIOD | 2.398818 | 2.413679 | 2.442856 | 2.453471 | 2.403063 | 2.415801 | 2.438353 | 2.451091 |
| PRE-COVID-19 KRIZE | 2.163180 | 2.183391 | 2.209954 | 2.224390 | 2.165290 | 2.182613 | 2.210350 | 2.227673 |
| COVID-19 KRIZA | 2.920527 | 2.951461 | 2.961073 | 2.988882 | 2.921830 | 2.955202 | 2.946411 | 2.979783 |




Grafikon 4.1 – Kretanje reziduala stopa prinosa berzanskog indeksa NYSE Composite za posmatrani period od 2012 – 2023. godine.
Chart 4.1 - Movement of the residual rate of return of the NYSE Composite stock market index for the observed period from 2012 to 2023.

Na grafikonu 4.1 predstavlja se kretanje reziduala stopa prinosa berzanskog indeksa finansijskog tržišta Amerike (NYSE Composite berzanski indeks) za posmatrani period od 2012 – 2023. godine. Ceo period posmatranja jasno prikazuje velike oscilacije reziduala prinosa u periodu. U donjem delu grafikona plavom bojom, odnosno plavim okvirnim linijama, obeležene su prosečne vrednosti kretanja reziduala dnevnih stopa prinosa. Na grafikonu se takođe uočavaju manje oscilacije koje u određenim periodima indikuju smanjeni obim trgovine.

Izbor najboljeg modela na osnovu datih kriterijuma pokazuje da postoji uticaj cene zlata na dnevne stope prinosa na berzanski indeks NYSE u posmatranim periodima (ceo period, pretkrizni period i krizni period). Iz dobijenih funkcija modela, izvodi se zaključak da se negativan „efekat cene zlata“ manifestuje u celom i kriznom periodu, dok se pozitivan „efekat cene zlata“ primećuje u pred-kriznom periodu.

Tabela 4.2 – Procenjeni parametri optimalnih multivarijantnih GARCH modela za merenje uticaja cene zlata na prinose berzanskog indeksa NYSE za posmatrane periode.
Table 4.2 - Estimated parameters of the optimal multivariate GARCH models for measuring the impact of the gold price on the returns of the NYSE stock index for the observed periods.

| NYSE CEO PERIOD | | NYSE PRE-COVID-19 KRIZE | | NYSE COVID-19 KRIZA | |
|---|---|---|---|---|---|
| Variance Equation PGARCH | | Variance Equation EGARCH | | Variance Equation PGARCH | |
| C(2) | 0.037031 (0.0000) | C(1) | -0.180784 (0.0000) | C(2) | 0.035143 (0.0001) |
| C(3) | 0.130091 (0.0000) | C(2) | 0.184745 (0.0000) | C(3) | 0.143849 (0.0000) |
| C(4) | 0.776726 (0.0000) | C(3) | -0.172390 (0.0000) | C(4) | 0.678297 (0.0000) |
| C(5) | 0.864511 (0.0000) | C(4) | 0.939242 (0.0000) | C(5) | 0.861441 (0.0000) |
| C(6)P_GOLD | -0.009310 (0.5903) | P_GOLD | 0.063769 (0.2318) | C(6)P_GOLD | -0.106894 (0.0446) |
| C(7) | 0.864754 (0.0000) | | | C(7) | 0.932388 (0.0000) |

gde je: C i C(1) – konstante modela, RESID(-1...-5)^2 – predstavljaju kvadrate standardizovanih reziduala, odnosno koeficijente reda docnji asimetričnog prilagođenog GARCH modela do 5.tog reda, P_GOLD – predstavlja nezavisnu promenljivu modela „procentualnu promenu cene zlata“, C(5) GARCH(-1) – GARCH efekat univarijacionog TGARCH i PGARCH modela, RESID(-1)^2*(RESID(-1)<0) – asimetrični ili leveridž efekat, C(2) – ARCH efekat, C(3) – leveridž efekat, C(4) – GARCH efekat. P – vrednosti su date u zagradama ispod svake vrednosti koeficijenta.

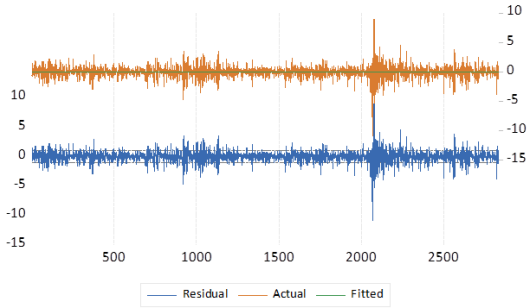
Tabela 4.3 – Distribucija dnevnih stopa prinosa berzanskog indeksa NYSE za posmatrani period od 2012 – 2023. godine.
Table 4.3 - Distribution of daily rates of return of the NYSE stock index for the observed period from 2012 to 2023.

| NYSE CEO PERIOD | | NYSE PRE-COVID-19 KRIZE | | NYSE COVID-19 KRIZA | |
|---|---|---|---|---|---|
| Series: Standardized Residuals | | Series: Standardized Residuals | | Series: Standardized Residuals | |
| Sample 2797 | | Sample 1928 | | Sample 855 | |
| Observations 2796 | | Observations 1927 | | Observations 854 | |
| Mean | -0.053323 | Mean | -0.051378 | Mean | -0.056745 |
| Median | -0.009525 | Median | -0.010139 | Median | -0.004814 |
| Maximum | 3.393717 | Maximum | 3.398319 | Maximum | 3.129756 |
| Minimum | -5.498741 | Minimum | -5.536172 | Minimum | -3.960682 |
| Std. Dev. | 0.985725 | Std. Dev. | 0.988822 | Std. Dev. | 0.993305 |
| Skewness | -0.562843 | Skewness | -0.566807 | Skewness | -0.416598 |
| Kurtosis | 4.602270 | Kurtosis | 4.712844 | Kurtosis | 3.657448 |
| Jarque-Bera | 446.7119 | Jarque-Bera | 338.7438 | Jarque-Bera | 40.08299 |
| Probability | 0.000000 | Probability | 0.000000 | Probability | 0.000000 |

Iz Tabele 4.3 mogu se uočiti vrednosti osnovnih statističkih informacija za prinose investiranja na finansijskom tržištu Amerike u posmatranom periodu od 2012-2023. godine. Prvo, prosečni dnevni prinosi indeksa imaju negativan predznak za sve periode posmatranja. U tabeli se takođe mogu videti maksimalne i minimalne vrednosti stopa prinosa. Dalje, iznos standardne devijacije govori o potencijalnom riziku investiranja u posmatranim periodima, gde je najmanje odstupanje od prosečnih dnevnih stopa prinosa zabeleženo u celom periodu posmatranja. Takođe, vrednosti mere asimetrije funkcije raspodele (*skewness*) i mere spljoštenosti funkcije raspodele (*kurtosis* - govori o debljini repova funkcije raspodele, tj., mogućnosti za ekstremne događaje), daju prikaz o ekstremnim kretanjima u povratima. Vrednosti mere asimetrije funkcije raspodele u posmatranim periodima su blago negativne što znači da je levi (negativan) rep raspodele dnevnih prinosa duži i da je bilo više negativnih nego pozitivnih kretanja, Mera spljoštenosti funkcije raspodele je u vrednostima iznad 3 i pokazuje da je verovatnoća ekstremnih kretanja prinosa bila velika. U narednom odeljku predstaviće se rezultati studije slučaja - EVROPA.

Tabela 4.4 – Reprezentativni kriterijumi za odabir optimalnih modela.
Table 4.4 - Representative criteria for selecting optimal models.

| Period posmatranja | PGARCH | | TGARCH / GJR GARCH | | EGARCH | | FIGARCH | |
|---|---|---|---|---|---|---|---|---|
| | AIC | SIC | AIC | SIC | AIC | SIC | AIC | SIC |
| CEO PERIOD | 2.470564 | 2.485421 | 2.520539 | 2.531151 | 2.477280 | 2.490015 | 2.515235 | 2.527969 |
| PRE-COVID-19 KRIZE | 2.297411 | 2.317570 | 2.348270 | 2.362670 | 2.301443 | 2.318722 | 2.346650 | 2.363929 |
| COVID-19 KRIZA | 2.838549 | 2.877483 | 2.900971 | 2.928781 | 2.855878 | 2.889250 | 2.909091 | 2.942463 |




Grafikon 4.2 – Kretanje reziduala stopa prinosa Londonski FTSE 100 berzanski indeks za posmatrani period od 2012 – 2023. godine.
Chart 4.2 - Movement of the residual rate of return of the London FTSE 100 stock index for the observed period from 2012 to 2023.

Na osnovu SIC kriterijuma u tabeli 4.5 izabrani su najoptimalniji multivarijantni GARCH modeli u periodu posmatranja. Što su niže vrednosti SIC kriterijuma, to se smatra da je model optimalniji. Rezultati primene kriterijuma za optimalni izbor GARCH modela su pokazali da je za merenje uticaja cene zlata na dnevne stope prinosa berzanskog indeksa finansijskog tržišta Evrope (FTSE 100 Londonski berzanski indeks) najoptimalniji PGARCH model za sve periode posmatranja.

Na grafikonu 4.2 predstavlja se kretanje reziduala stopa prinosa berzanskog indeksa FTSE 100 za posmatrani period od 2012 – 2023. godine. Ceo period posmatranja jasno prikazuje velike oscilacije reziduala prinosa u periodu. U donjem delu grafikona plavom bojom, odnosno plavim okvirnim linijama, obeležene su prosečne vrednosti kretanja reziduala dnevnih stopa prinosa. Na grafikonu se takođe uočavaju oscilacije koje indikuju voltilnost u periodu Covid-19 krize. Na grafikonu se takođe uočavaju manje oscilacije koje u određenim periodima indikuju smanjeni obim trgovine.

Tabela 4.5 – Procenjeni parametri optimalnih multivarijantnih GARCH modela za merenje uticaja cene zlata na prinose berzanskog indeksa FTSE 100 za posmatrane periode.
Table 4.5 - Estimated parameters of the optimal multivariate GARCH models for measuring the impact of the gold price on the returns of the FTSE 100 stock index for the observed periods.

| FTSE 100 CEO PERIOD | | FTSE 100 PRE-COVID-19 KRIZE | | FTSE 100 COVID-19 KRIZA | |
|---|---|---|---|---|---|
| Variance Equation PGARCH | | Variance Equation PGARCH | | Variance Equation PGARCH | |
| C(2) | 0.040800 (0.0000) | C(2) | 0.052069 (0.0000) | C(2) | 0.031123 (0.0001) |
| C(3) | 0.091947 (0.0000) | C(3) | 0.093494 (0.0000) | C(3) | 0.094318 (0.0000) |
| C(4) | 0.978182 (0.0000) | C(4) | 0.999980 (0.0000) | C(4) | 0.974796 (0.0000) |
| C(5) | 0.882233 (0.0000) | C(5) | 0.855628 (0.0000) | C(5) | 0.914782 (0.0000) |
| C(6)P_GOLD | -0.017436 (0.4469) | C(6)P_GOLD | 0.006039 (0.8905) | C(6)P_GOLD | -0.014307 (0.4678) |
| C(7) | 1.053808 (0.0000) | C(7) | 1.118185 (0.0000) | C(7) | 0.517908 (0.0000) |

gde je: P_GOLD – predstavlja nezavisnu promenljivu modela „procentualnu promenu cene zlata“, C(5) GARCH(-1) – GARCH efekat univarijacionog TGARCH i PGARCH modela, RESID(-1)^2*(RESID(-1)<0) – asimetrični ili leveridž efekat, C(2) – ARCH efekat, C(3) – leveridž efekat, C(4) – GARCH efekat. P – vrednosti su date u zagradama ispod svake vrednosti koeficijenta.

Izbor najboljeg modela na osnovu datih kriterijuma pokazuje da postoji uticaj cene zlata na dnevne stope prinosa na berzanski indeks FTSE 100 u posmatranim periodima (ceo period, pretkrizni period i krizni period). Iz dobijenih funkcija modela, izvodi se zaključak da se negativan „efekat cene zlata“ manifestuje u celom i kriznom periodu, dok se pozitivan „efekat cene zlata“ primećuje u pred-kriznom periodu.

Tabela 4.6 – Distribucija dnevnih stopa prinosa Londonski FTSE 100 berzanski indeks za posmatrani period od 2012 – 2023. godine.
Table 4.6 - Distribution of daily rates of return of the London FTSE 100 stock index for the observed period from 2012 to 2023.

| FTSE 100 CEO PERIOD | | FTSE 100 PRE-COVID-19 KRIZE | | FTSE 100 COVID-19 KRIZA | |
|---|---|---|---|---|---|
| Series: Standardized Residuals | | Series: Standardized Residuals | | Series: Standardized Residuals | |
| Sample 2797 | | Sample 1933 | | Sample 855 | |
| Observations 2796 | | Observations 1932 | | Observations 854 | |
| Mean | -0.004936 | Mean | -0.043093 | Mean | -0.030980 |
| Median | 0.007850 | Median | 0.003163 | Median | 0.041599 |
| Maximum | 3.076672 | Maximum | 3.595864 | Maximum | 3.558092 |
| Minimum | -3.224142 | Minimum | -4.513859 | Minimum | -6.085621 |
| Std. Dev. | 0.989801 | Std. Dev. | 0.994214 | Std. Dev. | 0.967857 |
| Skewness | -0.338494 | Skewness | -0.241200 | Skewness | -0.870313 |
| Kurtosis | 7.926999 | Kurtosis | 3.937541 | Kurtosis | 6.704079 |
| Jarque-Bera | 1295.424 | Jarque-Bera | 89.53760 | Jarque-Bera | 596.0202 |
| Probability | 0.000000 | Probability | 0.000000 | Probability | 0.000000 |

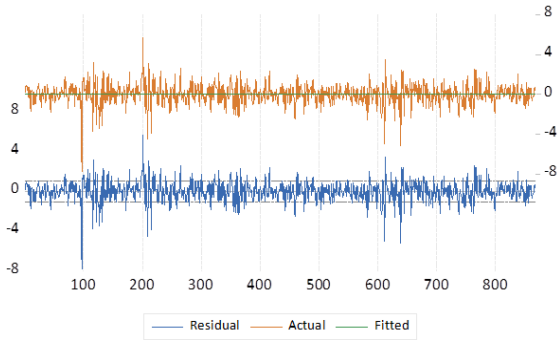
Iz Tabele 4.6 mogu se uočiti vrednosti osnovnih statističkih informacija za prinose investiranja na finansijskom tržištu Evrope koje reprezentuje Londonska berza i berzanski indeks FTSE 100 u posmatranom periodu od 2012-2023. godine (Londonska Berza, 2023). Prvo, prosečni dnevni prinosi indeksa imaju negativan predznak za sve periode posmatranja. U tabeli se takođe mogu videti maksimalne i minimalne vrednosti stopa prinosa. Dalje, iznos standardne devijacije govori o potencijalnom riziku investiranja u posmatranim periodima. Takođe, vrednosti mere asimetrije funkcije raspodele (*skewness*) i mere spljoštenosti funkcije raspodele (*kurtosis* - govori o debljini repova funkcije raspodele, tj., mogućnosti za ekstremne događaje), daju prikaz o ekstremnim kretanjima u povratima. Vrednosti mere asimetrije funkcije raspodele u posmatranim periodima su blago negativne što znači da je levi (negativan) rep raspodele dnevnih prinosa duži i da je bilo više negativnih nego pozitivnih kretanja, Mera spljoštenosti funkcije raspodele je u vrednostima iznad 3 i pokazuje da je verovatnoća ekstremnih kretanja prinosa bila velika. U narednom odeljku predstaviće se rezultati studije slučaja - KINA.

Tabela 4.7 – Reprezentativni kriterijumi za odabir optimalnih modela.
Table 4.7 - Representative criteria for selecting optimal models.

| **Period posmatranja** | **PGARCH** | | **TGARCH / GJR GARCH** | | **EGARCH** | | **FIGARCH** | |
|---|---|---|---|---|---|---|---|---|
| | **AIC** | **SIC** | **AIC** | **SIC** | **AIC** | **SIC** | **AIC** | **SIC** |
| CEO PERIOD* | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a |
| PRE-COVID-19 KRIZE | 2.828361 | 2.866763 | 2.841450 | 2.868880 | 2.832343 | 2.865259 | 2.836341 | 2.869257 |
| COVID-19 KRIZA | 2.840658 | 2.876556 | 2.854451 | 2.882235 | 2.844345 | 2.877687 | 2.839478 | 2.878819 |

*Napomenuće se da Eviews kompjuterski paket nije izbacio modele za ceo period posmatranja za berzansko tržište Kine, što može biti uzrok državnih intervencija i mešanja države na finansijskom tržištu putem određenih regulativa.

Na osnovu SIC kriterijuma u tabeli 4.7 izabrani su najoptimalniji multivarijantni GARCH modeli u periodu posmatranja. Što su niže vrednosti SIC kriterijuma, to se smatra da je model optimalniji. Rezultati primene kriterijuma za optimalni izbor GARCH modela su pokazali da je za merenje uticaja cene zlata na dnevne stope prinosa berzanskog indeksa finansijskog tržišta Kine (*Shanghai Composite* berzanski indeks) najoptimalniji PGARCH model za krizni period, dok je EGARCH model najoptimalniji za pred-krizni period posmatranja.




Grafikon 4.3 – Kretanje reziduala stopa prinosa Shanghai Composite berzanski indeks za posmatrani period od 2012 – 2023. godine.
Chart 4.3 - Movement of the residual rate of return of the Shanghai Composite stock index for the observed period from 2012 to 2023.

Na grafikonu 4.3 predstavlja se kretanje reziduala stopa prinosa berzanskog indeksa *Shanghai Composite* za posmatrani period od 2012 – 2023. godine. Period posmatranja jasno prikazuje velike oscilacije reziduala prinosa u periodu. U donjem delu grafikona plavom bojom, odnosno plavim okvirnim linijama, obeležene su prosečne vrednosti kretanja reziduala dnevnih stopa prinosa. Na grafikonu se takođe uočavaju manje oscilacije koje u određenim periodima indikuju smanjeni obim trgovine.

Izbor najboljeg modela na osnovu datih kriterijuma pokazuje da postoji uticaj cene zlata na dnevne stope prinosa na berzanski indeks *Shanghai Composite* u posmatranim periodima (pretkrizni period i krizni period). Iz dobijenih funkcija modela, izvodi se zaključak da se negativan „efekat cene zlata“ manifestuje i u pred-kriznom i kriznom periodu.

Tabela 4.8. Procenjeni parametri optimalnih multivarijantnih GARCH modela za merenje uticaja cene zlata na prinose berzanskog indeksa *Shanghai Composite* za posmatrane periode.
Table 4.8. Estimated parameters of the optimal multivariate GARCH models for measuring the impact of the gold price on the returns of the Shanghai Composite stock index for the observed periods.

| FTSE 100 PRE-COVID-19 KRIZE | | FTSE 100 COVID-19 KRIZA | |
|---|---|---|---|
| Variance Equation EGARCH | | Variance Equation PGARCH | |
| C(1) | -0.234090 (0.0000) | C(2) | 0.179006 (0.0001) |
| C(2) | 0.311152 (0.0000) | C(3) | 0.172995 (0.0000) |
| C(3) | -0.137142 (0.0000) | C(4) | 0.344313 (0.0000) |
| C(4) | 0.847960 (0.0000) | C(5) | 0.662424 (0.0000) |
| P_GOLD | -0.044322 (0.8429) | C(6)P_GOLD | -0.164412 (0.2299) |
| | | C(7) | 1.898194 (0.0000) |

gde je: C i C(1) – konstante modela, RESID(-1...-5)^2 – predstavljaju kvadrate standardizovanih reziduala, odnosno koeficijente reda docnji asimetričnog prilagođenog GARCH modela do 5.tog reda, P_GOLD – predstavlja nezavisnu promenljivu modela „procentualnu promenu cene zlata“, C(5) GARCH(-1) – GARCH efekat univarijacionog TGARCH i PGARCH modela, RESID(-1)^2*(RESID(-1)<0) – asimetrični ili leveridž efekat, C(2) – ARCH efekat, C(3)

– leveridž efekat, C(4) – GARCH efekat. P – vrednosti su date u zagradama ispod svake vrednosti koeficijenta.

Tabela 4.9. Distribucija dnevnih stopa prinosa Kineski *Shanghai Composite* berzanski indeks za posmatrani period od 2012 – 2023. godine.
Table 4.9. Distribution of daily rates of return of the Chinese Shanghai Composite stock index for the observed period of 2012 - 2023. Years.

| **Shanghai PRE-COVID-19 KRIZE** | | **Shanghai COVID-19 KRIZA** | |
|---|---|---|---|
| Series: Standardized Residuals | | Series: Standardized Residuals | |
| Sample 869 | | Sample 855 | |
| Observations 868 | | Observations 854 | |
| Mean | -0.024301 | Mean | -0.032425 |
| Median | 0.005872 | Median | -0.008101 |
| Maximum | 4.118332 | Maximum | 3.919622 |
| Minimum | -5.138636 | Minimum | -5373142 |
| Std. Dev. | 0.996723 | Std. Dev. | 0.994848 |
| Skewness | -0.487373 | Skewness | -0.461323 |
| Kurtosis | 4.762514 | Kurtosis | 4.733255 |
| Jarque-Bera | 146.8822 | Jarque-Bera | 137.3503 |
| Probability | 0.000000 | Probability | 0.000000 |

Iz Tabele 4.9 mogu se uočiti vrednosti osnovnih statističkih informacija za prinose investiranja na finansijskom tržištu Kine koje reprezentuje Šangajska berza i berzanski indeks *Shanghai Composite* u posmatranom periodu od 2012-2023. godine (Šangajska Berza, 2023). Prvo, prosečni dnevni prinosi indeksa imaju negativan predznak za sve periode posmatranja. U tabeli se takođe mogu videti maksimalne i minimalne vrednosti stopa prinosa. Dalje, iznos standardne devijacije govori o potencijalnom riziku investiranja u posmatranim periodima. Takođe, vrednosti mere asimetrije funkcije raspodele (*skewness*) i mere spljoštenosti funkcije raspodele (*kurtosis* - govori o debljini repova funkcije raspodele, tj., mogućnosti za ekstremne događaje), daju prikaz o ekstremnim kretanjima u povratima. Vrednosti mere asimetrije funkcije raspodele u posmatranim periodima su blago negativne što znači da je levi (negativan) rep raspodele dnevnih prinosa duži i da je bilo više negativnih nego pozitivnih kretanja, Mera spljoštenosti funkcije raspodele je u vrednostima iznad 3 i pokazuje da je verovatnoća ekstremnih kretanja prinosa bila velika.

## ZAKLJUČCI

Rezultati istraživačkog rada ukazuju na značaj predmeta istraživanja kroz prizmu validacije i kvantifikacije uticaja kretanja cene zlata na stope prinosa prilikom investicionih aktivnosti na finansijskim tržištima. U praksi, sprovedeno istraživanje testira uticaj kretanja cene zlata kao alternative ulaganjima na finsnsijskim tržištima i kvantifikuje ga na dnevne stope prinosa na posmatranim finansijskim tržištima Amerike, Evrope i Kine. Autori su istakli značaj i optimizaciju performansi korišćenih ekonometrijskih multivarijantnih modela GARCH u periodu pre i za vreme Covid-19 krize.

U studiji je testirano nekoliko hipoteza. Glavna hipoteza H0, uz pretpostavku da multivarijantni GARCH ekonometrijski modeli uspešno testiraju postojanje uticaja kretanja cene zlata na stope prinosa posmatranih finansijskih tržišta Amerike, Evrope i Kine, delimično je potvrđena. Naime, na finansijskom tržištu Kine u celom periodu posmatranja nije bilo moguće utvrditi uzročno-posledičnu vezu između promenljivih u celom periodu posmatranja. Međutim, na fianansijskom tržištu Kine u pred-kriznom i kriznom periodu je pronađena i egzaktno utvrđena korelaciona veza između uticaja cene zlata i kretanja dnevnih stopa povrata berzanskog indeksa *Shanghai Composite*. Na finansijskim tržištima Amerike i Evrope je pronađena i egzaktno utvrđena korelaciona veza između uticaja kretnja cene zlata i dnevnih stopa povrata berzanskih indeksa u svim posmatranim periodima (ceo period, pred-krizni i krizni). Uključivanjem nezavisne varijable – kretanje cene zlata prošireni su osnovni GARCH modeli. Koristeći *Schwarz* (SIC) informacione kriterijume u istraživanju, odabrani su optimalni modeli između korišćenih modela

GARCH sa svim varijacijama (FIGARCH, EGARCH, TGARCH/GJR-GARCH, PGARCH) na posmatranim finansijskim tržištima u celom, pred-kriznom i kriznom periodu posmatranja. Iz toga se može zaključiti da se jedan model ne može koristiti na svakom finansijskom tržištu za kvantifikaciju kretanja cene zlata, koji će imati najbolje procenjene parametre modela u zadatim periodima posmatranja. Zaključuje se, takođe da primena GARCH metodologije na posmatranim finansijskim tržištima uspešno testira uticaj kretanja cene zlata i doprinosi optimizaciji strategije investiranja sa tačno definisanim rezultatima pozitivnih i negativnih uticaja na kretanje dnevnih stopa prinosa berzanskih indeksa posmatranih finansijskih tržišta.

Delimično je potvrđena hipoteza H1, koja tvrdi da kretanje cene zlata negativno utiče na stope prinosa posmatranih finansijskih tržišta Amerike, Evrope i Kine. Rezultati istraživanja pokazuju da kretanje cene zlata negativno utiče na kretanje dnevnih stopa prinosa na sledećim posmatranim finansijskim tržištima i periodima (finansijsko tržište Amerike i Evrope u kriznom i celom periodu, dok na finansijskom tržištu Kine cena zlata negtivno utiče na prinose utiče i u pred kriznom i kriznom periodu). H1 je opovrgnuta u pred-kriznom periodu na finansijskim tržištimaAmerike i Evrope.

Potvrđena je pomoćna hipoteza H2, koja tvrdi da se primenom GARCH metodologije uočavaju različiti uticaji kretanja cene zlata na stope prinosa posmatranih finansijskih tržišta Amerike, Evrope i Kine u pred kriznom (pred Covid-19) i kriznom periodu (za vreme Covid-19). To znači da rezultati istraživanja pokazuju da se uticaj kretanja cene zlata različito ponašao u različitim periodima posmatranja: celom, pred-kriznom i kriznom. Na posmatranim finansijskim tržištima su pronađeni dokazi da u svim periodima posmatranja: ceo period, pred-krizni i krizni, cena zlata beleži različit stepen korelativne veze (jačina intenziteta korelativne veze koja se kreće od -1 do +1) sa kretanjem dnevnih stopa povrata u zavisnosti od perioda posmatranja. Zaključak je da je zajednička karakteristika za sve uzorke NYSE, FTSE 100 i Shanghai Composite u posmatranom periodu od 2012. do 2023. godine, da ne postoji normalnost distribucije i da u različitim periodima ispoljavaju različitu asimetriju i distorziju uzorka.

Realizovano istraživanje u radu i dobijeni rezultati pružaju nova saznanja o vezi između dnevnih stopa povrata i uticaja kretanja cene zlata na posmatranim finansijskim tržištima. Testiranje uticaja cene zlata putem GARCH metodologije pruža naučni doprinos istovremeno ostavljajući prostor za pravce daljih istraživanja. Dobijeni rezultati istraživanja imaju višestruki značaj za institucionalne investitore, investicione fondove, portfolio menadžere, analitičare na tržištu i druge, čime se potvrđuje i praktičan doprinos istraživanja. Dobijeni rezultati pomažu u procesu definisanja optimalne strategije o investiranju, kao i smanjenja rizika prilikom investiranja.

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# IMPACT OF GOLD PRICE MOVEMENT ON THE RATE OF THE RETURNS FROM INVESTMENT ACTIVITY ON FINANCIAL MARKETS

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**ABSTRACT**

Due to the consequences caused by the crisis of the COVID-19 virus pandemic (interrupted supply chains), energy crisis, geopolitical crisis (war conflicts between Russia and Ukraine) resulting in high inflation, the working paper analyzes, tests and quantifies the impact of gold price movements on daily rates of return from investment activities on the observed financial markets of America, Europe and China. The aim of the working paper is to arrive at concrete, practically tested and quantified results through the application of multivariate GARCH models in the function of quantifying the impact of the gold price on the yield rates of the observed financial markets. Investing in gold represents an alternative to investing in currencies (currency pairs) and financial instruments on the financial markets. The time period of the research is from 2012 to 2023, where the effectiveness of the application of the multivariate GARCH methodology is tested in the period before the COVID-19 crisis, during and after the crisis. The research methodology includes the use of SIC (Schwarz) information criteria for selecting optimal models. The results of the working paper confirm the significance of the application of econometric multivariate GARCH models in terms of quantifying the impact of the gold price on the daily rates of return from investment activities on the observed financial markets. The obtained research results will be useful both to the academic community for further research in the field, and to the professional in terms of making optimal investment decisions.

**Keywords**: gold price, returns on financial markets, GARCH models, risk, investing.

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# UTICAJ DIGITALNIH MEDIJA NA SAVREMENO POSLOVANJE

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## SAŽETAK

Moderno doba oblikuje intenzivna konkurencija i zahtjevni potrošači, zbog čega kompanije napuštaju tradicionalne metode komunikacije i fokusiraju se na digitalne medije nametnute razvojem informacionih tehnologija. Prisustvo kompanije na internetu nije cilj, već nešto što se podrazumijeva. Pažnja menadžmenta uspješne kompanije usmjerena je na interaktivni sadržaj koji stvara šira socijalna zajednica, a ne samo sama kompanija. Na ovaj način, kompanija brzo i lako dobija informacije o tržištu na kojem posluje, ponašanju potrošača koji koriste ili žele koristiti njihove proizvode i usluge, kreira kampanje koje se šire viralno, blogove, komunicira dvosmjerno sa potrošačima, promoviše svoje vrijednosti i način poslovanja. Cilj istraživanja ovog rada je analiza kako digitalni mediji utiču na moderno poslovanje.

Rezultati empirijskog istraživanja su pokazali da efektivno korišćenje digitalnih medija u modernom poslovanju direktno doprinosi boljem pozicioniranju i diferencijaciji kompanije na tržištu, dovodi do većeg stepena lojalnosti potrošača i postizanja konkurentske prednosti.

**Ključne riječi**: digitalni mediji, menadžment, komunikacija, poslovanje

## UVOD

U današnjem digitalnom dobu, poslovanje se neprestano mijenja i prilagođava novim tehnološkim trendovima. Pojava interneta je odigrala važnu ulogu u konceptu poslovnog modela (Ruggieri et al., 2018). Razvoj informacionih tehnologija i digitalizacija poslovnih procesa transformisali su način na koji kompanije komuniciraju sa svojim ciljnim grupama i tržištem uopšte. Sveobuhvatni prodor digitalne tehnologije razotkrio je ključnu ulogu platforme kao jednu od najvažnijih osobina inovacionih procesa i učinio je centralnim fokusom inovacionih aktivnosti mnogih firmi (Yoo et al., 2012).

Tradicionalne metode komunikacije više nisu dovoljne da zadovolje zahtjeve intenzivne konkurencije i sve zahtevnijih potrošača. U tradicionalnim medijima kao što su štampa i TV mjerenje efikasnosti i interaktivnosti bilo je ograničeno na uzorkovanje ili ankete, ali u digitalnim medijima efikasnost se može mjeriti i posmatrati u realnom vremenu.

Digitalna transformacija utiče na cijelu kompaniju i njene načine poslovanja (Amit, & Zott, 2001) i čak prevazilazi digitalizaciju promjenom jednostavnih organizacionih procesa i zadataka. Digitalna transformacija preuređuje procese poslovne logike firme (Li et al., 2018) te koristi digitalne tehnologije kako bi omogućila prekogranične interakcije sa dobavljačima, kupcima i konkurentima (Singh, & Hess, 2017). U modernom poslovnom okruženju ključna komponenta uspjeha za kompanije svih veličina je adekvatno razumijevanje i pravilno korišćenje digitalnih medija. Prisustvo kompanije na internetu više se ne smatra ekskluzivnim ciljem, već neophodnim korakom u uspješnom poslovanju. Međutim, postavlja se pitanje kako se kompanije mogu izdvojiti u ovom digitalnom haosu i ostvariti stvarnu vrijednost kroz svoje prisustvo na internetu.

Tehnološko umrežavanje društva utiče na sve poslove i suštinski mijenja strategije svih vrsta firmi (Evans, & Wurster, 1997). U fokusu mnogih uspješnih kompanija nalazi se ideja stvaranja interaktivnog sadržaja koji podstiče angažman i stvara šire društvene zajednice, a ne samo promociju proizvoda ili usluga. Ovaj pristup omogućava kompanijama da brže i lakše dobiju informacije o tržištu na kojem posluju, razumiju ponašanje potrošača koji koriste ili žele koristiti njihove proizvode i usluge, kreiraju kampanje koje se šire viralno, vode blogove koji grade

reputaciju, komuniciraju dvosmjerno sa potrošačima kako bi dobili povratne informacije te istovremeno promovišu svoje vrijednosti i način poslovanja.

Digitalni mediji otvorili su nove kanale komunikacije i pružili priliku kompanijama za razvoj bližeg odnosa između potrošača i njihovih brendova, ali i mogućnost učinkovitinijeg i jeftinijeg komuniciranja. Kompanije mogu razviti lojalnost brendu svojih proizvoda kod potrošača putem digitalnih medija na različite načine i metode jer marketinškim stručnjacima pružaju novu platformu. Zbog prethodno navedenog je stvaranje svijesti, uvjeravanje i izgradnja trajnog dvosmjernog odnosa također izazov koji ne samo da pomaže u procjeni interakcije sa potrošačima, već također pomaže u sticanju njihovih preferencija i razvijanju snažne figure marke (Ahmed et al., 2015).

Mnoge kompanije ili preduzeća shvataju važnost usvajanja društvenih medija kao moćnog alata u izgradnji odnosa sa potrošačima, a danas mnoge kompanije tragaju za zaposlenim koji posjeduju vještine korišćenja društvenih medija. Korišćenjem digitalnih medija naglasak bi trebalo da bude na povećanju upravljanja prihodima ili rashodima. Ukoliko je prihod cilj, postoje tri oblasti u kojima mnoge kompanije koriste digitalne medije: monetizacija sadržaja, kontrola kanala i konverzija kupaca. Svi oni se odnose na izgradnju vrhunske prodaje, bilo kroz prodaju samih digitalnih medija ili korišćenjem digitalnih medija za povećanje prodaje proizvoda i usluga. Druga strana medalje je interna upotreba ili korišćenje digitalnih medija za smanjenje troškova poslovanja. Uticaj ispod crte može se podijeliti u četiri kategorije: telekomunikacioni troškovi, korisnička usluga, vrijeme izlaska na tržište i kvalitet informacija. (Rayburn, 2007). Digitalna transformacija je inherentno povezana sa strateškim promjenama poslovnog modela kao rezultatom implementacije digitalnih tehnologija (Schallmo et al., 2017). Digitalni mediji se jednostavno ne koriste samo u svrhu marketinga već su postali i kanali prodaje preko kojih kupci direktno kupuju.

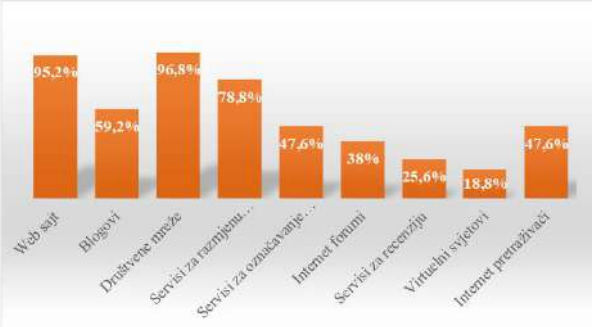
## METODE ISTRAŽIVANJA

Naučno-istraživački karakter ovog rada počiva na analizi relevantne naučne literature i savremenih izvora korišćenjem metode ispitivanja, metode analize, metode komparacije, metode deskripcije i metode dedukcije. Cilj istraživanja ovog rada je analiza uticaja digitalnih medija na savremeno poslovanje. Kao glavni metod prikupljanja podataka u ovom radu korišćena je metoda ispitivanja koja je sprovedena putem online upitnika tokom februara 2023. godine. Anketa je bila anonimna i sprovedena je na 250 preduzeća na teritoriji BiH. Upitnik se sastojao od 22 pitanja, od kojih su se tri odnosila na demografske karakteristike ispitanika, a ostalih devetnaest pitanja su se odnosila na temu ispitivanja.

Generalna hipoteza glasi efektivna upotreba digitalnih medija u savremenom poslovanju direktno doprinosi boljem pozicioniranju i diferencijaciji kompanije na tržištu i dovodi do većeg stepena lojalnosti potrošača i postizanja konkurentske prednosti.

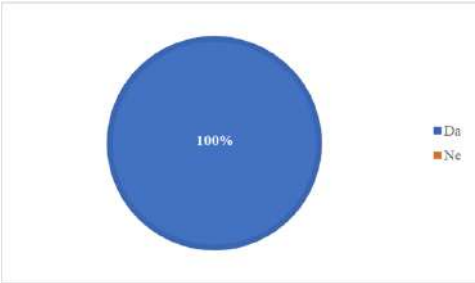
## REZULTATI I DISKUSIJA

Od ukupnog uzorka istraživanja, 40% ispitanika pripada preduzećima sa sjedištem u FBiH, dok 60% ispitanika preduzećima sa sjedištem u Republici Srpskoj. Kada je riječ o strukturi preduzeća, većina ispitanika, u oba entiteta, pripada kategoriji mikro 26% i malih 46% preduzeća, dok su najmanje zastupljena srednja 10% i velika preduzeća 18%. Najveći procenat ispitanika 54% nalazi na poziciji top menadžmenta, dok se najmanji procenat ispitanika 14.4% nalazi na poziciji nižeg nivoa menadžmenta. Na poziciji srednjeg nivoa menadžmenta nalazi se 31.6% ispitanika. Takođe, kada je u pitanju poznavanje pojma digitalin mediji, najveći procenat ispitanika 86% upoznato je sa pojmom digitalni mediji, dok 100% ispitanika koristi digitalne medije u poslovanju.




Grafikon 1. Koje digitalne medije najviše koristi Vaše preduzeće?
Figure 1. Which digital media does your company use the most?

Analizirajući podatke o vrsti digitalnih medija koje preduzeća najviše koriste, uočava se da dominiraju društvene mreže 96.8% i web sajtovi 95.2%, a zatim u nešto manjem procentu 78.8% servisi za razmjenu multimedijalnih sadržaja. Najmanji procenat preduzeća upotrebljava internet forume 38%, servise za recenziju 25.6% i virtuelne svjetove 18.8%. Ovi podaci se mogu objasniti činjenicom da ispitanici nisu u potpunosti upoznati sa svim oblicima digitalnih medija i njihovim koristima za poslovanja preduzeća. Mediji koji dominiraju u poslovnom svijetu, su mediji koji dominiraju i u privatnom životu ispitanika.

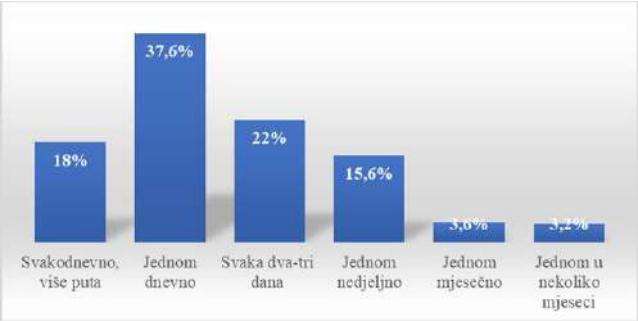



Grafikon 2. Prema Vašem mišljenju, da li su digitalni mediji korisni za poslovanje?
Figure 2. In your opinion, are digital media useful for business?

Podaci iz grafikona 2 pokazuju da su svi ispitanici (100%) svjesni značaja i uticaja digitalnih medija na sferu savremenog poslovanja.

Grafikon 3. Ako mislite da su digitalni mediji korisni za poslovanje, koji aspekt Vam se čini najkorisnijim?
Figure 3. If you think that digital media are useful for business, which aspect seems most useful to you?

Analizirajući podatke iz grafikona 3, uočava se da najveći procenat ispitanika smatra da su dva najkorisnija aspekta korišćenja digitalnih medija u poslovanju: povoljnost korišćenja i oglašavanja preduzeća 91.2% i bolje pozicioniranje proizvoda/usluga na tržištu 79.2%. Nešto manji procenat ispitanika ističe da su to uspostavljanje kontakta sa potrošačima 74.4% i praćenje konkurekcije 71.6%. Najmanji procenat ispitanika 59.2%, posmatra digitalne medije kao sredstvo za lako pronalaženje poslovnih partnera.

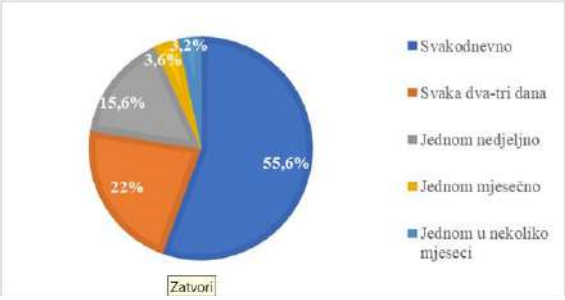



Grafikon 4. Koliko često Vaša kompanija koristi digitalne medije u poslovanju?
Figure 4. How often does your company use digital media in business?

Podaci iz grafikona 4 ukazuju da najveći procenat ispitanika 37,6% jednom dnevno koristi digitalne medije u poslovanju svoje kompanije, dok nešto manji procenat 22% svaka dva do tri dana koristi digitalne medije. Svakodnevno korišćenje digitalnih medija uočava se samo kod 18% ispitanika, dok 15% ispitanika iste koristi jednom nedjeljno. Najmanji procenat ispitanika digitalne medije koristi jednom mjesečno 3.6% ili jednom u nekoliko mjeseci 3.2%. Navedeni podaci ističu činjenicu da 44,4% ispitanika još uvjek neprofesionalno pristupa konceptu digitalnih medija.

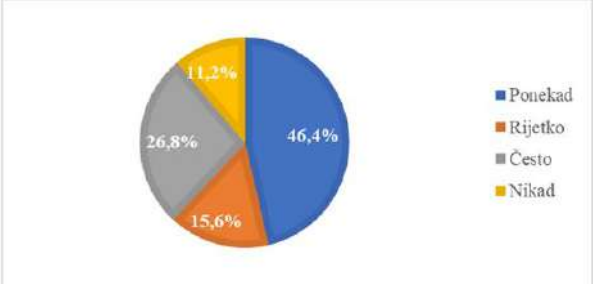
Grafikon 5. Ko je u Vašem preduzeću zadužen za digitalne medije?
Figure 5. Who is in charge of digital media in your company?

Posmatrajući podatke o upravljanju digitalnim medijima, najveći procenat preduzeća 40% ima jednu osobu koja se pored zaduženja za područje digitalnih medija bavi i drugim poslovima, što je poražavajući podatak, kao i da se kod 19.2% ispitanika niko određen ne bavi sa digitalnim medijima. Ovi podaci ukazuju na nedovoljnu svijest o beneftima i načinima korišćenja digitalnih medija u savremenom poslovanju čim se dovodi do situacije preopterećenja jedne osobe koja pored datog ima i druga zaduženja ili čak nepostojanosti odgovornog za vršenje istog. Takođe, ukazuje na nedostatak edukacije i neinformisanost rukovodećeg kadra o neophodnosti postojanja specijalizovanog osoblja za upravljanje digitalnim medijima, kao i adekvatnih resursa i podrške u ovoj oblasti, kako bi preduzeća ostvarila svoj pun potencijal u poslovanju. Ipak, treba pohvaliti i 40% ispitanika koji su ozbiljno shvatili značaj digitalnih medija za ostvarivanje konkurentske prednosti, bilo da su to u pitanju nekoliko osoba u preduzeću 20.4% ili jedna osoba u preduzeću 11,6% koji su zaduženi za digitalne medije ili odluka da se to delegira spoljnim saradnicima 8.8%.



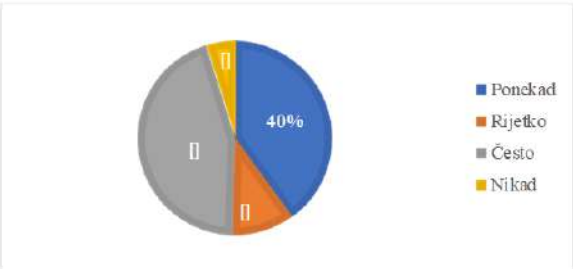

Grafikon 6. Koliko često dodajete nove sadržaje na digitalne medije?
Figure 6. How often do you add new content to digital media?

Podaci iz grafikona 6 pokazuju da najveći procenat ispitanika 55.6% svakodnevno dodaje nove sadržaje na društvene medije. Značajan broj ispitanika 22% ažurira sadržaje svaka dva do tri dana, što takođe pokazuje aktivnost na društvenim mrežama, iako ne tako često kao prethodna grupa. Manji procenat ispitanika dodaje sadržaje jednom nedjeljno 15.6%, jednom mjesečno 3.6% ili jednom u nekoliko mjeseci 3.2%, što može ukazivati na manju angažovanost ili manje resursa posvećenih održavanju prisustva na društvenim medijima.



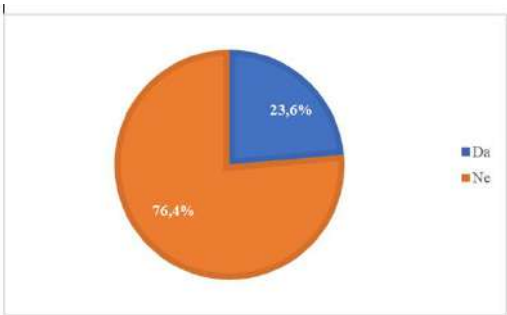

Grafikon 7. Koliko često nudite određene pogodnosti onima koji Vas prate na digitalnim medijima (popuste, nagrade, poklone i sl.)?
Figure 7. How often do you offer certain benefits to those who follow you on digital media (discounts, prizes, gifts, etc.)?

Podaci iz grafikona 7 pokazuju da najveći procenat ispitanika 46.4% ponekad nudi određene pogodnosti pratiocima na digitalnim medijama, dok najmanji procenat ispitanika 11.2% nikada ne nudi bilo koji oblik pogodnosti svojim pratiocima. Prethodni podatak ukazuje na postojanost pružanja pogodnosti pratiocima na digitalnim medijima, ali i da ta praksa nije konstantna ili ujednačena. Postoji prostor ukazivanja na benefite dosljednosti u pružanju pogodnosti i nagrađivanju pratilaca na društvenim medijima što bi moglo dovesti do jačanja angažmana potrošača i izgradnje lojalnosti prema preduzeću.



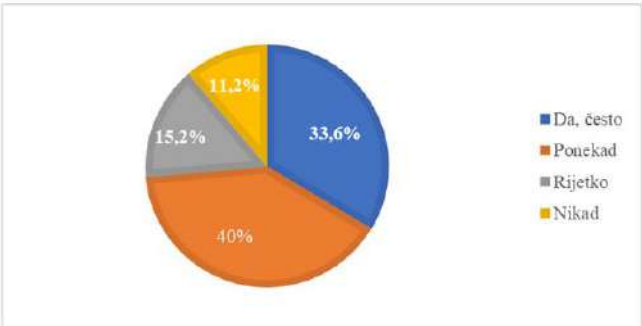

Grafikon 8. Koliko često pratite aktivnosti svojih konkurenata na tržištu putem društvenih medija?
Figure 8. How often do you follow the activities of your competitors in the market via social media?

Posmatrajući podatke iz grafikona 8 uočava se da najveći procent ispitanika 44.8% često prati aktivnosti konkurenata na tržištu putem društvenih medija, dok 40% ispitanika to radi ponekad. Najmanji procenat ispitanika 4.8% ispitanika nikad ne prati aktivnosti konkurenata na tržištu putem društvenih medija. Ovi podaci pokazuju želju ispitanika da budu informisani o potezima konkurencije i da koriste te informacije za unapređenje sopstvenog poslovanja. Praćenje aktivnosti konkurencije na digitalnim medijima je važno zbog ostvarivanja konkurentskog položaja, informisanosti o trendovima i inovacijama, analize efikasnosti marketinških aktivnosti, upravljanja reputacijom brenda i razumijevanja potreba ciljne grupe.




Grafikon 9. Da li koristite društvene medije za povezivanje sa drugim preduzećima?
Figure 9. Do you use social media to connect with other businesses?

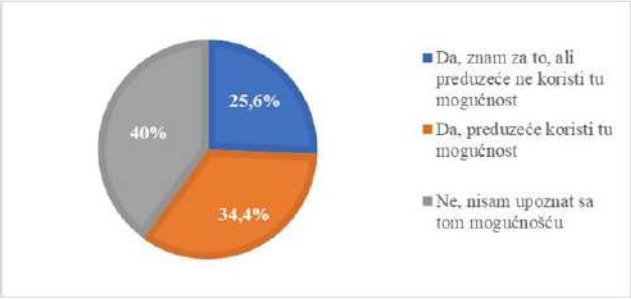
Od ukupnog uzorka ispitanika, 23.6% koristi društvene medije za povezivanje sa drugim preduzećima, dok 76.4% navodi da ne koristi društvene medije u tu svrhu. Prethodno navedeno može ukazivati na potencijalno ograničeno korišćenje društvenih medija kao sredstva za uspostavljanje veza i saradnje sa drugim preduzećima. Razlozi za ovo mogu biti nedovoljna svijesti o mogućnostima povezivanja putem društvenih medija ili nedostatak poverenja za ovakvu vrstu ostvarivanja kontakta. Preduzeća koja žele da iskoriste potencijal digitalnih medija za uspostavljanje veza sa drugim preduzećima mogu se suočiti sa izazovima u pogledu svijesti i spremnosti drugih preduzeća da se angažuju na ovaj način.




Grafikon 10. Da li posvećujete pažnju na komentare potrošača i da li uzimate u obzir njihove sugestije i kritike, kako bi unapredili svoje proizvode/usluge?
Figure 10. Do you pay attention to consumer comments and do you take into account their suggestions and criticisms, in order to improve your products/services?

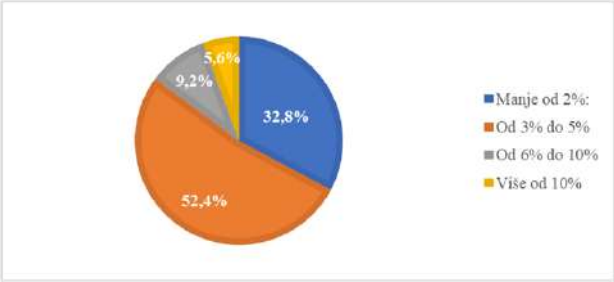
Analizirajući podatke iz grafikona 10 uočava se da najveći procenat ispitanika 40% ponekad posvećuje pažnju komentarima potrošača. Slijedi grupa ispitanika 33.6% koja često posvećuje pažnju tim komentarima, što ukazuje na njihovu veću angažovanost u slušanju potrošača i prilagođavanju njihovim potrebama. Sa druge strane, manji procenat ispitanika 15.2% rijetko posvećuje pažnju komentarima, dok 11.2% ispitanika nikada ne uzima u obzir komentare potrošača. Rezultati pokazuju da većina ispitanika 73.6% posvećuje pažnju komentarima potrošača i uzima ih u obzir za unapređenje svojih proizvoda/usluga što predstavlja pozitivan znak, jer

ukazuje na svijest o važnosti interakcije sa potrošačima i prilagođavanju njihovim potrebama. Međutim, postoji i određeni procenat ispitanika 26.4% koji rijetko ili nikada ne uzimaju u obzir komentare potrošača. Ova grupa preduzeća propušta priliku za unapređenje i može biti manje fleksibilna u odgovoru na potrebe potrošača.



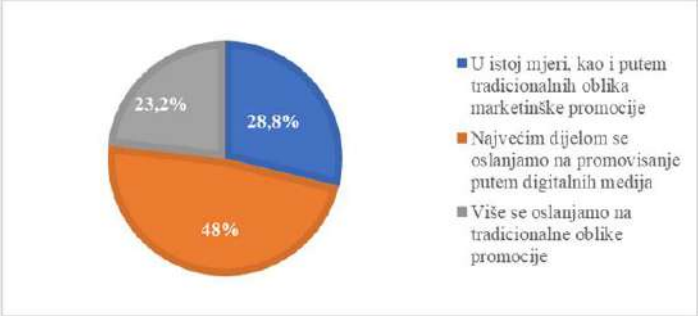

Grafikon 11. Da li ste upoznati sa mogućnostima targetiranja Vaše ciljne grupe koje pružaju neki digitalni mediji?
Figure 11. Are you familiar with the possibilities of targeting your target group provided by some digital media?

Posmatrajući podatke iz grafikona 11 uočava se da je najveći procenat ispitanika 34.4% upoznato sa mogućnostima targetiranja njihove ciljne grupe koje pružaju neki digitalni mediji i da to koriste, dok je 25.6% ispitanika upoznato sa mogućnostima targetiranja ciljnih grupa putem društvenih mreža, ali njihova preduzeća ne koriste tu opciju. Sa druge strane, 40% ispitanika nije upoznato sa tom mogućnošću. Ovi rezultati ukazuju na varijaciju u poznavanju i korišćenju mogućnosti targetiranja ciljne grupe putem digitalnih medija među ispitanicima, ali i na nedovoljno poznavanje pozitivnih ishoda primjene. Prepoznavanje i korišćenje ove opcije može pomoći preduzećima da bolje usmjere svoje napore i marketinške aktivnosti prema ciljnoj publici i postignu veći uspjeh u komunikaciji sa potrošačima.



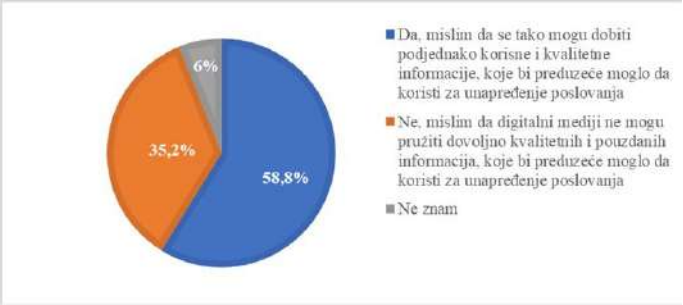

Grafikon 12. Koliki procenat budžeta se u Vašem preduzeću izdvaja za marketing na digitalnim medijima?
Figure 12. What percentage of the budget is allocated in your company for marketing on digital media?

Najveći procenat ispitanika 52.4%, izdvaja između 3% i 5% svog budžeta za ovu svrhu, dok, 32.8% ispitanika izdvaja manje od 2% budžeta za marketing na digitalnim medijima. Manji procenat ispitanika, 9.2%, izdvaja od 6% do 10% budžeta, dok samo 5.6% ispitanika izdvaja više od 10% budžeta za marketing na digitalnim medijima. Nedovoljna svijest o potencijalima društvenih medija, tradicionalni pristup marketingu, nejasnoće u merenju povratka ulaganja, nedostatak stručnosti i resursa samo su neki od potencijalnih razloga nedovoljnog ulaganja u marketing na društvenim medijima.




Grafikon 13. Koliko se Vaše preduzeće oslanja na oglašavanja i aktivnosti na digitalnim medijima u odnosu na tradicionalne oblike marketinške promocije?
Figure 13. How much does your company rely on advertising and activities on digital media compared to traditional forms of marketing promotion?

Najveći procenat ispitanika 48% ističe da se njihovo preduzeće najvećim dijelom oslanja na promovisanje putem digitalnih medija, dok je 28.8% ispitanika naglasilo da njihovo preduzeće koristi društvene medije i tradicionalne oblike promocije u jednakoj mjeri. Najmanji procenat ispitanika 23.2% više se oslanja na tracionalne oblike promocije. Ovi podaci ukazuju na postojanost pomaka u korišćenju marketinških kanala, pri čemu se sve više preduzeća oslanja na digitalne medije za promovisanje svojih proizvoda i usluga. Međutim, još uvek postoji određeni broj preduzeća koji preferiraju tradicionalne oblike promocije što može ukazivati na specifičnost njihovog poslovanja i ciljne grupe ili neprepoznavanje značaja promovisanja putem digitalnih medija



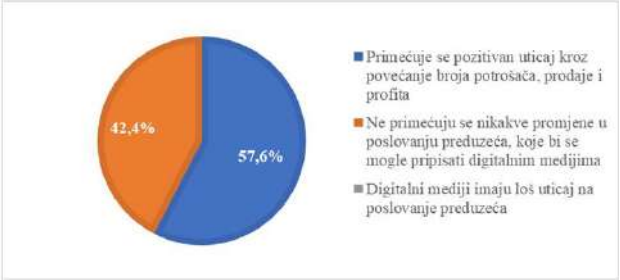

Grafikon 14. Da li smatrate da se aktivnim korišćenjem digitalnih medija i interakcijom sa potencijalnim potrošačima, može uštedeti dosta novca, koji bi preduzeće potrošilo na klasično istraživanje tržišta?
Figure 14. Do you think that by actively using digital media and interacting with potential consumers, a lot of money can be saved, which the company would spend on classic market research?

Podaci sa grafikona 15 pokazuju da većina ispitanika 58.8% smatra da aktivno korišćenje digitalnih medija i interakcija sa potrošačima može dovesti do uštede novca koji bi inače bio potrošen na klasično istraživanje tržišta. Međutim, postoji i značajan procenat ispitanika 35.2% koji ne vjeruje da društveni mediji mogu pružiti dovoljno kvalitetnih i pouzdanih informacija, dok 6% ispitanika nije sigurno po pitanju prethodna dva stava. Važno je da preduzeća pažljivo procijene prednosti i ograničenja digitalnih medija u kontekstu istraživanja tržišta i prilagode svoje strategije u skladu sa tim.

Razmatrajući podatke iz grafikona 16 uočava se velika zastupljenost ispitanika 91.2% koji smatraju da je prisutnost preduzeća na digitalnim medijima od velikog značaja za bolju informisanost potrošača o proizvodima/uslugama preduzeća i 90.4% ispitanika koji ističu jačanje brenda i reputacije preduzeća kao benefit prethodno navedenog. U bliskom procentu ispitanici smatraju važnost prisutnosti preduzeća na digitalnim medijima zbog brzine dobijanja povratnih informacija od potrošača 37.2% i razvijanje intenzivnijeg i lojalnijeg odnosa sa potrošačima 36.8%.

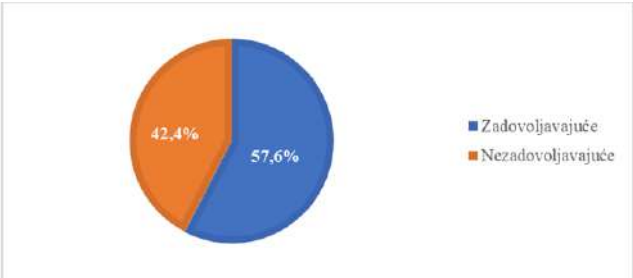
Grafikon 16. Prema Vašem mišljenju, zašto je važno da Vaše preduzeće bude prisutno na digitalnim medijima?
Figure 16. In your opinion, why is it important for your company to be present on digital media?

Najmanji procenat ispitanika kao benefit prepoznaje važnost prisustva preduzeća na digitalnim medijima u kontekstu kreiranja i provjere novih ideja 26% i različite oblike promocije i pogodnosti za potrošače koji prate preduzeće na digitalnim medijima 27.2%. Prethodni podaci potvrđuju značajan uticaj digitalnih medija na poslovanje preduzeća, pružajući brojne koristi u pogledu komunikacije, angažmana potrošača i izgradnje brenda. Preduzeća koja su prisutna na digitalnim medijima imaju priliku da uspostave direktan i interaktivan odnos sa potrošačima, što može doprinjeti njihovom uspjehu i boljem pozicioniranju na tržištu.




Grafikon 17. Kako procenjujete doprinos digitalnih medija poslovanju Vašeg preduzeća?
Figure 17. How do you assess the contribution of digital media to the business of your company?

Podaci iz grafikona 17 odnose se na stavove ispitanika o doprinosu digitalnih medija u poslovanju njihovih preduzeća. Rezultati pokazuju da većina ispitanika 57.6% primjećuje pozitivan uticaj digitalnih medija kroz povećanje broja potrošača, prodaje i profita. Sa druge strane, 42.4% ispitanika nije primijetilo nikakve promjene u poslovanju preduzeća koje bi se mogle pripisati digitalnim medijima. Prethodni podatak može ukazivati na nedostatak adekvatne strategije ili neiskorišćen potencijal digitalnih medija u datim preduzećima.




Grafikon 18. Kako ocenjujete prisutnost Vašeg preduzeća na digitalnim medijima?
Figure 18. How do you evaluate your company's presence on digital media?

Podaci iz grafikona 18 se odnose na ocjenu prisutnosti preduzeća na digitalnim medijima. Rezultati pokazuju da 57.6% ispitanika ocenjuje prisutnost svog preduzeća na digitalnim medijima kao zadovoljavajuću, dok 42.4% ispitanika smatra da je prisutnost nezadovoljavajuća. Prethodni podatak ukazuje na važnost pravilnog korišćenja digitalnih medija i adekvatnog upravljanja prisutnošću na tim platformama, kao i prostoru za poboljšanje istog. Preduzeća koja su zadovoljna svojom prisutnošću trebaju nastaviti sa uspešnim praksama i dalje unapređivati komunikaciju i angažovanje sa pratiocima. S druge strane, preduzeća koja su nezadovoljna prisutnošću na digitalnim medijima trebaju pažljivo analizirati svoje strategije i identifikovati oblasti za poboljšanje, kako bi bolje iskoristili potencijal digitalnih medija za svoje poslovanje.

## ZAKLJUČCI

Preduzeća trebaju prihvatiti činjenicu da digitalni mediji nisu samo prolazni trend, već neizostavan dio poslovnog svijeta. Njihova prisutnost omogućava kompanijama da dosegnu širu publiku, uspostave direktan i interaktivan kontak sa potrošačima i pruže personalizovano iskustvo.

Uzimajući u obzir brzi razvoj tehnologije i promjene u navikama potrošača, preduzeća moraju biti spremna prilagoditi se i iskoristiti sve mogućnosti koje digitalni mediji pružaju. Prethodno uključuje pravilno korišćenje digitalnih medija, razvoj sadržaja koji je relevantan i privlačan za ciljnu grupu, praćenje i analizu rezultata kampanja i prilagođavanje strategija u skladu sa tim. Pored toga, preduzeća trebaju uložiti napore u regrutovanje ili obuku osoblja koje je specijalizovano za upravljanje digitalnim medijima, a koji bi bili odgovorni za vođenje kampanja na društvenim mrežama, stvaranje sadržaja, targetiranja ciljane grupe, praćenje rezultata i održavanje kvalitetne interakcije sa pratiocima i potrošačima. Dolazak do informacija o najnovijim trendovima, takođe, je ključno za uspješno korišćenje ovog kanala komunikacije. Prethodno može uključivati praćenje konkurentskih kampanja, analizu njihovih strategija i identifikaciju prilika za inovaciju i poboljšanje vlastitih marketinških aktivnosti.

Uz sve navedeno, važno je da preduzeća budu svjesna uticaja digitalnih medija na njihovu reputaciju. Negativne povratne informacije ili loše upravljanje kriznim situacijama putem digitalnih medija mogu imati dugoročne posljedice po ugled i povjerenje potrošača. Digitalni mediji pružaju direktan pristup u povezivanju sa potrošačima i otvaraju mogućnosti razvoja kroz uvažavanje potrošačkih komentara i sugestija. Otvorena i proaktivna komunikacija sa potrošačima može biti ključni faktor za postizanje uspeha na tržištu i unapređenje poslovanja. Prisustvo autentičnosti na digitalnim medijima igra ključnu ulogu u uspjehu kompanija. Potrošači danas sve više cijene autentičnost i autentične priče. Kompanije koje uspiju prenijeti svoje vrijednosti, misiju i priče na autentičan način stvaraju dublju vezu sa potrošačima. Autentičnost stvara povjerenje, poboljšava percepciju brenda i povećava lojalnost potrošača.

Generalno posmatrano, korišćenje digitalnih medija u poslovanju zahtijeva sveobuhvatan pristup koji uključuje kontinuirano praćenje trendova, kvalitetan sadržaj i stručnjake za upravljanje. Ulaganje u ove aspekte može omogućiti preduzećima da iskoriste pun potencijal digitalnih medija i ostvare uspjeh. Imajući u vidu prethodno navedeno, može se zaključiti da efektivna upotreba digitalnih medija u savremenom poslovanju direktno doprinosi boljem pozicioniranju i diferencijaciji kompanije na tržištu i dovodi do većeg stepena lojalnosti potrošača i postizanja konkurentske prednosti, dokazana.

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# THE INFLUENCE OF DIGITAL MEDIA ON MODERN BUSINESS

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**ABSTRACT**

The modern era is shaped by intense competition and demanding consumers, which is why companies abandon traditional communication methods and focus on digital media imposed by the development of information technologies. The presence of the company on the Internet is not a goal, but something that is taken for granted. The attention of the management of a successful company is focused on interactive content, which is created by the wider social community, not just the company. In this way, the company quickly and easily obtains information about the market in which it operates, the behaviour of consumers who use or want to use their products and services, creates campaigns that spread virally, blogs, communicates two-way with consumers, promotes its values and way of doing business . The research goal of this paper is an analysis of how digital media influence modern business. The results of empirical research have shown that the effective use of digital media in modern business directly contributes to better positioning and differentiation of the company on the market and leads to a greater degree of consumer loyalty and achieving a competitive advantage.

**Keywords:** digital media, management, communication, business.

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# ZAJEDNIČKA AGRARNA POLITIKA EVROPSKE UNIJE I ODRŽIVI TRENDOVI U ISHRANI

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## SAŽETAK

Zajednička poljoprivredna politika Evropske unije za period 2023-2027 ima za cilj da zaustavi degradaciju životne sredine i preokrene je u korist ublažavanja klimatskih promena, efikasnog korišćenja ograničenih prirodnih resursa i očuvanja biodiverziteta. Poljoprivreda u Evropskoj uniji (EU) je pod jakim uticajem Zajedničke agrarne politike (ZAP). Međutim, usklađivanje poljoprivredne politike sa ishranom je složeno, prvenstveno zbog toga što su ciljevi poljoprivredne politike pretežno ekonomski, što predstavlja izazov za razvoj koherentnosti između poljoprivredne, trgovinske i zdravstvene politike. Danas evropski prehrambeni sistem karakterišu nezdravi prehrambeni trendovi, ekološki neodrživa proizvodnja i zavisnost od starenja poljoprivrednog stanovništva. Poljoprivredni sistemi i ishrana treba da budu održivi sa stanovišta životne sredine i zdravlja, tako da povećanje njihove održivosti mora biti glavni cilj poljoprivrednih i prehrambenih politika. Nažalost, klimatski, ekološki i zdravstveni šokovi će se verovatno povećati u narednim godinama. Zbog toga je izuzetno važno favorizovati zdraviju i ekološki prihvatljivu ishranu kroz promenu ponašanja potrošača kroz preporuke o ishrani i nutritivne oznake. Tekuća reforma Zajedničke agrarne politike (ZAP) predstavlja priliku za rešavanje ovih pitanja. Prepoznajući hitnost prelaska na održive sisteme ishrane, evropsko civilno društvo i druge organizacije od javnog interesa su pokazale doslednu podršku i konstruktivan angažman u strateškom planu od farme do viljuške. Cilj rada je da ukaže na značaj inkorporiranja pitanja održive ishrane u Zajedničku poljoprivrednu politiku Evropske unije.

**Ključne reči:** Zajednička agrarna politika Evropske unije, bezbednost hrane, održivi sistem ishrane, ishrana, Evropska unija.

## UVOD

Poslednji Sporazum o reformi Zajedničke agrarne politike Evropske unije je zvanično usvojen 2021. godine, a stupio je na snagu januara 2023. godine i kao takav, najsavremeniji, trasira put ka zelenoj Zajedničkoj agrarnoj politici Evropske unije koja će biti zasnovana na rezultatima. Cilj je da se pruži podrška malim farmerima koji će graditi svoju budućnost na održivim osnovama uz povećanje svesti o značaju biodiverziteta i zaštite životne sredine. Kvalitet hrane je imperativ i stoga ne bi trebalo da se dovodi u pitanje. U sklopu mera ruralnog razvoja cilj je povećati nivo konkurentnosti poljoprivrede, i to na osnovu povećanja nivoa obrazovanja i svesti ljudi koji žive u tim područjima ali i na osnovu primene inovacija. Potrebno je da se tim ljudima omogući da imaju adekvatan dohodak kako bi svoj životni standard povećali, ali ako povećanje dohotka ne prati nivo njihovog znanja onda je trud uzaludan. Stoga je važno uticati na te ljude da postanu otvorenijeg uma i da shvate kako samo ostvarenje prihoda nije jedini cilj njihovog mukotrpnog rada. Važno je da odgovorno postupaju prema ograničenim prirodnim resursima i da se u svom radu trude da što više ublaže efekte klimatskih promena. Dakle važno je pored ekonomske uključiti i socijalnu i ekološku komponentu u njihov život i rad, što će u krajnjem doprineti ostvarenju ciljeva Zajedničke agrarne politike Evropske unije moći da se ostvare.

Slobodna trgovina unutar Evropske unije, ali i liberalizacija trgovine kao jedan od ciljeva Svetske trgovinske organizacije dovode do toga da je u svakoj zemlji članici Evropske unije velika ponuda poljoprivrednih i prehrambenih proizvoda, koji se razlikuju po kvalitetu, asortimanu i ceni.

Ono što je obeležje XXI veka jeste kvalitet i to pre svega kvalitet hrane, pa je stoga neophodno voditi računa o tome da se ljudi hrane zdravo, i da je hrana zdravstveno bezbedna za upotrebu. To je imperativ koji važi u Evropskoj uniji, pa je stoga potrebno da sve zemlje koje žele da budu deo Evropske unije ili da sa njom sarađuju usaglase svoje zakonodavstvo u oblasti bezbednosti i kvaliteta hrane.

Cilj u ishrani stanovništva u Evropskoj uniji je da se obezbedi zdrava hrana za sve uz poštovanje ekoloških pravila koja podrazumevaju ublažavanje klimatskih promena i očuvanje biodiverziteta. Ovaj zadatak je izuzetno težak i zahteva sistemski pristup, pa je potrebno implementirati strategiju koja je u skladu sa Zelenim dogovorom, a to je strategija „Od farme do viljuške“ Stoga će u ovom radu biti nešto više reči o globalnom prehrambenom sistemu i njegovom štetnom uticaju na životnu sredinu, da bi se došlo do objašnjenja zašto je neophodno poljoprivredu i proizvodnju hrane učiniti održivom i bezbednom po zdravlje ljudi. U pozadini se svakako nalazi najnovija reforma Zajedničke agrarne politike Evropske unije i Zeleni dogovor, čije su strategije međusobno isprepletane, a to su strategija očuvanja biodiverziteta i strategija „Od farme do viljuške“.

## GLOBALNI PREHRAMBENI SISTEM I NJEGOV UTICAJ NA PRIRODU

Neosporiva je činjenica da prehrambeni sistem u svetu ne uspeva da zadovolji potrebe svih stanovnika planete Zemlje za kvalitetnom hranom. 2021. godine je čak 828 miliona ljudi gladovalo (United Nations [UN], 2022). S druge strane, oko 30% proizvedene hrane se ne pojede, a otpad od hrane izaziva čak 8-10% od ukupnog efekta staklene bašte (United Nations Environment Programme [UNEP], 2021).

Vrlo malo se u javnosti govori o emisijama štetnih gasova iz proizvodnje hrane i od bacanja hrane. Ekološki otisak čovečanstva je veliki i čak 30% tog otiska dolazi od aktivnosti vezanih upravo za hranu. Prema izveštaju UNEP-a iz 2021. godine, globalni prehrambeni sistem čini čak 37% svetske emisije štetnih gasova i to od onoga šta se uzgaja, jede, od šume koja se seče, ali i od hrane koja se baca (UNEP, 2021).

Istraživanja Džozefa Pura i Tomasa Nemečeka iz 2018. godine govore o ekološkom otisku vezanom za hranu. Prema ovom istraživanju najveći negativni uticaj na životnu sredinu ima upravo proizvodnja hrane od goveđeg mesa, jer dovodi do proizvodnje 99,48 kg ugljen dioksida ko kilogramu mesa, ali važno je napomenuti da je ovo prosečna veličina, odnosno ne odnosi se ni na jednu konkretnu zemlju, pošto svaka zemlja ima svoj specifičan način proizvodnje hrane od goveđeg mesa (Poore, & Nemecek, 2018). Ovaj podatak ne treba da obeshrabri ljude da pripremaju jela od goveđeg mesa, ali ima za cilj da ukaže na važnost promene načina uzgoja stoke i njene obrade prilikom proizvodnje hrane, kako bi se ekološki otisak od ove aktivnosti sveo na minimum. Na primer, razlika se ogleda u tome da li ta životinja šeta napolju i hrani se prirodno ili sedi u zatvorenom prostoru i hrani se isključivo veštačkom hranom, ali razlika postoji i u pogledu toga da li ta životinja pruža jedan ili više proizvoda za ishranu ljudi. Zemlja koja uspešno minimizuje ekološki otisak od uzgoja stoke je Finska zato što od jedne vrste stoke proizvodi više vrste hrane, a tu stoku hrani isključivo domaćom a ne veštačkom hranom. Ostale zemlje pretežno koriste soju koju uvoze, a da bi se proizvela soja potrebno je krčiti velike površine šuma da bi se napravilo mesto za farme soje za proizvodnju stočne hrane, što je veliki ekološki problem (Cottee, McCormack, Hearne, & Sheane, 2022).

## ODRŽIVA PROIZVODNJA HRANE U EVROPSKOJ UNIJI

Veliko tržište Evropske unije čini da je prehrambeni sistem Evropske unije jako složen ali i neodrživ. Proces proizvodnje hrane ali i drugih proizvoda je takav da se koriste hemikalije, koje se potom ispuštaju u vodu, vazduh, zemljište, i na taj način se utiče štetno na životnu sredinu i klimu. Upotreba savremene tehnike, ali i različitih aditiva u industrijskoj proizvodnji hrane stoga dovodi do proizvodnje hrane koja je jeftinija, nego kada bi se proizvodila ručno, na tradicionalni način (Food and Agriculture Organization of the United Nations [FAO], 2015).

Održiva proizvodnja hrane je prioritet u Zajedničkoj agrarnoj politici Evropske unije, ali je jako teško ostvariti ovaj cilj. Najpre je potrebno promeniti način razmišljanja kod poljoprivrednih

proizvođača i nosioca agrarne politike koji se do sad zasnivao na ostvarenju dovoljnosti u proizvodnji hrane po niskoj ceni. Danas u eri popularizacije ciljeva održivog razvoja potrebno je poboljšati efikasnost resursa u sistemu proizvodnje hrane sa fokusom na svest potrošača. Na ovaj način, doći će do smanjenja negativnog uticaja proizvodnje hrane na životnu sredinu, ali to ne znači da je došlo do promena u ishrani kod potrošača. Da bi ta promena bila definitivna potrebno je da se aktivno utiče na svest potrošača o značaju promena navika u ishrani. Što se tiče troškova proizvodnje hrane i cene hrane po kojoj će se ona prodavati potrebno je izvršiti rebalans, kako bi održivi proizvodi postali jeftiniji i pogodniji za potrošače, dok bi neodrživi proizvodi postali skuplji. Na taj način bi se potrošači pre odlučili da kupe održive proizvode, jer bi pored zdravstvenih benefita koje ta hrana nudi, i cena tih proizvoda bila niska.

Da bi se sprovela ovakva transformacija potrebno je kreirati određene alate. Koji će alati biti korišćeni zavisi od rezultata istraživanja na konkretnom tržištu, ali svakako bi moglo da se koristi dodatno oporezivanje nezdravih proizvoda na način koji zadovoljava socijalnu pravdu i pristup visokokvalitetnoj hrani za sve. Prihodi koji se uberu od ovih poreza mogli bi da se koriste za promovisanje zdravih navika u ishrani, ali i za subvencionisanje održive proizvodnje. Moguće je i da se uvedu različiti porezi na upotrebu štetnih hemikalija u procesu proizvodnje hrane, kako bi se takva proizvodnja smanjila na minimum ili eliminisala. Potrebno je i ohrabriti članice Evropske unije da koriste snižene stope poreza na dodatu vrednost kod održivih prehrambenih proizvoda kako bi zdrava hrana bila pristupačnija za tržište Evropske unije.

## PROBLEMI SA KOJIMA SE SUOČAVA ZAJEDNIČKA AGRARNA POLITIKA EU

Ozbiljan problem sa kojim se suočava Evropska unija u tekućem periodu jeste potencijalna nestašica hrane i to žitarica i stočne hrane, koje Evropska unija uvozi iz Rusije i Ukrajine. Rusija i Ukrajina su vodeći svetski proizvođači i izvoznici ovih namirnica, a rat u Ukrajini i međunarodne sankcije Rusiji ugrožavaju uvoz ovih proizvoda u Evropskoj uniji (FAO, 2022). Očekivanja su da će ukrajinska proizvodnja ozimih žitarica, kukuruza i suncokreta biti smanjena tokom ovog perioda barem za 20-30%, a ista su i očekivanja vezana za uvoz iz Rusije. Ovo je razlog što su Evropski parlament i administracije nekih zemalja Evropske unije odlučile da povećaju obim poljoprivredne proizvodnje uz popuštanje ili uklanjanje ekoloških preporuka (European Council, 2022).

FAO drugačije gleda na moguće uticaje ovih sukoba na snabdevenost hranom i sirovinama neophodnim za proizvodnju hrane. FAO smatra da bez obzira na nemogućnost uvoza ovih sirovina iz Rusije i Ukrajine, Evropska unija treba da se odluči za:

- izbor alternativnih dobavljača,
- korišćenje obaveznih rezervi,
- diversifikaciju domaće poljoprivredne proizvodnje ali i
- smanjenje zavisnosti od đubriva i smanjenje bacanja hrane.

Na taj način neće biti potrebe da se zanemari poštovanje ekoloških preporuka, pa će se ciljevi Zajedničke agrarne politike Evropske unije ostvarivati po predviđenom planu, a evropske potrebe za hranom će biti zadovoljene (FAO, 2022). U izveštaju Evropske komisije za 2022. godinu se navodi da snabdevanje hranom nije ugroženo u Evropskoj uniji, pa stoga nema razloga za brigu (European Commission, 2022a).

S obzirom na navedene okolnosti, očigledno je da se u smislu zaštite tržišta hrane Evropske unije očekuje upotreba neobradivog zemljišta u cilju proizvodnje hrane za ishranu životinja. Na taj način će se dobiti poljoprivredni proizvodi koji će se makar koristiti za ishranu stoke i za izvoz stočne hrane, što nije u skladu sa Zelenim dogovorom Evropske unije zbog negativnog uticaja na vazduh, zemljište i kvalitet vode (European Feed Manufacturers' Federation [FEFAC], 2021). Pored toga ovakva proizvodnja će dodatno ugroziti strategiju Zajedničke agrarne politike Evropske unije – od farme do viljuške, a vezano za smanjenje potrošnje mesa kako bi se podstakla zdravija ishrana među stanovnicima Evropske unije (European Commision, 2022b) (slika 1.). Zaključak je da će podsticanje stočarstva kroz obradu neobradivih površina naneti dodatnu štetu životnoj sredini, povećati gubitak biodiverziteta i povećati rizike po javno zdravlje.

Shodno navedenom, moraju se tražiti održive alternative u cilju poboljšanja prehrambenih navika u ishrani evropskog stanovništva. Te alternative podrazumevaju agroekološke pristupe za povećanje proizvodnje i to kroz unapređenje usluga kao što su oprašivanje i biološka kontrola, prilagođavanje obima obradivih površina u odnosu na strukturu i sastav pejzaža, ali i premeštanje useva koji su traženi u oblastima u kojima se proizvode (Beyer et al., 2022).

Dobro je poznato da je Zajednička agrarna politika najkomplikovanija jer sadrži trećinu propisa Evropske unije, ali je i jedna od najskupljih politika koje sprovodi Evropska unija. Stoga sav trud i novac potrošeni godinama unazad bili bi uzalud u slučaju da se skrene sa puta održive poljoprivredne proizvodnje koja podrazumeva poštovanje Zelenog dogovora. Ukoliko Evropska unija padne u iskušenje i odstupi sa svog puta održivosti, ugroziće svoje prethodne rezultate i neće moći da ostvari ekološke i socijalne ciljeve Zajedničke agrarne politike (European Commision, 2022c).

Slika 1. Strategija "Od farme do viljuške" (European Commission, 2022).
Figure 1. "Farm to Fork" Strategy (European Commission, 2022).

## VAŽNOST STVARANJA ZDRAVIH PREHRAMBENIH NAVIKA

Nedavna kriza izazvana Covid-19 virusom uticala je na to da ljudi obrate više pažnje na svoje zdravlje. Zdravlje može da se posmatra kao ograničen resurs, koji se troši, ali da bi što duže trajalo mora da se neguje. Često se spominje da je neophodno gajiti zdrave stilove života kako bi ljudi što duže živeli. Zdrav stil života svakako podrazumeva i zdravu i izbalansiranu ishranu. Ali šta to znači u eri kada se ceo svet bori za održivi razvoj, očuvanje biodiverziteta i ublažavanje klimatskih promena? Pitanje je jako široko i kompleksno, a cilj je inkorporirati zdrave trendove u nutricionizmu u Zajedničku agrarnu politiku Evropske unije.

Zabetakis i drugi su objasnili kako stil života može imati uticaj na ishod u slučaju bolesti (Zabetakis et al., 2020). U tom radu su pokazali kako pravilna ishrana može ublažiti simptome bolesti i doprineti razvoju imuniteta. Identifikovali su vrste hrane i ključne hranljive materije od značaja koje mogu uticati na pozitivan ishod bolesti. S obzirom na to da je u ovom radu konkretno bilo reči o virusu Covid-19, koji je u velikom broju slučajeva izazivao upale pluća, jasno je da u slučaju virusnih infekcija zdrava i kvalitetna ishrana doprinosi poboljšanju zdravstvenog stanja stanovništva i to dvostruko – kroz dalje sprečavanje progresije bolesti i kroz smanjenje uticaja tog virusa na imuni sistem ljudi. Stoga je usvajanje i negovanje trenda proizvodnje zdrave i kvalitetne hrane prioritet u Zajedničkoj agrarnoj politici Evropske unije.

Pored pandemije izazvane Covid-19 virusom i uticaja ishrane na proces izlečenja, u mnogim evropskim zemljama je sve veći broj gojaznih ljudi koji sve više pate od kardiovaskularnih bolesti. Dakle postoje veliki zdravstveni rizici povezani sa visokokaloričnom i neuravnoteženom ishranom. Stoga, potrebno je kreirati i forsirati alate i instrumente uz pomoć kojih će doći do poboljšanja kvaliteta ishrane ljudi. Do sada su ti alati korišćeni u svrhu boljeg informisanja potrošača o zdravstvenim prednostima korišćenja neke vrste hrane. Bili su u obliku preporuka za ishranu, kampanja o važnosti zdrave ishrane ili u obliku označavanja pakovanja gde postoji nutritivni skor neke konkretne namirnice.

Kada je reč o preporukama vezanim za ishranu, one se koriste u mnogim zemljama, a njima se bave nacionalne agencije za bezbednost hrane i unapređenje javnog zdravlja (Herforth et al., 2019). One se sprovode periodično i to putem različitih tradicionalnih i digitalnih kanala komunikacije. Nakon ovih kampanja sprovodi se evaluacija koja ima za cilj da pokaže da ove preporuke imaju pozitivan uticaj na promene u trendovima vezanim za ishranu ljudi. Međutim, rezultati su uglavnom skromni (Capacci, & Mazzocchi, 2011). Ove preporuke mogu biti uključene i u školske programe jer se zdrave navike najbolje usvajaju u ranom dečjem uzrastu (Murimi et al., 2018).

Drugi instrument koji se koristi za usmeravanje nutritivnih trendova jeste i obeležavanje proizvoda koje ima za cilj da utiče na ponašanje potrošača pri izboru hrane. Međutim, te informativne oznake koje ukazuju na nutritivni sastav prehrambenih i dalje imaju slab uticaj na potrošače (Shangguan et al., 2019). Potrošači generalno ne razumeju nutritivne informacije i obično imaju ograničeno vreme za kupovinu. Često je i cena faktor koji utiče na odluku potrošača o kupovini. Stoga postoje preporuke da pored obeležavanja proizvoda, nutritivne oznake sadrže i rangiranje proizvoda kako bi potrošači bili svesni eksplicitnih informacija o posledicama koje taj proizvod može da izazove njegovim konzumiranjem. U te svrhe neke zemlje su već uvele tzv. semafor oznake, korišćenjem logotipa na prednjoj strani pakovanja, gde se crvenom bojom označavaju proizvodi koji mogu imati negativne efekte po zdravlje potrošača, a zelenom proizvodi koji su bezbedni. Cilj ovih oznaka je da proizvodi privuku pažnju potrošača, kako bi se kreirala svest o štetnom uticaju pojedinih proizvoda na zdravlje potrošača (Muller et al., 2019). Usvajanje ovih oznaka je neophodno u Zajedničkoj agrarnoj politici Evropske unije.

Pored ovih kampanja potrebno je skrenuti pažnju javnosti o neophodnosti smanjivanja upotrebe soli, šećera i masti u hrani u cilju poboljšanja zdravstvenog stanja. Međutim, ljudi se teško odlučuju na promene, pa je potrebno sprovesti više prinudnih inicijativa zasnovanih na prehrambenim standardima. Kao instrument mogu da se koriste i cene hrane. Moguće je uvesti tzv. „poreze na nezdravu hranu“ kako bi se ograničila potrošnja nezdravih proizvoda. Postoje studije koje su rađene na ovu temu, pa je zaključeno da ovakve poreske politike utiču pozitivno na potrošače da poboljšaju kvalitet svoje ishrane, ali s druge strane ovakva politika negativno deluje na potrošače sa niskim primanjima koji sada zbog viših cena ranije jeftinih proizvoda ne mogu sebi da priušte dovoljno hrane za jedan obračunski period (Détang-Dessendre et al., 2020).

## STRATEGIJA „OD FARME DO VILJUŠKE“

Već duže vreme je fokus na ciljevima održivog razvoja, koji su institucionalizovani kroz Agendu 2030. Kao rezultat nastojanja da Evropa bude prvi klimatski neutralni kontinent nastao je Zeleni dogovor. Zeleni dogovor je zapravo jedan od šest prioriteta Evropske komisije. Strategija „Od farme do viljuške“ deo je Zelenog dogovora, a predstavlja pokušaj da se kreira zdrav, ekološki prihvatljiv i pravičan sistem ishrane (Eur-lex, 2019). Podrazumeva eliminisanje nedostataka u lancu ishrane između proizvođača i potrošača hrane. U nekim segmentima se poklapa sa strategijom Evropske unije o očuvanju biodiverziteta. Počiva na sledećim ciljevima (Wesseler, 2022):

- smanjene upotrebe hemijskih pesticida za 50%,
- smanjenje upotrebe opasnih pesticida za 50%,
- smanjenje gubitka hranljivih materija za 50% bez smanjenja plodnosti zemljišta,
- smanjenje upotrebe đubriva za 20%,
- smanjenje prodaje antimikrobnih sredstava za upotrebu u poljoprivredi za 50%,
- povećanje obradive površine gde se vrši organska proizvodnja hrane za 20%,
- smanjenje bacanja hrane za 50%,
- investiranje u istraživanja i inovacije vezanih za hranu, bioekonomiju, prirodne resurse, poljoprivredu, ribarstvo, akvakulturu i životnu sredinu.

Inače u periodu od početka primene ove strategije do danas, evropski program održive ishrane sukobio se sa čak dve krize – sa pandemijom izazvanom Covid-19 virusom i sa ratom u Ukrajini, a nisu za zanemarivanje ni klimatske promene koje su izazivale brojne požare i poplave.

Tu je i gojaznost, kao sve veći problem sa kojim se suočava ne samo Evropska unija nego i čitav svet, pa je neophodno što pre preći na održive sisteme ishrane.

Upravo zbog ovih problema sa kojima se suočava strategija „Od farme do viljuške“ postoje nastojanja da se odustane sa implementacijom ove strategije. S obzirom na sve negativne efekte koje ove promene nose sa sobom, neophodno je još više se posvetiti realizaciji ove strategije, jer ona će doprineti ostvarenju brojnih benefita po zdravlje ljudi (European Public Health Alliance [EPHA], 2022):

doći će do efikasnijeg korišćenja zemljišta, čime će se povećati sigurnost hrane,

pošto će kvalitetna hrana biti dostupna svima, ostvariće se sistem ishrane zasnovan na zdravstvenoj pravičnosti,

doći će do ublažavanja klimatskih promena i očuvanja biodiverziteta jer samo u zdravoj životnoj sredini može da se proizvede zdrava hrana,

s obzirom na to da je fokus na očuvanju biodiverziteta, preći će se na održivi uzgoj životinja, dok će se ishrana ljudi više bazirati na biljnoj osnovi,

sistem ishrane će biti takav da će u prvi plan biti stavljen javni interes a to je zdravlje populacije.

## ZAKLJUČCI

Zeleni dogovor koji je nastao iz Agende 2030 podrazumeva ublažavanje klimatskih promena, očuvanje biodiverziteta, usvajanje i implementaciju strategije održive proizvodnje hrane i ishrane i u toku je realizacija istog. Reč je o izuzetno značajnoj strategiji koja ima za cilj očuvanje životne sredine uz postizanje ekonomskih i socijalnih ciljeva.

Međutim, s obzirom na aktuelna dešavanja u svetu, postavlja se pitanje da li će ciljevi Zajedničke agrarne politike Evropske unije, a konkretizovani kroz strategiju „Od farme do viljuške“ uspeti da se realizuju u planirano vreme. Mnogo je faktora koji su ograničavajući i samim tim ne deluju podsticajno na ostvarenje ovih ciljeva. Ali kako je ostvarenje ovih ciljeva od vitalnog značaja za postizanje održive proizvodnje i potrošnje hrane, kreatori politika ali i ostali učesnici u lancu ishrane treba što više da se trude.

Potrebno je naći pravi način da se ciljevi zacrtani ovom strategijom realizuju i to kroz oporezivanje neodrživih proizvoda, kako bi se cene održivih i samim tim zdravih proizvoda nivelisale sa neodrživim, ili bile čak i niže. U tom nastojanju ne sme se zaboraviti ni interes potrošača da kupi proizvode po prihvatljivim cenama, pa je potrebno sprovesti takve mere koje će i najsiromašnijima omogućiti da radije biraju zdravije proizvode.

Kako je velika zavisnost zemalja Evropske unije od uvoza đubriva i žitarica iz Rusije i Ukrajine, potrebno je smanjiti potrošnju đubriva, što je i definisano strategijom „Od farme do viljuške“. Potrebno je da veći broj zemalja sledi finski primer i da primeni njihov sistem uzgoja stoke, kako bi povoljno uticale na očuvanje biodiverziteta i poboljšanje kvaliteta zemljišta i hrane. Okolnosti u kojima trenutno funkcioniše svetska ekonomija nisu sjajne, ali je neophodno uložiti napor kako bi se realizovali ciljevi definisani Agendom 2030 i Zajedničkom agrarnom politikom Evropske Unije koja se odnosi na period do 2027. godine.

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# EUROPEAN COMMON AGRICULTURAL POLICY AND SUSTAINABLE NUTRITION TRENDS

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**ABSTRACT**

The common agricultural policy of the European Union for the period 2023-2027 aims to stop environmental degradation and reverse it in favour of climate change mitigation, efficient use of limited natural resources and biodiversity conservation. Agriculture in the European Union (EU) is strongly influenced by the Common Agricultural Policy (CAP). However, aligning agricultural policy with nutrition is complex, primarily because the objectives of agricultural policy are predominantly economic, which poses a challenge for developing coherence between agricultural, trade and health policies. Today, the European food system is characterized by unhealthy dietary trends, ecologically unsustainable production and dependence on an aging agricultural population. Agricultural systems and food diets should be sustainable from an environmental and health point of view, so increasing their sustainability must be a major objective of farm and food policies. Unfortunately, climate, environmental and health shocks are likely to increase in the coming years. Therefore, it is extremely important to favor a healthier and environmentally friendly diet through changing consumer behavior through dietary recommendations and nutritional labels. The ongoing reform of the Common Agricultural Policy (CAP) represents an opportunity to address these issues. Recognizing the urgency of transitioning to sustainable food systems, European civil society and other public interest organizations have shown consistent support and constructive engagement in the Farm to Fork Strategy Plan. The aim of the paper is to point out the importance of incorporating sustainable nutritional issues within the Common Agricultural Policy of the European Union.

**Keywords**: Common Agricultural Policy, food security, sustainable food system, nutrition, European union.

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# ZAJEDNIČKA AGRARNA I PREHRAMBENA POLITIKA: IZAZOVI ODRŽIVOSTI

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## SAŽETAK

Zajednička agrarna politika Evropske Unije je široko poznata već više od 60 godina. Cilj ove zajedničke politike je da se obezbedi adekvatna snabdevenost hranom s obzirom na to da nakon rata i godina gladi ljudi nisu mogli adekvatno da uživaju u prisustvu raznovrsnih namirnica. Danas, prehrambene sisteme karakteriše prekomerna proizvodnja prerađene hrane sa niskim sadržajem hranljivih materija. To je dovelo do popularizacije nezdrave i neuravnotežene ishrane širom Evropske unije, ali i do niza zdravstvenih rizika, posebno za siromašne grupe stanovništva. Prehrambeni i poljoprivredni sistemi Evropske unije zahtevaju fundamentalnu promenu pravca u svetlu ozbiljnih, međusobno povezanih i sistematskih ekonomskih, ekoloških i zdravstvenih izazova sa kojima se suočavaju. Danas, Zajednička agrarna politika podržava jedinstveno tržište Evropske unije za poljoprivrednim prehrambenim proizvodima po pristupačnim cenama, uz napomenu da se ruralne zajednice održavaju vitalnim a standardi životne sredine na visokom nivou. Nažalost, klimatske promene, emisija štetnih gasova, ratovi i epidemije negativno utiču na poljoprivrednu proizvodnju, što dovodi u pitanje bezbednost i kvalitet hrane, kao i zdravlje ljudi. Da bi se ispunila nova globalna očekivanja, nova Zajednička agrarna politika Evropske unije bi trebalo da se transformiše u Zajedničku agrarnu i prehrambenu politiku, koja bi imala za cilj da ojača otpornost čitavog lanca ishrane prepoznajući promenjene odnose snaga u lancu i interakciju između potrošnje i proizvodnje. Cilj ovog rada je da ukaže na napore koje Zajednička agrarna politika ulaže da kvalitetna i zdrava hrana bude dostupna svima. Zato ovaj rad obuhvata teme vezane za kvalitet i bezbednost poljoprivredno-prehrambenih proizvoda, njihov uticaj na zdravlje ljudi u pravcu Zajedničke poljoprivredne i prehrambene politike.

**Ključne reči:** Zajednička agrarna i prehrambena politika, Zajednička agrarna politika, bezbednost hrane, zdravlje, održivost.

## UVOD

Savremeni prehrambeni sistem karakterišu nezdravi trendovi u ishrani, ali i ekološki neodrživa proizvodnja hrane. Svaka reforma agrarne politike podrazumeva uklanjanje tekućih nedostataka u lancu ishrane, tako da svaka izmena Zajedničke agrarne politike predstavlja pokušaj da se reše neka goruća pitanja. Evropska unija ali i vlade širom sveta su saglasne da je potrebno usaglasiti poljoprivredu i prehranu kako bi se uticalo na kreiranje zdravih prehrambenih navika i zdrave životne sredine. Klimatske promene, nestanak biodiverziteta, povećanje učešća procesuirane hrane u ishrani ljudi, sve veći broj ljudi sa visokim indeksom telesne mase, ali i veliki broj pothranjenih i gladnih, sve veći broj onkoloških bolesnika, dijabetičara, kardiovaskularnih bolesnika, samo su neki od razloga što se mora posvetiti veća pažnja prehrambenoj politici koja je deo agrarne politike. Veliki problem je i ekološki otisak koji ostavlja čovečanstvo, a u velikom procentu ovaj otisak potiče iz aktivnosti vezanih za proizvodnju hrane. Stoga je potrebno postaviti osnove nove Zajedničke agrarne i prehrambene politike, gde će prehrambena politika zauzeti veće mesto u ukupnoj agrarnoj politici u periodu koji sledi. Očigledno je da je strateški značaj poljoprivrede u Evropskoj uniji ali i globalno veliki, ali potrebno je da se da novi strateški pravac proizvodnji hrane kako bi ona pozitivno uticala na životnu sredinu i kvalitet i bezbednost hrane, a time i zdravlje ljudi. Stoga je tema ovog rada upravo promena pravca u prehrambenoj politici u Evropskoj uniji u smislu da se proizvede zdrava, bezbedna hrana, na prirodan način, a da bude dostupna svima, čime bi se ispunio zahtev za socijalnom pravdom.

## ZAJEDNIČKA AGRARNA POLITIKA I EVROPSKI ZELENI DOGOVOR

Strategija "Od farme do viljuške" nastala je kao deo Zelenog dogovora, usvojenog 2020. godine. Inače Zeleni dogovor je nastao kao pokušaj Evropske unije da odgovori na sve oštrije klimatske promene, degradaciju životne sredine i gubitka biodiverziteta. Prema prognozama Evropske komisije, Zeleni dogovor će transformisati Evropsku uniju u modernu, efikasnu i konkurentnu ekonomiju, obezbeđujući da do 2050. godine bude eliminisana emisija štetnih gasova i da se ekonomski rast više ne vezuje za eksploataciju ograničenih prirodnih resursa (European Commission, 2022).

Inače instrumenti uz pomoć kojih trebaju da se ostvare ciljevi evropskog Zelenog dogovora su strategija „Od farme do viljuške", strategija biodiverziteta i akcioni plan cirkularne ekonomije. Strategija „Od farme do viljuške" je centar evropskog Zelenog dogovora (European Commission, 2020). Još uvek nije pravno obavezujuća politika, ali da bi se postigli njeni ciljevi, ona mora još više institucionalno da se podrži.

Države članice Evropske unije očekuju da će u narednom periodu, prema važećoj Zajedničkoj agrarnoj politici koja se odnosi na period od 2023. do 2027. godine ciljevi identifikovani kroz strategiju „Od farme do viljuške" postati obavezni deo Zajedničke agrarne politike. Ovi ciljevi se odnose na upotrebu đubriva, sredstava za zaštitu bilja, emisiju štetnih gasova, povećanje površina koje se odnose na organsku proizvodnju, smanjenje bacanja hrane, povećanje investicija u istraživanje i razvoj u oblasti poljoprivrede i bioekonomije. Važno je napomenuti da se ciljevi u modeliranju strategije „Od farme do viljuške" u velikoj meri poklapaju i sa ciljevima strategije biodiverziteta i sa akcionim planom cirkularne ekonomije, pa je izazov modelirati ovu strategiju tako da se izbegne preklapanje ciljeva na nivou ovih strategija. Na primer, povećanje organske proizvodnje samo po sebi podrazumeva smanjenje ili eliminisanje upotrebe pesticida i mineralnih đubriva, a ovde je već navedeno tri cilja ove strategije koji se međusobno preklapaju kroz jedan cilj.

## PREHRAMBENI SISTEM EVROPSKE UNIJE

Prehrambeni sistem Evropske unije se suočava sa čak tri izazova (The European Environment and Sustainable Development Advisory Councils Network [EEAC Network], 2022):

- garantovanje zdrave i bezbedne hrane svima,
- ublažavanje klimatskih promena i
- očuvanje životne sredine i biodiverziteta.

Trenutna situacija evropskog prehrambenog sistema je takva da on pruža ishranu koja je neodrživa jer ima jako mali uticaj na ostvarenje ovih izazova. Da bi se ova situacija rešila neophodan je sistemski pristup. Potrebno je rekonstruisati celokupni lanac snabdevanja u agrarnom sektoru kako bi prehrambeni sistem mogao da se transformiše. To znači da je neophodno ponovo definisati pozicije i uloge svih aktera u ovom lancu. Zato je neophodno usvajanje neke regulative u vidu zakona koja bi se bavila održivim sistemima ishrane, kako je i predloženo u strategiji „Od farme do viljuške" (EEAC Network, 2022).

To znači da ostvarenje ciljeva prehrambenog sistema Evropske unije znači prelazak na održivu ishranu. Zdrava hrana nažalost nije u velikoj meri pristupačna za potrošače jer je odlikuju visoke cene, pa stoga treba vršiti rebalans cena tako da se povećaju cene hrane koja je neodrživa. Ovde je jako važno voditi računa o tome da se ne ugrozi egzistencija najsiromašnijih slojeva stanovništva koji trenutno imaju samo za osnovne neodržive namirnice ili nemaju ni toliko novca. S druge strane, potrebno je zakonski usmeriti poštovanje ekoloških propisa u poljoprivredi kako se isti ne bi izbegavali zbog ostvarivanja većih prihoda. Ovo podrazumeva podudarnost između politike održivog prehrambenog sistema i socijalne i fiskalne politike država članica. Politika prehrambenog sistema treba da je usmerena ka očuvanju zdravlja ljudi i planete u celosti, a to podrazumeva održivo upravljanje poljoprivredom, životnom sredinom i potrošnjom hrane. Poslednja reforma Zajedničke agrarne politike Evropske unije podrazumeva da se deo nadležnosti

u okviru agrarne politike vrati zemljama članicama, pa se od njih očekuje da same spoznaju izazove i prilike kako bi u svojoj zemlji obezbedile održiv prehrambeni sistem.

Ovakva politika koristi različite instrumente kako bi se ostvarili zadati ciljevi. Najčešće korišćen jeste uklanjanje neodrživih proizvoda sa tržišta. Međutim da bi se takvi proizvodi uklonili potrebno je izvršiti klasifikaciju hrane u više ili manje održive vrste u okviru kategorije hrane. Tu su i cenovni mehanizmi, koji se ogledaju u oporezivanju neodrživih proizvoda. Pored ovih instrumenata interesantni su i nagrađivanje poljoprivrednika u slučaju da uspe da poveća održivost svoje proizvodnje.

## SNABDEVENOST HRANOM NAKON 2020. GODINE – BORBA PROTIV GLADI

Zajednička agrarna politika Evropske unije za period 2021-2027. godine počiva na ostvarenju čak devet ciljeva (Đurić et al., 2020):

- Obezbeđenje održivog dohotka poljoprivrednih gazdinstava i sigurnog snabdevanja hranom;
- Obezbeđenje veće tržišne orijentacije proizvođača i rasta konkurentnosti zasnovanog na istraživanju, novim tehnologijama i digitalizaciji;
- Unapređenje položaja poljoprivrednih proizvođača u prehrambenom lancu;
- Ostvarivanje doprinosa ublažavanju i prilagođavanju klimatskim promenama, kao i održivoj energiji;
- Obezbeđivanje podsticaja održivom razvoju na osnovu efikasnog upravljanja prirodnim resursima kao što su zemljište, voda i vazduh;
- Ostvarivanje doprinosa zaštiti biodiverziteta na osnovu očuvanja ekosistema i zaštite staništa i pejzaža;
- Motivisanje mladih poljoprivrednika i obezbeđivanje uslova za poslovanje u ruralnim područjima;
- Promovisanje zapošljavanja, rasta, socijalne inkluzije i lokalnog razvoja ruralnih područja, uključujući bioekonomiju i održivo šumarstvo;
- Odgovaranje na zahteve društva za zdravstveno bezbednom hranom i pružanje punog doprinosa dobrobiti domaćih životinja.

Kao što se vidi iz priloženih ciljeva, hrana se spominje u čak dva, dok se provlači kroz svih devet ciljeva Zajedničke agrarne politike Evropske unije. Posebno je važan deveti cilj, koji govori o proizvodnji zdravstveno – bezbedne hrane uz očuvanje fonda domaćih životinja. To znači da u periodu koji je u toku treba negovati zdrave prehrambene navike, kako bi se fond životinja očuvao, i radi očuvanja biodiverziteta.

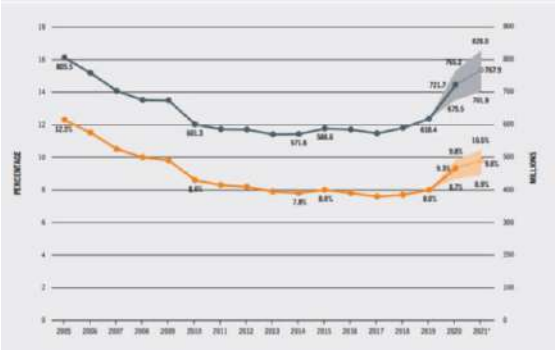
Nažalost, nije sve u rukama proizvođača i distributera hrane. Veliki deo odgovornosti u rešavanju ovih ciljeva je upravo na krajnjim potrošačima, koji trebaju usvojiti zdrave prehrambene navike. Svi bi želeli da koriste hranu koja je proizvedena na bezbedan način koji nije štetan po zdravlje. Međutim, kada je reč o zdravoj hrani, obično preferencije ka njoj rastu sa rastom dohotka i svesti ljudi o značaju zdrave ishrane, dok pojedinci sa nižim primanjima teže ka tome da ostvare osnovnu egzistenciju.

U ovoj analizi može se primeniti i Engelov zakon, po kome domaćinstva sa nižim prihodima najveći deo dohotka troše upravo na hranu (hranu sa nižom cenom, samim tim neodrživu hranu, koja nije u skladu sa poslednjim preporukama), dok sa rastom dohotka dolazi do smanjenja udela troškova za hranu u ukupnom dohotku domaćinstva, a struktura ovih troškova se menja u korist zdravijih i kvalitetnijih namirnica (Štaka et al., 2022). Tada se onaj drugi deo dohotka koji beleži rastući trend troši za obrazovanje, putovanja i ostale aktivnosti koje pružaju emocionalno zadovoljstvo ljudima. Samim tim, dolazi do razvoja svesti o negovanju zdravih životnih stilova koje treba usvojiti i primenjivati.

Zemljište je ograničen resurs, kojim se treba pametno upravljati. Prilikom proizvodnje hrane, vrši se obrada zemljišta, pa se stoga mora voditi računa o tome da se to zemljište ne eksploatiše previše kako ne bi došlo do njegovog uništavanja. Radi zadovoljenja potreba za hranom što većeg broja ljudi, često se vrši intenzifikacija poljoprivredne proizvodnje, što znači da se koriste različite

mere kako bi se produktivnost tog zemljišta povećala. Rast produktivnosti znači rast obima proizvodnje poljoprivrednih proizvoda. Međutim, na taj način dolazi do zagađenja zemljišta, ali i vode i vazduha, što dovodi .do zagađivanja životne sredine i klimatskih promena koje su štetne po opstanak planete. S druge strane u veliki broj ljudi trpi posledice zbog nedovoljnog unosa hrane. Prema podacima Organizacije Ujedinjenih nacija za hranu i poljoprivredu (Food and Agriculture Organization of the United Nation [FAO], 2022), 2021. godine je gladovalo između 702 i 828 miliona ljudi na svetu. Ovaj broj je veći u odnosu na 2020. godinu za oko 46 miliona ljudi, a u odnosu na 2019. godinu za oko 150 miliona ljudi (FAO, 2022). Nakon relativno stabilnog perioda, procenat pothranjenosti skače sa 8% u periodu do 2019, na 9,3% 2020. godine i sa 9,3% 2020. godine na 9,8% 2021. godine (FAO, 2022) (Slika 1.).

Što se tiče teritorijalnog pregleda, procenat pothranjenosti je najveća u Africi, dok najveći broj pothranjenih živi u Aziji. Borba protiv gladi traje, ali nažalost procena je da će 2030. godine procenat pothranjenosti biti ista kao i 2015. godine, na nivou od 8%. To znači da ciljevi zacrtani Agendom 2030, koji su vezani za dostupnost hrane i smanjenje gladi u svetu neće biti ostvareni (Održivi razvoj za sve, 2021).



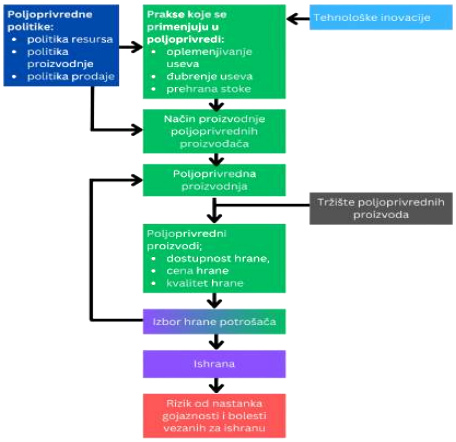
Slika 1. Broj pothranjenih u milionima i procenat pothranjenih do 2020. godine sa projekcijama za 2021. godinu (FAO, 2022).
Figure 1. Number of undernourished in millions and percentage of undernourished by 2020 with projections for 2021 (FAO, 2022).

## PROIZVODNJA ZDRAVE HRANE DOSTUPNE SVIMA – IZAZOV ODRŽIVOSTI POLJOPRIVREDNE PROIZVODNJE

Pored svoje osnovne namene – obezbeđenje dovoljnog kalorijskog unosa radi obavljanja osnovnih životnih funkcija, hrana treba da zadovolji i neke zdravstvene standarde vezane za unos odgovarajućih mikro i makro nutrijenata na dnevnom nivou. Pored toga što je potrebno uneti odgovarajuće količine proteina, masti i ugljenih hidrata dnevno, potrebno je unositi hranu koja obiluje vitaminima i mineralima, koji nisu uništeni merama intenzifikacije poljoprivredne proizvodnje. Stoga izazov u predstojećem periodu, nije samo eliminacija gladi, nego i proizvodnja zdravstveno ispravne hrane koja je bez pesticida i sa manjom upotrebom veštačkih i mineralnih đubriva. S obzirom na to da se velika količina hrane baca, a u drugim krajevima sveta ljudi gladuju, zaključak je da hrane verovatno ima dovoljno za sve, ali je potrebno da se ona pravilno rasporedi.

Veza između poljoprivrede i bolesti povezanih sa ishranom može da se predstavi slikom 2. Hawkes je identifikovao dve ključne tačke intervencije u poljoprivrednom sektoru, koje se mogu koristiti za promovisanje zdrave ishrane ljudi i za promovisanje prakse održive poljoprivredne proizvodnje (Hawkes, 2007; Walls et al., 2016). Ugovorom o funkcionisanju Evropske unije utvrđeni su ciljevi Zajedničke agrarne politike o povećanju produktivnosti u poljoprivrednoj proizvodnji uz osiguranje adekvatnog životnog standarda za poljoprivrednike, stabilizaciju tržišta i osiguranje dostupnosti zaliha i razumnih cena za potrošače. Ovi ciljevi su bili predmet reformi iz godine u godinu. Međutim, vremenom je došlo do usvajanja novih vrsta useva, upotrebe đubriva i pesticida, što je uticalo kako na dostupnost i cenu tako i na kvalitet poljoprivrednih proizvoda. S

obzirom na veću ponudu i pristupačnije cene ovako gajene hrane došlo je do razvoja gojaznosti ali i hroničnih bolesti vezanih za ishranu. Stoga cilj poljoprivredne proizvodnje jeste da se u budućnosti proizvodi zdrava hrana na održiv način, kako bi se adekvatno uticalo na izbor potrošača.




Slika 2. Veza između proizvodnje poljoprivrednih proizvoda i bolesti povezanih sa ishranom (Walls et al., 2016).
Figure 2. The relationship between agricultural production and diet-related diseases (Walls et al., 2016).

Ozbiljan zdravstveni problem današnjeg društva jeste gojaznost, a sve su više prisutne i druge bolesti koje su u korelaciji sa nezdravom hranom i nezdravim stilovima života. Tokom poslednje četiri decenije procenat gojaznih osoba se učetvorostručio među muškarcima i udvostručio među ženama, a taj procenat raste svake godine. Reč je o velikom zdravstvenom problemu (Krzysztoszek et al., 2019). Višak kilograma prati kombinacija nekoliko faktora kao što su konzumacija visoko obrađene i brze hrane u odnosu na hranu bogatu voćem, povrćem i robom, sedeći način života i slično. Pored gojaznosti, nekvalitetna hrana je uzrok bržeg starenja ljudi, razvoja kardiovaskularnih bolesti, dijabetesa i mnogih drugih. Zato je pored ciljeva agrarne politike Evropske unije a koji se odnose na upotrebu đubriva, pesticida, na povećanje organske proizvodnje i slično potrebno voditi i adekvatnu ekonomsku politiku, pre svega fiskalnu, kako bi se cene poljoprivrednih proizvoda rebalansirale u smislu da neodrživi proizvodi budu skuplji, a održivi proizvodi jeftiniji. Pri uvođenju ovakve vrste politike misli se pre svega na uvođenje poreza kojim bi se dodatno oporezivali neodrživi proizvodi. U svakom slučaju potrebno je voditi računa da se ovim merama ne utiče na sposobnost najsiromašnijeg sloja stanovništva da sebi obezbedi egzistenciju, odnosno potrebno je voditi računa o svim grupama ciljeva održivog razvoja (ekonomski, ekološki i socijalni).

## ZAJEDNIČKA AGRARNA POLITIKA EVROPSKE UNIJE I ZDRAVLJE LJUDI – TRENDOVI U ISHRANI

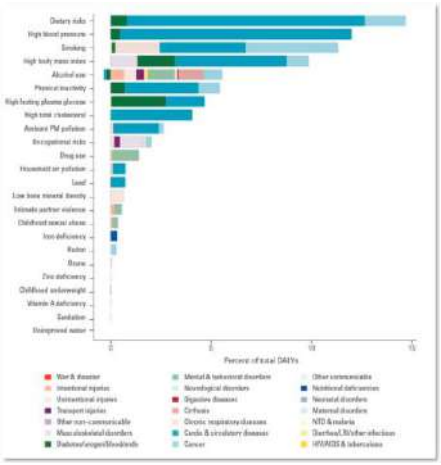
Proizvodnja hrane, odnosno poljoprivreda je usko povezana sa glavnim uzročnicima bolesti i smrtnosti u Evropskoj uniji i svetu. Ishrana zajedno sa konzumiranjem cigareta i alkohola, sa fizičkom neaktivnošću je odgovorna za većinu bolesti u Evropi (World Health Organization [WHO], 2016). Procesuirana hrana je najveći pojedinačni faktor rizika za nastanak bolesti za godine starosti prilagođene bolesti (eng. The Disability Adjusted Life Year [DALY]).

Slika 3. pokazuje glavne faktore rizika za izgubljene godine zbog bolesti ljudi, a najveći faktori rizika su lako povezivi sa poljoprivredom. Poznato je da su alkohol i duvan produkti poljoprivredne proizvodnje. Hrana je takođe proizvod koji potiče iz prehrambenog sektora koji povezuje poljoprivredu i prehrambenu industriju. Visok krvni pritisak, visok indeks telesne mase, visok nivo šećera u krvi, visok loš holesterol povezani su direktno sa načinom ishrane i života

ljudi. Na ove zdravstvene varijable utiču ekonomske varijable kao što su laka dostupnost hrane i adekvatne cene.

Međutim, kada se govori o poljoprivrednoj proizvodnji i prehrambenim proizvodima jako je bitno podvući da su poljoprivredni proizvodi namenjeni ishrani ljudi esencijalni proizvodi u svakoj privredi, koji zadovoljavaju osnovne ljudske potrebe i ključna su odrednica kvaliteta života. Zdravstveno gledano, nisu sve vrste poljoprivrednih proizvoda iste ali nisu iste ni sve metode proizvodnje. Neki poljoprivredni proizvodi više a neki manje utiču bilo pozitivno bilo negativno na zdravlje ljudi. Ono što je tema ovog rada je usklađivanje Zajedničke agrarne politike sa naporima u promovisanju održive i zdrave ishrane. Prema tome održiva ishrana je takav vid ishrane gde se malo ili nimalo utiče na životnu sredinu. Ona kao takva utiče pozitivno na sigurnost hrane a samim tim i na zdravlje sadašnjih i budućih generacija. Održiva ishrane neguje biodiverzitet, kulturno je prihvatljiva, pristupačna, ekonomski opravdana, nutritivno adekvatna, bezbedna i zdrava (FAO, 2012).

Nije nikakva novina to što hrana utiče na zdravlje ljudi, a samim tim i na javno zdravlje (Lang, & Rayner, 2012). Čak i danas, deset godina kasnije, sve veći broj dokaza pokazuje da je ljudsko zdravlje suštinski povezano sa zdravljem životne sredine. Zato je jako važno ozbiljno se posvetiti ostvarivanju ciljeva održivog razvoja a pre svega ciljevima vezanim za ishranu ljudi, kako bi se eliminisala glad u svetu i ljudima pružila kvalitetna i zdravstveno ispravna hrana koja će pozitivno uticati na zdravlje.



Slika 3. Glavni faktori rizika za DALY (Pushkarev, 2015).
Figure 3. Main risk factors for DALYs (Pushkarev, 2015).

Broj godina prilagođen zdravstvenom stanju. To je indikator koji pokazuje ukupno opterećenje nekog pojedinca bolešću, izražen izgubljenim godinama zbog bolesti, lošeg zdravlja, invaliditeta, rane smrti.

Ono što predstoji u sledećem periodu je svakako izlazak iz prehrambene krize i ostvarivanje ciljeva definisanih Agendom 2030, kao i inkorporiranje ovih ciljeva u Zajedničku agrarnu politiku Evropske Unije. Globalni cilj prehrambene politike je zapravo cilj 2 održivog razvoja – svet bez gladi (obezbediti dovoljno kvalitetne hrane za zdrav život za ceo svet). Da bi se ovaj cilj postigao potrebno je da se promoviše održiva poljoprivreda (Stanković et al., 2023). Neki od tih ciljeva nižeg ranga koji se odnose na svet bez gladi su:

- da svi, a pre svega deca imaju pristup zdravoj i kvalitetnoj hrani svaki dan,
- da se do 2030. godine eliminišu svi oblici pothranjenosti,
- da se do 2030. godine udvostruče i poljoprivredna proizvodnja i prihodi poljoprivrednih proizvođača a pre svega žena, etničkih manjina, porodičnih farmera, stočara i ribara uz jednak pristup svim resursima i mogućnostima,

- do 2030. obezbediti održive sisteme proizvodnje hrane i primeniti otporne poljoprivredne prakse koje povećavaju produktivnost i proizvodnju, jačaju kapacitet za prilagođavanje klimatskim promenama, ekstremnim vremenskim prilikama, suši, poplavama i drugim katastrofama, koje progresivno pogoršavaju kvalitet zemljišta,
- povećati ulaganja u poljoprivrednu infrastrukturu pogotovu u ruralnim krajevima i to kroz međunarodnu saradnju,
- korigovati trgovinska ograničenja u pogledu uvoza i izvoza poljoprivrednih proizvoda,
- obezbediti stabilno tržište hrane i blagovremeni pristup informacijama.

## ZAKLJUČCI

Poljoprivredni proizvođači zarađuju tako što prodaju poljoprivredne proizvode koje sami proizvode i od direktnih plaćanja i koja dobijaju od države, odnosno iz agrarnog budžeta. Međutim, taj lanac ishrane nije savršen, ima dosta nedostataka i objedinjavanjem Zajedničke agrarne i prehrambene politike ti nedostaci bi trebali da se eliminišu.

Opšte je poznato da Zajednička agrarna politika počiva na dva stuba. Prvi stub utiče na prihod farme i podstiče stabilnost tržišta. Da bi poljoprivredni proizvođači dobili direktna plaćanja, regrese, premije moraju da se pridržavaju raznih propisa koji se odnose za zaštitu životne sredine, što je u teoriji poznato kao „unakrsna usklađenost“. Drugi stub se odnosi na ruralni razvoj i upravljanje životnom sredinom i biodiverzitetom a sve u cilju postizanja konkurentske pozicije poljoprivrede u odnosu na druge grane i uvođenja inovacija.

Javnost ima velika očekivanja od Zajedničke agrarne politike Evropske unije. Međutim da bi se ta očekivanja i ostvarila potrebno je da se Zajednička agrarna politika transformiše u Zajedničku agrarnu i prehrambenu politiku (eng. Common Agricultural and Food Policy [CAFP]). Takva zajednička politika ima za cilj da ojača otpornost čitavog lanca ishrane.

Nažalost, nastanak ovakve politike bez učešća potrošača u njenom kreiranju i sprovođenju nema nikakvog smisla. Mnogi potrošači ne vide sopstvenu priliku da utiču na prehrambenu politiku. U suštini, mali je broj potrošača koji će se pre odlučiti za održive proizvode. Tu su i tradicionalni proizvođači hrane koji u medijima plasiraju primamljive reklame za svoje neodržive proizvode, što utiče na odluku potrošača o kupovini. S obzirom na to, najveću ulogu u sprovođenju ove politike bi imale vlade svake zemlje pojedinačno gde bi one ograničile na neki način prodaju neodrživih proizvoda.

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# TOWARDS A COMMON AGRICULTURAL AND FOOD POLICY: SUSTAINABIILITY CHALLENGES

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**ABSTRACT**

The Common Agricultural Policy of the European Union has been widely known for more than 60 years. The aim of this joint policy is to ensure an adequate supply of food, given that after the war and years of hunger, people could not adequately enjoy the presence of a variety of foods. Current food systems are characterized by the overproduction of processed foods with low nutrient content. This has contributed to unhealthy and unbalanced diets across the EU, leading to a range of health risks, especially for poorer population groups. The EU's food and agricultural systems require a fundamental change of direction in light of the serious, interconnected and systemic economic, environmental and health challenges they face. Today, Common Agricultural Policy supports the European Union single market for agricultural food products, ensures affordable prices, keeps rural communities vital and high environmental standards. Unfortunately, climate change, the emission of harmful gases, wars, and epidemics have a negative impact on agricultural production, which calls into question the quality and safety of food as well as people's health. In order to meet new global expectations, new CAP should be transformed into a CAFP (Common Agricultural and Food Policy) that aims to strengthen the resilience of the entire food chain, recognizing the changed power relations in the chain and the interaction between consumption and production. The aim of this work is to point out the efforts that the Common Agricultural Policy to make quality and healthy food available to everyone. Therefore, this paper will cover topics related to the quality and safety of agricultural food products, their impact on human health, towards a Common Agricultural and Food Policy.

**Keywords**: Common Agricultural and Food Policy, Common Agricultural Policy, food security, health, sustainability.

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# DECISION SUPPORT SYSTEMS IN MANUFACTURING: A BIBLIOMETRIC ANALYSIS

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## ABSTRACT

The digital transformation of businesses is currently experiencing significant improvements, supported by the use of artificial intelligence. The manufacturing sector is being substantially transformed using emerging technologies. Consequently, the manufacturing environment has become more dynamic and complex, causing more interdependencies, uncertainties, and large amounts of data that should be processed and analysed. In this sense, artificial intelligence plays a crucial role in supporting data-driven decision-making, which is beneficial for the digitalization of manufacturing processes. The aim of this paper is to present a bibliometric analysis that comprehensively describes who the main contributors are and what the main streams of research are in the field of developing and implementing decision support systems based on artificial intelligence in manufacturing. The research findings should be a valuable resource for other academics interested in learning more about the most recent developments in the field. Furthermore, it opens possibilities for further research related to the development of intelligent decision support systems in manufacturing.

**Keywords:** Manufacturing, Industry 4.0, Decision support systems, Artificial intelligence, Bibliometric Analysis.

## INTRODUCTION

The manufacturing industry is undergoing a profound transformation driven by advancements in technology. One of the key drivers of this transformation is the concept of Industry 4.0, which refers to the integration of digital technologies into the manufacturing sector (Lasi et al., 2014). Within this framework, decision support systems (DSS) and artificial intelligence (AI) play a crucial role, empowering manufacturers with intelligent tools and capabilities to optimize operations, enhance decision-making, and achieve new levels of productivity and efficiency (Lo, 2023).

Manufacturing has always strived to improve operational processes, reduce costs, and deliver high-quality products. With the advent of Industry 4.0, traditional manufacturing practices have been revolutionized by the integration of digital technologies. This new industrial paradigm embraces concepts such as the Internet of Things, big data analytics, cloud computing, and AI (Wichmann et al., 2019). Among these technologies, AI stands out as a powerful tool that enables machines to exhibit intelligent behavior, learn from data, and make informed decisions (Nti et al., 2022).

DSSs, closely intertwined with AI, are instrumental in facilitating effective decision-making within the manufacturing environment. These systems leverage AI algorithms, machine learning techniques, and data analysis capabilities to process vast amounts of information, derive insights, and assist human operators in making optimal decisions (Brougham, & Haar, 2018). DSS in the context of Industry 4.0 provide real-time monitoring, predictive analytics, and prescriptive recommendations to guide manufacturers in various aspects of their operations (Zhou et al., 2016).

AI, as a core component of DSS, brings a range of capabilities to the manufacturing sector. Machine learning algorithms can analyze large datasets to identify patterns, correlations, and trends, enabling manufacturers to predict demand, optimize production schedules, and manage inventory effectively. AI-driven algorithms can also detect anomalies and anticipate potential faults

or quality issues in products, facilitating proactive maintenance and quality control processes (Peres et al., 2020).

Furthermore, AI-powered robots and automation systems enhance manufacturing processes by augmenting human capabilities. Collaborative robots equipped with AI algorithms can work alongside human operators, enhancing productivity, precision, and safety in manufacturing environments. These robots can handle repetitive tasks, perform complex assembly operations, and adapt to changing conditions, resulting in improved efficiency and reduced production costs (Tantawi et al., 2023).

The connection between manufacturing, Industry 4.0, DSS, and AI forms a symbiotic relationship where each component reinforces the others. Industry 4.0 provides the infrastructure and digital ecosystem necessary to harness the power of AI and DSS, while AI and DSS enable manufacturers to extract insights, optimize operations, and make data-driven decisions within the Industry 4.0 framework (Jan et al., 2023). Together, they foster a dynamic and intelligent manufacturing environment that is responsive, adaptable, and capable of driving innovation and competitiveness (Dwivedi et al., 2021).

As manufacturing continues to embrace the principles of Industry 4.0, the integration of DSS and AI will play an increasingly pivotal role. The synergy between these technologies empowers manufacturers to navigate complex challenges, unlock new opportunities, and accelerate their digital transformation journey (Leo Kumar, 2017). By leveraging AI and DSS, manufacturers can achieve higher productivity, improved quality, enhanced agility, and ultimately, maintain a competitive edge in an ever-evolving global market (Liu et al., 2020).

In order to create and implement decision support systems based on artificial intelligence in manufacturing, this study will give a bibliometric analysis that fully identifies the key contributors and the primary research streams. Other academics who are interested in learning more about the most current advancements in the discipline might find the research findings to be a useful resource. Additionally, it creates opportunities for additional study into the creation of intelligent decision support systems in manufacturing.

## MATERIAL AND METHODS OF WORK

The Scopus database was used to collect scientific research relevant for the topic in hand because of its widespread reputation for hosting high-quality journals and research documents. For the collection of the relevant work in the field, the following keywords were used: “Manufacturing”, “Industry 4.0”, “Decision support systems”, “Artificial intelligence”. The general information about the data used for the analysis are given in Table 1.

The Biblioshiny app from the RStudio cloud was used as a tool to obtain and organize database. Biblioshiny offers data about the most productive countries, institutions, authors, research fields, and journals, as well as about keywords, h-index, impact factor, total citations, etc. This open-source application is proposed for performing comprehensive science mapping analyses (Aria, & Cuccurullo, 2017).

Table1. General information about the data.

| **Timespan** | **2015:2023** |
|---|---|
| Documents | 76 |
| Annual Growth Rate % | 25.1 |
| Average citations per doc | 14.78 |
| Authors | 281 |
| Articles | 27 |
| Books | 3 |
| Conference papers | 46 |

## RESULTS AND DISCUSSION

This section presents the main bibliometric analysis related to the development of intelligent decision support systems in manufacturing.

Figure 1 provides information about the top ten sources where the articles dealing with the topic of intelligent decision support systems in manufacturing are published. It can be seen that IFIP group and Procedia CIRP have the highest number of articles published. However, the number of published papers does not necessarily reflect their influence and relevance. Figure 2 shows which articles and related sources obtained the highest number of citations.

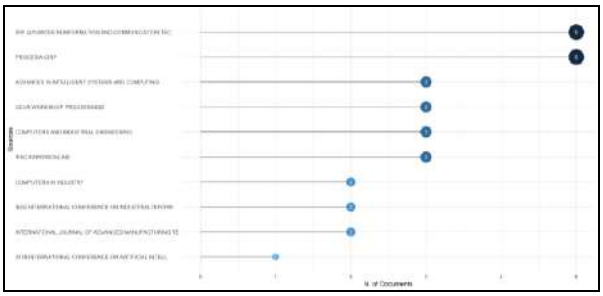

Figure 1. Top relevant sources.

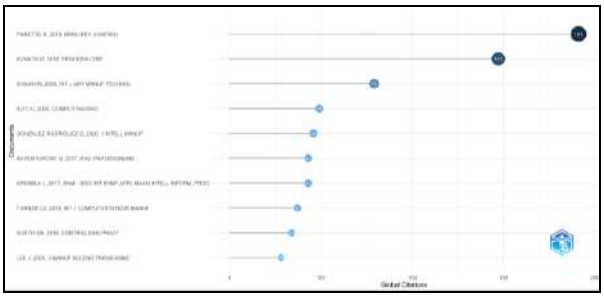

Figure 2. Top cited documents.

Figures 3 and 4 should inform the audience about the countries of the authors that are working on the topics concerning intelligent decision support systems in manufacturing. More specifically, it gives an overview of the total number of citations which are credited to authors coming from a specific country. The highest number of articles are published from authors who are coming from Germany, Italy, Portugal, United Kingdom, and China. Considering citations, the most relevant authors are coming from France, Germany, China, USA, and United Kingdom.

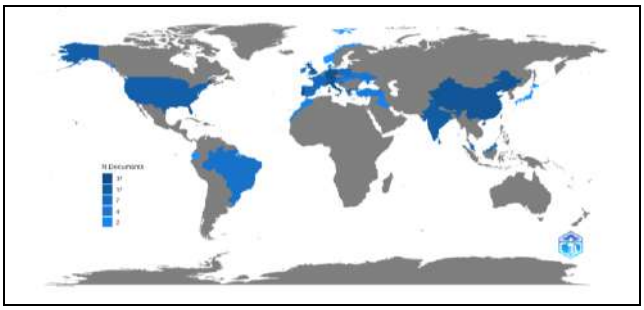

Figure 3. Country scientific production.

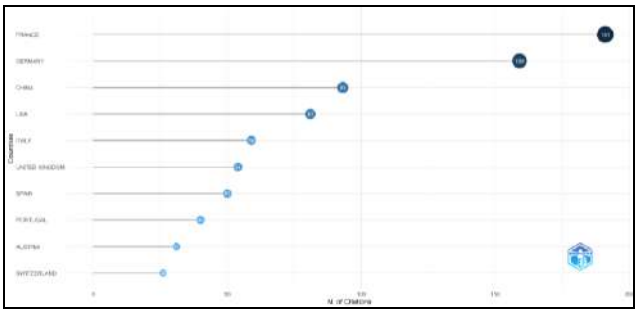

Figure 4. Top cited countries.

Co-word analysis is the most beneficial technique for comprehending the conceptual framework of research conducted in a certain topic. The most often occurring words and phrases in the paper's title and keyword list are determined using a similar methodology (Figure 5). Co-word analysis shows that "Decision support systems", "Artificial intelligence", "Industry 4.0", "Decision making", "Manufacture", and "Internet of Things" are the most often used keywords in the paper titles and abstract. The combination of potential keywords that stand for intelligent decision support systems in manufacturing is shown in the tree map below (Figure 6), while the word cloud higlights the most important keywords (Figure 7).

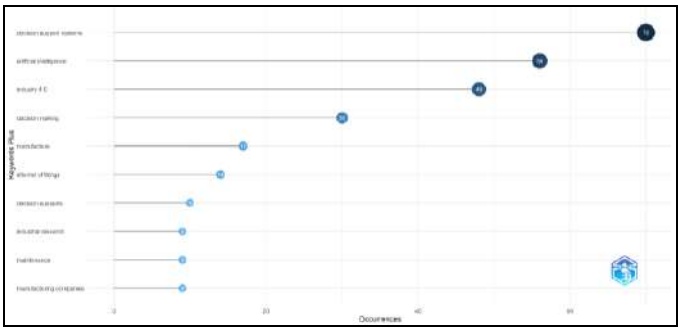

Figure 5. Most relevant keywords.

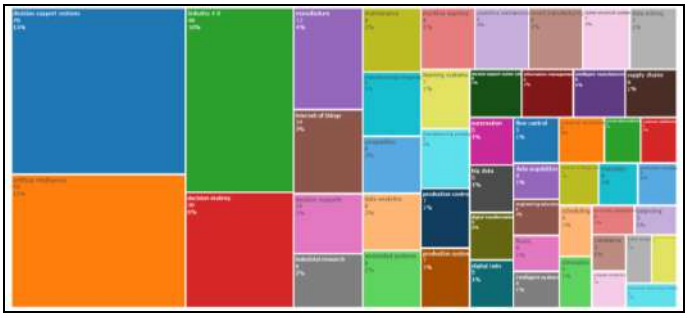

Figure 6. Tree map of keywords.

Figure 7. Word cloud.

Finally, thematic map which shows basic themes (i.e. industrial revolution, maintenence, and data mining), niche themes (i.e. cognitive systems, human decision making and engineering, and sustainable manufacturing), motor themes (i.e. smart manufacturing, AI aplication, data analytics, and simulation), and emerging or declinig themes (i.e. industry 5.0, digital manufacturing, and prognostic managament) is presented in Figure 8.

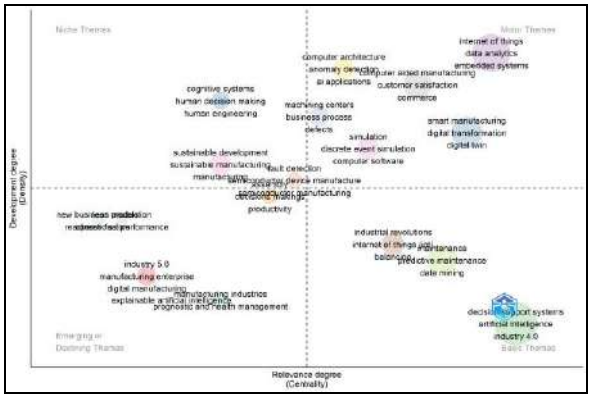


Figure 8. Thematic map.

## CONCLUSIONS

This paper goal was to present the connection between manufacturing, Industry 4.0, DSS, and AI that should be understood as a transformative force that is reshaping the manufacturing landscape. As the manufacturing industry embraces the principles of Industry 4.0, the integration of DSS and AI provides manufacturers with intelligent tools and capabilities to optimize operations, enhance decision-making, and drive productivity and efficiency to new heights.

Using bibliometric analysis, the authors tried to comprehensively describe and present he main contributors and the main streams of research in the field of developing and implementing decision support systems based on artificial intelligence in manufacturing. The main idea was to present the common and basic information that should serve other academics interested in learning more about the most recent developments in the field.

The analysis is based on the Scopus database which is considered as a relevant source for high-quality journals and research documents. However, there are other databases that could be considered to obtain relevant articles in the field. Therefore, the authors propose that further research should consider other databases, such as Web of Science or other, to perform more detailed and comprehensive analysis. Furthermore, the analyzed topic is expected to be on the rise in recent future, as continuous evolution of AI and the ongoing advancements in Industry 4.0 will further revolutionize the manufacturing sector, enabling manufacturers to adapt and thrive in an increasingly digital and interconnected world.

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# E-BUSINESS IN FUNCTION OF SUPPLY CHAIN MANAGEMENT IMPROVEMENT

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## ABSTRACT

The subject of this research paper is the possibility of improving supply chain management (SCM) using electronic business. In order to be competitive, a company needs to develop in line with market trends. The impact of electronic business on SCM has led to the development of e-SCM, which creates new business opportunities in the market. This paper reviews the adventaged of implementing electronic business and information technologies in SCM.

To ensure the successful implementation of e-SCM and the potential benefits of electronic business on SCM, it is essential to consider factors such as suitable infrastructure, education, and legal regulation. This paper discuss these prerequisites and presents a symbiosis of theoretical reviews and statistical research results on the application and possibilities of e-SCM in the Republic of Serbia.

**Keywords:** e-business, supply chain management, information technologies, contemporary business.

## INTRODUCTION

According to (Gunasekaran, & Ngai, 2004) Supply Chain Management (SCM) is a global strategy in the 21st century to achieve competitive advantage. That is why procurement logistics today plays a very important role in the supply chain, and its optimization has a significant effect on the entire logistics system of the company. The concept of the supply chain has changed over time, but essentially it has kept its original form (Figure 1), gained more and more importance and became the strategic focus of leading manufacturing companies. This is caused by very rapid changes in the environment, the globalization of the market and the high demands of users, for which the high quality of products and services becomes a priority. According to (Monczka et al., 2015) a supply chain is a set of multiple organizations that are directly connected to one or more product, service, financial and information flows from the source to the end user, in modern supply chains it is often necessary to coordinate activities and flows to an extent that exceeds current boundaries. The complexity of the supply chain stems from the fact that its participants are various companies - from those related to the procurement of raw materials to end users. According to the same authors, supply chain management is proactive management, where business results are not expected but managed. Supply chain management has a huge impact on the quality of products and services (Bal, & Demirhan, 2013), which increases the importance of the relationship between procurement, external suppliers and quality. The supply chain includes material flow, information flow and cash flow (payments), different participants and includes different levels: suppliers of raw materials, suppliers of semi-finished products, manufacturers, distributors, merchants, end customers. The supply chain includes the processes of shopping, payments, material handling, planning, production control, management of stored stocks, distribution and delivery. The goal of any supply chain is to maximize the total value produced, and it represents the difference between the value of the final product for the consumer and expenses incurred due to the satisfaction of consumer demands. Supply chain profitability is the total profit to be distributed between all members of the supply chain. It represents the difference between achieved revenue from customers and total supply chain costs. SCM includes managing flows between and within supply chain members to maximize overall profitability.

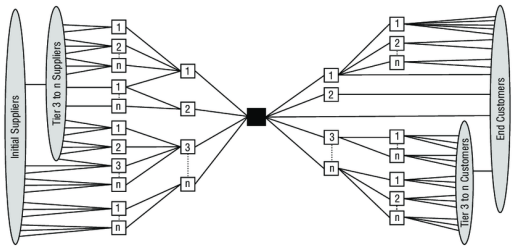



Figure 1. Supply chain network structure (Lambert et al., 1998).

## CONTEMPORARY TENDENCIES IN SCM

The development of digital technologies is driving change that provides opportunities for more efficient business (Paunović, & Veljović, 2018).

Information technologies (IT) are used in various industries and organizations, including business, healthcare, education, and government, to improve communication, collaboration, and the efficient use of resources. The development of IT support systems for SCM improve all business activities. This is accomplished with IT for internal and external integration of business processes. Many companies need IT techniques to enable the integration of their internal business functions (Murthy et al., 2020). This can help companies to become more efficient, respond rapidly to customer needs and improve their productivity. Implementing IT in SCM can bring a number of benefits as shown in Table 1.

Table 1. Benefits of implementation IT in SCM.

| Benefits of IT | Description |
|---|---|
| Increased visibility and traceability innovation | IT systems can provide real-time data on the location, status, and movement of goods, allowing for better monitoring and control of the supply chain. |
| Improved efficiency and coordination | IT systems can automate and streamline processes, such as inventory management, logistics, and order fulfillment, leading to faster and more accurate decision-making. |
| Increased flexibility and adaptability | IT systems can enable companies to quickly respond to changes in demand or supply, allowing them to be more agile and competitive. |
| Reduce cost | IT systems can help to minimize waste and inefficiencies in the supply chain, resulting in cost savings. |
| Improve customer satisfaction | IT systems can provide customers with up-to-date information on their orders, delivery status, and inventory, which can improve customer satisfaction. |

Automation communaction flow of data using IT in SCM is presented in Figure 2. Enterprise Resource Planning (ERP) systems are included as part of the broader SCM software. ERP systems are used to integrate business processes, by organizing, automated and standardizing business processes and all relevant data (Barykin et al., 2020). They enable employees to integrate and manage data in database, saving time and preventing the expense on transportation of data between departments. Data integration ensures the correctness of data in every moment and prevents repetitions of data and redundancy. Moreover, ERP reports can be used to forecast production and make decisions.

Manufacturing Execution System (MES) are used to track, analyse and collect information in real-time. All transformations that occur in the shop floor from the raw materials into finished goods are provide with MES. MES provides overall equipment effectiveness and collaborating with intelligent decision support systems. MES needs to communicate with other systems.

SCADA is a control and network system architecture for data exchange between a supervisor, the SCADA computer, distributed Human Machine Interfaces (HMIs), the controllers such as PLCs (Programmable Logic Controller) and different devices like sensors and actuators in the

shop floor. The SCADA system architecture is used for data acquisition, providing high reliability of machine controls using IoT, PLC, HMI, etc.

At the bottom level of the device are technologies for identification and tracking of resources, providing traceability and supporting intelligence systems with the most significant data.

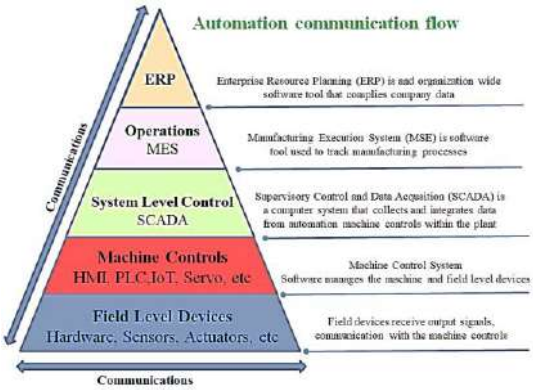



Figure 2. Automation pyramid corresponding IT systems hierarchy levels (Martinez et al., 2021).

The application of IT in various areas of SCM has a significant contribution and the emergence of e-business. E-business has made it possible to send all the data and financial transactions that are important for the entire production system.

## THE IMPACT OF ELECTRONIC BUSINESS ON SUPPLY CHAIN MANAGEMENT

Electronic business or e-business arose as a response to increasingly complex market demands conditioned by the progress of technique and technology. It implies a concept that includes all forms of business interactions as well as the exchange of information using information and communication technologies (Turban et al., 2008). E-business includes business process optimization, improvement of relations with the target audience and improvement of other business support services. The main goal of introducing e-business is to improve the competitiveness of the company through the use of information technology between the company and the consumer, the company and its business partners, as well as within the company itself. E-business does not only mean the use of information technology in the automation of existing business processes, but also the use of modern technologies to change business processes and increase their efficiency. In order for e-business to be successfully implemented in a company, a broad knowledge of all business processes and activities of the company in the value chain, from marketing, through sales, to product development is necessary (Chaffey, 2011).

Digital transformation, as a process of integrating digital technologies into all business areas, has created an extremely competitive environment. In order to remain competitive, organizations are moving their business to the electronic market. One of the areas of business that can be improved by the application of electronic business is SCM.

According to Arthi Ramesh “Technologies such as the Internet, electronic, data interchange, transportation and warehouse management software, including software that manages plant scheduling, demand forecasting, procurement, makes SCM a resourceful strategy to adopt.” (Ramesh, 2018; Ahmi et al., 2018).

The basic elements and participants in the supply chain in relation to the time of the appearance of its concept are almost the same today, with the fact that more and more attention is paid to the end user and satisfying his needs and demands. In order to fulfill this, on the one hand, and on the other hand to make a profit and efficiently carry out all activities in the supply chain with the lowest possible costs, the electronic supply chain has been imposing itself as a current trend in the development of supply chains for some time. Electronic supply chain includes fully

integrated SCM and components of electronic commerce, such as: electronic ordering, electronic payment, electronic data processing and exchange, electronic catalogs and others.

The e-SCM can be described as a network of independent partners who are not only distributers of certain products and services in the supply chain, but also stimulate the demand and lead the synchronization of capabilities and resources in the whole supply chain in order that they provide levels of operational efficiency and leadership on the market (Ivanovska, & Kaleshovka, 2013). The e-SCM allows a company to monitor its business in all of its productive chain, from the initial suppliers to the end customers, all interconnected by means of IT (Salgado et al., 2011). According to (Ghasemi et al., 2015; Trinh et al., 2017) e-SCM is the internet impact on the integrity of the original business processes from end-user to the main supplier of products, services and provides information to customers and other stakeholders and creates value. In order to achieve maximum effect when implementing e-SCM, the organization must be capable of creating, collecting, storing, maintaining, sharing and managing knowledge (Figure 3).

Internet as well as IR 4.0 has changed the SCM to an e-enabled or electronic SCM (e-SCM) where it has transformed all the traditional methods and processes in SCM into automated or electronic technologies (Ahmi et al.,2018). This technology is assisting the chains in making their levels of service more adequate (Hendriks et al., 2007). Defining the scope of e-business implementation implies taking into account legal frameworks, infrastructure and support services.

Figure 3. The impact of E-business on SCM.

The application of electronic business in supply chain management is vital in numerous ways. Some of the impact of e-business on SCM is shown in the figure. With the development of electronic business, the impact on SCM will go beyond more efficient, faster and more reliable exchange of goods and information.

## IMPLEMENTATION OF ESCM IN THE REPUBLIC OF SERBIA

Several factors are important as a prerequisite for implementing eSCM, as well as electronic business in general. Some of them include:

- suitable infrastructure i.e. technology, as well as access to the Internet,
- education, i.e. computer skills,
- legal regulation.

### Infrastructure

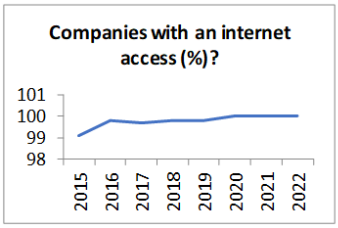
The subject of this research paper is the impact of e-business on SCM, so the topic of infrastructural readiness and possibilities of eSCM implementation is discussed in more detail below. The research carried out by the Statistical Office of the Republic of Serbia covered 1.573 companies. The survey was carried out by telephone, and the sample was stratified by the size and activity of the company. Out of the total number of companies, 1300 successfully completed the survey.

The results of the research show that companies in Serbia have access to the Internet. However, in 32,6% of companies, the Internet is used by 1% to 24% of employees, while in 41.2% of companies, this parameter ranges from 75% to 100% (Figure 4).

Figure 5 shows that slightly more than 80% of companies have a website.

When it comes to the content on the website (Figure 6), the results show that on 90% of the websites, there is a product catalog and price list, as usual content, while online ordering is enabled on slightly less than 20% of the websites. Order tracking is available on about 10% of websites.

Compared to the number of companies that have a website, this percentage is low. In addition, the ratio of receiving orders online and placing orders online is disproportionate, which is explained by the fact that companies order goods through foreign companies' websites (Figure 7).



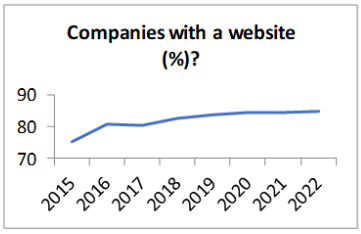




Figure 4. Percentage of companies with an internet access.
Figure 5. Percentage of companies with website.

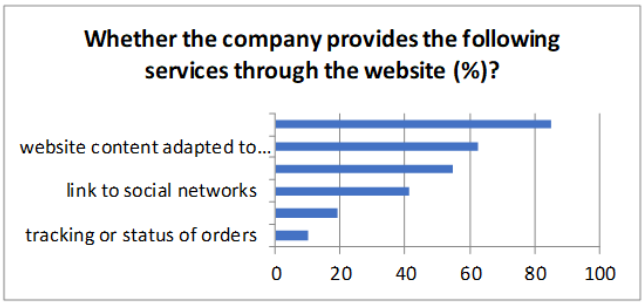
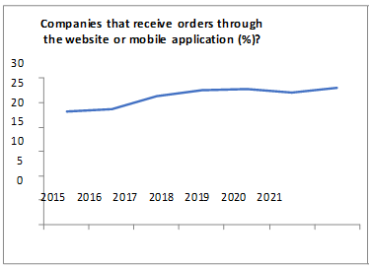
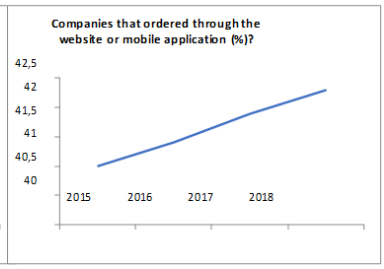



Figure 6. Percentage of provided services through the website.




(a) (b)

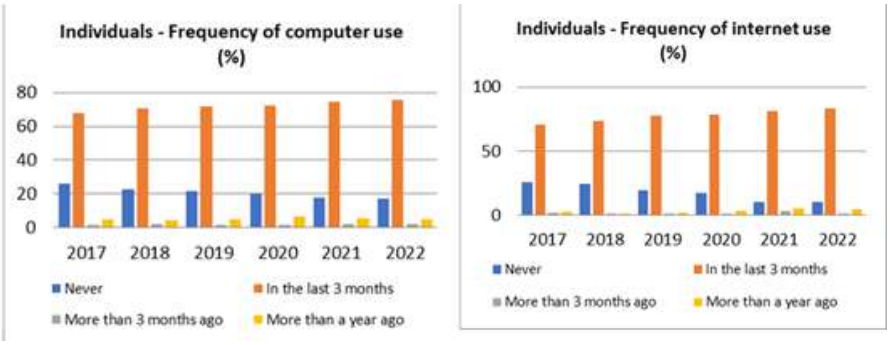
Figure 7. a) Companies that recieve orders through website (%) b) Companies that ordered through the website (%).

**Education/Computer skils**

A prerequisite for using a computer is to be computer literate. The survey was conducted by the Statistical Office of the Republic of Serbia and included 2.800 people, aged 16 to 74, from the territory of the Republic of Serbia. During the year 2022, over 3.990.000 people use a computer several times a day in the Republic of Serbia (Statistical Office of the Republic of Serbia, 2023).

The answers to the question of how often the respondents use the computer or the Internet are shown in Figure 8. It is evident that the number of respondents who have used the computer and

the Internet in the last 3 months is increasing. On the other hand, the number of respondents who have never used a computer or the Internet is decreasing. The results show that by 2022, as many as 17.3% of respondents have never used a computer, and only 10.6% have not used the Internet. The relationship between these two results is like this because the respondents also use the Internet through mobile devices.




(a) (b)

Figure 8. a) Frequency of computer use (%)b) Frequency of internet use.

When it comes to the time frame in which Internet users bought/ordered goods or services online (Figure 9), last year 47.8% of users made a purchase/order in the last three months, 15.7% more than three months ago, and 9.5% more than a year ago.

The percentage of internet users who have never bought/ordered goods or services online was 27.1%.

The results of the survey conducted from March to May 2021, on the territory of the Republic of Serbia, on a sample of 4.697 companies, are as follows:

Total number of employees in all companies: 1.072.861

Number of employees in companies that organized some kind of courses/seminars: 799.154 (68,4% of the total number of employees in all companies)

Number of employees in companies who attended any type of courses/seminars: 266.552 (24,8% of the total number of employees in all companies)

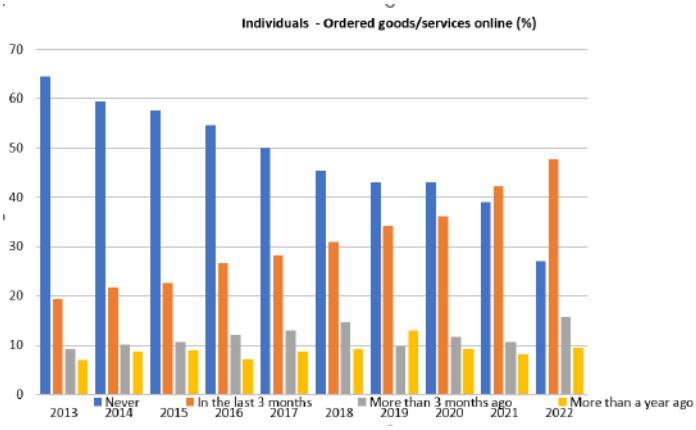



Figure 9. Internet users who ordered goods or services online.

**Legal regulation**

From a legal point of view, in the Republic of Serbia there is a legal regulation related to the management of electronic supply chains. These are the Law on electronic documents, electronic identification and trusted services in electronic business (Law on electronic documents [LED],

2021), as well as the Law on Electronic Commerce (Law on Electronic Commerce [LEC], 2019) which regulate the application of electronic business, but also components, such as electronic management of supply chains. In addition to the law, there are regulations and standards related to e-SCM, such as ISO 20022 and GS1. Nevertheless, there is a possibility for additional definition and prescription of legal frameworks, all with the aim of more efficient and safer application of e-SCM in business.

## CONCLUSIONS

In recent decades, electronic business has become an inevitable part of business processes, including SCM. The application of electronic business has a significant impact on the effectiveness and efficiency of SCM, but also on cost reduction.

Electronic business in SCM includes various aspects, such as electronic ordering, electronic sending of invoices, tracking of deliveries, inventory status, etc. When all these processes are integrated into one system, there is an increase in the relevance and timeliness of information.

When it comes to the possibilities of implementing eSCM in the Republic of Serbia, there are certain prerequisites that have been met, but there is room for improvement. Encouragement and support for the further development and application of eSCM in the Republic of Serbia is needed, through infrastructure, education as well as legal regulations, so that companies can use all the opportunities that the development of technique and technology provides. Only companies that invest in their development can survive on the business scene in the future.

**Acknowledgment**

This study was supported by the Ministry of Education,Science and Technological Development of the Republic of Serbia, and these results are parts of the Grant No. 451-03-47/2023-01/200132 with University of Kragujevac - Facultyof Technical Sciences Čačak.

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# OPTIMIZATION HOUSEHOLD ENERGY MANAGEMENT SYSTEM USING GWO ALGORITHM: A REVIEW

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## ABSTRACT

The paper provides an overview of the application of the Gray Wolf Optimization (GWO) algorithm in the management of electrical energy. Modern society cannot function without the use of electricity. In every household, there are various appliances that consume electricity, some of which are larger while others are smaller consumers. The main goal is the rational use of these appliances and their operation during periods of lower energy prices. People's habits in homes or residential buildings vary, leading to fluctuating electricity consumption. It is necessary to create a schedule for the use of appliance in order to reduce electricity bills. However, energy consumption is increasing, and energy sources are becoming insufficient, so it is essential to optimize consumption.

There are numerous nature-inspired algorithms used for the optimization of complex problems, one of which is the GWO algorithm. It has significant applications in solving various management problems. The mathematical model of the GWO algorithm and its functioning method are described in the paper. Additionally, the paper presents an overview of the application of the GWO algorithm in scientific research to reduce electricity bills, optimize the use of heating/cooling appliances, and implement alternative energy sources (solar, thermal, wind energy, etc.).

By implementing smart technologies, nature-inspired algorithms, and renewable energy sources, we can effectively manage our energy consumption while maintaining a comfortable and sustainable living environment.

**Keywords:** GWO algorithm, EMS, optimization, electricity, appliances.

## INTRODUCTION

Energy management systems (EMS) optimize the energy usage with the help of advanced technologies for measurement, monitoring and analysis of data at homes, buildings and even at grid. Uncertainty due to the intermittent nature of renewable energy sources and the loads can be taken care of using EMS. The major objective of EMS is reduction in energy consumption and cost minimization. It also helps in managing the energy storage systems based on the renewable energy output (Han et al., 2023).

Optimization of household energy management systems plays a vital role in promoting energy efficiency and sustainability. With the increasing demand for electricity and the integration of renewable energy sources, it has become crucial to develop intelligent systems that can effectively manage and optimize energy consumption in households. One approach to address this challenge is the utilization of optimization algorithms to achieve efficient energy utilization.

The GWO algorithm is a population-based heuristic algorithm developed by Mirjalili et al. which models hunting mechanism and the leadership hierarchy of grey wolves (Mirjalili et al., 2014). In this paper is discussed the application of GWO algorithm to optimize energy usage in residential homes and buildings. It has proven to be a powerful optimization technique for solving various complex problems. The various objectives considered along with the constraints are

explained in detail. In order to reap the benefits of different algorithms, many authors have optimized the objectives of EMS using different nature inspired algorithms as well (Meera, & Lavanya, 2023).

The objective of this study is to give review of paper where is analyzed an EMS that optimizes household energy consumption using the GWO algorithm. The paper explores methods for minimizing energy costs while ensuring optimal utilization of resources. The GWO algorithm will be employed to determine the optimal scheduling of household appliances and the allocation of energy resources.

## OVERVIEW OF THE MAIN HOUSEHOLD ENERGY CONSUMERS

Managing the power system has become significantly more challenging since the introduction of renewable energy sources into the electricity production process. Despite the significant advantages of obtaining electrical energy from renewable sources in terms of reducing harmful gas emissions, it has become increasingly difficult to maintain a balance between electricity production and consumption.

Introducing an efficient Home Energy Management System (HEMS) and Building Energy Management System (BEMS) could be one of the solutions to this problem. In order for the HEMS and BEMS to be as efficient as possible, it is necessary to monitor and control the energy consumption of household appliances and devices through various parameters. On Figure 1 is presented proposed system architecture of sample HEMS. By managing the activation sequence of household devices, energy consumption can be reduced, leading to energy cost savings of up to 35% (Malapatra, & Nayyar, 2022).

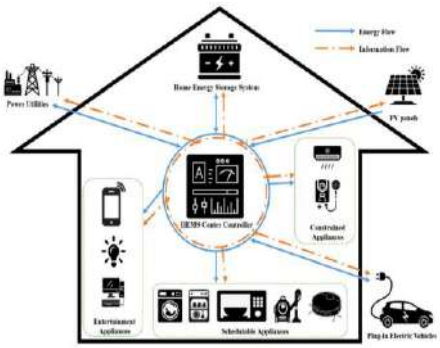


Figure 1. Proposed system architecture of sample HEMS.

Proper selection of devices to be controlled without compromising user comfort is crucial. It is assumed that smart devices are used, whose energy consumption can be optimized through proper handling. Based on user habits, it is necessary to forecast consumption based on when and how often household appliances are used. These would be the input data for consumption management analysis. Energy consumption in homes and buildings can be limited through optimal heating or cooling of rooms (Rehman et al., 2021).

### Problem Formulation

Length of operation time (LOT) for HEMS/BEMS (Table 1) are presented in papers (Ahmad et al., 2017; Ahmad et al., 2021). Required objectives are:

- Consumers' high comfort level by reducing appliances' average waiting time,
- Minimization household electricity bill,
- Minimization of the Peak to Average Ratio (PAR) and
- Integration of Renewable Energy Sources (RES) and a Battery Storage Unit (BSU) in the system for further reduction of end-user waiting time.

By using different scheduling techniques for the optimization of the energy consumption profiles of home appliances, these objectives could be achieved. The operating time of devices can be either flexible or non-flexible (Figure 2), which significantly impacts the consideration of energy savings. By keeping aggregated energy consumption of cumulative home appliances within the maximum threshold limit of VT (maximum energy capacity in every time slot), it could be minimized the end-user electricity cost along with PAR, (Ullah, & Hussain, 2019).

Table 1. LOT and running time constraints for different energy appliance.

| No. | Appliance | Category | Power Rating [kW] | Starting Time (α) | Ending Time (β) | Time Span (β-α) [h] | LOT [h] |
|---|---|---|---|---|---|---|---|
| | Fridge | Non-flexible | 0.35 | 00 | 24 | 24 | 24 |
| | Interior Lighting | Non-flexible | 0.79 | 18 | 02 | 8 | 8 |
| | Dish Washer | Flexible | 2.13 | 10 | 16 | 6 | 2.16 |
| | Washing Machine | Flexible | 0.63 | 09 | 13.33 | 4.33 | 1.77 |
| | Spin Dryer | Flexible | 2.33 | 12 | 17.66 | 5.66 | 1.33 |
| | Cook Top | Flexible | 3.23 | 08 | 9.33 | 1.33 | 0.5 |
| | Oven | Flexible | 5.23 | 17 | 19 | 2 | 1.16 |
| | Microwave | Flexible | 1.83 | 8.33 | 10.66 | 2.33 | 0.76 |
| | Laptop | Flexible | 0.13 | 16.66 | 23.66 | 7 | 2.5 |
| | Desktop | Flexible | 0.33 | 16.66 | 21.33 | 4.66 | 2 |
| | Vacuum Cleaner | Flexible | 1.3 | 10 | 15 | 5 | 0.83 |
| | Electrical Car | Flexible | 3.4 | 16.66 | 08 | 15.33 | 4 |

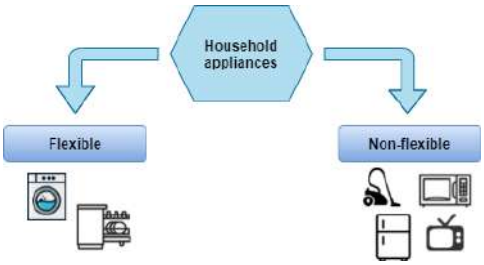


Figure 2. Two categories of home appliances: flexible and non-flexible.

This constraint can be shown mathematically, as follows (Hafeez et al., 2020):

$$ET \leq VT \quad (1)$$

Where the ET is the total energy requirement of the end-user.

The peak to average ratio - PAR

Using the scheduling algorithms, PAR can be minimized, which is in favor of both the utility and consumer for maintaining requirement-supply balance. In every interval of time, the ratio of the peak load of the consumer to the average load of the consumer, and it is denoted by μ. In (Liu et al. 2014), it is mathematically defined as:

$$\mu = \frac{E_{max}}{\frac{1}{T}\sum_{n=1}^{T} E_{T,n}} \tag{2}$$

User's Comfort in Terms of Waiting Time (TW)

For end-users it is important, in terms of waiting time the user's comfort. In order to avoid end-user frustration and to achieve a high level of comfort, waiting times must be kept to a minimum. TW is that interval of time when a consumer switches on an appliance, and due to the scheduling limitations of the system, consumer has to wait to start its operation. As we have defined the earliest starting time $\alpha$ and the latest ending time $\beta$ of an appliance, then another parameter $\eta$ will be the operational starting time of the same switched-on appliance (Figure 3). Here, $\beta$ - is the time span, defined by the consumer. The maximum waiting time of consumers can be up to $\eta_{max}$ as seen in Figure 3. Since LOT (Length of the Operational interval of Time) is already defined by the consumer, so at, the algorithm will have to start the appliance to complete its operation up to the final time $\beta$. For example, Dish Washer (Table 1) has a time span of 8 h (from 10:00–16:00) and LOT = 2,16 h. This means that Dish Washer must start from 10:00–16:00 to complete its operation of 2,16 h, with a waiting time ranging from 0–6 h.

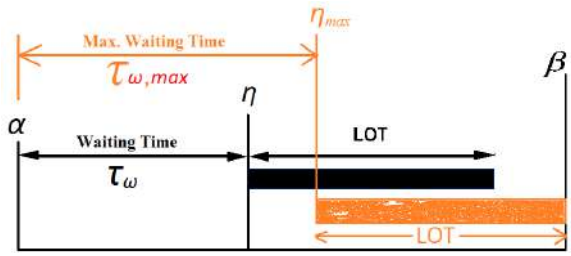


Figure 3. Starting time, ending time, LOT and waiting time.

There is no problem with waiting time, in case of fixed appliances, because whenever the consumer wants to switch them on, he can do so. Therefore, we do not include fixed devices in the scheduling problem. Now, since

$$(\beta - \alpha) \geq LOT \tag{3}$$

Figure 3 shows that the waiting time range can be from $\alpha$ to $\eta_{max}$. The normalized waiting time (TW) of appliances can be calculated as follows:

$$\tau_w = \frac{\eta - \alpha}{(\beta - LOT) - \alpha} \tag{4}$$

The normalized waiting time can be from "0" (when $\eta = \alpha$) to "1" (when ($\beta$ - LOT) = $\eta$) as can be seen from equation (4). The typical electricity requirement of a single home and multiple homes, with different types of appliances and power ratings, their LOTs and ($\alpha$) and ($\beta$) constraints is shown in Table 2.

Our objective function can be defined as follows:

$$min\left(\sum_{m=1}^{48}\left[\lambda_1 \times \sum_{n=1}^{N}(E_{T,n} \times \zeta_n) + (\lambda_2 \times \tau_w)\right]\right) \tag{5}$$

where are:

$\zeta_n$ - the energy cost in every interval of time.

$\lambda_1$ and $\lambda_2$ - multiplying factors of the objective function. Their values can be either "0" or "1" so that $(\lambda_1 + \lambda_2) = 1$. If a consumer does not want to participate in the load scheduling process, then his/her multiplying factors will be $\lambda_1 = 1$ and $\lambda_2 = 0$ in the objective function.

Our proposed objective function aims to reduce electricity cost, while maintaining a higher end-user comfort level by minimization of waiting time.

## GRAY WOLF OPTIMIZATION ALGORITHM

Gray Wolf Optimization (GWO) is a relatively new metaheuristic algorithm that is based on the social behavior and hunting strategies of gray wolves. The algorithm was inspired by the way that wolves hunt in packs, where each member of the pack has a distinct role in the hunt, and the pack works together to achieve a common goal.

What sets GWO apart from other metaheuristic algorithms is its use of four types of wolves – alpha (α), beta (β), delta (δ), and omega (ω) - to simulate the social hierarchy within a wolf pack (Figure 4). The alpha wolf is the leader of the pack and makes the major decisions, while the beta, delta, and omega wolves support the alpha and help to execute the hunt (Fatima et al., 2019).

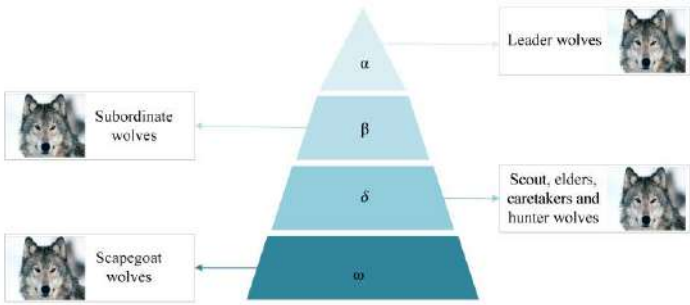


Figure 4. Hierarchical representation of grey wolves.

The leaders of the pack are the alpha male and alpha female. The alpha usually makes decisions about hunting, sleeping, and waking times. The rest of the pack follows the alpha's decisions. The alpha is not necessarily the strongest member of the pack, but the one who manages it the best. Below the alpha in the hierarchy are the beta wolves. Betas assist alphas in decision-making. In the event of the alpha's death, the beta takes on their role. Therefore, the beta follows the alpha's commands, but commands the other wolves. They act as advisors to the alpha and enforce discipline in the rest of the pack.

The lowest members of the hierarchy are the omega wolves. Omegas play the role of the sacrificial lamb. Omega wolves must obey the orders of the other wolves and are last in line for food. Although omega wolves may seem unimportant in the hierarchy, internal conflicts can arise in the pack if there are no omega wolves. This helps the pack maintain its dominance structure. In some cases, omegas guard the young in the pack. If a wolf is not an alpha, beta, or omega, they belong to the class of delta wolves. Delta wolves follow the orders of the alpha and beta wolves, but dominate over the omega wolves. This category includes scouts, old wolves, hunters, and caretakers in the pack.

### Mathematical model of GWO algorithm

The GWO algorithm begins by initializing a population of random solutions, which are represented by a group of wolves. The wolves' positions in the search space represent the potential solutions to the optimization problem, and the fitness function evaluates the quality of each solution.

In each iteration of the algorithm, the positions of the wolves are updated using four types of equations, which are based on the hunting behavior of gray wolves. The first equation updates the position of the alpha wolf, while the second equation updates the positions of the beta, delta, and

omega wolves. The third equation updates the positions of the other wolves in the population, and the fourth equation updates the position of a wolf based on its distance from the prey.

The GWO algorithm continues to iterate until a stopping criterion is met, such as a maximum number of iterations or a target fitness value. The solution with the highest fitness value is then selected as the best solution.

In addition to the social hierarchy of gray wolves, group hunting is their another fascinating social behavior. The main stages of gray wolves hunting are:

- *random searching for prey,*
- *chasing*, surrounding, and harassing prey until it stops moving,
- *attacking* the prey.

This particular hunting technique and the social hierarchy of gray wolves have been mathematically modeled to design an algorithm.

*Random searching for prey (Exploration)* - Gray wolves typically carefully explore the surroundings in search of prey based on the positions of α, β, and δ. They wander apart from each other to locate prey, and then gather to attack it. Assume that the random vector $\vec{A}$ is between -1 and 1 to force the search agent to wander away from the prey, highlighting the global search in GWO. When |A| is greater than 1, gray wolves are forced to move away from the prey. This allows the GWO algorithm to search globally (Figure 5) (Fatima et al., 2019).

The next component of the GWO algorithm that favors exploration is $\vec{C}$. The vector $\vec{C}$ contains random values in the range of [0,2]. These components provide random weight to the prey to determine if it (C>1) or reduces the significance (C<1) of the prey's influence on defining the distance from the wolf. GWO exhibits a random behavioral nature during optimization, favoring exploration and avoiding local optima.

C does not decrease linearly compared to A. C obtains a random value to emphasize exploration during the final iteration.

*The phase of encircling the prey* - According to an evaluation of the random location of each wolf, the hierarchy of solutions is determined and alpha, beta, delta, and omega are obtained. According to these values, the next location of each wolf X(t+1) is calculated as their current location X(t), the best location (called pray location $X_p(t)$) as follows (Behzadi, et. al., 2023):

$$\vec{D} = \left|\vec{C} \cdot \overrightarrow{X_p} - \vec{X}(t)\right| \quad (6)$$

$$\vec{X}(t+1) = \left|\overrightarrow{X_p}(t) - \vec{A} \cdot \vec{D}\right| \quad (7)$$

Where A and C are vector coefficients randomly generated as follows (Behzadi, & Sadrizadeh, 2023):

$$\vec{A} = 2 \cdot \vec{a} \cdot \overrightarrow{r_1} - \vec{a} \quad (8)$$

$$\vec{C} = 2 \cdot \overrightarrow{r_2} \quad (9)$$

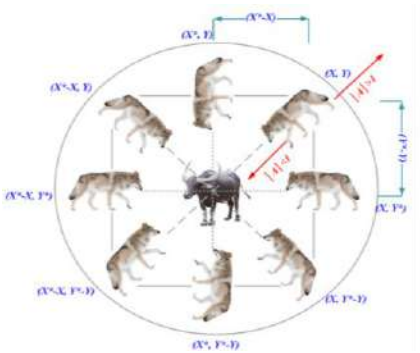

Figure 5. Searching for pray.

Where $\vec{r_1}$ and $\vec{r_2}$ are random scalars in the range of [0, 1]. Also, a is a number in the range of [0, 2] which is reduced linearly after each iteration.

All gray wolves are directed towards the position of the prey, which serves to change their own position. Different positions around the best solution are achieved by the values of vectors $\vec{A}$ and $\vec{C}$, while $\vec{r_1}$ and $\vec{r_2}$ allow the position around the prey to be randomly selected. Vector $\vec{a}$ is used to linearly reduce the size of vector $\vec{A}$ during iterations. Vector $\vec{A}$ introduces convergence towards the prey, when its size is less than one, or divergence from the prey, when its size is greater than one. Vector $\vec{C}$ is a random component that introduces exploration of the problem space. It can also be considered to model obstacles that may appear on the way to the prey.

As can be seen in Figure 6, a gray wolf in position (X,Y) can update its position towards the position of the prey (X*,Y*). Different positions around the best agent can be achieved by adjusting the values of the vector. For example, (X*-XY*) can be reached by adjusting the vector. Therefore, the gray wolf can update its position within the space around the prey to any random location using the equations.

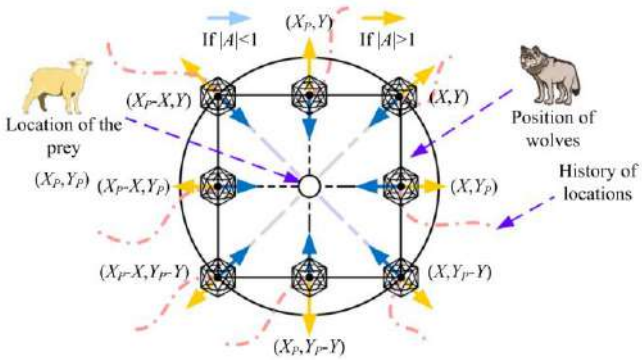


Figure 6. Impact of |A| on the movement vectors.

*Hunting* - The next movement of each wolf is based on its distance with alpha, beta and gamma locations. This means that each wolf must be aware of other wolves. This validates the swarm behavior of this population based on algorithms. The hunting in grey wolves is expressed through the following equations (Mirjalili et al., 2014):

$$\begin{aligned} \overrightarrow{D_\alpha} &= \left|\overrightarrow{C_1}\cdot\overrightarrow{X_\alpha} - \vec{X}\right| \\ \overrightarrow{D_\beta} &= \left|\overrightarrow{C_2}\cdot\overrightarrow{X_\beta} - \vec{X}\right| \\ \overrightarrow{D_\delta} &= \left|\overrightarrow{C_3}\cdot\overrightarrow{X_\delta} - \vec{X}\right| \end{aligned} \tag{10}$$

$$\begin{aligned} \overrightarrow{X_1} &= \overrightarrow{X_\alpha} - \overrightarrow{a_1}\cdot\left(\overrightarrow{D_\alpha}\right) \\ \overrightarrow{X_2} &= \overrightarrow{X_\beta} - \overrightarrow{a_2}\cdot\left(\overrightarrow{D_\beta}\right) \\ \overrightarrow{X_3} &= \overrightarrow{X_\delta} - \overrightarrow{a_3}\cdot\left(\overrightarrow{D_\delta}\right) \end{aligned} \tag{11}$$

$$\vec{X}(t+1) = \frac{\overrightarrow{X_1} + \overrightarrow{X_2} + \overrightarrow{X_3}}{3} \tag{12}$$

These equations show the change in positions of alpha, beta, and delta wolves by changing the position of the prey. Formula (11) shows that the position of the wolf will be updated based on the three best wolves from the previous iteration. The position of the prey is fictitious and depends

on the positions of alpha, beta, and delta wolves, while the other wolves approach the prey. As soon as the gray wolves approach and the prey is not moving, they attack. The change in position of the gray wolves can be illustrated with Figure 7.

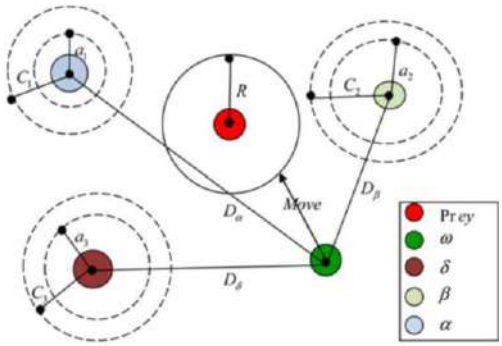


Figure 7. The model of change in position of gray wolves.

## THE APPLICATION OF GWO IN OPTIMIZATION EMS

The GWO algorithm can also be used to minimize household electricity cost. Here's how the GWO algorithm can be applied to this problem (Zaini, et al., 2022):

Initialization: Initialize the position of each gray wolf randomly within the search space. The search space should be defined in terms of the variables that control household electricity consumption, such as the usage schedule of different appliances and devices, and the temperature control of air conditioning and heating.

Fitness evaluation: Evaluate the fitness of each gray wolf by calculating the electricity cost of the household with the corresponding variable values.

Boundary handling: Handle the boundary constraints of the variables to ensure that the updated positions are within the feasible range.

Fitness evaluation: Evaluate the fitness of each updated gray wolf by calculating the electricity cost of the household with the corresponding variable values.

Dominance: Determine the dominance of each gray wolf based on its fitness value. The alpha, beta, and delta wolves are selected based on their dominance and used to update the position of the next generation.

Termination: Terminate the algorithm if the stopping criteria are met, such as a maximum number of iterations or reaching a desired solution accuracy.

Social behavior: Update the position of each gray wolf based on its position, as well as the positions of the other wolves in the pack. This step includes three sub-steps:

Exploration: The alpha wolf updates its position by exploring the search space to find a better solution.

Exploitation: The beta and delta wolves update their positions by exploiting the current best solutions found by the alpha wolf.

Encircling: The remaining gray wolves update their positions by encircling the prey (i.e., the best solution found so far).

By using the GWO algorithm to minimize household electricity cost, it is possible to find optimal or near-optimal solutions for household electricity consumption that reduce electricity costs. This can be achieved by optimizing the usage schedule of different appliances and devices and the temperature control of air conditioning and heating. In the Table 2 is presented overview of paper where GWO is used to solve HEMS or BEMS problem.

Table 2. Overview of paper where GWO is used to slove HEMS or BMS problem.

| Ref. no. | Objective | Application | Assumptions/Limitation |
|---|---|---|---|
| (Kazemi et al., 2017) | Give the residents the benefit of reducing the energy cost by scheduling appliances, | Real-time pricing for smart homes in the smart grid was assumed to be demand-respond with a day-ahead plan along with Inclining Block Rate (IBR) pricing. | The penalty for using electricity more than IBR threshold and appliances' time intervals and duration are the most important ones. |
| (Nimma et al., 2018) | Intelligent EMS and battery sizing are in the micro grids ensure the optimal use of the renewable sources and reduce conventional fuel utilization. | GWO with a smart utilization of battery energy storage helped to minimize the operational costs of micro grid. | Constraints in the micro grid based on the smart use of storage devices among other sources in the network. |
| (Zhou et al., 2019) | Optimization of daily total electricity bill, user discomfort, and power peaks and valleys. | HEMS is applied to intelligent buildings and improved the electricity habits of residential users and optimize the residential electricity structure. | Can only be applied to smart grid environment. |
| (Jordehi, 2019) | Determine optimal schedule of appliances in order to minimize electricity bill of the home. | Solving the problem of optimal scheduling of appliances in HEM systems. The problem is solved for two different homes with different set of appliances. | For the appliances with adjustable power scheduling is defined based on the difference between optimal power and baseline power. |
| (Molla et al., 2019) | Minimization of energy cost | Apply the idea of HEMS to intelligent buildings and build a building electricity optimization model for the problems of electricity economy, user comfort and grid stability. | Appliances are working at its maximum power rating. |
| (Ayub et al., 2020) | Proposed scheduling appliances to minimization of energy cost. | Optimum energy consumption pattern that will give the customer maximum satisfaction at the predefined user budget. | The relationship between the budget and the consumer satisfaction index. |
| (Iqubal et al., 2020) | Reduction in energy consumption cost. | Analyzed the effects on the operational cost of electricity by installing the rooftop PV and ESS in SH. | When the consumer only receive power from the grid the cost is enormous. |
| (Ghalambaz et al., 2021) | GWO was used to minimize the yearly energy consumption of an office building in different weather conditions. | The GWO coupled with the EnergyPlus software were successfully employed to a building EMS optimization problem. | The best optimization methods in the literature was Particle Swarm Optimization (PSO) for proposed model. |
| (Zaini, 2022) | The building envelope is meant to minimize energy demand or the energy required to power the house independent of the appliance and mechanical system efficiency. | Data utilized include readings of temperature and humidity sensors from a wireless network and a positive correlation between appliances' consumption and weather conditions. | With proposed framework (Feature Optimization Prediction Framework) is only predicted energy consumption. |
| (Behzadi, & Sadrizadeh, 2023) | In the winter to the creation of hydrogen highlights the significance of renewable hybridization in reducing the dependence of buildings on energy networks. reduce peak capacity, lower emissions, and save energy costs. | Presents an innovative and cost-effective solution for advancing state-of-the-art intelligent BEMS and aiding the intended worldwide green transition with maximum renewable integration. | Solar technology sometimes is not enough to storage to meet the annual consumption needs. |

| | | | |
|---|---|---|---|
| (Mehmood et al., 2023) | Use an optimization technique that addresses energy saving including the use of air pressure, dew point, and wind speed. | This enhancement is provided by the inclusion of weight coefficients that refer to the levels of impact of weather metrics on the appliance energy. | Must be use of properly estimated weight factors. |

## CONCLUSIONS

The optimization of household EMS using the GWO algorithm has been extensively reviewed in this study. The objective was to evaluate the effectiveness and applicability of the GWO algorithm in achieving efficient energy utilization and cost savings in residential settings.

Based on the review, it can be concluded that the GWO algorithm holds great potential for optimizing household EMS. The algorithm, inspired by the social hierarchy and hunting behavior of gray wolves, exhibits excellent search and optimization capabilities. It has shown promising results in solving complex optimization problems and has been successfully applied in various fields.

The application of the GWO algorithm in household EMS offers several advantages. Firstly, it enables the optimization of energy consumption patterns by intelligently scheduling the operation of household appliances based on factors such as electricity tariffs, user preferences, and renewable energy availability. This leads to significant cost savings for households and promotes energy efficiency.

Moreover, the GWO algorithm facilitates the integration of renewable energy sources into the EMS. By considering the fluctuating availability of renewable energy, the algorithm can allocate resources effectively and maximize the utilization of clean energy. This contributes to the reduction of carbon emissions and promotes sustainability in residential energy consumption.

The review also highlighted the adaptability and flexibility of the GWO algorithm. It allows households to respond to changing energy conditions, such as grid demand and supply fluctuations. This dynamic optimization capability ensures that the energy management system remains efficient and effective in different scenarios.

In conclusion, the review of the optimization of household EMS using the GWO algorithm has demonstrated its potential in achieving efficient energy utilization and cost savings. The algorithm's ability to optimize appliance scheduling, consider renewable energy sources, and adapt to changing energy conditions makes it a promising tool for intelligent energy management in residential settings.

However, further research is needed to address implementation challenges and optimize the algorithm's performance for practical applications. Future research should focus on refining the algorithm, addressing system complexity, computational requirements, and real-time data integration, and conducting real-world experiments to validate its effectiveness.

**Acknowledgment**

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# GIVING EVERYONE THE RIGHT TO TRAVEL: MANAGEMENT OF ACCESSIBLE TOURISM

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## ABSTRACT

Accessible or barrier-free tourism is still an under-researched area in tourism research in Hungary. With a better management and a more focused marketing, better access and more successful involvement of this this target group with special needs is an unused reserve in tourism development. Based on the results of a questionnaire survey, the authors highlight some important aspects of the travel demand of people living with disabilities, which should be considered by tourism destination management when developing tourist attractions and products, as well as in the design of visitor management tools and methods. Accessible tourism concerns more than one-tenth of the European population, so in addition to its social and societal importance, it is also a non-negligible business opportunity. Understanding the expectations and specific consumer habits of the stakeholders is essential to develop an appropriate offer and to ensure equal access to services. The authors, having acted as experts in the Erasmus Peer Act project, are demonstrating findings of a Hungarian survey on the issue, with international outlook.

**Keywords**: accessible tourism, travel habits and frequency, motivation.

## INTRODUCTION

In developed countries, accessibility is also receiving increasing attention in the organisation of tourism supply, partly out of humanity and partly in recognition of the significant business potential. In the most general terms, accessible tourism is tourism that is equally accessible to all, including people with disabilities, people with temporary disabilities, older people, people with young children and multi-generational families. Accordingly, the main areas of analysis of equal access are the same as the main areas of the supply side of tourism, namely: accommodation services; hospitality; tourist attractions; transport; communication. Of these, it is perhaps the accessibility of attractions that is the most addressed in the literature, probably in the context of the fact that a significant number of attractions are public institutions owned by the state (Csesznák et al., 2009; Káldy, 2010). In this study, based on the results of a questionnaire survey, we will investigate which are the most popular tourism products in the demand of people with disabilities and what type of offer they are looking for.

The definition of the target group for accessible tourism is problematic. In many cases, the public does not even include in the target group those who, due to their life situation, are members of the target group for a shorter or longer period of time: for example, pregnant women, people with temporary disabilities recovering from surgery, or the elderly. The proportion of the latter in the overall population is steadily increasing, and for them many forms of accessibility are a major need. In a broader and philosophical approach, accessibility is a constant aspiration of human existence, constantly striving for comfort (Farkas, & Petykó, 2019; Farkas, & Petykó, 2020). Many of the people live with some kind of permanent or temporary disability, which can be an obstacle in their lives and a barrier to their journeys. In fact, "Accessible tourism is a *continuous effort to make* all destinations, tourism products and services accessible to all people, regardless of their physical limitations, disabilities or age, and whether they are private or public tourist sites" (Accessible Tourism, 2017).

Accessibility is no longer an issue at the level of declarations, but the reality is different. This is confirmed by the results of research carried out in the framework of the Peer Act international project.

## LITERATURE SUMMARY

Defining disability is not an easy task, as it takes many forms. “We can include not only people with limited mobility, visual and hearing impairments, intellectual disabilities, but also those who suffer from other conditions that have a long-term impact on their quality of life, such as allergies" (Zsarnóczky, 2018). According to WHO estimates, *one in six people on earth has* a disability, and the proportion is steadily increasing (World Health Organization, [WHO], 2011). The Convention on the Rights of Persons with Disabilities, adopted by the UNO in 2006 and proclaimed in Hungary, obliges States Parties to ensure access for persons with disabilities to sport, recreation and tourism facilities and services (2007). Special needs occur in older age for everyone, but there are also other life situations that can give rise to special needs: people undergoing rehabilitation after an accident, families with young children (Darcy, & Dickson, 2009).

The World Tourism Organisation is committed to promoting accessible tourism; it dedicated World Tourism Day 2016 to this theme. The organisation has issued several recommendations and a handbook on the issue (World Tourism Organization a UN Specialized Agency [UNWTO], 2016). Throughout human history, there have been many efforts to promote accessibility, but it only became a widely recognised social issue in the first and even more so in the second half of the 20$^{th}$ century. It is now widely accepted that everyone, despite a disability, should be able to enjoy the pleasures of travel as much as anyone else, “since the enjoyment of the fullness of life is a right for all” (Végh, 2005). The European Parliament’s resolution of 29 October 2015 on the European Union’s priorities for the future and the European Agenda for European Tourism stresses: the importance of developing sustainable, responsible and accessible tourism; the principle of ‘tourism for all’; and that full accessibility and affordability of tourism are key to the sustainability of the sector.

According to the 2011 census data of the Hungarian Census Office (KSH), there were 595,187 persons with disabilities living in Hungary (Ernszt et al., 2019). The population affected by accessible tourism may be much larger than this, as it can be assumed that elderly persons in good health do not consider themselves as persons with disability, but at the same time, they already require accessibility when using tourism services. As tourism has become a social phenomenon, it is also important factor in shaping quality of life (Gonda et al., 2019). Facilitating travel for people with disabilities and providing the necessary physical conditions is not only a human, ethical, moral and legal obligation, but also an important economic issue. At present, accessible tourism is an untapped niche in the tourism market, despite several positive counter-examples in the recent past (Buhalis et al., 2012). However, this untapped market segment is not a homogeneous group, as they have different specific needs for services depending on the type and extent of their disability. There are barriers that can affect all travellers and barriers that are insurmountable problems for certain narrow segments, only (Shaw, & Coles, 2004). The existence of different disabilities leads to different and specific needs, which can be addressed with specific ideas and solutions. The needs of blind and hard of hearing (or deaf) people and creative solutions for accessibility designed to meet their needs are presented by Zajadacz, (2015); Zajadacz, & Lubarska, (2020).

Different tourist destinations are at different levels in implementing accessibility. Some are developing special offers for people with disabilities, others are presenting accessibility as a distinctive feature – recognising its market potential (Lőrincz et al., 2019; Raffay-Danyi, & Ernszt, 2021). The major European countries in the international tourism market are clearly placing a strong emphasis on this issue. Thus, the efforts made by Spain (Vila et al., 2015) and Italy (Agovino et al., 2017) in the field of accessibility in tourism deserve to be highlighted. Among the former socialist countries, Poland has paid a lot of attention to research on this topic (Zajadacz, 2014; Zajadacz, & Lubarska, 2019), and it is clear that there is also a growing interest among Hungarian researchers in research on accessible tourism (Gonda, & Raffay, 2020a; Farkas et al., 2022a; Farkas et al., 2020b; Farkas et al., 2022C; Farkas et al., 2023). The implementation of accessible tourism is not the same as physical accessibility, the experience provided by an accessible destination is much more than that: it is the implementation of the principles of

independence, equality and human dignity in the tourism experience. Experiencing the spirit of a place, exploring a geographical space, is as important for people with disabilities as it is for anyone else. Therefore, the geographical aspects of the subject should be addressed in the analysis of this topic. From a bibliometric analysis of social geography, we can see that neither urban studies nor general social geography journals give much attention to the study of accessibility or equal access (Csomós, 2018). Important perspectives can be drawn from Kitchin, (2009) work on the interpretation of place, on the approach and values of positive geography (Kitchin, 2015) and on the threats and opportunities of smart settlement (Kitchin, & Dodge, 2017). By examining these issues, we can place the issue of equal access in the context of the use of space. It is generally accepted that the experience of travelling and holidays enhances subjective feelings of happiness (Csapó et al. 2018; Gonda et t al. 2019). This is particularly true for people with disabilities, for whom tourism often offers the opportunity to escape from the daily hardships of everyday life. In many cases, travel is a holiday for them, and the experience helps them connect and integrate more easily into society (Gonda, & Raffay, 2020a; Gálné Kucsák, 2008). Several empirical studies in Hungary have shown that people with disabilities face significant problems when travelling and that their disability hinders them in realising their travel plans. This is why many people choose not to travel (Csapó, & Gonda, 2019, Csapó et al., 2019).

Very few Hungarian publications have addressed the issue of accessibility of accommodation and the motivation of people with disabilities when choosing accommodation. Around half of people with reduced mobility have a disability that prevents them from taking part in a tourism programme, compared to 75% of visually impaired people (Motivation Foundation and Revita Foundation Research Workshop, 2009). Providing a high level of service to disabled guests requires empathy and attention from tourism industry stakeholders, be they state organisations, business actors or NGOs (Máté, 2021; Angler, 2021).

## RESEARCH METHODOLOGY

When making the technical preparation of the questionnaire survey applied in the research, it was decided that the Hungarian partner in charge of the research would carry out the baseline survey on a sample of 200 people, which would be compared with national characteristics, for which the partners undertook to complete 30-30 questionnaires. It was very difficult to reach disabled stakeholders. The questionnaire was mainly completed through an online software, but in some cases it was also possible to collect data in person. In this respect, the Hungarian partner was very successful, as 89 questionnaires were completed in person at the Orfű Accessible Tourism Day in early September 2019, with the involvement of university students. In fact, 262 Hungarian completions were actually completed, which is one of the largest sample numbers in the Hungarian accessible tourism research to our knowledge. To this result, we compare the results of the other 4 countries, where the number of completions ranged from 22 to 34, as control. The larger sample was evaluated first, with the results expressed as a percentage. Given the low number of foreign samples, in their case percentages were not calculated but the number of responses was indicated. A short research summary of the results and a workshop paper presenting the full research results were prepared (Gonda, & Raffay, 2021). 47.8% of the Hungarians who completed the questionnaire were male and 52.2% were female (Table 1).

Table 1. Distribution of people with disabilities by sex.

| **Breakdown by sex**<br>No/Country | English | Spanish | Italian | German | Croatia |
|---|---|---|---|---|---|
| Female | 140 | 12 | 13 | 22 | 14 |
| Male | 128 | 9 | 21 | 11 | 18 |

Hungarians aged between 36 and 50 are the most numerous (47.8%), with almost half of the respondents in this group, 20.1% between 18 and 25, 14.2% between 50 and 65, 12.7% between 26 and 35 and 5.2% over 66 (Table 2).

Table 2. Age distribution of people with disabilities.

| **Distribution by age**<br>Age/Country | Englih | Spanish | Italian | German | Croatia |
|---|---|---|---|---|---|
| 18-25 years | 54 | 1 | 9 | 8 | 0 |
| 26-35 years | 34 | 0 | 10 | 8 | 12 |
| 36-50 years | 128 | 13 | 11 | 6 | 12 |
| 50-65 years | 38 | 8 | 3 | 8 | 7 |
| Over 66 years | 14 | 0 | 1 | 2 | 2 |

Other demographic data included economic activity, housing type, educational attainment and marital status (Gonda, & Raffay, 2020b).

## RESULTS OF THE RESEARCH

### Composition of disabled people surveyed and frequency of travel

An important aspect of the survey was to include a wide range of disabilities. The majority of respondents have a disability that makes life difficult, with 44% of all respondents having this type of problem. The second most frequent response was about vision, with 20% of respondents experiencing difficulties in their daily lives. This is followed by hearing and other intellectual disabilities with 12-12%, followed by speech impairment (5%) and autism or Asperger's syndrome (3%). 4% of respondents said they have a multiple disability. When asked the question, more than one response was possible.

All partners sought diversity and managed to include different types of disability in the survey. In all cases, people with a motor disability are the most numerous, except in the survey in Croatia, where people with an intellectual disability make up the largest group (Figure 1).

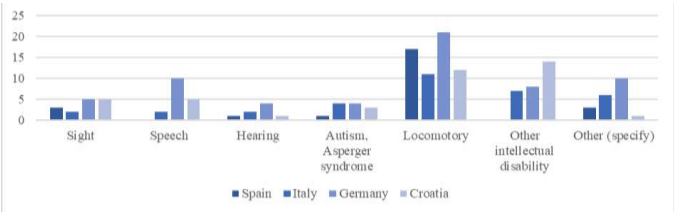


Figure 1. What disability do you live with?

The difficulties most commonly encountered by people with disabilities are as follows: transport difficulties (30%), difficulties using a catering facility (20%), difficulties using accommodation (18%), difficulties in doing sports (15%), difficulties in finding attractions (12%) and communication difficulties (2%). Only 4% of respondents said they did not encounter any difficulties in their daily lives. The results are similar for the other four partners, with transport being the most frequent response, followed by accessing attractions (Figure 2).

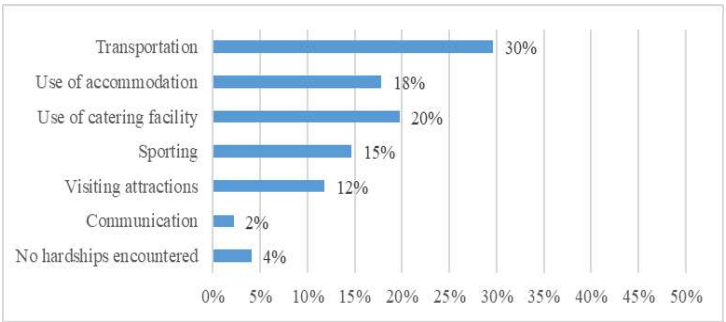


Figure 2. What difficulties do you encounter most often?

The survey also asked whether respondents travel abroad or use domestic tourism services. Respondents were asked whether and how many times they had travelled abroad in the previous five years). 36% of all respondents said they had not travelled abroad at all in the five years before the survey. Of those who had, 13% of respondents had travelled only once, 21% twice, 6% three times and 24% more than three times (Figure 3).

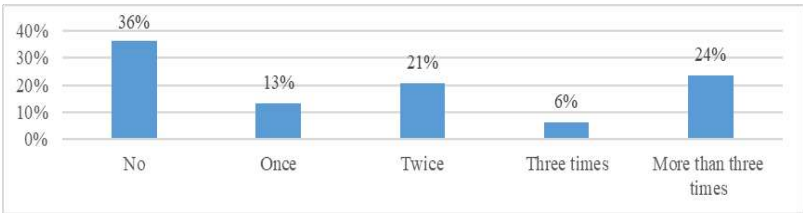


Figure 3. Have you travelled abroad in the last five years? (n=254).

The next question asked whether respondents had travelled domestically for tourism purposes in 2018. 77.1% of respondents had travelled, while 22.9% had not. Of those who had travelled, 29% had travelled once, 23% twice, 21% three times and 27% four or more times domestically. This is a much higher frequency of travel than we know from the Central Statistical Office's report on the travel habits of the domestic population (Central Statistical Office [CSO], 2019) or than we had previously thought based on a representative survey carried out in 2018 (Csapó et al., 2018).

The next question was about why respondents did not travel. The main reason was clearly lack of money (25%), followed by lack of an assisting person (15.7%), and lack of company (10.2%). In addition, respondents feared not receiving the accessibility promised and/or needed during the trip (9.7%), and lack of language skills and finding the trip cumbersome were the deciding factors (9.3-9.3%). Some are afraid of new situations (7.4%), some choose to stay at home because of lack of time (6%) and some simply because their health does not allow them to travel (4.2%). Some justified their decision saying that they could gain travel experience at home with the help of the internet and technology (2.3%) or cited transport difficulties (0.9%).

**Tourism preferred by people with disabilities**

The importance of accessibility of tourist services is also underlined. A small proportion of respondents, only 19.1%, prefer to participate in programmes made specifically for people with disabilities. Another small share (19.8%) of respondents prefer inclusive programmes; and almost two thirds (61.1%) of them said they do not prefer to participate in programmes specifically for people with disabilities, but would like to use the same offer as anyone else.

An important question in the analysis of demand is what kind of tourism products are of interest to the members of the target group, motivated by what kind of incentives. Several of the preferred programmes could be ticked in response to the questionnaire. The most popular programmes were cultural (60.2%), nature (55.6%) and sightseeing (50.4%) (Figure 4).

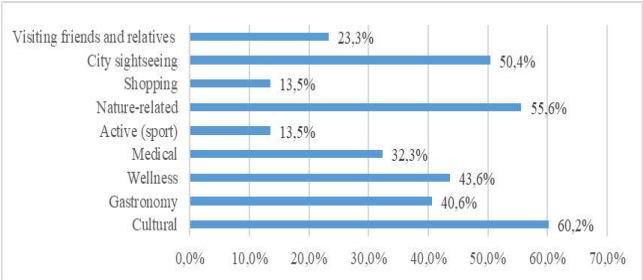


Figure 4. Which programmes do you prefer when you travel (n=264)?

More respondents voted for wellness (43.6%), gastronomy (40.6%) and VFR (23.3%). In addition, there were also responses for shopping and active programmes (13.5-13.5%). This suggests that the motivation to travel of people with disabilities is more diverse than the national average and that they have a very strong interest in cultural and natural values. A question about interest in extreme sports was deliberately included. Practising extreme sports and living with a disability seem to be mutually exclusive. However, if they were provided with adequate technical support and accompaniment to try extreme sports, these activities would also attract people with disabilities at a rate well above the average for the population, see Figure 5.

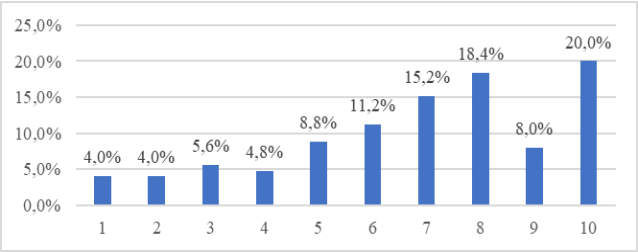


Figure 5. Extreme sports and activities would attract people with disabilities if they were provided with adequate technical support and accompaniment (n=250).

Respondents from the other four countries gave similar answers to the statement on extreme sports and activities (Figure 6).

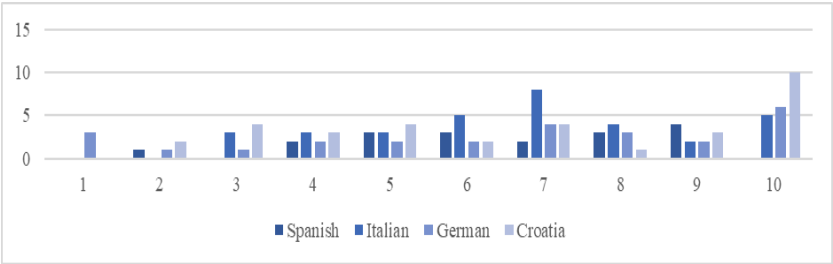


Figure 6. Extreme sports and activities would attract people with disabilities if they were provided with adequate technical support and accompaniment.

**Impact of accessibility improvements on accessible tourism**

An attitude survey was conducted to find out how the target group members perceive the situation of accessible tourism, asking respondents to indicate their level of agreement on a scale of 1 to 10 (1: strongly disagree; 10: strongly agree). The most important actors are tourism service providers, who themselves can do a lot to promote equal access. This is why tourism service providers were asked whether they are better prepared and more open to welcoming disabled

guests. The results are illustrated in Figure 7. Here again, there is a relatively high disparity in the responses, with no overall agreement on the issue. The highest response rate is for the median comfort level (16.9%), followed by a scale of 8 (15.4%), and then a scale of 2 at the other extreme (13.8%). There is roughly a 50/50 split between agree and disagree. The lowest number of responses was 'strongly agree', so it can be said that tourism operators have room for improvement in terms of preparedness and openness.

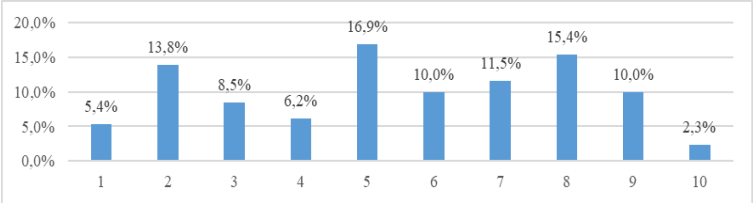


Figure 7. Tourism service providers are becoming more prepared and open to visitors with disabilities (n=260).

As in the previous statement, there is no agreement in Figure 8, with a wide variation in responses, similar to the Hungarian values. The highest scores are on the 4-7 scale.

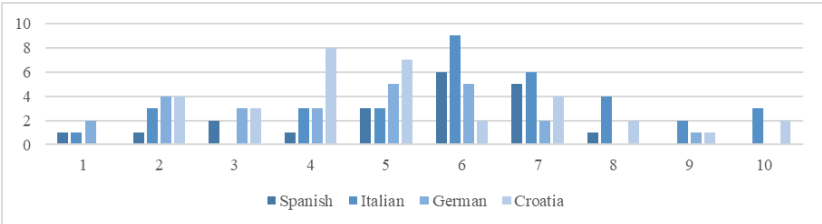


Figure 8. Tourism service providers are becoming more prepared and open to disabled visitors.

The link between travel and the mobility offered by transport is obvious. That is why we thought it important to ask specifically about accessibility in public transport in this context. The claim was that if wheelchair access to public transport in the respective countries were possible, more disabled people would travel. There was broad agreement on this statement. The majority of respondents agreed, with almost 2/3 of the top three scales (8 to 10) receiving a response rate. Only a small percentage of those who disagreed were spread across the lower scales (Figure 9).

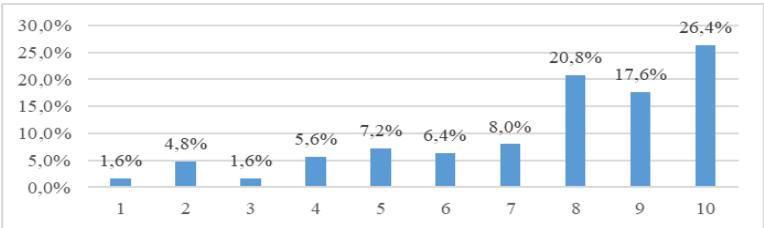


Figure 9. If wheelchair access to trains and long-distance buses were available in Hungary, more disabled people would travel (n=250).

More than 90% of respondents in all four countries agree, and their responses are above the median. Most responses from all four countries were in full agreement (scale of 10). The existence of barrier-free tourist routes also helps individual mobility. Unfortunately, this infrastructure is still very limited, though cycle paths are generally well adapted to wheelchair users, and their development is well underway in Hungary. The fact that there will also be a demand for this among people with disabilities is confirmed by the results of the answers to the question that if there were wheelchair accessible tourist routes in Hungary, at least in the park forests surrounding

the cities, more people with disabilities would be able to get out. As with the previous statement, there is a high level of agreement with this, with over 60% of respondents voting for the top three scales (8 to 10). Results for the lower scales are scattered, with none of them significant (Figure 10). The results of the international survey showed a similar scatter.

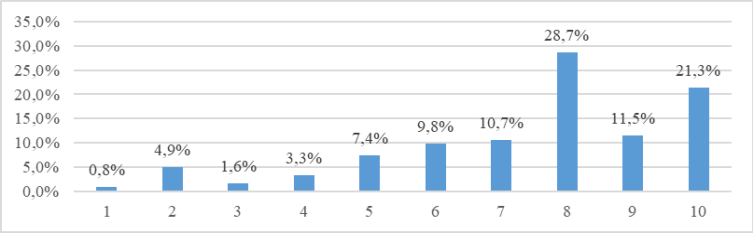


Figure 10. If there were wheelchair-accessible tourist routes in Hungary, at least in the park forests surrounding cities, more disabled people would move out (n=244).

Lastly, we examine the claim that if there were a reliable online collection of wheelchair accessible hiking trails, more people would choose to travel in nature. The answer is clear, with more than half of respondents voting for the top three scales. Four fifths of respondents think that more people would choose this type of trip if it were available.

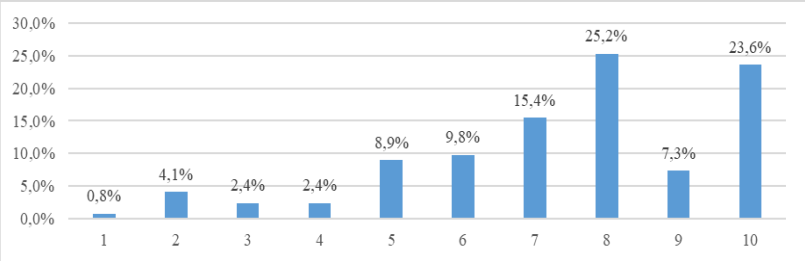


Figure 11. If there was a reliable online collection of wheelchair accessible hiking routes, more people would choose a nature trip (n=246).

The highest response from Germans and Croatians to the statement about the Internet collection was a scale of 10, i.e. full agreement. The Italians' highest response is a scale of 8 and 10, they also agree. Spaniards slightly agreed (scale 6) with the statement (Figure 12).

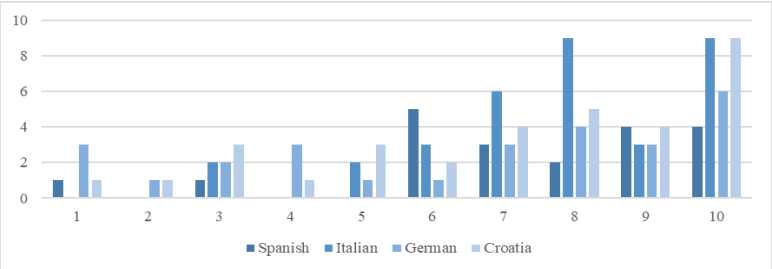


Figure 12. If there was a reliable online collection of wheelchair accessible hiking routes, more people would choose to travel in nature.

## CONCLUSIONS

The number of people living permanently or temporarily with a disability, whether acquired at or since birth, is in the billions of people in the world's population, and this group with special needs and special circumstances is growing in numbers and in proportion in almost every country. In order to live a full life like their non-disabled peers, in addition to ensuring the usability of

spaces and buildings used in everyday life, they also need to be able to travel, to participate in the 'beatific journey' of tourism. This is not only an ethical duty for the profession, but also a financial interest, because people with disabilities (and in many cases their accompanying persons) represent a significant, and far from fully exploited, market potential for tourism.

There are three ways of making travel easier or even more accessible: special travel programmes and packages for people with disabilities; inclusive travel, i.e. programmes for people with and without disabilities; and traditional travel solutions, where people with disabilities are as much a part of the journey as their non-disabled counterparts. Unsurprisingly, the latter is by far the most popular among people with disabilities, according to research by PeerAct, a five-country EU project involving the authors. In addition to complying with the provisions of international conventions and national legislation on accessibility, this also requires sensitising society and changing attitudes towards people with disabilities, as well as sensitising and training those working in the travel sector and, of course, making tourist facilities and services (travel facilities, accommodation, catering, attractions) accessible to all, not just physically. The research also clearly shows that the willingness and frequency of travel among the target group is higher than the national average. Their motivation and interests are similar to those of the vast majority in terms of seeking similar tourist attractions and services. It was also confirmed that if physical accessibility was to improve significantly in certain areas (public transport, access to extreme sports, accessible tourist routes), demand would increase by leaps and bounds.

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# POSLOVNA KOMUNIKACIJA I MENADŽMENT

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## SAŽETAK

Čovjek je djelo, koje se nalazi u okruženju drugih, takvih da im može direktno pružati važne informacije, neophodne za mudro usmjeravanje sopstvenih i njihovih aktivnosti. Mnoge važne činjenice se nalaze van mjesta i vremena ili ostaju skrivene unutar njih. Tako se, na primjer, „istinski“ ili „pravi“ stavovi, vjerovanja i emocije čovjeka mogu dokučiti samo indirektno, bilo kroz njegova priznanja, ili kroz ono što izgleda kao nesvjesno ekspresivno ponašanje. Čovjek igra svoju ulogu, posjeduje osobine, obavlja radnje koje će za posljedicu imati ono što želi. U skladu sa ovim vlada uvjerenje da čovjek nudi svoje izvođenje i postavlja svoju životnu predstavu „za dobrobit drugih“. Uspješna poslovna komunikacijaje veoma bitna funkcija menadžmenta. U ovom radu se ukazuje na značaj poslovne komunikacije ljudskim resursima u savremenim uslovima poslovanja.

**Ključne riječi**: simedonija, eudemonizam, altruizam, empatija, menadžment, komunikacija.

## UVOD

### Značaj poslovne komunikacije za uspješnost poslovanja

“Najvažnija stvar u komunikaciji je čuti ono što nije rečeno.” - Peter Drucker

Život ljudskog bića, njegov rast, kreativnost, napredak, uspjeh, sreća sadrže fizički, intelektualni, društveni i duhovni aspekt. Različiti oblici ljudske kreativnosti, napredovanja, uspjeha, sreće, mogu biti izraženi u poslovnim, književnim, naučnim, društvenim djelatnostima... ali ne može graditi vlastitu sreću ako ne pomaže i podržava ostvarenje sreće drugih ljudi oko sebe.

Živimo u dobu u kojem je tehnološka revolucija svojim pronalascima promijenila i olakšala život ljudima, ali im je stvorila i iluziju da mogu da žive sami. Živimo u društvu u kojem raspad jednog sistema vrijednosti ostavlja za sobom automatizovane ljude koji svoj poljuljani identitet, lični identitet i samopoštovanje teže ponovo da pronađu i uspostave jačajući poslovne, tradicionalne, kolektivne, društvene identitete.

U ovom radu se ukazuje šta je presudno za proučavanje poslovnosti, čovjekoljublja, odnosno karakteristika svijesti i ponašanja usmjerenih ka dobroti drugog, podršci drugog, pomaganju drugima, radovanju njihovom poslovnom napretku, uspostavljanju dobrih poslovnih odnosa sa drugima, učenju o drugima i razumijevanje poslovnog komuniciranja u savremenim uslovima poslovanja. Sve to teži se dovesti u kontekst značaja za poslovanje (Abegg, & Benford, 2008).

Tačnije cilj je povezati navedene vrijednosti sa poslovanjem i ukazati na njihov značaj za uspješnost poslovanja. Predmet istraživanja rada jeste da se pokaže kako pojedinac kroz razvijanje simedonije, eudemonizma, altruizma i empatije, može uspješnije razvijati poslovnu komunikaciju, a zatim kroz poslovnu komunikaciju doprinijeti efikasnijem organizacionom ponašanju što će u krajnjoj liniji doprinjeti većoj uspješnosti cjelokupnog poslovanja.

## SIMEDONIJA

Da bi ljudsko biće imalo simedonijski karakter kulture treba da bude u stanju da ostvari jedinstvo sa čovječanstvom kao i da bude u stanju da neprestano razvija svoj menatalni sklop. Uspostavljanje međuljudske saradnje je veoma bitno. Moramo imati dobre ideje kako simedoniju sprovesti u dobru poslovnu djelatnost.

Pojam simedonija (*symhedonia*) se najjednostavnije definiše kao „simpatija za sreću drugih“, to jest sklonost čovjeka da podrži drugoga, da mu pomogne i omogući njegov uspjeh i napredovanje, da se raduje sreći drugog (Suzić, 2008).

Svaka osoba sa sobom donosi svoje jedinstvene misli, osjećaje, iskustva. Ona je sposobna da izrazi svoju kreativnost na dva nivoa:

- Ona kreira svoje sopstveno poslovno ljudsko biće,
- raduje se sreći i napredovanju drugog.

Posmatrano sa obrazovnog sistema, može se raći da treba da se uvažavaju potrebe i mogućnosti svakog čovjeka i da maksimalno razvija njegove duhovne, fizičke, poslovne potencijale i obezbjeđuje uslove za stvaralačko uključivanje u poslovni proces. Pojam simedonija nije svojstvena samo za pojedince. Ona se odnosi i na narode i civilizacije.

U savremenim uslovima života, kada se pred čovjeka postavljaju novi izazovi sve više je očigledno da poslovno napredovanje ne obezbjeđuje razvoj onog tipa neegoistične ličnosti koja je sposobna da se raduje sreći drugih (Suzić, 2007).

Ponekad je put ka radovanju, pomaganju ka boljem životu suočen sa poteškoćama. Kada posrćemo, najlakše je očajavati i odustati, ali planove treba mijenjati, ukoliko želimo uspjeti moramo naći put, izdizati se neizmjerno, snažno koristiti svoju moć, snagu i pamet, odnosno s ljubavlju, pozitivno davati podršku drugima svim svojim srcem.

Čovjek je jedan, obični građani su djelići čovječanstva, a čovječanstvo se ogleda u čovjeku. Dobrobit jednog je dobrobit svih. Nema razdvajanja među ljudima, potpuno smo povezani, i zbog toga jedni drugima treba da pomažemo i da se radujemo i da smo srećni zbog toga.

Fokusiranje na pozitivno razmišljanje, pozitivne emocije, pomaganje drugima kako u životu tako i u poslovnom svijetu ima jasne vizije, vodi nas da postanemo bolji, da učimo da izbjegnemo loše i borimo se protiv „negativnog“, a jačamo „pozitivno“.

Zadovoljan čovjek je sretan čovjek. Zadovoljstvo se razvija u nama. Koliko ćemo i u kojoj mjeri biti sretni, radovati se i biti zadovoljni zavisi od nas samih .

Simedonija (symhedonia) se najjednostavnije definiše kao simpatija za sreću drugih ljudi to jest sklonost čovjeka da podrži drugoga, da mu pomogne u uspjehu i napredovanju, da se raduje sreći drugog (Suzić, 2008).

Ako se sada vratimo na Williamovu misao, zaključujemo da je svaka osoba individualna, originalna, neponovljiva, sa sebi svojstvenim motivima, željama, i kao takva ima sposobnost da voli, razumije, raduje se, stvara. Način na koji izražavamo ove sposobnosti je jedinstven za svakog pojedinca i grupu. Ljudska bića nisu samo predmet biološkog rasta, nego se razvijaju i kao emocionala, spoznajna, društvena rast. Taj put, kada se život razvija od jedinstvenosti i zrelosti, protkan je vaspitanjem i obrazovanjem od čijeg kvaliteta će zavisiti krajnji ishod. Da bi ljudsko biće imalo simedonijski karakter kulture treba da bude u stanju da ostvari jedinstvo sa čovječanstvom kao i da bude u stanju da neprestano razvija svoj menatalni sklop. Uspostavljanje međuljudske saradnje je veoma bitno, trebamo biti u mogućnosti prepoznati svoju energiju i talente i upotrijebiti ih i simedoniju sprovesti u dobru poslovnu djelatnost, jer simedonija nije svojstvena samo za pojedince, ona se odnosi na narode i civilizacije.

## EUDEMONIZAM

Ako je ljudska priroda nasljedno plemenita, naš pogled na život i svijet pogoduje zdravom i integrisanom razvoju života. Teško je uskladiti biološke, psihološke, duhovne, poslovne dimenzije ljudske prirode, a da ne zapostavimo ili odbacimo bilo koju od njih. Ali ako smo plemeniti, znamo da volimo radost, sreća i zadovoljstvo se razvija u nama. Što se više tazvijaju u nama mi znamo da biramo, a samim tim naši stavovi i ponašanje su okarakterisani istinom, pravednošću, jedinstvu (Tudor, 2006; Weissman, 2006).

Ljudska priroda je u osnovi plemeniti subjekt stvarnosti, najplemenitiji kreativni impuls svakog čovjeka (Aronson et al., 2005).

*Eudemonizam (grč. Eudaimonia),* stanje zadovoljstva, sreće blaženstva, shvatanje da sreća nastaje zbog toga što u sebi imamo dobrog demona, pa je ostvarenje takvog zadovoljstva cilj

života. To može imati ne samo individualni već i opšti karakter (altruizam) (Bošnjak, 1989; Klein, 2008).

Eudemonizam – dobrobit povezuje sa aktualizacijom ljudskih potencijala, a ispunjenjem ili ostvarenjem istinske prirode pojedinca. .Ako shvatimo ljude kao biološka, psihološka i duhovna bića koja prolaze kroz razvojne procese, vidjećemo u ljudima veće mogućnosti za dobrim životom i poslovnim ostvarenjem.

Čovjek je ostvaren kada je zadovoljan, zadovoljstvo proizilazi iz razumijevanja. Da bismo razumijeli i poslovali sa drugima trebamo eudemonizam i simedoniju primjenjivati u poslovnom svijetu.

## ALTRUIZAM

Ljubav – emocija koja životu daje značenje i svrhu, obezbjeđuje uslove za ljepši život čovjeka, daje mu mogućnost da voli, da bira i da ima izbor.

Čovjek koji se razvija i raste okružen ljubavlju postaje univerzalna samopouzdana, ispunjena osoba.

Altruizam, (lat. Alter, drugi), altruismus; altruisme. Osećanje ljubavi za druge bilo instinktivno ili nastalo iz odnosa sa bićima iste vrste ili poteklo iz razmišljanja i individualnog odricanja; moralna doktrina po kojoj je motiv moralnog delovanja saosećanja sa ljudima, a njegov cilj je raditi za dobro drugih (Marić, 1991).

Altruizam je naklonost i ponašanje kojem je cilj pomaganje drugome u kojem se ne očekuje neka vrsta nagrade od drugih.

U poimanju altruizma nalaze se dva kriterijuma: isključivost usmjerenosti ponašanja na dobrobit drugih osobina nasuprot ličnoj dobrobiti, i veličina dobrobiti određenog namjerno učinjenog dijela po druge ljude.

Oblici altruizma:

- Nediferencirana afektivna osjetljivost (Stadijum 0),
- Egocentrična akomodacija (Stadijum 1) – egocentrična akomodacija je, uglavnom, orijentisana na zadovoljavanje potreba za sigurnošću,
- Instrumentalna saradnja (Stadijum 2) – instrumentalna saradnja je usmjerena na izvršavanje svog udjela u konkretnim razmjerama sa drugim,
- Obostrani altruizam (Stadijum 3) – obostrani altruizam je osjetljiv na publiku „uopštenih drugih“ i ima za cilj ispunjavanje obaveza koje proističu iz zajdničkih uloga i izbjegavanja društvenog neodobravanja, održavanja dobre reputacije, njegovanja prijateljskih veza, obezbjeđivanje sopstvenog mjesta u referentnim grupama, saglašavanja i ponašanja na društveno prihvatljiv način,
- Altruizam savjesti (Studijum 4) – ovaj oblik prosocijalnog ponašanja rukovođen je unutrašnjim osjećanjem društvene odgovornosti i savjesti,
- Autonomni altruizam (Stadijum 5) – ovaj oblik altruizma rukovodi se unutrašnjim vrijednostima kao što su poštenje, dostojanstvo, jednaka prava ljudi i povećanje dobrobiti svih ljudi. Počiva na dubokom uvažavanju individualnih razlika što doprinosi toleranciji i primjeni načela kao što su sloboda, jednakost i pravda za sve ljude,
- Integrisani altruizam (Stadijum 6) – pošto je dihotomija ja-drugi prevaziđena kada jedinka počinje da osjeća sebe kao dio čovječanstva, lični interesi postaju intttegrisani sa interesima drugih. Podržavaju se prava i krajnja dobrobit svih ljudi, uključujući i sebe sama, što dovodi do toga da se podržavaju načela koja se nalaze u osnovi svih vrijednosti,
- Univerzalna samožrtvujuća ljubav (Stadium 7) – altruizam potiče iz kosmičkog osjećanja jednakosti sa univerzumom, poistovjećenosti sa ljudskom vrstom i Vrhovnog aktivnog saosjećanja sa zajednicom ljudskih bića, punog osjećaja odgovornosti za dobrobit i razvoj svih ljudi, posebno onik koji su u nepovoljnom položaju:
    - osobama koje su članovi uže porodice ili su prijatelji,

- osobama koje traže da im se pomaže i pomoć im je stvarno potrebna
- osobama koje su doživjele nesreću i ne mogu da je prebole. (Joksimović, Gašić-Pavišić i Miočinović, 1997; prema Suzić, 2005).

Najdjelotvornija je ona pomoć koja doprinosi da se ljudi oslanjaju na sopstvene snage. Ponašanje neke osobe se može definisati kao voljno ponašanja. Da li je to ponašanje koje ima pozitivne ili negativne posljedice za druge, zavisi od osobe do osobe. Altruizam podrazumijeva istinski nesebično ponašanje, dok empatija uključuje dijeljenje emocija drugih osoba. Samopoštovanje je samoevoluacija kojom pojedinac održava stav prihvatanja ili neprihvatanja sebe (Kets, 2008).

Ponašanje ljudi, saradnja, pomaganje drugima i dr. oblici ponašanja predstavljaju jedan od najvažnijih ciljeva socijalizacije.

Altruističko ponašanje daje veću šansu genetskoj strukturi, jer činiti dobro drugom u poslovnom svijetu znači da ćemo se dobro poslovati i da ćemo se dobro osjećati u poslovnim poduhvatima.

## EMPATIJA

Naši pogledi na ljudsku prirodu odražavaju naša očekivanja ljudskog potencijala, i proširuju naše granice da saosjećamo sa drugim ljudskim bićima. Osoba koja je sposobna da otkrije stvarnost, da razlikuje raznolikost među ljudima, odnosima, da razumije njihova ponašanja, poslovne poduhvate, njihove osobine biće u stanju da na zdrav način priđe drugom čovjeku, razumije ga, moći će djelovati na njega i poslovno sarađivati.

Ljudska bića su biološka, psihološka i duhovna i ono po čemu se razlikuju jedni od drugih su njihove sposobnosti da znaju, vole i biraju, a ljubav je ta dinamična sila privlačnosti koja privlači da individua individuu razumije, pomogne, liječi. Čovjek kada vlada vlastitim emocionalnim doživljajima u stanju je da priđe drugom čovjeku. Kod ljudskih bića mišljenje prethodi ponašanju, a ono što mislimo, osjećamo, suosjećamo je početak onoga što ćemo uraditi.

Ljudi su savršena bića, kao takva žive u skladu s principima i standardima ljudske prirode, sposobni da razumiju sebe i druge.

Svako ljudsko biće je jedinstveno ljudsko biće. Svi kreiramo vlastite živote i od svih stvari koje kreiramo tokom života, najvažnija je da kreiramo sami sebe. Da bismo kreirali sebe, kao jedinstvenu osobu, trebamo ljubavi i ohrabrenja. Ohrabrenje znači dati ljudima hrabrost da urade najbolje što mogu. Jako je važno da postanemo agenti promjene u životima onih do kojih nam je stalo (Lewicki et al., 2009; Marković, 2008).

U svakodnevnom govoru empatična osoba se opisuje kao ona koja je senzitivna na potrebe i osjećanja drugih, a altruistično, saosjećajno, taktično ili pak povlađujuće ponašanje smatra se empatičnim. Empatija, upotrijebljena u altruističke svrhe, je proces koji inicira i unapređuje socioemocionalni razvoj subjekta i objekta empatisanja, kao i odnosa osoba u stanju empatije. Ona je nezamjenjivo sredstvo i metod emocionalnog saznavanja u međuljudskim odnosima, ali i specifična socijalna vještina koju pojedine profesije rafinirano upotrebljavaju.

Samo čovjek koji ima velike mogućnosti za raznovrsne kontakte i iskustva spreman je za interakciju, human odnos, predusretljivost i pozitivnu inicijativu, unosi se vlastitim emocijama na simedonijski način spreman je da ostvari dobre poslovne kontakte (Whitmore, 2006; Manning i Reece, 2008).

Poslovna komunikacija obrađuje razne aspekte razmjene informacija među ljudima s ciljem obavljanja poslovnih aktivnosti. Stvaranje novih poslovnih poduhvata i ideja dogovorom, primjenjujući simedonijski karekter, empatiju, eudemonizam, altruizam predstavlja vitalan dio svih funkcija menadžmenta –planiranja, organizovanja, brige o ljudskim resursima, vođenja, kontrolinga...

## ZAKLJUČCI

Menadžment je nužan i cjelini i njenim dijelovima, bavi se ljudskim bićima koja će osposobiti za zajednički rad, kako bi svoje snage učinili djelotvornima, a svoje slabosti nevažnima.

Kako menadžment prolazi kroz svoje funkcije i kreće se od početka do kraja zapravo je i sam živo biće koje se razvija usporedno s promjenama, svojim potrebama i mogućnostima. Postignuća kao glavni dio internog dijela organizacije su mjerila koja pokazuju uspješnost menadžmenta. Poslovna komunikacija obrađuje razne aspekte razmjene informacija među ljudima s ciljem obavljanja poslovnih aktivnosti u svakom menadžmentu. Primjenjujući simedonijski karekter poslovne komunikacije, empatiju, eudemonizam, altruizam u menadžmentu podrazumijeva stvaranje novih poslovnih poduhvata i ideja dogovorom.

Cilj analiza prikazanih u ovom radu jeste bio da se dokaže i zaključi da je uspješan samo onaj kolektiv u kome su ljudi zadovoljni. Zadovoljstvo se postiže upravo kroz poslovnu komunikaciju zasnovanu na simedoniji, eudemonizmu, altruizmu i empatiji. Razvijanje ovakve poslovne komunikacije za rezultat će imati konkurentno preduzeće.

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# BUSINESS COMMUNICATION AND MANAGEMENT

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## ABSTRACT

The man is a piece which is in the environment of others where it can directly provide the important information that are necessary for the wise direction of its own and their activities. Many important facts are located outside of place and time or remain hidden within them. For example, the "true" or "real" attitudes, beliefs and emotions of a person can only be understood indirectly, either through its confessions, or through what it appears to be unconscious expressive behavior. The man plays his role, possesses the qualities, do the actions that will have the results which he wants. In accordance with this, there is a belief that man offers his performance and sets his life show "for the benefit of others". Successful business communication is a very important function of management. This paper points out the importance of business communication of human resources in modern business conditions.

**Keywords**: simedonia, eudaimonia, altruism, empathy, management, communication.

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# DO DIFFERENCES IN THE MARITAL STATUS OF WOMEN AFFECT THEIR BEHAVIOR AT THE WORKPLACE?

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## ABSTRACT

Our personal lives and our work commitments should be in balance. Many female employees face the double burden of their careers and families. Previous studies have established that there are differences in women's work behavior by marital status, but these results are still largely unclear and sometimes questionable. The aim of this research is to prove that the differences in behavior between married women and those who are not (unmarried, divorced, widowed) are not only reflected in family relationships and roles, but also in workplaces. The research was carried out using an online model at the beginning of 2023. on a quota, representative sample (n=140). Five hypotheses were set, four of which were confirmed in the research. A 5-point Likert scale was used as a research instrument. The correlation partial analysis method was applied. All women were observed through three statistical characteristics: (1) women without children; (2) women with small children; (3) women with adult, independent children. The statements in the scale reflected the following eight forms of organizational behavior: job satisfaction, creativity and innovation, taking responsibility, absenteeism, stress, conflicts, work engagement and loyalty to the organization. The research results indicate that the differences in the behavior of women according to their marital status are more significant and are reflected in most of the observed forms of organizational behavior. As such, they should be useful knowledge in human resource management, especially in the motivation and management of employees.

**Keywords**: marital status, behavior at work, women.

## INTRODUCTION

Our personal lives with all their characteristics in today's complex, uncertain and turbulent times significantly affect our business lives in many different ways, but also vice versa. For example, parental responsibilities, such as childcare, transportation and school drop-off, may limit the time parents can spend at work or require flexible working hours. In addition to the limitations and schedules of the total available time, our personal lives impose a number of norms and forms of behavior in the workplace. In addition, numerous mega trends determine a number of forms of human behavior. Statistics show that fewer people are getting married today than in the past, and both the average age of first marriage and the divorce rate are on the rise worldwide. Such trends raise the important question of how single people fare in terms of organizing their private lives and work commitments compared to their married counterparts. One of the key problems that is emerging more and more in research today is the issue of balance between family and work obligations. Some even point out that this balance is only a theoretical assumption and that in fact it does not even exist.

Organizations that provide employees with (or believe that they provide) a good balance between work and family can derive a number of benefits, such as improved performance of assigned tasks, greater organizational loyalty, greater creativity and responsibility at work, reduced turnover and absenteeism rates, etc. This balance should be primarily observed through the individual's perception of the degree, content and form in which he or she experiences positive relationships between work and family roles. In this approach, this relationship is considered compatible and in mutual balance. Thus, work and family systems are interconnected (Sirgy et al., 2001). However, family life can interfere with work life, and the latter can interfere with the former. It is a kind of phenomenon that is ideally observed in the work-family relationship and

which led to the emergence of a new research stream (Clark, 2000). Over the last decade, a changing society has identified numerous factors that generate job satisfaction, which is key knowledge for practitioners who manage human resources in companies. The balance between family and work obligations, or thinking about it, is becoming more and more a part of this process among many researchers.

In this paper, the efforts are to show through the observation of the marital statuses of women - employees who are married and those who are not (unmarried, divorced, widows) whether these differences are reflected only within family relationships and roles or are they also reflected in workplaces? Female employees, whether married or not, have to earn a living while taking on the roles of caring for their families and children. The main concerns of many female employees who work in hospitality and tourism (included in the sample of this research) are that they mostly work two shifts, they are physically strained during work, job security and income uncertainty are a constant threat to them.

Although many published studies have so far highlighted the issue of work-life balance in the Western world, research focusing on this balance in transition countries is insufficiently known, researched and thus limited (Kandasamy, & Ancheri, 2009).

## LITERATURE REVIEW

Frone tried to explain the meaning and significance of the balance between family and work obligations and established that work and family life should be in balance. He defines this balance as the lack of conflict or interference between work and family roles (Frone, 2003). Greenhaus and Beutell, on the other hand, identified this balance as a form of role conflict in which role pressures from family domains are mutually incompatible in some respect. That is, participation in the work (family) role is hindered by participation in the family (work) role (Greenhaus and Beutell, 1985). Numerous studies looked at social support starting from the status of spouse, parents, siblings, children, extended family and friends (Palaz, 2010; Petrakis, 2021). This family support includes the exchange of support among relatives (Voydanoff, 1988). The role of the workplace, which includes support from superiors and co-workers, is highlighted as another critical element of balance (Gutek et al., 1991; Verick, 2014; Xiao, & Asadullah, 2020).

Many studies have argued that the role of women has recently undergone major changes in industrial societies. Milkie and Peltola found that married women have more frequent mental disorders compared to unmarried women because they work under pressure to earn a living without any choice (Milkie, & Peltola, 1999). Moreover, married women are more emotionally unstable in their jobs. Therefore, they are likely to be challenged to achieve a balance between work and family obligations (Becker, & Moen, 2019; Lee et al., 2008). Several studies have argued that women have different ideas about the appropriate amount of time they spend at work and for personal time (Blasche et al., 2021). Other studies have found that age, career stage, and family structure influence hours worked (Frone et al., 2018). Married women with children achieve a significantly lower balance than unmarried women (Tausig, & Fenwick, 2015). The presence or absence of children in the family continues to create significant differences in the degree of balance (Gilbert, 2010; Matlin, 2014; Contreras, & Plaza, 2018).

Some studies have shown that single women feel lonely, less attractive, less satisfied with life and have functional problems with regard to social relationships and self-confidence (Adamczyk, 2017; Byrne, & Carr, 2015). Single women also experience isolation and stigma in the workplace (Collins, 2011). Women in this category are more likely to develop psychological disorders such as depression, aggression and obsessive-compulsive disorder (Safiri, & Shahanavaz, 2016). They also face problems of living independently and communicating with friends and at the workplace (Qaderzadeh et al., 2017). Most research on single women has focused on young single women, but it is important to consider all age groups and a range of individual and social characteristics (Ahmadi, & Babashahi, 2012). Marital intimacy, which is a by-product of marital interaction, has also been shown to reduce family and work stress by promoting the sharing of housework and parenting in dual-parent couples (Kang, & Yoo, 2015). It can also reduce work-family role stress (Choi et al., 2009).

Some researchers tend to argue that single parents may experience more work-family conflict than married parents because they have to handle the dual demands of paid work and family responsibilities with fewer resources (Avison et al., 2007). Previous research is partly contested by Kendig and Bianchi, arguing that it is not clear whether the lack of resources of single parents is due to lack of partners or other factors such as lower socioeconomic status (Kendig, & Bianchi, 2008). For example, having more children or having young children at home is associated with more home-to-work conflict (Dilworth, 2004). Parents who often take work home, whose jobs require frequent travel, night shift work, or who feel more pressure to increase productivity may feel that it is difficult to meet the demands of work because of their family (Grzywacz, & Marks, 2000). Little research has yet focused on how single parents differ from married parents in home-work conflict (Heyman, 2000). Single parents experience more home-to-work conflict than married parents, but differences were not further examined at the multivariate level (Avison et al., 2007).

It is obvious that work and family are increasingly becoming antagonistic spheres, equally occupied with energy and time, and responsible for the conflict between work and family (Hays, 2014). These conflicts were intensified by the so-called cultural contradictions of motherhood, as women are increasingly encouraged to search for themselves. Accomplished in demanding careers, they also face increased pressures to sacrifice for their children by providing "intensive parenting," highly involved child rearing and development (Aryee, 2012). Workplace characteristics may also contribute to higher levels of imbalance. Researchers have found that the number of hours worked per week, the amount and frequency of overtime required, inflexible work schedules, unsupportive supervisors, and an inhospitable organizational culture increase the likelihood that female employees will experience conflict between their work and family roles (Frone et al., 2022). Baruch and Barnett found that women who had multiple life roles (eg, mother, wife, employee) were less depressed and had more self-confidence compared to women who were never married, unemployed, or childless (Baruch, & Barnett, 2019). Kandel et al. argued that it is the quality of the role that matters, not the quantity of the role (Kandel et al., 2020). They studied the nature of specific tensions and stressors among married women in their marital, professional, and domestic affairs. They found that tensions and stresses are lower in family roles than in professional and domestic roles among married women.

## OBJECTIVE AND HYPOTHESES

The aim of this research is to prove that the differences in behavior between women who are married and those who are not (unmarried, divorced, widowed) are not only reflected in their family relationships and roles, but also in the workplace. The following five hypotheses are based on this goal:

$H_1$ – Unmarried women are more satisfied with their work than married women.

$H_2$ – Married women are more innovative and creative than unmarried women.

$H_3$ – Married women are more responsible and loyal to the organization than unmarried women.

$H_4$ – Unmarried women are more prone to stress and absenteeism than married women.

$H_5$ – Unmarried women are more prone to conflicts than married women.

In the presentation of the research results, a review will be given on the acceptance or rejection of these hypotheses.

## METHODOLOGY

The primary data for this research was collected through an online survey on a sample size of n=140. The respondents were female employees in permanent employment in 14 medium and small companies in the field of hospitality and tourism from the area of two Croatian counties: Split-Dalmatia and Šibenik-Knin. Included are female employees who work in the following jobs: receptionists, waitresses, cooks and housekeepers. All women selected for the sample were classified into two subgroups: (1) employed women who are married and (2) women who are not married (unmarried, divorced, widows). Both groups were observed through three statistical

characteristics: (a) women without children; (b) women with small children; (c) women with adult, independent children.

The choice of companies in the sample was random. The sample size and sampling technique were based on stratified random sampling. Of the questionnaires sent, 123 respondents responded with correctly and completely filled questionnaires, which can be considered an acceptable selection considering the type of survey. Of these, there were 74 respondents in subgroup 1, and 49 respondents in subgroup 2. The survey was conducted in the period from January to March 2023.

It was completely anonymous and the respondents were informed of this before participating in the survey. They were also informed about the purpose of the survey.

Secondary data for this research was limited to empirical studies that deeply examine the concept of employee motivation. Free access to several databases including Scopus, EBSCO, PsycARTICLES and ScienceDirect was used.

The research instrument was 16 statements targeted for the construction of a 5-point Likert scale. There were two statements each for the construction of eight forms of organizational behavior: (1) job satisfaction; (2) creativity and innovation; (3) assuming responsibility; (4) loyalty to the organization; (5) absenteeism; (6) stress; (7) conflicts; (8) preoccupation with work. This is shown in table 1.

Table 1. Variables and statements for constructing the Likert scale.

| No | Forms of behavior | Claims |
|---|---|---|
| 1. | Job satisfaction | In this job I find myself and the realization of my life goals and plans<br>I don't believe I could find a better job than this, nor will I try |
| 2. | Creativity and Innovation | I believe that I can always do something better in my work<br>Things in my environment encourage me to find new approaches to problems |
| 3. | Taking responsibility | I look for and force action to achieve the goal and not waste time unnecessarily<br>I would open a discussion to stimulate new ideas from others in the team that would move things for the better |
| 4. | Loyalty to the organization | I would accept any job just to continue working in this organization<br>I am proud to tell others that I am part of this organization |
| 5. | Absenteeism | Family problems can burden me so much that I am not able to work<br>I can't work at the same time while I'm in my mind with unresolved things at home |
| 6. | Stress | I often get into a state of depression, tension, withdrawal at work<br>It takes me more time to do the same work than before |
| 7. | Conflicts | When I get angry, I want to beat someone at all costs<br>Colleagues who don't understand my good intentions get on my nerves |
| 8. | Preoccupation with work | I am comfortable and happy at work and I do my work with ease<br>I wouldn't trade this job for any other and I do it for a lot of personal satisfaction |

Respondents' levels of agreement with the statements are: 1-do not agree at all, 2-disagree, 3-partially agree, 4-agree, 5-completely agree. The statements are weighted with weight ratios that have been established and identified with the respondents' scaling degrees. Statistical processing of the collected primary data was performed using the software packages Microsoft Excell and SPSS 21.0 (Statistical Package for Social Sciences).

The correlation partial analysis method was applied.

There are a couple of limitations that are worth noting in this research. It would certainly be good if the research included the support provided to married women in caring for children by their husbands, so that more clear conclusions could be drawn about certain forms of behavior at work.

## RESULTS AND DISCUSSION

The demographic characteristics of the respondents are shown in tables 2 and 3.

Among the respondents, women who are not married, it would be valuable to know who helps them with their obligations towards their children (parents, relatives, etc.). One of the limitations is that there were no similar studies on this topic on the population that was studied in a geographical sense. Thus, it is impossible to compare the obtained results with some other, comparable findings.

In short, the typical map of the most frequently represented respondent in subgroup 1 is as follows. This respondent lived with small (non-independent) children (44.59%), was between the ages of 26 and 40 (36.49%), had a secondary vocational education (75.68%) and came from a company that has up to 10 employees.

The most frequently represented respondents in first subgroup were those with small (non-independent) children (57.14%), between the ages of 26 and 40 (46.94%), with a secondary vocational education (83.67%) and coming from a company with up to 10 employees.

Greenhaus and Beutell determined and indicated that the mother's participation in the family role makes it difficult for her to participate in the work role (Greenhaus, & Beutell, 1985). Both Palaz and Petrakis pointed out the importance of social support starting from the status of spouses, parents, siblings, children, extended family and friends. This was the basis for setting the second and third hypotheses. In other words, married women are more innovative and creative, as well as more responsible and loyal to their organization.

Table 2. Demographic map of respondents of subgroup 1 (employed women who are married).

| No | Demographic characteristic | Number of respondents | Percentage | Cumulative |
|---|---|---|---|---|
| **A.** | **Characteristics of the family:** | | | |
| | Childless | 16 | 21,63 | 21,63 |
| | Small (non-independent) children | 33 | 44,59 | 66,22 |
| | Adult (independent) children | 25 | 33,78 | 100,00 |
| **B.** | **Age structure of respondents (years):** | | | |
| | To 25 | 8 | 10,81 | 10,81 |
| | 26-40 | 27 | 36,49 | 47,30 |
| | 41-60 | 24 | 32,43 | 79,73 |
| | 61 and more | 15 | 20,27 | 100,00 |
| **C.** | **Structure of respondents by professional training:** | | | |
| | Secondary level | 56 | 75,68 | 75,68 |
| | Higher education | 18 | 24,32 | 100,00 |
| **D.** | **The size of the company from which the respondents come (total number of employees):** | | | |
| | To 10 | 29 | 39,19 | 39,19 |
| | 11-30 | 26 | 35,14 | 74,33 |
| | 31-50 | 12 | 16,21 | 90,54 |
| | More than 50 | 7 | 9,46 | 100,00 |

Table 3. Demographic map of respondents of subgroup 2 (employed women who are not married).

| No | Demographic characteristic | Number of respondents | Percentage | Cumulative |
|---|---|---|---|---|
| **A.** | **Characteristics of the family:** | | | |
| | Childless | 9 | 18,37 | 18,37 |
| | Small (non-independent) children | 28 | 57,14 | 75,51 |
| | Adult (independent) children | 12 | 24,49 | 100,00 |
| **B.** | **Age structure of respondents (years):** | | | |
| | To 25 | 11 | 22,45 | 22,45 |
| | 26-40 | 23 | 46,94 | 69,39 |
| | 41-60 | 13 | 26,53 | 95,92 |
| | 61 and more | 2 | 4,08 | 100,00 |
| **C.** | **Structure of respondents by professional training:** | | | |
| | Secondary level | 41 | 83,67 | 83,67 |
| | Higher education | 8 | 16,33 | 100,00 |
| **D.** | **The size of the company from which the respondents come (total number of employees):** | | | |
| | To 10 | 29 | 39,19 | 39,19 |
| | 11-30 | 26 | 35,14 | 74,33 |
| | 31-50 | 12 | 16,21 | 90,54 |
| | More than 50 | 7 | 9,46 | 100,00 |

The demographic characteristics of respondents in subgroup 2 do not nominally differ from those in subgroup 1, except that they differ in structural proportions.

Table 4. Partial correlation coefficients of subgroup 1.

| Form of organizational behavior | a | b | c |
|---|---|---|---|
| Job satisfaction | 0.4176 | 0,3820 | 0,5176 |
| Creativity and innovation | 0,5264 | 0,6308 | 0,7762 |
| Taking responsibility | 0,5597 | 0,6814 | 0,7223 |
| Loyalty to the organization | 0,6415 | 0,8310 | 0,7274 |
| Absenteeism | 0,6375 | 0,7248 | 0,7103 |
| Stress | 0,7301 | 0,6722 | 0,7548 |
| Conflicts | 0,5913 | 0,7102 | 0,6624 |
| Preoccupation with work | 0,6283 | 0,7814 | 0,7256 |

The creativity and innovation of respondents in the first subgroup shows a stronger correlation in all three family statuses: without children, with small children and adults (independent children). This was not found in the second subgroup, where this interconnection is less pronounced. The same can be said for assuming responsibility and loyalty to the organization. Therefore, the second and third hypothesis can be accepted. Employed wives most likely (although this was not the content of this research) had social support within the immediate or extended family in raising and generally taking over part of the care of children. This gave them the opportunity to actively focus on contributing to the creation and innovation of new solutions related to their scope of work. They felt that they could take more responsibility for their work and show a higher level of loyalty to their organization. What is certainly debatable in this research is that women, employees who are married are less satisfied with their jobs than employees who are not married. This confirmed the first hypothesis. The reasons can be found in the knowledge presented by Milkie and Peltola, who found that married women have more frequent mental disorders compared to unmarried women because they work under pressure to earn a living without any choice. Becker and Moen, and Lee and colleagues also found that married women are more emotionally unstable in their jobs and thus face the challenge of achieving a balance between work and family obligations. It is possible that all this leads to a relative feeling of less satisfaction with the work they do. This should be connected with the simultaneous efforts to achieve greater creativity, innovation, responsibility and loyalty, which can then lead to a reduced sense of job

satisfaction. Especially if these efforts are not fulfilled in accordance with the expectations of female employees.

Table 5. Partial correlation coefficients of subgroup 2.

| Form of organizational behavior | a | b | c |
|---|---|---|---|
| Job satisfaction | 0,6742 | 0,8014 | 0,7629 |
| Creativity and innovation | 0,3617 | 0,4825 | 0,5106 |
| Taking responsibility | 0,4108 | 0,5203 | 0,4706 |
| Loyalty to the organization | 0,4237 | 0,3691 | 0,3826 |
| Absenteeism | 0,7318 | 0,8046 | 0,7914 |
| Stress | 0,8226 | 0,7450 | 0,8217 |
| Conflicts | 0,5811 | 0,6492 | 0,7018 |
| Preoccupation with work | 0,6294 | 0,6807 | 0,7605 |

Unmarried women expressed greater job satisfaction than married women, which confirmed the first hypothesis. Tausig and Fenwick found that married women with children achieve a significantly lower balance between family and work obligations than unmarried women, which may be one of the reasons for the lower level of job satisfaction among married women compared to single women. Unmarried women were more prone to stress and absenteeism than married women, which confirmed the fourth hypothesis. No significant difference was observed between the first and second subgroups in the tendency to conflicts, so the fifth hypothesis cannot be accepted. Avison and his colleagues proved that single parents can feel more conflict between work and family than married parents because they have to handle the double demands of work and family obligations with fewer resources, which is certainly one of the important causes of stress in unmarried women, which was also confirmed in this research. Also, this research confirms the findings of Baruch and Barnett claiming that women who had multiple life roles were less depressed and had more self-confidence compared to women who were not married.

## CONCLUSIONS

This research has shown that there are evident differences in the perceived forms of organizational behavior between female employees who are married and those who are not. If the organization can provide a healthy work environment that is more supportive of their family, then female employees can generate significant job satisfaction and create productive relationships for the organization, thus achieving a 'win-win' situation. Therefore, practitioners in the field of human resource management should understand what these employees need. The statements they made in eight forms of organizational behavior indicate that they should find a balance between family and work obligations of female employees in both observed subgroups. Practitioners may assign differentiated workloads to single and married women. Consequently, they can rotate the schedule and distribution of chores and show a greater understanding of their family roles and family burdens. Certainly, the researched issue is much broader than the scope of work and human resources management and requires a broader sociological and psychological treatment that includes numerous and very broad aspects of social support of the social community and married and unmarried female employees.

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# PERCEPTION OF STRATEGIC CORPORATE GOALS AND EMPLOYEES' MOTIVATION

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## ABSTRACT

The majority of authors in previous researches agree that strategic corporate goals should be clear, timely, transparent and accessible to all stakeholders. What is not yet completely clear and sufficiently researched is how much the perception of these goals by employees as stakeholders affects their motivation? The goal of this research is aimed at finding an answer to that question. The research was conducted on a representative quota sample of 120 respondents. In order to determine the perceptual processes of strategic goals and motivation of employees, a five-point Likert scale with 12 defined statements was constructed and used. The method of partial correlation was used. The determined coefficients point to three key conclusions. (1) The perception of goals by employees reflects positively on employee identification (r = 0.6611). (2) The perception of goals by employees is not significantly reflected in employee motivation (r = 0.3171). (3) Identification of employees with a strategic organizational goal has a positive effect on employee motivation (r = 0.8358). This segment of human resource management is still insufficiently known and researched, and therefore represented in practice. This should be a clear guide for researchers, but also for entrepreneurs and managers to make a turnaround in the creation and realization of organizational goals. More effective creation of perceptual flows and identification processes should be given its respectable place in the motivation of employees.

**Keywords**: goals, human resources, motivation.

## INTRODUCTION

According to the theory of business goal management, which was once proposed by Peter Drucker, organizational, especially strategic goals have a significant stimulating effect on the work motivation, attitudes and behavior of employees. The participation of employees in the realization of set goals primarily starts from the clarity and comprehensibility of those goals, and then from the assessment of the importance of the individual and the availability of the goal. If they have clearly understood the organizational goals, they will remain aligned and committed to the organizational values. One of the frequent wrong assumptions that managers make is the belief that clear, unambiguous, understandable and accessible strategic goals will in themselves be sufficient to motivate employees. Unfortunately, reality often denies them. A wrong or distorted perception (in the loose translation, an idea, a mental image) that employees consciously or unconsciously form about a specific goal that is being set will not motivate employees to become active in the realization of such a goal. This knowledge is often either not understood or ignored in setting goals, which then seriously jeopardizes the realization of such goals. In order for employees to be motivated, they must know that their efforts will enable them to achieve their desired goals. The essence of employee motivation is conscious goals, that is, those with which employees have clearly identified and which they strive to achieve. These are the goals that the employees recognized as part of themselves and their path to achieving their life goals and careers. If they do not recognize themselves in these goals and find their interests and personal goals in them, motivation will be absent.

In this research, an interdisciplinary approach was applied, in which knowledge created in the field of psychology (perception, identification, motivation) is connected with those created in the sphere of management as a segment of business economics. An effort is made to prove that the

clarity, availability, rationale and comprehensibility of strategic goals are not sufficient to motivate employees to creatively and selflessly engage in the realization of these goals. If the perceptual processes and identification processes of employees with such goals are not examined and monitored, efforts to motivate employees will be a futile and missed activity. This is to point out the need for a more intensive and well-designed, interdisciplinary approach to the management of human resources and human capital. Until now, the segment of research and monitoring has been mostly neglected.

## LITERATURE REVIEW

A number of methods and models have been published so far related to defining strategic business goals and requirements that need to be met in order for these goals to be supported by stakeholders, including employees. The SMART goal setting framework as an elaborate form of the acronym stands for goals that are specific, measurable, achievable, realistic and time-bound. The business goal should primarily be understandable and clear. Unclear and unintelligible, often confused, sketchy, and ambiguous are not motivating for stakeholders. (Ogbeiwi, 2017). BHAG (short for Big, Hair, Audacious Goals) are massive goals that are compelling, long-term, and intriguing enough to motivate an organization's employees to take some concrete big action. These goals include an emotional component that pulls people out of the abyss of decline (Locke, & Lathan, 2013, p. 147). Backward Goals are also one of the methods that can be used creatively when defining or redefining goals. The core of this method boils down to the attitude: we should plan backwards, start with the end goal, and then work out the way forward to develop a plan of action (Park et al., 2017). Objective Key Results (OKR) goals are set quarterly and are based on partial settings (things we want to achieve), and key results are the numbers we must achieve to achieve the set goal. A correct goal must describe what we will achieve and how we will measure its achievement (Irikefe, 2021). Concise goals in one sentence is a widely used approach in defining business goals. Mention of the one-sentence goal-setting technique was first found in Britton, Jon Gordon, and Jimmy Page's book "One Word That Will Change Your Life." Although this method of defining business goals seems interesting, there are several doubts, pitfalls, and ambiguities that can lead to stagnation or paralysis in achieving such a set goal (Hoek et al., 2016). In 1968, Edwin Locke in his article "Towards a Task and Incentive Theory of Motivation" showed that clear goals and feedback motivate employees. Five principles included in this approach to setting goals are clarity, challenge, commitment, feedback, and task complexity. The so-called "hard goals" are a form of the acronym HARD (from the heart, emotional, animated, obligatory, and difficult). These goals, he believes (Roose, 2017). WOOP goals (short for: Wish, Outcome, Obstacle and Plan) use so-called mental contrasting, asking participants to contrast a wish with an internal obstacle, and then to make an "if-then" plan. This is important because research shows that positive thinking alone does not help adults achieve their goals (Saddawi-Konefika et al., 2017). The Pyramid Method (Goal Pyramid) is one of the methods that is often used when defining, analyzing and redefining business goals. The most important and largest goal is at the top of the pyramid, followed by major milestones, medium milestones and minor milestones (Kenrick et al., 2010).

The setting of strategic goals is reflected in the perceptual processes and in the identification of employees with these goals. One study tested how goal type affected perceived control for goal attainment over time while controlling for motivational persistence, gender, self-efficacy, initial perceived control, emotional involvement, and perceived difficulty (Bostan et al., 2022). Kim et al. explored the need for role clarity and employee engagement for strategic alignment. The results of a structural model tested using partial least squares regression reveal that strategic alignment is indirectly related to organizational performance through goal clarity and employee engagement (Kim et al., 2020). Ludviga and Kalvina examined the mediating role of perceived strategic agility of a public sector organization in relation to employee outcomes in times of crisis. The results identified leadership, organizational learning and goal clarity as the main drivers of resilience in public sector organizations (Ludviga, & Kalvina, 2023).

Employee identification with goals is one of the key drivers of employee motivation. Okoth and Florah tried to define employee motivation in several ways. They mainly claimed in their research that "employee motivation supports companies by creating a competitive advantage over the competition by motivating workers to work towards a certain goal" (Okoth, & Florah, 2019). In addition, employee motivation is also explained as a tendency to react in a certain way to achieve certain goals. Others, on the other hand, explain employee motivation as the effort employees make to achieve organizational goals; these are the efforts they are willing to put in considering the fact that their needs are met at the same time. They claim that it is a feeling, effort, energy, and driving force that an employee uses to achieve individual and/or organizational goals (Sabbagha et al., 2018). Sari and colleagues argue that workers will be motivated to put in extra effort at work if their own needs, interests and goals are taken into account. They describe motivation as the forces found within employees that define the extent to which they are capable of working, and at the same time, their persistence in fulfilling organizational goals and tasks (Sari, & Sari, 2019). Thus, they link work motivation with organizational goals and the company's competitive advantage. Sabbagha and colleagues believe that employee efforts are characterized by three parameters: effort direction (choosing between several alternatives to achieve goals), effort strength (employee's degree of commitment to the desired alternative) and effort persistence (conservation of behavior) (Sabbagha et al., 2018). Robins and Coulter explain the concept of motivation as the desire and will to manifest a high level of inspiration to achieve organizational goals, conditioned by the ability of efforts to satisfy some individual need (Robins, & Coulter, 2005). Locke was the first to propose the theory of goal setting. The theory believes that setting appropriate goals can enable individuals to achieve goals and motivate employees. In goal setting, employee participation and employee feedback on goal achievement are key elements that motivate employees. In pursuit of goals, achievement needs will transform into intrinsic motivation, which will make people work hard to achieve goals. In this process, individuals will constantly compare the results of behavior with the set goals. They will adapt and improve their efforts in real time to ensure the realization of goals Clarity and difficulty are two fundamental attributes of a goal (Locke, & Lathan, 2013).

## OBJECTIVE AND HYPOTHESES

One goal of this research is: Do the perceptual processes and identification of employees with set strategic organizational goals have a significant impact on the process of employee motivation? In other words: do the perceptual processes of strategic goals of employees affect their identification with these goals and does this identification have a significant role in employee motivation? It is shown graphically in fig.1.

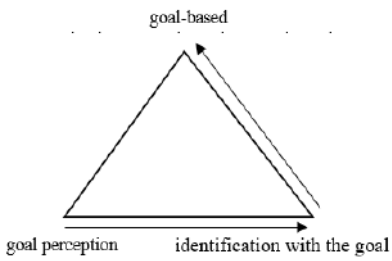


Figure 1. Research objective.

In accordance with this goal, three research hypotheses are defined:

$H_1$ – The perception of strategic organizational goals by employees reflects positively on employee identification.

$H_2$ – The perception of strategic organizational goals by employees reflects positively on employee motivation.

$H_3$ – Employee identification with strategic organizational goals has a positive impact on employee motivation.

These hypotheses are shown graphically in Fig. 2.

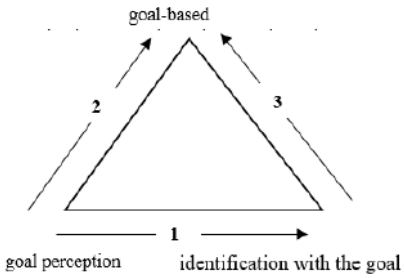


Figure 2. Research hypotheses.

## METHODOLOGY

The primary data for this research was collected through an online survey on a sample size of n=120. The respondents were full-time employees in 12 medium-sized and small companies from different industries in the area of two Croatian counties: Split-Dalmatia and Šibenik-Knin. Only those respondents who were fully aware of the strategic goals of their company were included, which was confirmed by an insight into the strategic plans of those companies. The choice of companies was random. The sample size and sampling technique are based on stratified random sampling as outlined by Cooper and Schindler in a situation where the population is not homogeneous (Cooper, & Schindler, 2008, p. 74). Of the questionnaires sent, 104 respondents responded with correctly and completely filled questionnaires, which can be considered an acceptable selection considering the type of survey. The survey was conducted in the period from September to November 2022. It was completely anonymous and the respondents were informed of this before participating in the survey. They were also informed about the purpose of the survey.

Secondary data for this research was limited to empirical studies that deeply examine the concept of employee motivation. Free access to several databases including Scopus, EBSCO, PsycARTICLES and ScienceDirect was used.

The research instrument was 12 statements aimed at constructing a 5-point Likert scale. Four statements each were for the construction of perception, identification and motivation of employees, as shown in table 1.

Table 1. Variables and statements for constructing the Likert scale.

| Number | Varijable | Claims |
|---|---|---|
| 1. | A. Perception of employees with strategic goals | I understood and it is clear to me what is to be achieved with this goal |
| 2. | | I have a positive idea of the set strategic goal |
| 3. | | I understood and accepted the sense and meaning of the set goal |
| 4. | | I am aware of what the achievement of the set goal means to us |
| 5. | B. Identification of employees with strategic goals | I see myself and my colleagues in the set goal |
| 6. | | I find my interests to achieve the set goal |
| 7. | | That goal is exactly what he would have set himself |
| 8. | | A better goal could not be set |
| 9. | C. Motivation of employees for the realization of strategic goals | I will do my best to achieve this goal |
| 10. | | I will try to contribute to the achievement of that goal |
| 11. | | I will encourage all my associates towards this goal |
| 12. | | I see my future in achieving that goal |

Respondents' levels of agreement with the statements are: 1-do not agree at all, 2-disagree, 3-partially agree, 4-agree, 5-completely agree. The statements are weighted with weight ratios that have been established and identified with the respondents' scaling degrees. Statistical processing of the collected primary data was performed using the software packages Microsoft Excell and SPSS 21.0 (Statistical Package for Social Sciences).

There are a couple of limitations that are worth noting in this research. The identification processes of employees with business goals are interpreted here only through the perceptual flows of employees. For more complete interpretations of identification processes, it would be desirable to include, in addition to perceptual processes, the goals and career progression of employees, life goals and styles, job satisfaction, etc. Similarly, in addition to identification processes, motivation is influenced by a whole series of known and unknown factors that would also was worth including in the research. This, however, would require a significantly more complex and comprehensive approach, which deviates from the goal set in this research. In addition, it requires significantly greater resources than the ones the author of the research had at her disposal.

## RESULT AND DISCUSSION

The demographic characteristics of the respondents are shown in Table 2

Table 2. Demographic map of respondents.

| Number | Demographic characteristic | Number of respondents | Percentage | Cumulative |
|---|---|---|---|---|
| **A.** | **Sexual structure:** | | | |
| | Men | 36 | 34,62 | 34,62 |
| | Women | 68 | 65,38 | 100,00 |
| **B.** | **Age structure:** | | | |
| | Do 25 | 23 | 22,12 | 22,12 |
| | 26-40 | 47 | 45,19 | 67,31 |
| | 41-60 | 28 | 26,92 | 94,23 |
| | 61 and more | 6 | 5,77 | 100,00 |
| **C.** | **Structure by professional training:** | | | |
| | Medium | 61 | 58,65 | 58,65 |
| | Higher vocational education | 43 | 41,35 | 100,00 |
| **D.** | **Size of the company from which they come (total number of employees):** | | | |
| | Until 10 | 26 | 25,00 | 25,00 |
| | 11-30 | 42 | 40,38 | 65,38 |
| | 31-50 | 23 | 22,12 | 87,50 |
| | More than 50 | 13 | 12,50 | 100,00 |

The most frequently represented respondent was female (65.38%), between the ages of 26 and 40 (45.19%), had a secondary vocational education (58.65%) and came from a company with between 11 and 30 employees (40 .38%).

Table 3. Correlation coefficients between variable A (perception of strategic goals) and variable B (identification of employees with goals).

| Assertions of variable B | Assertions of variable A | | | |
|---|---|---|---|---|
| | 1 | 2 | 3 | 4 |
| 1 | 0,4104 | 0,6507 | 0,5638 | 0,5702 |
| 2 | 0,6611 | 0,5923 | 0,5618 | 0,4893 |
| 3 | 0,5306 | 0,4271 | 0,4504 | 0,6070 |
| 4 | 0,5058 | 0,6935 | 0,6742 | 0,4806 |

All values of Pearson's coefficients (table 3) show that the correlations between the observed variables are statistically significant at the 0.01 level and range from 0.4104 (min) to 0.6611 (max). A moderate correlation (medium strong connection) is found in most statements between the perception and identification of strategic goals by employees. With this statement, the first hypothesis can be confirmed, i.e. that the perception of strategic organizational goals by employees reflects positively on the identification of employees. It was realistic and to be expected that the processes of observation and presentation (perception) of these goals affect the identification of

goals. However, in addition to perception, a number of other different psychological and situational factors affect identification processes. This could point to the importance of the WOOP model in goal creation and to mental contrasting in goal identification processes, where employees are asked to contrast a desire with an internal obstacle (identification) and then create a plan of action to achieve that goal as shown by Saddawi - Communication with colleagues.

Table 4. Correlation coefficients between variable A (perception of strategic goals) and variable C (motivation of employees to realize strategic goals).

| Assertions of variable C | Assertions of variable A 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| 1 | 0,2407 | 0,2836 | 0,1036 | 0,1283 |
| 2 | 0,1014 | 0,3171 | 0,2781 | 0,1496 |
| 3 | 0,3083 | 0,2417 | 0,2260 | 0,2108 |
| 4 | 0,2592 | 0,1525 | 0,1029 | 0,3030 |

The partial correlation coefficients shown in Table 4 show that between the perception of strategic goals as one variable and the motivation of employees as another variable at the significance level of 0.01, a weak mutual connection was established. It ranges from 0.1014 (min) to 0.3171 (max). The second hypothesis, according to which the perception of strategic organizational goals by employees reflects positively on employee motivation, was not confirmed. Employee motivation is usually a very complex process influenced by numerous factors. On the basis of only the input stimuli of business goals, the creation of a "picture" of these goals and their interpretation by employees (perceptual flows), motivation is not often activated among employees. Employees can understand, understand, and interpret the goals presented to them by the management in the way that the management would like, but this in itself will not be sufficient to direct the employees to engage in the realization of such set goals. This cannot accept the thesis presented by E. Locke, where he claims that clear goals and feedback motivate employees. The five principles he included in this approach: clarity, challenge, commitment, feedback and task complexity are not confirmed in this research (through perceptual flows) as drivers of employee motives and motivation.

Table 5. Correlation coefficients between variable B (identification of employees with goals) and variable C (motivation of employees to realize strategic goals).

| **Assertions of variable C** | **Assertions of variable B** 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| 1 | O,6291 | 0,6271 | 0,8358 | 0,6424 |
| 2 | 0,7105 | 0,7510 | 0,6398 | 0,7372 |
| 3 | 0,7826 | 0,7359 | 0,7102 | 0,8264 |
| 4 | 0,6374 | 0,6823 | 0,6608 | 0,7269 |

Mostly all the values of variable B (statements related to the identification of respondents, i.e. employees with goals) and variable C (motivation of employees motivated by strategic goals) at the significance level of 0.01 indicate the existence of a strong correlation. Pearson's partial correlation coefficients range from 0.6271 (min) to 0.8358 (max). The dispersion of the determined coefficients does not show a significant dispersion of them. The third hypothesis, which read: identification of employees with strategic organizational goals has a positive effect on employee motivation, was confirmed. The strongest degree of correlation was determined between the identification of employees with the motivation to achieve these goals. Respondents who declared themselves in favor of this constellation of statements indicated that in the set strategic goals they clearly recognized their life goals, the path for the realization of their career and generally expressed their satisfaction with their work. They have motives and are ready to actively participate with their knowledge and experience to achieve these goals as successfully as possible. These results confirm those reached by Sabbagha and colleagues who explain employee motivation

through the effort they make to achieve organizational goals and which they are willing to make considering the fact that their needs are simultaneously satisfied. Thus, motivation is the result of identifying organizational goals and personal needs. Confirmation of the results reached in this research can be found in the results presented by Sari and colleagues, claiming that employees will be encouraged to make extra effort at work if their own needs, interests and goals are respected.

## CONCLUSIONS

This research clearly indicates the direction and direction in which strategic organizational goals influence employee motivation. This fulfilled the research goal. It is not enough, as is often said, that these goals are clear, comprehensible, realistic, big, promising and that the employees will immediately and without question accept them and do their best to achieve them. This is indicated by the second hypothesis in this paper. On the contrary, the path from creating strategic goals to motivating employees to achieve them with their work is a little more complex. It is necessary, first, that the established goals are correctly perceived, and then that these perceptual processes stimulate and support the identification of employees with these goals. The first and third hypotheses confirm this. That employees accept these goals as part of their life goals and the realization of their career plan. Only then is it realistic to expect that, with complete identification, there will be a motive for achieving the goals set in this way. This path is not simplified, but, on the contrary, complex and demanding. He is looking for a series of changes in the segment of access and human resource management. Above all, it is an interdisciplinary work on research and monitoring of perceptual and motivational flows and content that promises quality advances in the management of employee motives and motivation.

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# TIMSKI RAD U KLUBU KAO PODRŠKA SOCIJALIZACIJI MLADIH SPORTISTA

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## SAŽETAK

Kako bi na odgovarajući način pristupili procesu socijalizacije, koji je od izuzetne važnosti za mlade sportiste, poželjno je da treneri, ali i svi članovi jednog sportskog kluba budu upoznati sa osnovnim znanjima koja se tiču ovog procesa. Bitno je razlikovanje izvora od agenasa socijalizacije, pri čemu je glavni izvor kultura, a glavni agensi porodica, vaspitno-obrazovne institucije, vršnjaci i, u savremenom dobu sve prisutniji, mediji, posebno oni virtuelni. Umnožavanje najrazličitijih modela i eksponencijalni rast informacija koje nas svakodnevno „zatrpavaju" predstavljaju rastući problem u procesu vaspitanja uopšte, pa i u radu u sportskih klubova. U okviru malih grupa, kakve su i one u sportskim klubovima odvija se intenzivna socijalna interakcija vršnjaka povezanih zajedničkim sportskim interesovanjima. Ukoliko je ta grupa dobro vođena u okruženju pozitivne klupske atmosfere moguće je da se putem socijalne facilitacije kod vaspitanika zadovolje i razvijaju socijalne potrebe i veštine koje će poslužiti kao podsticaj celokupnom razvoju ličnosti. Uz pomoć procesa učenja po modelu, ukoliko je razvijena i emocionalna bliskost i poštovanje prema lideru grupe (treneru) moguća je internalizacija odgovarajućih normi, pravila ponašanja i vrednosti na nivou identifikacije, što onda postaje trajni deo ličnosti vaspitanika.

**Ključne reči:** socijalizacija, timski rad, sport, mladi.

## UVOD

Ljudi imaju potrebu za fizičkom aktivnošću i to je osnovni drustveni značaj sporta. S druge strane, sport je profesija mnogim ljudima, te je i izvor egzistencije. Sport je deo kulture, ali i deo naučno-obrazovnog, te se sa pravom kaže da je sport ogledalo stanja u državi. Sportisti su predstavnici nacije, svojevrsni vitezovi savremenog društva, oni poseduju hrabrost, dostojanstvo, odvažnost, plemenitost – jednom rečju, sportski duh.

Sport je zahvaljujući velikoj medijskoj pažnji postao jedna od najprofitabilnijih grana svetske privrede. Sport se danas sve više modernizuje i postaje razvijeniji čak i od muzike i filma. Sasvim je jasno da danas neki od najvećih sportskih klubova predstavljaju i uspešna preduzeća koja ostvaruju velike profite na tržištu sportskih usluga, roba i kapitala. Sport danas pripada najbrže rastućim privrednim granama u svetu i čini čak 3% ukupne svetske trgovie.

Sport je u proteklih nekoliko stotina godina dospeo od igre i zabave do velike industrije. Klubovi su od neformalnih udruženja postale kompaije globalnih razmera. Takmičenja su od puke zabave dospele do ogromnih spektakala.

Cilj ovog rada je da kroz multidisciplinarni pristup pruži teorijski prikaz koji bi mogao biti od pomoći pre svega trenerima, ali i drugim profesionalcima uključenim u klupski rad sa mladim sportistima, da se bliže upoznaju sa konceptualnim osnovama na kojima treba da bude baziran vaspitno-obrazovni i stručni rad sa mladima u sportu.

Predmet istraživanja je da se na osnovu dostupne relevantne literature ukase na važnost sticanja socijalnih veština i procesu socijalizacije koji je jedan od ključnih procesa u razvoju ličnosti u ovom uzrasnom periodu.

## MATERIJAL I METODE

Na osnovu dostupne literature u radu ćemo pokušati da dobijemo podatke i informacije koje smo definisali predmetom i ciljem istraživanja. U radu su korišćene metode analize, sinteze, indukcije, dedukcije, kao i komparativna metoda.

## REZULTATI ISTRAŽIVANJA

Ako pođemo od toga da je osnovni izvor socijalizacije kultura kojoj kao pojedinci pripadamo, onda je jasno da je i proučavanje tako složenog fenomena neophodno uključiti metodologiju i pojmovnu analizu različitih naučnih oblasti. Može se reći da se polje njenog proučavanja nalazi na tromeđi antropologije, sociologije i psihologije. Kako navodi Nikola Rot u toj oblasti možemo razlikovati tri grupe pitanja (Rot, 2010):

- Izučavanje izvora i agenasa socijalizacije, dakle kulture kao osnovnog izvora i pojedinaca i institucija u kojima se socijalizacija odvija, kao agenasa.
- Proučavanje procesa socijalizacije, odnosno glavnih sociopsiholoških procesa (učenje, imitacija, identifikacija) preko kojih se socijalizacija ostvaruje;
- Proučavanje efekata socijalizacije: na koji način i u kojoj meri taj proces deluje na formiranje stavova, sistema ponašanja i vrednosti kod pojedinca.

Sportski klubovi dakle spadaju u agense socijalizacije, sigurno ne tako bitne kao što su porodica i škola, ali nikako na poslednjem mestu po važnosti. Tokom bavljenja sportom mladi ljudi dolaze u interakciju sa vršnjacima sličnih interesovanja, dobijajući priliku da razviju svoje psihofizičke i socijalne veštine što je od velikog značaja za njihov dalji razvoj nezavisno od uspeha koji će postići u sticanju veština u datom sportu. Isto se ogleda u sledećem (Frojd, 2005):

- Pojedinca i društva, pri čemu se zahtevi kulture često vide kao opresivni;
- Ja kao zasebne strukture ličnosti i Onog kao njenog nagonskog dela;
- Ja i moralnog predstavnika unutar ličnosti u obliku Nad-Ja;
- Konflikti između grupa ljudi, kako unutar društva tako i prema spolja;
- Bazični sukob dve vrste nagona: Erosa i nagona smrti, odnosno agresije.

Bavljenje sportom i odgovarajući timski rad u klubu u okviru grupe vršnjaka koji su usmereni na zajedničke ciljeve koje u sebi imaju i kompetitivni element u velikoj meri omogućavaju dobru sredinu za ublažavanje ovih sukoba i stvaranje fleksibilnih i raznovrsnih odbrambenih mehanizama koji će omogućiti pojedincu da iskaže svoj potencijal na društveno prihvatljiv i produktivan način. A to bi bila i jedna od sasvim dobrih definicija pozitivnog ishoda procesa socijalizacije. Ovo, naravno, podrazumeva i timski (kolektivni) zajednički napor i činilaca izvan kluba, pre svega kroz uvažavanje porodične dinamike svakog vaspitanika i uključivanje pedagoškog potencijala škole koji treba da procenjuje napredak svakog učenika i na vaspitnom, a ne samo na obrazovnom nivou, kako to naglašava Nenad Havelka u svojoj knjizi o grupnom radu u procesu vaspitanja i obrazovanja (Havelka, 1980).

Postoje mnogobrojne vrste grupa koje se formiraju u datom društvu, a njihov način formiranja je u ovom veku dostigao neverovatno veliki broj kombinacija sa pojavom mogućnosti formiranja „virtuelnih grupa“ među ljudima koji nemaju nikakve realne kontakte. Može se, međutim reći da su razlozi za formiranje grupa, sociopsihološki posmatrano, uglavnom određeni sa nekoliko osnovnih motiva koje je sjajno pobrojala i opisala profesorka Univerziteta iz Sankt Petersburga Ljudmila Stoljarenko:

- Grupa može služiti biološkom opstanku, naročito u kriznim situacijama;
- Može biti u službi socijalizacije i psihičkog formiranja pojedinca;
- Može biti način na koji se organizuje proizvodnja, stiču znanja i veštine (instrumentalna funkcija grupe)

- Grupa je uvek, u manjoj ili većoj meri, način da se zadovolji opšteljudska potreba za opštenjem i socijalnom interakcijom, za sticanjem priznanja, odobravanja, poverenja, uvažavanja (ekspresivna funkcija grupe)
- Takođe služi kao anksiolitik, odnosno kao sredstvo za ublažavanje osećanja straha, izolovanosti i napetosti;
- Kroz grupe se takođe razmenjuju (dez)informacije, materijalna dobra i emocije između članova grupe (Столяренко, 2012).

Ono što je od posebnog značaja jeste da grupe koje se formiraju u klubovima predstavljaju male realne grupe koje nastaju na dobrovoljnoj osnovi i gde se odvija intenzivna socijalna interakcija koja dopušta razvoj mnogobrojnih odnosa prijateljskog i rivalskog karaktera, kao i učenja kroz identifikaciju sa trenerom ili drugim pripadnicima kluba, naročito ako su oni istaknuti sportisti.

Kao što je već rečeno, osnovni izvor socijalizacije je kultura kao skup svih materijalnih i nematerijalnih dobara, znanja i vrednosti koji se u datom društvu prenose sa generacije na generaciju. Sve neformalne i formalne grupe koje prenose te vrednosti nazivaju se agensima socijalizacije, među njima su i sportski klubovi. Svi agensi deluju u vaspitno-obrazovnom okruženju koje se generiše dominantnim vrednostima kao i ideološkom strukturom datog društva. Čini se da aktuelni proces globalizacije, ma kako razumeli ovaj termin, stvara u velikoj meri nepovoljno okruženje za smisleni vaspitno-obrazovni rad postavljajući mnoge, često kontradiktorne, zahteve pred vaspitače i učenike podjednako (Price et al., 1997).

Celokupni potrošački sistem je, naizgled, usmeren na jačanje samopoštovanja i ambicije pojedinca od kog se traži da ima stav i „mišljenje“ o svemu, a u stvari se vrednost pojedinca posmatra gotovo isključivo kroz njegovu „ekonomsku i potrošačku“ efikasnost. Potrebno je postići sve više za sve manje vremena: obraditi sve više informacija, brže se adaptirati na sve veći broj uloga, po svaku cenu biti „srećan“ i pozitivno razmišljati i pri tom se prilagođavati na dinamiku života koji je stalno okružen tranzicijom i krizom (Tomić, 2003). To su samo neke od teškoća koje aktuelno vreme postavlja pred vaspitače koji su pod stalnim pritiskom jednog sve značajnijeg agensa socijalizacije: modela ponašanja i svakakvih „vrednosti“ koji se nameću kroz medijsku sferu, od sada već tradicionalne televizije do bezbrojnih virtuelnih mreža.

Osnovni procesi kojima se odvija socijalizacija u psihološkom smislu povezani su sa iskustvom koje deca i kasnije mladi ljudi imaju sa svojim porodičnim i društvenim okruženjem (Anderson, & Thomas, 1969). Svaki pojedinac, naravno ta iskustva oblikuje na osnovu već postojećih karakteristika temperamenta, sposobnosti i načina reagovanja koja su deo njegove biološke i psihičke structure (Clark, 1997). Ovo iskustvo se uobličava kroz stalni proces učenja koji uključuje principe klasičnog i instrumentalnog uslovljavanja kojima se ovde nećemo baviti, kao i posebnog oblika učenja koje se naziva opservaciono ili još i učenje po modelu ili socijalno učenje (Harro, 2000). Kao što samo ime kaže, mnoge socijalne veštine, stavovi i vrednosti se preuzimaju na ovaj način i postaju deo ličnosti mladog čoveka. Kao što su Albert Bandura i saradnici pokazali u mnogobrojnim ogledima na deci i odraslima, ovo učenje je deo našeg svakodnevnog života, odvija se često na nesvesnom nivou i svi učesnici vaspitno-obrazovnog procesa moraju biti svesni da je ono što rade, u vaspitnom pogledu mnogo važnije od onog što govore, ili sportskim rečnikom rečeno: demonstracija je kod mladih sportista mnogo bitnija od upustava i to u svakom pogledu, na samo kod usvajanja sportskih veština (Bandura, & Walters, 1983).

Od posebnog značaja je činjenica da trajnost neke promene koja se stiče putem socijalnog učenja zavisi od stepena emocionalne bliskosti koju ispitanik oseća prema modelu koji oponaša. Zbog toga se nikako ne može prenaglasiti značaj koji ima stvaranje pozitivne grupne atmosfere, pri čemu je za tako nešto uvek najodgovorniji lider tima - u klubu je to svakako trener mladih sportista, ali naravno bitna je i celokupna „klupska atmosfera“ koja svakodnevno okružuje mlade sportiste i same trenere. Psihološki posmatrano, cilj je da se od puke imitacije ponašanja, stavova i vrednosti vaspitača pređe na nivo identifikacije koji obezbeđuje da te vrednosti postanu sastavni delovi moralnog dela ličnosti vaspitanika, u ovom slučaju mladog sportiste.

Sama dinamika male grupe pozitivno deluje na socijalizaciju i razvoj ličnosti: u grupi, ukoliko je pravilno vođena, ostvaruju se mnoge potrebe mladih ljudi za bliskošću, samodokazivanjem, upoređivanjem sa vršnjacima, stvaranjem prijateljstava, takođe grupa kao takva nudi mogućnost osvešćivanja sopstvenih jakih i slabih strana (Karnish, 2019). Sve ovo je u psihologiji poznato kao socijalna facilitacija, odnosno jačanje ličnosti pojedinca unutar grupe. Postoji i suprotan proces koji se često naziva socijalna lenjost koji može da rezultira povlačenjem i deaktivacijom pojedinca u slučaju kada se ne primećuju i ne priznaju individualni doprinosi grupnom radu, već se samo ističe grupa, pa pojedinac nema dovoljno podsticaja da se ističe već se utapa u grupno, odnosno timsko sivilo.

Možemo zaključiti da sportski klubovi imaju svoje istaknuto mesto u procesu socijalizacije mladih, da sa odgovarajućom organizacijom grupnog rada mogu bitno doprineti razvoju samokontrole kod mladih sportista i stvaranju pounutrenih normi i pravila ponašanja kako prema članovima svog kluba tako i prema sportskim rivalima. Ova pravila, putem identifikacije, mogu da postanu trajni deo ličnosti, tako da ona po njima postupa ne samo zato što se to od nje očekuje, što joj donosi dobit ili se plaši kazne, nego stoga što je to postala unutrašnja potreba date osobe.

## ZAKLJUČCI

Važnost stvaranja i održavanja radnog reda i solidarnosti među sportskim timovima jedna je od pretpostavki koje se više uzimaju zdravo za gotovo među učesnicima i posmatračima. Čak i tako, ocrtavanje dinamike njegovog značaja, posebno u pogledu timskog rada i insajderskog znanja (ili tajnosti) ostaje neistraženo. Ovaj rad pokušava da popuni ovu prazninu korišćenjem klasičnih socioloških koncepata Dirkima, Mida i Gofmana da bi se raspravljalo o praktičnom i sociološkom značaju timskog rada. Ispitujemo dva međunarodno uspešna islandska sportska tima da bismo pokazali kako prosocijalni aspekti timskog rada, tajnovitosti i ponašanja u pozadini održavaju saigrače povezanim jedni sa drugima i sa kulturom u koju su utkani. Naša analiza takođe naglašava važnost kolektivnih reprezentacija, organske solidarnosti i dinamičkih procesa koji uključuju samoprezentaciju, ideokulturu i pregovaranje o značenju.

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# TEAMWORK IN THE CLUB AS A SUPPORT FOR THE SOCIALIZATION OF YOUNG ATHLETES

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**ABSTRACT**

In order to appropriately approach the socialization process, which is extremely important for young athletes, it is desirable that coaches, as well as all members of a sports club, be familiar with the basic knowledge regarding this process. It is important to distinguish between sources and agents of socialization, where the main source is culture and the main agents are families, educational institutions, peers and, in the modern age, increasingly present media, especially virtual ones. The multiplication of various models and the exponential growth of information that "burdens" us every day represent a growing problem in the process of education in general, including in the work of sports clubs. Within small groups, such as those in sports clubs, intensive social interaction of peers connected by common sports interests takes place. If that group is well managed in the environment of a positive club atmosphere, it is possible to satisfy and develop the social needs and skills of the students through social facilitation, which will serve as an incentive for the overall development of the personality. With the help of the model learning process, if emotional closeness and respect for the group leader (coach) is developed, it is possible to internalize appropriate norms, rules of behavior and values at the level of identification, which then becomes a permanent part of the pupil's personality.

**Keywords**: socialization, teamwork, sport, youth.

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# ULOGA I ZNAČAJ BRENDIRANJA SRPSKE KOŠARKE

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## SAŽETAK

U današnje vreme, gde se svet menja velikom brzinom potrebno je biti spreman odreagovati i prilagoditi se svim promenama kako unutar organizacije tako i u spoljnjem okruženju. Pravilno upravljanje brendiranjem pojedinca, organizacije, kompanije pa sve do nivoa jedne države veoma je važno i upravo nas ono vodi do uspešnog odgovora na neočekivane situacije, što samim tim daje konkurentsku prednost na tržištu. Srbija kao zemlja sa epitetom „košarkaška nacija“ i nagradama koje se nižu iz godine u godinu, ima ogroman potencijal vezan za brendiranje košarke i svog sporta uopšte. Taj potencijal je moglo bi se reći zanemaren, koliko mu je malo pažnje posvećeno i koliko je neiskorišćen. Zbog toga se mora posvetiti veća pažnja tom segmentu sporta i pokrenuti inicijativa da se popravi brendiranje srpske košarke a i sporta uopšte.

**Ključne reči:** brendiranje, brend, košarka, Srbija, sport, marketing.

## UVOD

Sport, imenica koja koren reči vuče još iz latinskog, odnosno kasnije starofrancuskog jezika a nosi značenje razonode, odmaranja, uživanja danas predstavlja sve fizičke aktivnosti u kojima se ističe takmičarski duh, borba u vidu igre kao i trud pojedinca ili tima da nadmaši svog protivnika. Još od početka razvoja civilizacije sport je bio svakodnevni deo života ljudi, prvenstveno kroz zabavu a kasnije je on sticao, kako religioznu ulogu u antičkom svetu, tako i ratnu kao na primer kod starih Grka (Afuah, & Tucci, 2003). Jedno od takvih takmičenja koje je svakako ostavilo veliki trag kroz istoriju i pristuno je sve do danas jesu Olimpijske igre (Olimpics, 2023; Vuksanović et al, 2019). U današnje vreme teško je pronaći osobu koja nije upoznata barem sa nekom vrstom sporta. Ta činjenica sama govori o tome koliko je sport rasprostranjen i opšte prisutan u našim životima, hteli mi to ili ne (American Marketing Association [AMA], 2017; Bjelica et al., 2020).

Naime, kako pojedinac tako i država kao jedinka nastoji da ima svoje predstavnike u svetu sporta i samim tim su neki sportovi zastupljeniji od drugih. Srbija ima veliki broj uspešnih sportista kroz istoriju ali činjenica je da u današnje vreme u Srbiji vladaju četiri sporta: tenis, košarka, fudbal i odbojka (Parry, 2019). Iako je fudbal možda najpopularniji sport što se gledanosti kod nas tiče, tenis i košarka su izneli Srbiju na mapu svetskog sporta, kako u bivšoj Jugoslaviji tako i u poslednjih 20ak godina (Masanovic, 2018). Popularnost zlatne generacije 90-ih godina prošlog veka, nasledili su mnogi mladi igrači i timovi u periodu koje je sledio.

Ukoliko se okrenemo repreznatativnim uspesima prošlog veka, svakako je neophodno pomenuti Olimpijske igre 1996. i susret sa ’’Timom snova’’, koji je sam po sebi bio brend. Iako je tim Amerike predstavljao samo skup izabranih košarkaša koji će predstavljati svoju zemlju, on je dobio konotaciju svetske sile u svetu sporta i time zaslužio poštovanje ljudi širom sveta (Burrows, 2004). Naša reprezentacija je u svom sastavu imala nekoliko igrača, poput Divca, Danilovića, Saše Djordjevića, koji su u nekom trenutku svoje karijere igrali u NBA(National Basketball Association), odnosno najjačoj ligi na svetu. Samim tim, razlika u kvalitetu između ove dve ekipe nije bila preterano velika, zato se postavlja pitanje žašto su naši momci ušli u meč kao autsajderi?

Odgovor na to pitanje sigurno nije lako dati, ali činjenica je da su marketing i odnosi s javnošću u mnogom doprineli takvom stavu (Burrows, 2005; Ljubojević, 2020).

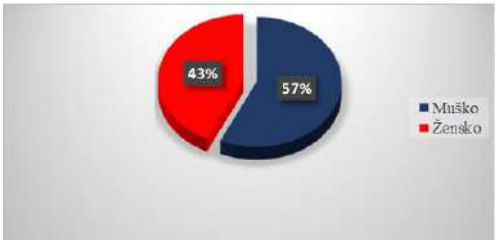
U istraživačkom radu će se na temelju analize dobijenih podataka iz anketa pokušati doći do sveobuhvatnog zaključka o brendiranju srpske košarke. Autori smatraju da odabranom temom mogu doći do korisnih podataka o stanju košarke u Srbiji, njegovom postojećem i razvijenom ili nerazvijenom brendu i mogućnostima koje postoje i koje se nude u budućnosti. Takodje, zanimljiva je činjenica da i pored velikog broja uspešnih košarkaša, a generalno i sportista u Srbiji, naša zemlja nije toliko prepoznatljiva u svetu po tom pitanju. U svakom slučaju dok god imamo dobar sport koji je na visokom nivou uvek možemo podsticati brendiranje Srbije kao zemlje košarke, a i sporta generalno i to van granica Balkana i Evrope.

## MATERIJAL I METODE RADA

Kroz analizu dobijenih rezultata iz anketa nadam se pružiti adekvatan odgovor na sva tri postavljena pitanja i time predstaviti moguća rešenja za dalje brendiranje srpske košarke.

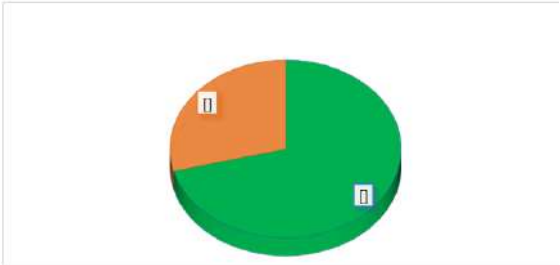
Anketno istraživanje se sprovedeno kako bi se dobio bolji uvid u to koliko ljudi iz Srbije prate domaću košarku, poznaju domaće klubove i igrače i da li smatraju da je srpska košarka na visokom nivou u svetu. Na osnovu tih činjenica možemo doći do ne toliko preciznih, ali opet relevantnih podataka vezanih za to koliko je srpska košarka kao brend zastupljena i na čemu bi se moglo poraditi u budućnosti kako bi se pozitivni rezultati unapredili a nedostaci minimalizovali. Ukupan broj ispitanika je 134.

Za početak je bitno spomenuti da je 57% ispitanika muškog pola, dok je 43% ispitanika bilo ženskog pola (Grafikon 1.). Nakon toga slede opšta pitanja vezana za košarku, domaće igrače i timove kao i samu istoriju domaće košarke.

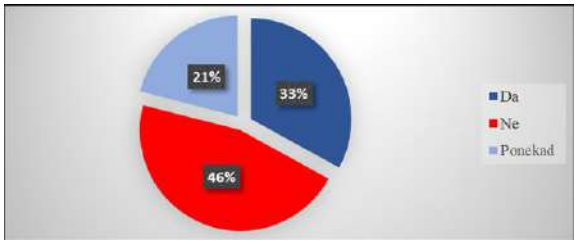



Grafikon 1. Odnos pola ispitanika.
Graph 1. Gender ratio of respondents.

Preko 50% ispitanika izjavilo je da prati košarku (Grafikon 2.), ali time misleći na lige poput najpoznatije evropske lige odnosno EuroLeague ili američke NBA lige. Sldeći grafikon nam prikazuje koliko Srbi zapravo prate domaću košarku (Grafikon 3).



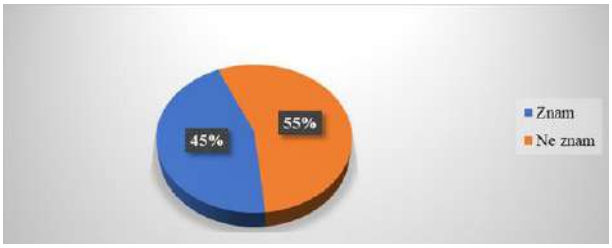
Grafikon 2. Prikaz odgovora na pitanje: „Da li pratite košarku?
Graph 2. Display of answers to the question: "Do you follow basketball?"




Grafikon 3. Prikaz odgovora na pitanje: „Da li pratite domaću košarku?“
Chart 3. Display of answers to the question: "Do you follow local basketball?"

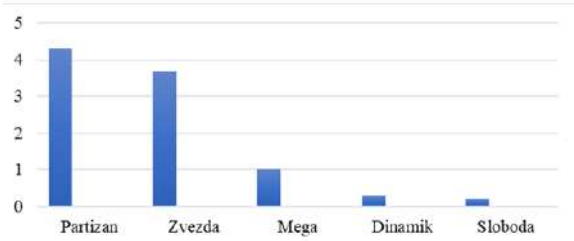
Prema rezultatima iz grafikona br. 3 možemo zaključiti da samo 33% ljudi redovno, a 21% ponekad prati domaće lige (odnosno KLS i Aba ligu koje su zastupljene kod nas). To su razočaravajuće činjenice s obzirom na to da su se neki naši klubovi takmičili na najvišem evropskom nivou a neki to rade i sad.

Sledeće pitanje iz ankete se odnosi na pitanje da li ljudi znaju da nabroje 4 kluba iz prve lige Srbije odnosno KLS-a (Grafikon 4.).




Grafikon 4. Prikaz odgovora na pitanje: „Da li znate da nabrojite 4 kluba iz KLS-a?“
Chart 4. Display of answers to the question: "Do you know how to name 4 clubs from KLS?"

Dobijen rezultat je pokazao da skoro 50% ljudi ima uvid u to koji su naši domaći klubovi pa se postavlja pitanje koji su to klubovi (Grafikon 5) i da li to ima veze sa tim što ljudi ne prate domaće lige u većem broju. Sama činjenica da veći broj ljudi prati stranu košarku od domaće nam govori o tome koliko je slabije prihvaćena, a ako bi to preveli u biznis svet onda bi to bilo veoma jednostavno- potrošač nezadovoljavajuć proizvod menja sa onim zadovoljavajućim. Stoji jedna stvar, a to je da se košarka prati, međutim postavlja se pitanje šta je to što je gledaocima zanimljivije na stranom tržištu, a da ne mogu pronaći kod nas i u našem košarkaškom brendu.

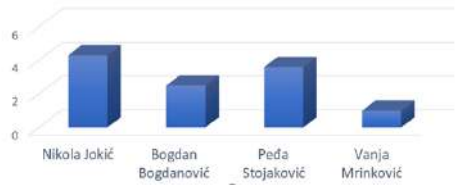



Grafikon 5. Prikaz imena najčešće pomenutih klubova.
Chart 5. Display of the names of the most frequently mentioned clubs.

Zanimljivo je pogledati imena klubova koje su ispitanici najčešće navodili, jer se jasno može videti da je tu pet klubova: Partizan, Zvezda, Mega, Dinamik i Sloboda iz Užica. Ono što je zanimljivo je to da su prva četri od ovih pet klubova iz Beograda. To nam samo govori o tome da je košarka najzastupljenija u glavnom gradu Srbije, što je donekle i logično, ali postavlja se pitanje zašto to nije barem na približnom nivou i u drugim većim gradovima. Stoga, trebalo bi podići svest o tome da postoje dva dominantna kluba u Beogradu, što znači da treba otići u sve regione i

gradove gde se košarka igra kako bi se pružila novčana pomoć onima kojima je potrebna u cilju pružanja prilike svim sredinama da se aktivno uključe u proces obnavljanja i učestvovanja u najjačem rangu takmičenja.

Daljim istraživanjem ideja je bila da se vidi koliko su ljudi upoznati sa domaćim igračima i da li znaju imena naših igrača koji igraju košarku profesionalno. Rezultati tog istraživanja su pokazani u grafikonu 6.

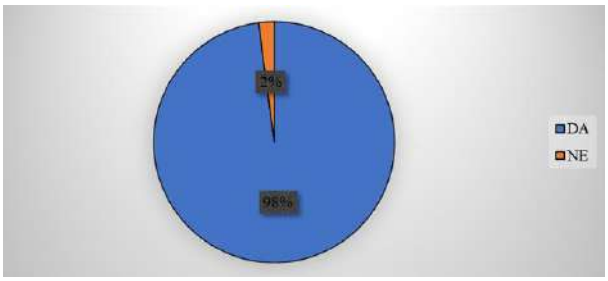



Grafikon 6. Prikaz najčešće navedenih imena košarkaša.
Chart 6. Display of the most frequently mentioned names of basketball players.

Dobijenim rezultatima jasno je prikazano da su ljudi znali da navedu imena naših košarkaša. Bitna činjenica je da su tri od četri navedena igrača trenutno aktivna i igraju košarku dok je Peđa Stojaković u penziji. Još jedna zanimljiva stavka je da opet tri od četri igrača igraju ili su igrali u NBA ligi. To nam može pomoći da stvorimo sliku o tome koga naši ljudi prate i prema kome imaju simpatije, jer logično je da kad treba da navedete ime nekog igrača prvo će vam na pamet pasti ime onoga prema kome imate odredjenu povezanost.

Često se dešava da publika reaguje na poznato lice ali zaboravi ime osobe koju konstantno viđaju, ali je prirodno da se u najviše odogvora nabrajaju dva aktuelna srpska košarkaša Nikola Jokić i Bogdan Bogdanović jer su se njih dvojica isprofilisali najviše putem medija i društvenih mreža i napornim radom uspeli probiti u redove NBA lige. To navodi na razmišljanje da se sve nekako svodi na srpske košarkaše koji su otišli igrati „preko“ i da su pomoću svojih ličnih uspesha usmerili pažnju ka srpskoj košarci.

Cilj grafikona ispod je bio da se dobije uvid u to koliko ljudi znaju ili pamte neke straije košarkaše koji su sada u penziji i na taj načim vidimo da li je slika promenjena u odnosu na sad.

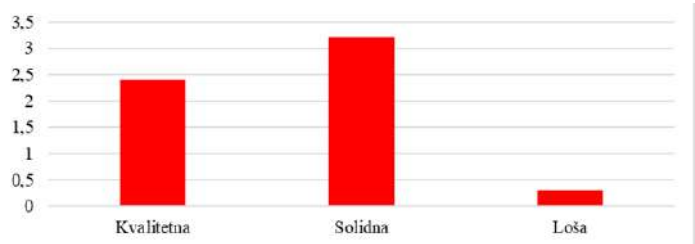



Grafikon 7. Prikaz odgovora na pitanje jesu li ispitanici nekada čuli za Sašu Đorđevića ili Vladu Divca.
Graph 7. Display of answers to the question whether respondents have ever heard of Saša Đorđević or Vlada Divac.

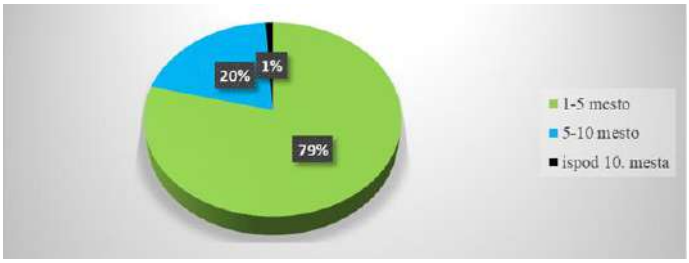
U odnosu na odgovore iz grafikona 7. jasno je da samo 2% ispitanika tvrdi da ne zna ili nikad nije čulo za Sašu Đorđevića ili Vladu Divca. To je pozitivna, ali ne i toliko iznenađujuća činjenica jer kao što je pomenuto ranije naši igrači koji su igrali širom sveta, a pogotovo u NBA su veoma prepoznatljivi među našim ljudima. Naravno, teško je upoređivati se sa NBA ligom koja je jaka kao brend sam po sebi, a da ne pominjemo brendove koji su izrasli uz pomoć nje ili zajedno sa njom, poput Jordan, Nike, Under Armour.. To je samo jedan strana snage NBA brenda. Ukoliko se okrenemo igračima koji su svestki poznati kao što su Kobe Bryant, LeBron James, James Harden, Shaquille O’Neal, Magic Johnson i mnogi durgi, shvatamo koliko su to „jaka“ i „zvučna“ imena u svetu košarke, ali i mi sami imamo u ovom trenuntku nekoliko igrača u NBA, a u poslednjih 20ak godina ih je bilo i više. Iz tog razloga bi trebalo pokušati povećati i iskoristiti popularnost naših

košarkaša, pogotovo ovih koji igraju u NBA jer je to jedinstvena prilika da se srpska košarka još više popularizuje u svetu.

Na kraju, grafikon 7 i grafikon 8 ukazuje šta naši ljudi misle i kako bi okarakterisali domaću košarku i na kom mestu misle da se ona nalazi u svetu. Rezultati su veoma zaniljivi uzimajući u obzir da je gledanost domaće košarke na ne tako visokom nivou kao recimo Evrposke ili NBA-a.




Grafikon 7. Prikaz odgovora na pitanje: „Kako bi okarakterisali srpsku košarku?“
Graph 7. Display of answers to the question: "How would you characterize Serbian basketball?"




Grafikon 8. Prikaz odgovora na pitanje: „Na kom mestu bi se našla srpska košarka u svetu?“
Chart 8. Display of answers to the question: "Where would Serbian basketball be in the world?"

## DISKUSIJA

Nakon što je odradjena analiza i procena rezultata anketa i intervjua preostaje samo videti jel došlo do adekvatnih odgovora na istraživačka pitanja. Prvo istraživačko pitanje je glasilo: „Kakav je obrazac ponašanja trenutnog brenda srpske košarke?“ Odgovor na to pitanje je sve u svemu jednostavan. Srpski košarkaški brend je u velikoj stagnaciji i trebalo bi što pre preduzeti mere kako bi se nešto promenilo. Kao da je tu, a i nije. Definisan, a u stvari potpuno nedefinisan na mnoge načine. Obrazac ponašanja se ispoljava u tome da je naglasak na reprezentativnom brendiranju kroz neke starije generacije ili starije uspehe. To samo utiče na stagnaciji i smanjenoj gledanosti košarke. Drugo istraživačko pitanje je glasilo: „Šta se desilo da nekadašnja prepoznatljiva srpska košarka došla do stagnacije u popularnosti i prepoznatljivosti?“ Popularnost nam je padala sa padom kvaliteta lige i s obzirom na nezasupljenost srpskek košarke i srpskog košarkaškog brenda u javnom životu. Odlazak igrača u strane lige i NBA je sve veći. Da, to jeste krajnji cilj i trebalo bi da bude svakog sportiste, da igra na najvišem nivou. Ali to nije ralog da mi ne možemo da naoravimo i izbacimo takve igrače, nego oni moraju da idu prvo po Evropi da bi na kraju završili u Americi. Popularnost je takođe povezana sa nemogućnošću srpskog košarkaškog brenda da privuče nove generacije u većem broju, ne komunicira adekvatno sa ciljem da privuče, informiše i zainteresuje odredjene ciljne grupe. Ukratko, desio se pad kvaliteta igre, smanjen broj domaćih igrača u našim ligama, nezainteresovanost da se bilo šta promeni počev od nas i samim tim je došlo do stagnacije brenda. Sledeće i poslednje pitanje je glasilo: „Kako podstaći stvaranje uspešnijeg košarkaškog brenda?“ Uvek postoji adekvatno kroz komunikaciju i oragnizacione sposobnosti. U srpskoj košarci prvo je bitno razdvojiti grane marketinga i odnosa s javnošću kako bi se molgo poraditi na tom planu pojedinačno. Nažalost, to je tek sad kod nas krenulo i to samo u nekim segmentima. Moramo shvatiti da marketing nije, niti će ikada biti odnos s javnošću. Oni se ponekad isprepleću i poklapaju, ali to su dve različite stvari. Baš odnosi s javnošću mogu biti iskorišćeni u rebrendiranju srpske košarke i njenom daljem napretku.

## ZAKLJUČAK

Cilj ovog istraživačkog rada bio je približiti trenutni brend srpske košakre i istražiti mogućnosti daljeg brendiranja istog. Korišćenjem ankete dobijen je bolji uvid u to kakvo mišljenje i znanje ispitanici poseduju vezano za brend srpske košarke i srpske košarkaške istorije.

Zanimljivo je sagledati činjenicu da u današnje vreme Srbija ima veliki broj vrhunskih košarkaša ali brend srpske košarke nije ni na približnom nivou nekih drugih zemalja. Ovaj rad istražuje zašto je to tako i da li postoje načini da se srpska košarka kao brend unapredi.

Na osnovu ovog rada, može se zaključiti da je brend srpske košarke nedovoljno razvijen, ali i da ima velike mogućnosti i potencijal. Od klupske košarke preko reprezentativne i 3x3 košarke do individualnog kvaliteta naših košarkaša, sve ukazuje da Srbija na košarkaškom planu najviše zaostaje u vidu marketinga i iskorišćenosti kvaliteta koji nam je pružen. Zbog toga treba podići svest o tome da Srbija ima veliku šansu u smislu podizanja svog košarkaškog brenda, a nakon toga treba pokrenuti sve korake kako bi se ta šansa i iskoristila.

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# THE ROLE AND SIGNIFICANCE OF BRANDING OF SERBIAN BASKETBALL

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**ABSTRACT**

Nowdays, when the world is changing really fast, it is necessary to be ready to react and adapt to all the changes, both within the organization and in the external environment. Proper managment of branding of an individual, organization, company all the way up to the level of one country is very important and it leads us to successfull response to unexpected situations, which thus gives a competitive adventage in the market. Serbia, know as „basketball nation“ and with awards coming year after year, has a huge potential related to the branding of basketball and it’s sport in general. We could say that that potential have been neglected, because how little attention has been paid to it and how much it hasn’t been used. Therefore, more attention must be paid to that segment and an initiative must be launched to improve the branding of Serbian basketball and sports in general.

**Keywords:** branding, brand, basketball, Serbia, sport, marketing.

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# IMPULSE BUYING OF FASHION PRODUCTS

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## ABSTRACT

Vendors utilize various sales strategies to secure the greatest possible return and the most favorable customer experience. One of the most commonly used sales promotion method refers to discounts that can be highlighted in a variety of ways with the aim of encouraging customers to buy products. The subject of the paper is the analysis of the impulse buying of fashion products, prompted by a certain amount of discounts. The aim of this research is to examine how a certain amount of discount affects the frequency of impulse purchases of fashion products online and in physical stores, by taking into account the following independent variables: gender, generation and level of income. The survey method was used, with the application of an online questionnaire in a sample of 1,002 respondents in the Republic of Serbia. The results revealed that fashion products were more likely to be purchased on impulse when discounts exceeded 30%. It is concluded that this information may be useful to the product suppliers, because they can increase the price of the fashion products to pay off the discounts of over 30%, which can result in a more frequent impulse buying, thereby ensuring the desired results in financial terms.

**Keywords**: impulse buying, fashion products, amount of discount, online shopping.

## INTRODUCTION

Although the purchases of goods and services tend to be planned consumer activities, driven by defined needs and motives, the so-called unplanned (impulse) buying is also not uncommon (Slijepčević, 2019). These are purchases the consumers do not plan ahead of time before entering the store, but make them on the spur of the moment. In other words, impulse buying is the result of consumers' failure to weigh their options before making a purchase. They will be prepared to unexpectedly and swiftly buy those goods and/or services they consider to be a good deal. Therefore, many companies use various promotional techniques (primarily sales promotion) in order to encourage consumers to engage in impulse buying. This facilitates an increase in sales of their goods and/or services, thus allowing them to make a profit.

## DISCOUNTS AS ONE OF THE METHODS OF PROMOTING SALES AIMED AT THE END USER

Discounts (price-off or money-off deals) are the most common method of sales promotion (Pickton, & Broderick, 2005). It provides the customer with a temporary price reduction (cash savings), and thus the immediate value, and therefore represents an unmistakable incentive to purchase (Jobber, & Fahy, 2006). More precisely, customers may perceive a product at a discounted price as being more cost-effective in comparison to another similar product. Therefore, the customer considers the purchase of that product to be a smart decision (Gordon-Hecker et al., 2020).

Discounts can be found along any stage of the distribution process. They can be created by manufacturers (discount printed on packaging), retailers (discount displayed on a sticker, i.e. a tag near the product) or distributors in order to introduce a new or improved product, reduce inventory,

increase short-term sales, retain existing customers or increase revenue. Discounters should consider the following questions (Day, & Ryans, 1988; Tellis, & Zufryden, 1995):

*when the reduction will be applied* – for example, weekly or monthly, during the holidays, during in or out of season;

*what products the discount will apply to* – whether it be a single product or a specific range of products, as well as whether these products are new or outdated;

*what will be their value* – providing big discounts can motivate consumers to buy large quantities of products, to buy repeatedly, as well as to buy on impulse, but only for a certain period of time. However, it is important that the product is well established in the consumer's mind because, otherwise, a lower perceived quality could directly lead to fewer purchases;

*which consumers it will apply to* – referring to different groups of consumers and

*where and how the discount will be displayed* – at the point of sale (by highlighting the price reduction on the packaging, on labels near the product or in store windows) or by means of advertising (flyers, newspapers, advertisements on television, radio and the Internet) to ensure customers are aware of the upcoming discounts.

Numerous studies (Banks, & Moorthy, 1999; Kopalle, & Mela, 1999; Smith, & Sinha, 2000; Percy et al., 2001) have demonstrated that discounts spur short-term rise in sales. According to research results (Blackwell et al., 2001; Gilbert, & Jackaria, 2002; Osman et al., 2011; Neha, & Manoj, 2013; Salvi, 2013) discounts are the only factor that has a substantial impact on consumer behavior, and is especially efficient in promoting rapid purchases (impulsive behavior) and testing of products (new or redesigned). This indirectly attracts new consumers who have never sampled the product before, as well as those who have previously been purchasing from competitor companies. These results were partially confirmed by the research conducted by Shi et al. (2005) according to which discounts are the most effective in encouraging the acceleration of purchases, stocking up and spending more money than planned. In addition, the results were partially confirmed by the research conducted by Obeid (2014), according to which the discounts are the most effective in spurring impulse buying, causing customers to spend beyond their intended budget and drawing in rival customers. Specifically, according to the results of some recent research (Osman et al., 2011; Tinne, 2011; Banerjee, & Saha, 2012; Rittipant et al., 2013; Nagadeepa et al., 2015; Zhou, & Gu, 2015; Alimpić et al., 2020; Nikčević et al., 2020) discounts are the most effective tool to motivate impulse buying.

## CONSUMER IMPULSIVE BEHAVIOR

Over the past sixty years, numerous researchers and practitioners have been interested in studying this type of consumer behavior. More precisely, they all tried to define the concept of impulse buying differently. The first among them were Clover (1950) and Stern (1962). It is noteworthy that these studies considered the product, rather than consumers and their personal characteristics, as a major factor influencing impulse buying. However, this changed due to the research conducted by Rook (1987) who highlighted that the consumer is subjected to a sudden, intense and powerful desire during impulse buying. In other words, he described this type of buying as an unintentional and unthoughtful reaction that manifests itself shortly after exposure to a stimulus in a particular store. According to Rook and Gardner (1993), this is unanticipated behavior that implies quick decision-making and a tendency to purchase products immediately. Beatty and Ferrell (1998) describe this type of buying as immediate, i.e. without a predetermined purpose of either obtaining a certain type of product or fulfilling a particular need. On the other hand, Bayley and Nancarrow (1998) define this behavior as sudden, uncontrollable and hedonistically complex buying behavior in which the speed of making impulsive decisions hinders thoughtful and careful consideration of alternative information and choices. More precisely, the term refers to purchases that consumer makes with little or no thought, in response to the sudden and intense impulse (Block, & Morwitz, 1999). Therefore, it can be concluded that impulsive behavior is more likely to stimulate a consumer to act than planned behavior, which is more dependent on deliberation (Kacen, & Lee, 2002). This is due to impact of impulsive behavior to consumer’s emotions and feelings (Piron, 1991; Parboteeah, 2005; Virvilaite et al., 2009).

According to Yin and Jin-Song (2014) and Solomon (2017), these purchases were not specifically pre-meditated by consumers before arriving at the store, i.e. in advance, but were instead made on the spur of the moment.

## IMPULSIVENESS IN BUYING FASHION PRODUCTS

Clothing items are one of the most common categories that consumers buy on impulse (Dittmar et al., 1995). All segments of consumers buy them. This is due to the fact that, aside from its practical advantage, buying clothes often brings a psychological benefit as a source of pleasure in the shopping experience, and often serves as a tool for consumer self-presentation (Dittmar et al., 1995; Činjarević et al., 2011).

Impulse buying of clothes, as a specific category, belongs to fashion-oriented impulse buying. Consumers are often enticed to engage in impulse buying when they spot trendy products that draw their attention and buy them motivated by the idea to upgrade their style by purchasing new and innovative products (Park et al., 2006).

The price of a product is considered the main factor that encourages consumers to make impulse buys, whether online or in-store (Mesiranta, 2009; Karbasivar, & Yarahmadi, 2011). Some customers believe that electronic shopping can cost them more compared to traditional shopping (Mesiranta, 2009). In other words, they tend to act more on impulse when shopping online, than when shopping in physical stores. Therefore, the price is a major factor in exerting positive influence on consumers to search online for information about products, and it encourages the realization of impulse buying.

Research by Chen (2011) showed that consumers are less inclined to impulsively purchase clothing products than computer equipment, in cases where these two product categories are compared when examining impulsive tendencies and involvement in purchasing the products online. Chen explained that, when buying computer equipment, it is more convenient to search and gather information on the Internet. However, when it comes to clothing, impulse buying is reduced, because the clothes cannot be touched and tried on, which is important when buying this kind of products. Therefore, it has been concluded that the tendency for impulse buying is greater when it comes to computer equipment.

## METHODOLOGY

Empirical, quantitative research was conducted by a test method. An online survey was prepared specifically for the purpose of this research and was distributed to respondents. The research was conducted in the Republic of Serbia, between March 24 and June 21, 2021. Consumer habits have been examined in terms of the frequency of impulse buying of fashion products, which was encouraged by a certain amount of discount, online and in physical stores. The random sample consists of 1,002 respondents and comprises both genders (male: 26%, female: 74%), aged 18 to 72. According to age categories, the structure of the sample is as follows: 18-25 years old (Gen Z): 18%; 26-40 years old (Gen Y): 31%; 41-55 years old (Gen X): 35%; 56-72 years old (Baby boomers): 16%. According to the level of monthly income, the structure of the sample consists of respondents reporting the following income levels: up to RSD 50,000, 43%; RSD 50,000-70,000, 20%; RSD 70,000-100,000, 14%; over RSD 100,000, 7%. The sample includes respondents from all regions of Serbia. The statistical error of the sample is 3%.

The SPSS was used for data processing and analysis. The following quantitative statistical methods were applied: descriptive statistics (frequency distribution, mean, standard deviation) and comparative statistics (ANOVA, t-test). Questions in the questionnaire were formulated in the form of a five-point Likert Scale.

The following research hypotheses have been set:

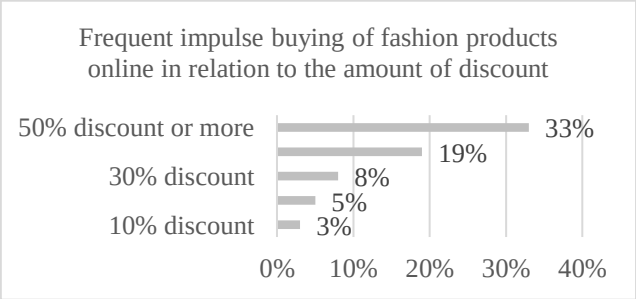
$H_1$: There is a statistically significant difference in the answers of respondents of different genders in relation to the frequency of impulse buying of fashion products encouraged by a certain amount of discount, both online and in physical stores.

$H_2$: There is a statistically significant difference in the answers of respondents of different generations in relation to the frequency of impulse buying of fashion products encouraged by a certain amount of discount, both online and in physical stores.

$H_3$: There is a statistically significant difference in the answers of respondents of different levels of income in relation to the frequency of impulse buying of fashion products encouraged by a certain amount of discount, both online and in physical stores.

## RESULTS OF EMPIRICAL RESEARCH AND DISCUSSION

Based on graph 1, 3% of consumers often impulsively buy fashion products online at a 10% discount; 5% of consumers often impulsively buy fashion products at a 20% discount; 8% of consumers often impulsively buy fashion products at a 30% discount; 19% of consumers often impulsively buy fashion products at a 40% discount; 33% of consumers often impulsively buy fashion products online at a discount of 50% or more.



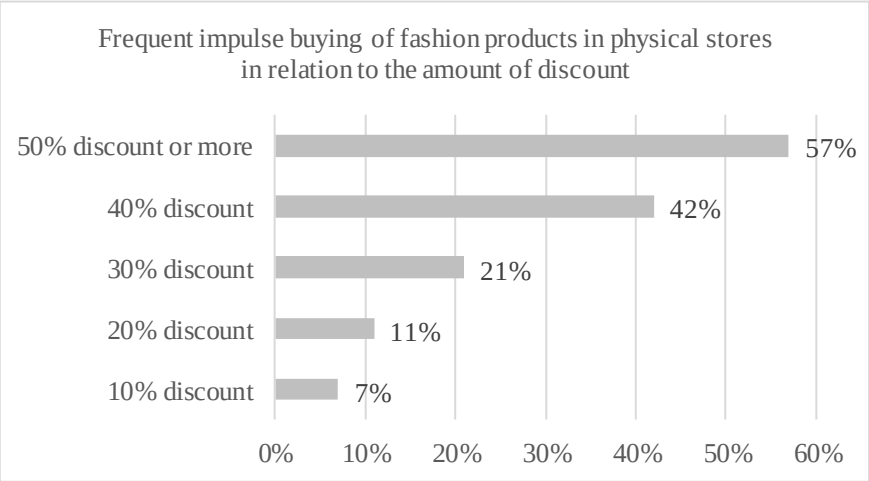

Graph 1. Frequent impulse buying of fashion products online in relation to the amount of discount.

When fashion products are at a 30% discount, the frequency of buying them online significantly increases. The fashion products most frequently bought online are those discounted by 50% or more. When fashion products are at a 30% discount, the frequency of buying them in physical stores significantly increases as well. The fashion products most frequently bought in physical stores are those discounted by 50% or more. There is a higher frequency of buying fashion products in physical stores when they are on discount, than buying them online (Table 1).

Table 1. Frequency of impulse buying of fashion products online and in physical stores in relation to the amount of discount.

| **How impulsive are you in buying fashion products...** | | | | | | | |
|---|---|---|---|---|---|---|---|
| **...online...** | | | | **...in physical stores...** | | | |
| **...if discounted...** | **N** | **Std. Deviation** | **Mean** | **...if discounted...** | **N** | **Std. Deviation** | **Mean** |
| 10% | 1,002 | 0.857 | 1.84 | 10% | 1,002 | 0.941 | 2.20 |
| 20% | 1,002 | 0.886 | 1.98 | 20% | 1,002 | 0.936 | 2.46 |
| 30% | 1,002 | 0.977 | 2.25 | 30% | 1,002 | 0.934 | 2.84 |
| 40% | 1,002 | 1.107 | 2.55 | 40% | 1,002 | 0.980 | 3.27 |
| 50% or more | 1,002 | 1.273 | 2.87 | 50% or more | 1,002 | 1.027 | 3.62 |

Based on graph 2, 7% of consumers frequent impulsively buy fashion products in physical stores at a 10% discount; 11% of consumers frequent impulsively buy fashion products at a 20% discount; 21% of consumers frequent impulsively buy fashion products at a 30% discount; 42% of consumers frequent impulsively buy fashion products at a 40% discount; 57% of consumers frequent impulsively buy fashion products in physical stores at a discount of 50% or more.




Graph 2. Frequent impulse buying of fashion products in physical stores in relation to the amount of discount.

The t-test (Table 2) revealed a statistically significant difference in the answers of respondents of different genders in relation to the amount of discount that influenced the impulsiveness of buying fashion products online and in physical stores, in favor of female respondents in both cases.

Table 2. Examination of statistically significant differences in the answers of respondents of different genders in relation to the amount of discount that influenced the impulsiveness of buying fashion products online and in physical stores (t-test).

| The amount of discount that influenced the impulsiveness of buying fashion products | Online | | | In physical stores | | |
|---|---|---|---|---|---|---|
| | t | df | p | t | df | p |
| 10% | 67.940 | 1,001 | 0.00* | 73.996 | 1,001 | 0.00* |
| 20% | 70.738 | 1,001 | 0.00* | 83.321 | 1,001 | 0.00* |
| 30% | 72.891 | 1,001 | 0.00* | 96.130 | 1,001 | 0.00* |
| 40% | 73.032 | 1,001 | 0.00* | 105.611 | 1,001 | 0.00* |
| 50% or more | 71.233 | 1,001 | 0.00* | 111.681 | 1,001 | 0.00* |

*Asterisks are used to denote statistically significant differences in the answers of respondents, where $p < 0.05$.

Many researchers have come to the conclusion that it is women who show a greater tendency towards impulse buying than men (Harwani, & Kanade, 2017; Barakat, 2019; Tifferet, & Herstein, 2012). Kurtović et al. (2020) obtained the same results from the research conducted in Bosnia and Herzegovina, and explained them by the fact that women spend more time shopping and enjoy it to a greater extent than men. Research shows that buying clothes represents a kind of relaxing and socializing activity, and that clothing, jewelry and skin care products are the categories of products more often purchased impulsively by women (Dittmar et al., 1995). According to the research by Saarela et al. (2008), it was recognized that in impulse buying, female consumers are more attracted to cheaper goods, more aggressive promotional campaigns and price reductions on the Internet, especially for products in the category of cosmetics and clothing, while male consumers are more attracted to the purchase of electronic equipment and technical products.

Table 3. Examination of statistically significant differences in the answers of respondents of different generations in relation to the amount of discount that influenced the impulsiveness of buying fashion products online and in physical stores (ANOVA).

| The amount of discount that influenced the impulsiveness of buying fashion products | Online | | | | | In physical stores | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Sum of Squares | df | Mean Square | F | p | Sum of Squares | df | Mean Square | F | p |
| 10% | 15.690 | 3 | 5.230 | 7.255 | 0.00* | 1.790 | 3 | 0.597 | 0.674 | 0.57 |
| 20% | 29.512 | 3 | 9.837 | 12.967 | 0.00* | 0.373 | 3 | 0.124 | 0.141 | 0.94 |
| 30% | 38.682 | 3 | 12.894 | 14.026 | 0.00* | 3.273 | 3 | 1.091 | 1.252 | 0.29 |
| 40% | 64.578 | 3 | 21.526 | 18.473 | 0.00* | 18.389 | 3 | 6.130 | 6.488 | 0.00* |
| 50% or more | 115.985 | 3 | 38.662 | 25.606 | 0.00* | 57.476 | 3 | 19.159 | 19.160 | 0.00* |

*Asterisks are used to denote statistically significant difference in respondents' answers, where $p < 0.05$.

According to Table 3, there is a statistically significant difference in the answers of respondents of different generations in relation to the frequency of impulse buying of fashion products online. When it comes to discounts of 10%, 20% and 30%, members of Gen Y are the most numerous in impulse buying, while Gen Z leads the way when it comes to discounts of 40% and 50% or more (Table 4).

Table 4. Distribution of respondents by generation and amount of discount – those who frequent (often and almost always) impulsively buy fashion products online

| The amount of discount that influenced the impulsiveness of buying fashion products online | Gen Z | Gen Y | Gen X | Baby boomers |
|---|---|---|---|---|
| 10% | 2% | 6% | 2% | 3% |
| 20% | 5% | 7% | 5% | 1% |
| 30% | 11% | 12% | 6% | 0% |
| 40% | 27% | 25% | 13% | 9% |
| 50% or more | 51% | 39% | 22% | 24% |

According to Table 3, there is a statistically significant difference in the answers of respondents of different generations, in relation to the frequency of impulse buying of fashion products in physical stores when it comes to discounts of 40% and 50% or more, among Gen Z and Gen Y. The percentages of members of Gen Z (49%) and Gen Y (48%) who frequent impulsively buy fashion products in physical stores when on a discount of 40%, are approximately the same, while the percentage of respondents from Gen Z (73%) who frequent impulsively buy the mentioned products in physical stores when discounted by 50% or more (Table 5) is much higher.

Table 5. Distribution of respondents by generation and amount of discount – those who frequent (often and almost always) impulsively buy fashion products in physical stores

| The amount of discount that influenced the impulsiveness of buying fashion products in physical stores | Gen Z | Gen Y | Gen X | Baby boomers |
|---|---|---|---|---|
| 40% | 49% | 48% | 40% | 24% |
| 50% or more | 73% | 61% | 52% | 41% |

According to the results of several studies carried out so far, it can be concluded that young respondents demonstrate a greater inclination towards impulse buying than older respondents (Jalees, 2009; Mihić, & Kursan, 2010; Awan, & Abbas, 2015; Barakat, 2019), and that the

tendency towards impulse buying most often occurs between the age of 25 and 35 and increases in correlation with increasing monthly income (Harwani and Kanade, 2017).

Consumer impulsive behavior in online shopping is also different if older and younger consumers are taken into account (Saarela et al., 2008). Younger consumers are more likely to be guided by impulse buying behavior than older consumers. They value availability of information and additional product information more, but are more likely to be influenced by external factors (they spend more time in online shopping), compared to older consumers. At the same time, both groups also have different preferences when shopping online.

Table 6. Examination of statistically significant differences in answers of respondents of different levels of income in relation to the amount of discount that influenced the impulsiveness of buying fashion products online and in physical stores (ANOVA).

| **The amount of discount that influenced the impulsiveness of buying fashion products** | **Online** | | | | | **In physical stores** | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | **Sum of Squares** | **df** | **Mean Square** | **F** | **p** | **Sum of Squares** | **df** | **Mean Square** | **F** | **p** |
| 10% | 0.408 | 3 | 0.136 | 0.192 | 0.90 | 1.813 | 3 | 0.604 | 0.701 | 0.55 |
| 20% | 3.813 | 3 | 1.271 | 1.759 | 0.15 | 1.900 | 3 | 0.633 | 0.741 | 0.53 |
| 30% | 4.302 | 3 | 1.434 | 1.621 | 0.18 | 3.263 | 3 | 1.088 | 1.246 | 0.29 |
| 40% | 10.299 | 3 | 3.433 | 3.034 | 0.03* | 9.835 | 3 | 3.278 | 3.518 | 0.02* |
| 50% or more | 17.320 | 3 | 5.773 | 3.750 | 0.01* | 10.587 | 3 | 3.529 | 3.441 | 0.02* |

*Asterisks are used to denote statistically significant difference in respondents' answers, where $p < 0.05$.

A statistically significant difference was found in the answers of respondents of different levels of income in relation to the frequency of impulse buying of fashion products online when it comes to discounts of 40% and 50% or more (Table 6), among respondents with the lowest income (up to RSD 50,000) (Table 7).

Table 7. Distribution of respondents by the level of income in relation to the amount of discount – those who frequent (often and almost always) impulsively buy fashion products online.

| **The amount of discount that influenced the impulsiveness of buying fashion products online** | **Under RSD 50,000** | **RSD 50,000 – 70,000** | **RSD 70,000 – 100,000** | **Over RSD 100,000** |
|---|---|---|---|---|
| 40% | 18% | 13% | 15% | 13% |
| 50% or more | 35% | 24% | 26% | 29% |

A statistically significant difference was found in the answers of respondents of different levels of income in relation to the frequency of impulse buying of fashion products in physical stores when it comes to discounts of 40% and 50% or more (Table 6), among respondents with the lowest income (up to RSD 50,000). On the other hand, as for discounts of 50% or more, respondents with the highest income (over RSD 100,000) are most numerous (Table 8).

Table 8. Distribution of respondents by the level of income in relation to the amount of discount – those who frequent (often and almost always) impulsively buy fashion products in physical stores

| The amount of discount that influenced the impulsiveness of buying fashion products in physical stores | Under RSD 50,000 | RSD 50,000 – 70,000 | RSD 70,000 – 100,000 | Over RSD 100,000 |
|---|---|---|---|---|
| 40% | 46% | 41% | 32% | 42% |
| 50% or more | 60% | 56% | 41% | 58% |

Mihić and Kursan (2010) conclude that respondents with the lowest income are less impulsive when buying than other categories of consumers. However, respondents with the highest personal income do not show greater tendency towards impulse buying than members of the remaining categories. Such results are explained by the prudent shopping habits of those with the lowest personal income, because their financial capabilities force them to be rational and deliberate when buying. On the other hand, the results of the research by Kurtović et al. (2020), conducted in Bosnia and Herzegovina, show that respondents of different levels of income do not significantly differ in statistical terms when it comes to tendency towards impulse buying. The explanation may lie in the fact that everyone buys apparel, and all consumer segments experience a strong social pressure to look attractive. The theoretical determination of impulse buying as a non-adaptive behavior (Verplanken, & Herabadi, 2001) is clearly indicated by purchases beyond the financial possibility, and therefore the existence of such behavior in respondents of different levels of income is logical. It is possible that there is a statistically significant difference in the amount of money spent during impulse buying, since respondents with higher income have less to worry about when it comes to the amount of money they spend, while people with low income buy on impulse when they are encouraged to do so by various discounts and promotions.

As the existence of a statistically significant difference in the answers of respondents of different genders is found in relation to the frequency of impulse buying of fashion products encouraged by a certain amount of discount, both online and in physical stores, the hypothesis $H_1$ is confirmed. Also, as the existence of a statistically significant difference in the answers of respondents of different age is found in relation to the frequency of impulse buying of fashion products encouraged by a certain amount of discount, both online and in physical stores, the hypothesis $H_2$ is confirmed. Moreover, the hypothesis $H_3$ is also confirmed by the existence of a significant statistical difference in the answers of respondents of different levels of income in relation to the frequency of impulse buying of fashion products encouraged by a certain amount of discount, both online and in physical stores.

## CONCLUSIONS

There is no doubt that the findings acquired are of utmost importance to marketers and for the creation of marketing strategies for promotions and discounts. If the clothing market suppliers want to increase the percentage of impulse buying, a strategy for promotions and discounts aimed at the female population will enable them achieve this, both in physical stores and online.

Due to the specificity of fashion clothing and the very purchase process (because the customers want to touch the clothing and try it on), the frequency of purchase is greater in physical stores than online, when offering high discounts. Thus, marketers should rely more on brick-and-mortar stores for lesser-known brands and products that are discounted beyond 30%. On the other hand, well-positioned fashion products could be dominantly directed to online sales.

Manufacturers of fashion clothing intended for young people (Gen Y and Z) should create prices that will allow them, as soon as possible, to secure discounts of 40% or more, because this will stimulate the young to make frequent purchases.

It has been proven that high discounts stimulate impulse buying by both consumers with the highest and lowest incomes. Marketers should be aware that high discounts will not necessarily put off high-end customers and that, whenever there is economic justification, they can safely offer discounts of 50% or more (on fashion products sold in physical stores).

The limitations of the research are primarily related to the fact that the research did not include fashion brands and nameless fashion products in order to consider the influence of consumer loyalty when it comes to impulse buying. The second issue concerns stockpiling of clothing - whether and to what extent impulse buying contributes to the accumulation of waste, which is in contrast to sustainable fashion (i.e. green fashion), bearing in mind the fact that the fashion industry is one of the biggest polluters in the world. These two important aspects could be the subject of some further research.

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# FACTORS AFFECTING CONSUMER ETHNOCENTRISM, WITH FOCUS ON SERBIA

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## ABSTRACT

The introduction provides a review of the context that favors ethnocentrism and leads to this phenomenon. The paper explains the meaning of the very term and provides the general characteristics of consumer ethnocentrism, connecting the emergence of this phenomenon with ethnocentrism itself. The subject of the paper is consumer ethnocentrism as an important category that affects the purchase of products, and therefore the overall market. In-depth consideration is given to the research of multiple works by authors who studied various factors that can influence consumer ethnocentrism to a greater or lesser extent, such as socio-psychological, demographic, economic, political and situational ones. The aim of the paper is to review literature that deals primarily with consumer ethnocentrism as a derivative of ethnocentrism, so as to gain a better insight into consumer behavior and needs, as well as the interests of manufacturers, for the purpose of formulating a successful marketing strategy.

**Keywords**: ethnocentrism, consumer ethnocentrism, consumer behavior, marketing strategy.

## INTRODUCTION

Understanding consumer behavior in the current market environment is very important for all companies seeking to gain a competitive edge. Owing to a range of factors that determine their attitudes and intentions in the purchase process, consumers should be viewed as an indispensable resource. The concept of consumer ethnocentrism, showing the inclination of customers to buy domestic products, is particularly significant in the current business atmosphere that is marked by extreme complexity, unpredictability and uncertainty. Recognizing the impact of various factors on consumer purchasing habits can facilitate the process of creating a multinational business strategy and executing the process of segmentation, targeting and positioning.

Consumer ethnocentrism can be caused and encouraged by numerous factors, the most noteworthy of which are socio-psychological and demographic. Political, economic and situational factors are among the others. Socio-psychological factors include patriotism, nationalism, cultural openness, animosity, etc. The most common demographic variables examined in the research of consumer ethnocentrism are age, gender, income and education. Economic factors refer to incentives to buy domestic products in order to protect a certain branch of domestic industry, with the aim of preventing negative phenomena that can be reflected not only in the profitability drop in the specific branch in question, but also in the wider social community. Therefore, it is not surprising to see many manufacturers use moral appeals in their advertising campaigns that directly invite consumers to buy domestic products. Serbia faced a similar situation at the time of Yugoslavia's dissolution, with many local companies left without their property dispersed over the former republics, and no market to sell their products. The aim of disqualifying certain products was a result of political reasons due to negative political circumstances. In recent times, we have witnessed such phenomena when Serbia refrained from buying Slovenian and Croatian products, and now, the products from Serbia are boycotted in Kosovo. This matter is likely to remain until the political situation is settled. Situational factors also influence consumer behavior. These are numerous and diverse factors in the surroundings, with an impact on specific purchasing situations

that dictate the consumer's specific choice. The Covid-19 pandemic is one such factor that has triggered a shift in consumer behavior, resulting in a heightened need for hygiene products, medicines and supplements. Specifically, as a result of the isolation, people all over the world have experienced a transformation in their lifestyle and work which, in turn, caused a decrease in the purchase of goods and services, particularly pronounced in the fields of tourism and fashion industry. New trends emerged, and face masks became a leitmotif.

## THE TERM AND CHARACTERISTICS OF CONSUMER ETHNOCENTRISM

Before analyzing consumer ethnocentrism, it is necessary to explain the broader concept called ethnocentrism. According to the first formal definition of ethnocentrism (Sumner, 1906), this phenomenon refers to the viewpoint of members of one group that puts their group at the forefront of everything, with all other groups being inferior to it (Shankarmahesh, 2006; Nadiri, & Tumer, 2010; Strehlau et al., 2012; Lymperopoulos et al., 2014; Bizumić, 2019). In other words, ethnocentrism implies attitudes oriented toward the idea that one's own culture and way of life are superior to others. Therefore, ethnocentrism is a typical sociological phenomenon whose purpose is to preserve the existence of a collective society, and it can be perceived as a form of group defense (Gašević, et al., 2017; Prince et al., 2019).

The concept of ethnocentrism includes two components: attitude and behavior. Ethnocentric attitudes are expressed through seeing one's own group as dominant in relation to other groups, while, on the other hand, ethnocentric behavior represents cooperation with members of one's own group, with the absence of cooperation with members of other groups (Veljković, 2009). Ethnocentrism can play an important role in ethnic conflicts, in enforcing a country's policy, but also when it comes to consumer decision-making in the purchasing process (Marinković et al., 2011).

The concept of ethnocentrism has led to the emergence of a novel term - consumer ethnocentrism, which is related to understanding of ethnocentrism from a marketing perspective, but also, generally speaking, from the viewpoint of economy. As such, this phenomenon has become the subject of study by numerous authors and experts in the field of marketing, but also in other fields of science in which consumer behavior plays a significant role in economic analysis and decision-making (Javalgi et al., 2005; Marinković et al., 2011; Pentz et al., 2017).

Consumer ethnocentrism represents an attempt to apply the general sociological concept of ethnocentrism to a business context and, as such, is linked to the patriotic feeling of the individual that it is preferable to buy domestic products (Alsughayir, 2013; Pentz et al., 2013; Schnettler et al., 2011; Siamagka, & Balabanis, 2015; Cleveland et al., 2017; Karoui, & Khemakhem, 2019; Bakti et al., 2020; Rašković et al., 2020; Kostić et al., 2021). The abovementioned relation was also identified in the research carried out on the Serbian market (Pavlović, & Savić, 2017). Specifically, consumer ethnocentrism is a preference for products and brands from one's own country over products and brands from other countries (Gašević et al., 2019; Casado-Aranda et al., 2020; Ma et al., 2020). This term could be used to explain the reasons why some consumers have negative attitudes towards foreign products, as well as to justify consumer inclination to purchase domestic products rather than foreign ones (Bešlagić, 2015). Furthermore, from a marketing perspective, consumer ethnocentrism should be viewed as a consumer choice conditioned by the attitude that ethnocentrism helps not only the economic, but also the political and social development of the country (Kragulj et al., 2017; Das, & Mukherjee, 2020; Vuong, & Giao, 2020). The main starting point for the consumer ethnocentric tendencies is the family, but also opinion leaders, reference groups, the media, etc. (Veljković, 2009).

The foundations of the consumer ethnocentrism concept were first introduced in the marketing literature by Shimp (1984), who defined ethnocentrism as "the beliefs held by consumers about morality/immorality of purchasing foreign-made products". Sharma et al. (1995) confirmed the consumption tendencies of American consumers in overestimating domestic products. At the same time, this marked the commencement of genuine acknowledgement of the concept of consumer ethnocentrism, which is based on the idea that the purchase of domestic products is not only an economic, but also a moral issue (Siamagka, & Balabanis, 2015; Cleveland

et al., 2017; Pentz et al., 2017; Khan et al., 2019). Based on the above, it can be inferred that ethnocentric consumers hold those who purchase imported products accountable for the domestic economic problems, including unemployment (Cleveland et al., 2017; Ejiofor et al., 2019; Vuong, & Giao, 2020; Farah, & Mehdi, 2021). On the other hand, non-ethnocentric consumers do not care about the geographical origin of the product, as long as it meets their needs to the greatest possible extent (Marinković et al., 2011).

## FACTORS AFFECTING CONSUMER ETHNOCENTRISM

Consumer ethnocentrism can be affected by numerous factors. In his work, Shankarmahesh (2006) analyzed a large number of studies in the field of consumer ethnocentrism and identified numerous drivers, i.e. factors that have an influence on this phenomenon. Primarily, socio-psychological and demographic factors are what propel consumer ethnocentrism. Political, economic and situational factors are among the others. Socio-psychological factors include patriotism, nationalism, cultural openness, animosity, etc. (Shankarmahesh, 2006). Patriotism is defined as love for or loyalty to a particular country (Sharma et al., 1995). When it comes to purchasing habits, patriotism can be a strong driver of consumer ethnocentrism (Vida, & Reardon, 2008). For patriots, love for one's country creates a fondness for domestic products. For them, the purchase of domestic products is a duty and a patriotic act, and they will often pay more for a domestic product than for a foreign one, even if it is of lower quality (Kipnis et al., 2012). Consumer ethnocentrism can also be encouraged by the state with its strategies and actions by which it motivates consumers to buy locally (Shah, & Ibrahim, 2012). The influence of patriotism on ethnocentric tendencies of consumers is particularly pronounced in developing countries (Altintaş, & Tokol, 2007). The research conducted by Javalgi et al. (2005), Vida and Reardon (2008), Marinković (2017) and Pavlović and Savić (2017) found that patriotism has a positive influence on consumer ethnocentrism. Unlike patriotism, nationalism represents love for one's own country, but with a sense of superiority, dominance and stereotypes towards other countries. Nationalist-oriented individuals are characterized by aggressive and stereotypical behavior towards other cultures, militaristic attitudes, isolationism, trade protectionism, tendency towards ethnic violence and terrorism (Balabanis et al., 2001). Nationalism can be a powerful driver of purchasing habits. People with a strong sense of patriotism consider domestic products to be more attractive and believe that the purchase of foreign products can be detrimental to the national economy (Ding, 2017). Nationalism is more pronounced among less powerful and economically disadvantaged groups, developing countries, older and less educated people (Wang, & Chen, 2004; Todosijević, 2013). The research by Balabanis et al. (2001), Lee et al. (2003), Tsai et al. (2013), Pavlović and Savić (2017) and Zdravković et al. (2020) found a positive influence of nationalism on consumer ethnocentrism. Cultural openness is determined by the willingness to interact with people from other countries and cultures (Javalgi et al., 2005). In the fields of marketing and economics, people who exhibit a higher level of cultural openness are ready to meet other people, their cultures and lifestyles, try foreign products and buy well-known global brands (Deb ,& Sinha, 2016). The research by Park and Yoon (2017) found that people with greater cultural openness tend to buy high quality global products, that they are not nationalistic and accept foreign products without fear that those products will threaten the national economy. In other words, the greater the cultural openness, the lower the degree of consumer ethnocentrism. The research by Howard (1989) and Sharma et al. (1995) found the existence of a negative correlation between cultural openness and consumer ethnocentrism. However, according to the results of the research by Pavlović and Savić (2017) and Zdravković et al. (2020), cultural openness does not have a statistically significant effect on consumer ethnocentrism in Serbia. In other words, there is a positive correlation between cultural openness and consumer ethnocentrism in our country. This can be explained by the fact that, in contact with other cultures, one tries to preserve one's own identity by emphasizing cultural differences. Animosity or antipathy associated with previous or current military, political or economic events is also one of the socio-psychological factors responsible for consumer ethnocentrism that affects consumer behavior in the international market (Deb, & Chaudhuri, 2014). Animosity, in contrast to consumer ethnocentrism, does not concern all

foreign countries, but only certain ones towards which one feels repulsion. These are often neighboring countries (e.g. Serbia-Croatia, Serbia-Albania) (Riefler, & Diamantopoulos, 2007; Josiassen et al., 2011). According to the results of research by Deb and Chaudhuri (2014), Fernández-Ferrín et al. (2015), Cheah et al. (2016), Marinković (2017), Pavlović and Savić (2017) and Zdravković et al. (2020), animosity has a positive influence on consumer ethnocentrism both in the world and in Serbia.

Demographic characteristics of consumers represent a very important factor in the research of consumer ethnocentrism. The most common demographic variables in the research of consumer ethnocentrism are age, gender, income and education (Javalgi et al., 2005). A slightly different classification is given by Shankarmahesh (2006), pointing out that the most important variables within this group are age, income level, level of education, race, social class. In his later work, Nguyen (2017) states that gender, age, level of education and average level of monthly income are socio-demographic characteristics relevant for the research in the context of consumer ethnocentrism. Although the research results are not consistent, there seems to be more empirical support for the hypothesis that younger people have lower levels of consumer ethnocentrism than older people (Watson, & Wright, 2000; Bawa, 2004; Luque et al., 2004; Čutura, 2006; Kavak, & Gumusluoglu, 2007; Nadiri, & Tumer, 2010; Matić, 2012; Shah, & Ibrahim, 2012; Aziz et al., 2014; Lajevardi et al., 2014; Garmatjuk, & Parts, 2015; Awdziej et al., 2016; Rakić et al., 2018; Abdalrahman et al., 2019; Bernabéu et al., 2020; Migliore et al., 2021). Bawa (2004) believes that the reason for the above may rest with the fact that older customers are likely to be conservative and distrustful. Younger customers, on the other hand, have a much lower level of consumer ethnocentrism. This is thought to be the result of their openness to other cultures, greater knowledge, as well the influence of the media through which foreign products are advertised more often (Javalgi et al., 2005; Jain, & Jain, 2013). On the other hand, the studies conducted by Sharma et al. (1995) and Al Ganideh and Al Taee (2012) found no existence of a statistically significant correlation between age and consumer ethnocentrism. Research also shows that women have greater ethnocentric tendencies than men (Watson, & Wright, 2000; Lee et al., 2003; Alfnes, 2004; Bawa, 2004; Javalgi, et al., 2005; Chambers et al., 2007; Josiassen et al., 2011; Szromnik, & Wolanin-Jarosz, 2013; Fernández-Ferrín et al, 2015; Grbić, & Puška, 2015; Bernabéu et al., 2020; Migliore et al., 2021). The probable explanation is related to the fact that women are more conservative, more inclined to adapt and feel obliged to maintain social harmony and positive feelings within the group (Grbić, & Puška, 2015). However, some studies observed no difference in the level of consumer ethnocentrism between genders (Good, & Huddleston, 1995; Caruana, & Magri, 1996; Hamelin et al., 2011). Also, with few exceptions, research results point to a negative correlation between consumer ethnocentrism and level of education (Watson, & Wright, 2000; Lee et al., 2003; Luque et al., 2004; Shankarmahesh, 2006; Bandyopadhyay, & Muhammad, 2010; Wanninayake, & Chonvancova, 2012; Hassouneh, 2017; Gašević et al., 2017; Rakić et al., 2018; Bernabéu et al., 2020; Guo, & Özdinç, 2021). An explanation may be sought in the fact that educated people have fewer ethnic prejudices and are less conservative (Matić, 2012; Meeusen et al., 2013). However, there are also studies in which the aforementioned correlation was not found (Han, 1988; Balabanis et al., 2001; Nguyen et al., 2008; Hamelin et al., 2011). Furthermore, most studies found a negative correlation between individual income and scores on the scale of consumer ethnocentrism (Lee et al., 2003; Shoham, & Brenčič, 2003; Kumar, & Kim, 2008; Nadiri, & Tumer, 2010; Hamelin et al., 2011; Richardson, 2012; Wanninayake, & Chonvancova, 2012; Mockaitis et al., 2013; Aziz et al., 2014; Garmatjuk and Parts, 2015; Grbić and Puška, 2015; Zalega, 2017; Wel et al., 2018; Stepchenkova et al., 2019; Bernabéu et al., 2020; Aljukhadar et al., 2021). However, some studies found no effect of income on consumer ethnocentrism (Josiassen et al., 2011; Jain and Jain, 2013; Awdziej et al., 2016; Bešlagić et al., 2018), while other studies found a positive correlation (Balabanis and Diamantopoulos, 2011; Al Ganideh and Al Taee, 2012; Al Ganideh, & Good, 2016). Moving up the social ladder leads to a decrease in ethnocentric tendencies. The research by Watson and Wright (2000) found that highly ethnocentric consumers are more likely to be women, as well as those who are older, less educated and less wealthy. Women are more inclined, for example, to buy and test domestic and natural cosmetic products,

and will prefer products that are produced locally. They will resort to other products only if the domestic product fails to meet their expectations.

As for the consumer ethnocentrism in Serbia, i.e. the demographic factors that determine it, the research by Marinković et al. (2011) found that men are more likely to display ethnocentric tendencies than women are. This result is different from the one obtained from research in other countries where the level of consumer ethnocentrism was higher among women. Results of this research further reveal that consumer ethnocentrism is at its lowest level among respondents aged 18 to 31. The score of consumer ethnocentrism is slightly higher in the second group (respondents aged 32 to 45), and is the highest in the third group (respondents aged 46 and over). At the same time, the greatest distinction is manifested between ethnocentricity of respondents from the first and third groups. According to the research by Pavlović (2018) which partially confirmed these findings, when it comes to age, the results show a statistically positive correlation between age and consumer ethnocentrism. Specifically, it was proven that older people have more national pride and patriotic attitudes that are more pronounced, and that they consider the domestic products to be better than foreign ones, which is why they express a higher degree of consumer ethnocentrism than younger consumers do. Gender was found to have no significant effect on consumer ethnocentrism. The Republic of Serbs is not immune to globalization, current changes, and current events in a world where the differences between women and men are decreasing more rapidly, and this could account for the lack of discrepancy in the level of consumer ethnocentricity. According to other studies conducted in our country, the highest degree of consumer ethnocentrism is present in Central Serbia, then in Belgrade and finally in Autonomous Province of Vojvodina (Marinković, 2017). In addition, the increase in household income implies a decrease in consumer ethnocentrism (Veljković, 2009; Pavlović, 2018). The reason for the above is the fact that people with higher incomes travel more often, buy well-known world brands and have positive attitudes towards foreign products. The rural population, as well as older citizens, demonstrate a greater degree of consumer ethnocentrism than the urban population and younger citizens (Marinković et al., 2011; Gašević, 2022). The fact that the elderly and consumers with the lowest level of monthly income are more ethnocentric and show a greater degree of economic patriotism, has been proven in recent research conducted on the market of the Republic of Serbia (Rakić et al., 2018; Gašević, 2022). Older consumers are nostalgic, and therefore they decide to buy domestic products for rational, as well as emotional and moral reasons (Veljković, 2009). Finally, education as a demographic factor has a statistically significant impact on consumer ethnocentrism. Education broadens people's intellectual perspectives and reduces traditional and conservative attitudes. Specifically, the results of the research by Pavlović (2018) showed that consumers with higher and high levels of education show a lower degree of consumer ethnocentrism in relation to those with a lower level of education. On the other hand, according to the results of the research by Gašević (2022), there are no statistically significant differences in consumer ethnocentrism among consumers classified by the level of education.

Economic factors of consumer ethnocentrism, according to Siamagka (2009), include phenomena such as recession, high unemployment rate, and rapid technological and organizational changes that strengthen ethnocentric tendencies among consumers. Varied economic conditions in the country create different preferences among consumers when it comes to imported products. In countries in transition, Western products will be preferred due to their quality and innovation. However, as a country's economic development progresses, nationalistic sentiment of its citizens intensifies and they adopt an ethnocentric shopping pattern.

Rosenblatt (1964) includes political propaganda among the factors influencing ethnocentrism. Political leaders can strengthen ethnocentric approach of a nation by raising awareness of the threat posed by a foreign group (an example is the USA during the Bush regime). The strength of influence of political leaders depends on the political structure of the country. The political history of a country also determines the level of ethnocentrism in a society (Shankarmahesh, 2006). A country with a long history of oppression (Poland) is more ethnocentric than a country with a long history of conquest (Russia). The reason for the above rests with the collective repulsion (animosity) towards everything imposed by the aggressors, including their products. Conquering

countries like Russia will accept good ideas from other countries without fear of adopting the entire culture of that country. Moreover, Alsughayir (2013) does not bypass the political environment as a determinant of consumer ethnocentrism. He believes that events such as, for example, the attack on the World Trade Center in New York, on September 11, 2001 affect the possibility that the US government could use such events as part of its propaganda, with the aim of strengthening the ethnocentric tendencies of the US population.

Kragulj et al. (2017) investigated the consumer ethnocentrism among young students in the Republic of Serbia. The aim of the research was to examine whether there was an increase in the level of consumer ethnocentrism among young people in Serbia, considering all the negative demographic and economic circumstances, as well as political turbulence in the country. According to the obtained results, consumer ethnocentrism is within moderate limits, but also a slight upward trend is found in comparison to previous research. This trend is a consequence of a specific socio-economic and political environment that has influenced young people to develop awareness that the purchase of domestic products is a way to help the domestic economy to recover.

The Covid-19 pandemic, as an unprecedented situational factor, has had significant implications for consumer psychology and behavior during the pandemic and afterwards (He, & Harris, 2020). It is a collective traumatic event that has caused increased concern for health and safety (Maltseva, & Li, 2020), and that inflicts physical, psychological and emotional harm to consumers (He, & Harris, 2020). In addition to health and psychological problems, the Covid-19 pandemic has also caused financial problems and difficulties for individuals. The pandemic has brought about a considerable shift in marketing conditions and consumer behavior (Sheth, 2020; Zwanka, & Buff, 2021). An important area of consumer (ethical) decision-making that has been changing under the influence of the Covid-19 pandemic, relates to behaviors directed towards the purchase of domestic and foreign products. The question of purchasing domestic and foreign products is not only a question of affordability, quality and price, but also a question related to consumer ethics in terms of whether it is right (or wrong) to act in a certain way (He, & Harris, 2020). Thus, the research conducted by Verma and Naveen (2021) showed that, during the Covid-19 pandemic, consumers avoided foreign products, which had a positive effect on their level of ethnocentrism, i.e. on the purchase of domestic products.

## CONCLUSIONS

Based on the review of the literature relating to the factors affecting consumer ethnocentrism, it is possible to better understand why some consumers prefer domestic rather than foreign products. Accordingly, product selection can be made and the company's marketing strategy can be defined. The presented results of previous research in relation to socio-psychological factors that affect consumer ethnocentrism provide companies with information regarding whether and which products should be imported, and from which countries. In addition, the collected results may be useful to experts and scientists from government bodies and industry, since those results provide insight into consumer purchasing habits that have a significant impact on the country's economy. Moreover, based on the presented results it is possible to better understand the influence of demographic factors on consumer ethnocentrism and, accordingly, better perform the marketing processes of segmentation, targeting and consumer positioning. Among other things, gaining insight into the socio-psychological and demographic factors of consumer ethnocentrism could help better plan and implement the multinational business strategy of a company. One should certainly not overlook the impact of the remaining factors (economic, political and situational) on consumer ethnocentrism. The contribution of this paper is reflected in all of the aforementioned.

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# VJEŠTAČKA INTELIGENCIJA U DIGITALNOM MARKETINGU

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## SAŽETAK

Cilj ovog rada je istraživanje uticaja vještačke inteligencije na potrošače, upoznatost potrošača s vještačkom inteligencijom, kao i interakcija potrošača sa alatima koji u svom radu koriste vještačku inteligenciju. Glavni zaključci istraživanja ukazuju na to da se marketing sve više mijenja i prilagođava novim trendovima kao i da će vještačka inteligencija sa svojim metodama postati nezaobilazni dio marketinga. Moderni potrošači vole provjeravati podatke o proizvodu, vrlo dobro razgledati sve ponude i na kraju se odlučiti za kupovinu. Pri ovom procesu vještačka inteligencija može stvoriti odličan personalizovani ambijent za korisnika kako bi se osjećao pozvanim na kupovinu. Moderni marketing uključuje metode vještačke inteligencije kako bi lakše profilisao kupce i stvorio personalizovani sadržaj. Osim upotrebe vještačke inteligencije za profilisanje i lakšu selekciju relevantnih informacija, moderni marketing uvodi moderne metode oglašavanja kako bi se brendovi mogli lakše približiti svojim potrošačima. Stoga se u poslednje vrijeme više pažnje posvećuje marketingu na društvenim mrežama, mobilnom marketingu, kao i e-mail marketingu. Na kraju se može konstatovati da vještačka inteligencija ima uticaj na kupovne navike potrošača. Anketiranje je bilo podijeljeno u tri dijela od kojih je svaka zastupala jednu hipotezu. Sve su hipoteze djelimično ili u potpunosti potvrđene.

**Ključne riječi**: Vještačka inteligencija, mobilni marketing, digitalni marketing, moderno oglašavanje.

## UVOD

Digitalni marketing i online trgovina su dio industrije koja se mijenja gotovo svakodnevno. Kako sami pojmovi nagovještavaju, digitalni marketing i online trgovina odvijaju se online, stoga potrošači sve češće robu i druge potrepštine kupuju putem interneta (Arbona, 2018). Nakon revolucije koju je internet donio, svakodnevno generisanje podataka dovelo je ljude do tačke gdje nisu u mogućnosti sami obraditi podatke, čak ni uz pomoć tradicionalnih statističkih načina i analiza. Zbog toga se počinje upotrebljavati vještačka inteligencija koja je otvorila mnoga vrata, kako u marketingu, tako i u drugim oblastima. Vještačka inteligencija je evoluirala i uticala na način provođenja marketing aktivnosti. Ona, kao alat, ima mogućnost mnogo toga analizirati, pogotovo potrošače od kojih je svaki jedinstven. Budući da se ponašanja potrošača mijenjaju, brendovi pokušavaju što tačnije predvidjeti u kojem smjeru ona idu i tako kupcima pružaju bolju uslugu. Pri tome se koriste vještačkom inteligencijom sa namjerom stvaranja personalizovanog sadržaja za svakog kupca.

Cilj ovog rada je da istraži primjenu vještačke inteligencije u digitalnom marketingu i njen uticaj na potrošače, odnosno samu svjesnost potrošača o vještačkoj inteligenciji. Za izradu istraživačkog dijela rada korištena je anketa izrađena putem Google obrazaca. Anketom su se željeli ispitati stavovi ispitanika o tvrdnjama koje se odnose na pojmove vezane za vještačku inteligenciju, marketing kao i ulogu i uticaj vještačke inteligencije na kupovne odluke ispitanika.

## POJAM I ZNAČAJ VJEŠTAČKE INTELIGENCIJE

Vještačka inteligencija nije nova pojava u svijetu, ali ljudi nisu dovoljno svjesni koliko je uticajna na njihovu okolinu. Vještačka inteligencija je sposobnost digitalnog kompjutera ili kompjuterski kontrolisanog robota da obavlja zadatke koji se najčešće povezuju sa inteligentnim

bićima. Ovaj pojam ima široku primjenu u projektima razvoja sistema koji su obdareni intelektualnim procesima karakterističnih za ljude, kao što su sposobnost otkrivanja značenja, rasuđivanja, ekstrapolacija iz prošlih iskustava ili generaliziranja.

Vještačka inteligencija je simulacija procesa ljudskog razmišljanja uz pomoć mašina, tj. kompjuterskih sistema. Specifična primjena vještačke inteligencije uključuju razne ekspertske sisteme, obradu prirodnog načina govora i jezika, prepoznavanje govora, kao i mašinski govor. Sistemi vještačke inteligencije rade na način da unose velike količine označenih podataka prikupljenih tokom treninga i zatim analiziraju te podatke za korelacije i obrasce te ih na kraju koriste za predviđanje budućih stanja (Burns et al., 2022). Tačno na ove načine, chatbot, koji dobija primjere tekstualnih razgovora iz raznih izvora, može naučiti prilagoditi svoj način komunikacije i primjene tekstualnih poruka koje liče na realistične razmjene poruka među ljudima. Osim toga, ovi podaci se mogu koristiti i kao alati za prepoznavanje slika, gdje sistem može naučiti identifikovati i opisati objekte na slikama pregledavajući milione primjera. Programiranje vještačke inteligencije najviše se fokusira na tri kognitivne vještine, a to su: učenje, zaključivanje i samoispravljanje.

## MJERENJE UČINKA VJEŠTAČKE INTELIGENCIJE

Kada je u pitanju mjerenje učinka vještačke inteligencije u marketingu, postoje različiti pokazatelji i metrike koje se mogu koristiti, a to su (Anderson, & Rainie, 2018):

Konverzija: Konverzija je jedan od najvažnijih pokazatelja uspješnosti marketinške kampanje. Može se mjeriti brojem posjetilaca web stranice koji izvrše željenu radnju, poput kupovine proizvoda, pretplate na newsletter ili slanja upita. Grafikon konverzija prikazuje procenat korisnika koji su izvršili konverziju tokom određenog vremenskog perioda.

Angažman na društvenim mrežama: Za marketing kampanje koje se fokusiraju na društvene mreže, angažman korisnika može biti važan pokazatelj. To uključuje broj lajkova, komentara, dijeljenja i pregleda sadržaja na društvenim mrežama. Grafikon angažmana može prikazivati trendove i poređenje angažmana sa različitim kampanjama ili sadržajem.

Povećanje prometa na web stranici: Ovaj pokazatelj se može mjeriti pomoću analitičkih alata poput Google Analytics-a, a grafikon prometa prikazuje trendove rasta ili padanja prometa na web stranici tokom određenog vremena.

ROI (Return on Investment): ROI je mjera uspješnosti marketing kampanje u odnosu na uložena sredstva. Može se izračunati kao odnos prihoda i troškova kampanje. Grafikon ROI-a prikazuje povrat ulaganja tokom vremena i omogućava poređenje različitih kampanja.

Stopa otvaranja e-pošte: Stopa otvaranja e-pošte je važan pokazatelj koliko je uspješno e-pošta dostavljena primaocima i koliko je primalaca otvorilo e-poštu. Grafikon stope otvaranja e-pošte može prikazati trendove i poređenje sa prethodnim kampanjama.

Ovi pokazatelji su samo neki od mnogih koji se mogu koristiti za mjerenje učinka vještačke inteligencije u marketingu. Izbor odgovarajućih metrika zvisi od ciljeva kampanje i vrste aktivnosti koje se provode. Takođe, može biti korisno prilagoditi mjerenje učinka prema specifičnim potrebama i ciljevima marketing strategije.

Evo nekoliko primjera istraživanja koja se mogu provesti koristeći vještačku inteligenciju u marketingu:

Analiza sentimenta na društvenim mrežama: Istraživanje može uključivati praćenje i analizu komentara, objava i reakcija korisnika kako bi se utvrdilo koliko su pozitivni ili negativni prema marki.

Prediktivna analiza potrošačkog ponašanja: Vještačka inteligencija može analizirati velike količine podataka o potrošačima kako bi predvidjela njihove preferencije, potrebe i ponašanje. Istraživanje može uključivati analizu istoirijskih podataka o kupovini, demografskih podataka i ponašanja korisnika kako bi se izradili modeli predikcije potrošačkog ponašanja.

Segmentacija ciljne publike: Vještačka inteligencija može analizirati podatke o korisnicima kako bi identifikovala različite segmente ciljne publike. Istraživanje može uključivati analizu demografskih podataka, interesa, preferencija i ponašanja korisnika kako bi se identifikovali segmenti sličnih potrošača.

Personalizacija marketing poruka: Istraživanje može uključivati analizu podataka o ponašanju korisnika, preferencijama proizvoda i interakcijama sa markom kako bi se razvile personalizovane marketing strategije.

Optimizacija cjenovnih modela: Istraživanje može uključivati analizu podataka o cijenama, ponudi i potražnji kako bi se izradili algoritmi za dinamičko prilagođavanje cijena.

Generisanje kreativnih sadržaja: Vještačka inteligencija se može koristiti za generisanje kreativnih sadržaja kao što su naslovi, opisi proizvoda ili marketing materijali. Istraživanje može uključivati analizu velikih količina teksta i kreativnih uzoraka kako bi se razvili algoritmi koji generišu relevantan i privlačan sadržaj.

Praćenje i upravljanje reputacijom: Vještačka inteligencija se može koristiti za praćenje i analizu javnog mišljenja.

## NIVOI VJEŠTAČKE INTELIGENCIJE

Postoje tri nivoa vještačke inteligencije a to su (ChatGPT, 2023) :

ANI (Uža vještačka inteligencija, Narrow artificial intelligence): ANI se odnosi na trenutno najčešći oblik vještačke inteligencije koji je usmjeren na izvršavanje specifičnih zadataka. ANI sistemi su usko specijalizovani i dizajnirani za rješavanje konkretnih problema poput prepoznavanja slika, prepoznavanja govora ili preporuka proizvoda. Ovi sistemi imaju ograničenu sposobnost učenja i obično rade na osnovu unaprijed definisanih pravila i algoritama.

AGI (Opšta umjetna inteligencija, General artificial intelligence): AGI se odnosi na oblik vještačke inteligencije koji ima sposobnost razumijevanja, učenja i izvršavanja bilo kojeg intelektualnog zadatka koji bi mogao obavljati čovjek. AGI sistemi bi bili opšte inteligentni, fleksibilni i sposobni primjenjivati svoje znanje i vještine na različite zadatke. AGI bi mogao imati svijest o okolini, sposobnost donošenja odluka, kreativnost i emocionalnu inteligenciju.

ASI (Superinteligencija vještačke inteligencije, Superintelligence of artificial intelligence): ASI se odnosi na oblik vještačke inteligencije koji je značajno superiorniji u intelektualnim sposobnostima od najpametnijih ljudi. ASI bi bio ekstremno napredan i mogao bi brže obraditi informacije, imati izvanredne sposobnosti učenja i stvaranja, te prepoznati i rješavati probleme na načine koji su daleko izvan dometa ljudske inteligencije. ASI bi mogao imati potencijal za samoučenje, samoizmjenu i razvoj.

Važno je napomenuti da trenutno imamo ANI sisteme koji su široko rasprostranjeni u mnogim područjima, ali AGI i ASI sistemi još nisu postignuti i predstavljaju područja istraživanja i razvoja u budućnosti. AGI i ASI predstavljaju ambiciozne ciljeve koji bi mogli imati značajan uticaj na društveno-tehnološki napredak kada se postignu.

## KOJE RADNIKE VJEŠTAČKA INTELIGENCIJA NEĆE MOĆI DA ZAMIJENI

Rast upotrebe tehnologije sa vještačkom inteligencijom izazvao je paniku među radnicima različitih profesija, koji su u strahu da bi u bliskoj budućnosti robot mogao da zamijeni njihovo radno mjesto (ChatGPT, 2023).

Izvještaj studije koju je proveo Goldman Saks pokazuje da su oko dvije trećine američkih poslova izloženi određenom stepenu automatizacije zasnovane na vještačkoj inteligenciji. Prosječan broj zadataka na dnevnom nivou za dati posao kreće se između četvrtine do jedne polovine, ostavljajući značajnu količinu posla za ljude.

### Koji poslovi su ugroženi?

Iako će uticaj vještačke inteligencije biti značajan na tržištu rada, većina industrija i poslova su djelimično izloženi automatizaciji što znači da će prije biti dopunjeni, radije nego zamijenjeni vještačkom inteligencijom – rekli su iz Goldman Saksa prenosi Fox Business.

Šef Googlea Sundar Pičai u nedavnom intervjuu istakao je koji su poslovi ugroženi od strane vještačke inteligencije. Naveo je da su to: pisci (novinari, kopirajteri), računovođe, arhitekte i – ironično – softverski inženjeri.

**Talas inovacija**

S druge strane, studija Goldman Saksa otkriva na koje industrije će vještačka inteligencija imati slabiji uticaj. U pitanju su oni poslovi koji zahtijevaju više manuelnog rada, rad na otvorenom ili specijalizovano znanje, poput popravki, konstrukcije, proizvodnje, transporta…

Autori studije naglasili su da bi šire usvajanje alata vještačke inteligencije moglo da zamijeni neke poslove, ali da povećana produktivnost i ekonomski učinak mogu da dovedu do kreiranja novih vrsta poslova, pokrenutih talasom inovacija (Barker, 2021).

## ISTRAŽIVANJE

U skladu sa temom rada, provedena je anketa kako bi se testirale postavljene hipoteze. Provedeno je istraživanje koje se odnosi na svjesnost potrošača o vještačkoj inteligenciji. Istraživački dio rada nastoji prikazati u kojoj su mjeri učesnici upoznati sa pojmom vještačke inteligencije i njihovu svjesnost o tome koliko vještačka inteligencija utiče na njihove odluke pri kupovini.

**Hipoteze**

Tokom istraživanja u fokusu su bile tri hipoteze koje su se nastojale dokazati odgovorima ispitanih učesnika. Definiranjem i identifikacijom predmeta, cilja i svrhe istraživanja, postavljene su tri glavne istraživačke hipoteze:

H1: Uticaj vještačke inteligencije u digitalnom marketingu postaje sve uočljiviji.

H2: Potrošači su svjesni češće primjene chatbotova i digitalnih asistenata na prodajnim portalima, stranicama, radnim mjestima i domaćinstvima.

H3: Sve većim uticajem vještačke inteligencije na proces donošenja odluke o kupovini, online kupovina postaje češća.

**Rezultati istraživanja**

Prvi dio ankete odnosi se na opšte podatke o ispitanicima. Prvo pitanje obuhvata izjašnjavanje ispitanika o polu. Od 100 ispitanika, njih 30, odnosno 30 % je muškog pola, dok je njih 70 ili 70 % ženskog pola.

Slika 1. Polna struktura ispitanika.
Figure 1. Gender structure of respondents.

Dobna struktura ispitanika koji su učestvovali u rješavanju anketnog upitnika izgleda ovako: Najviše ispitanika je u dobi od 18 do 23 godine, čak 51%, nakon čega su ispitanici starosti od 24 do 29 godina života (36%). Nešto manje ispitanika imalo je između 30 i 35 godina (9%), iza kojih slijede ispitanici od 36 do 41 godina (1 %) te oni od 47 do 55 godina(2 %), a samo 1 osoba (1 %) ima više od 55 godina.

Slika 2. Dobna struktura ispitanika.
Figure 2. Age structure of respondents.

Sljedeće pitanje koje je postavljeno je da li su ispitanici upoznati sa pojmom vještačke inteligencije. Od 100 ispitanika samo se troje njih izjasnilo da nije upoznato sa pojmom, dok ostalih 97 % tvrdi da su upoznati sa značenjem pojma vještačke inteligencije. Dvije osobe su ženskog pola, a jedna muškog pola i spadaju u stariju grupu, što je očekivano.

Slika 3. Da li ste upoznati sa vještačkom inteligencijom?
Figure 3. Are you familiar with artificial intelligence?

Na pitanje smatrate li da vještačka inteligencija može dovesti do većeg razvoja digitalnog marketinga ispitanici su odgovorili: njih dvoje (2 %) označilo da se uopšte ne slažu s tvrdnjom, njih 9 (9 %) izjasnilo se kako se djelimično ne slažu s tvrdnjom, a 15 ispitanika je neutralnog mišljenja. Čak 55 (55 %) ispitanika djelimično se slažu s tezom, dok se njih 19 (19 %) u potpunosti slaže s tezom.

Slika 4 . Vještačka inteligencija će dovesti do većeg razvoja digitalnog marketinga.
Figure 4. Artificial intelligence will lead to greater development of digital marketing.

Uticaj vještačke inteligencije u digitalnom marketingu postaje sve uočljiviji. Prema tabeli 1. vidljivo je da se najveći broj ispitanika slaže sa većinom tvrdnji.

Tabela 1. Dokazivanje Hipoteze 1.
Table 1. Proof of Hypothesis 1.

| **TVRDNJA** | **Stepen slaganja ispitanika s navedenim tvrdnjama *0 Nisam upoznat/a s pojmom, 1 Uopšte se ne slažem, 2 Djelimično se ne slažem, 3 Neutralnog sam mišljenja, 4 Djelimično se slažem, 5 U potpunosti se slažem** | | | | | |
|---|---|---|---|---|---|---|
| | **0** | **1** | **2** | **3** | **4** | **5** |
| Vještačka inteligencija prezentuje bolji i jasniji sadržaj. | 2 | 3 | 7 | 17 | 43 | 28 |
| Sve češće na društvenim mrežama primjećujem reklame i oglase. | 3 | 3 | 3 | 8 | 12 | 71 |
| Oglasi i reklame koje viđam na društvenim mrežama uglavnom su slične. | 2 | 3 | 2 | 7 | 15 | 71 |
| Češće kliknem na preporučene online reklame. | 5 | 14 | 12 | 24 | 25 | 20 |
| Sviđaju mi se preporučeni video sadržaji ili serije na društvenim mrežama. | 2 | 14 | 9 | 18 | 44 | 13 |

Tabela 2 obuhvata grupu odgovora vezanih uz drugu hipotezu: Potrošači su svjesni češće primjene chatbotova i digitalnih asistenata na prodajnim portalima, stranicama, radnim mjestima i domaćinstvima.

Tabela 2. Dokazivanje Hipoteze 2.
Table 2. Proof of Hypothesis 2.

| **TVRDNJA** | **Stepen slaganja ispitanika sa navedenim tvrdnjama**<br><br>***0 Nisam upoznat/a s pojmom, 1 Uopšte se ne slažem, 2 Djelimično se ne slažem, 3 Neutralnog sam mišljenja, 4 Djelimično se slažem, 5 U potpunosti se slažem** | | | | | |
|---|---|---|---|---|---|---|
| | **0** | **1** | **2** | **3** | **4** | **5** |
| Koristim glasovnog/digitalnog asistenta(*Alexa, Cortana...).* | 15 | 61 | 4 | 7 | 8 | 5 |
| Moji kolege/prijatelji/bližnji koriste digitalne asistente. | 15 | 45 | 16 | 9 | 10 | 5 |
| Chatbotovi su digitalni asistenti koji su važni u tehnologiji vještačke inteligencije. | 15 | 14 | 13 | 22 | 26 | 10 |
| Chatbotovi utiču na poboljšanje kupovine. | 12 | 14 | 11 | 25 | 27 | 11 |
| Primjećujem sve češću pojavu chatbotova na internet stranicama. | 14 | 10 | 7 | 11 | 28 | 30 |

Tabela 3 prikazuje tvrdnje koje se odnose na hipotezu broj tri koja nastoji dokazati da online kupovina postaje češća većim uticajem vještačke inteligencije na proces donošenja odluke o kupovini.

Tabela 3. Dokazivanje Hipoteze 3.
Table 3. Proof of Hypothesis 3.

| **TVRDNJA** | **Stepen slaganja ispitanika sa navedenimtvrdnjama *0 Nisam upoznat/a sa pojmom, 1 Uopšte se ne slažem, 2 Djelimično se ne slažem, 3 Neutralnog sam mišljenja, 4 Djelimično se slažem, 5 U potpunosti se slažem** | | | | | |
|---|---|---|---|---|---|---|
| | **0** | **1** | **2** | **3** | **4** | **5** |
| Novi marketing trendovi podstiču kupce na kupovinu. | 1 | 0 | 5 | 6 | 21 | 67 |
| Oglašavanja na društvenim mrežama utiču na moju odluku o kupovini. | 2 | 17 | 15 | 20 | 35 | 11 |
| Tradicionalni oblik kupovine se sve višezamjenjuje online kupovinom. | 0 | 2 | 7 | 9 | 40 | 42 |
| Često koristim mobilne aplikacije za kupovinu i narudžbe. | 3 | 12 | 8 | 10 | 29 | 38 |
| Radije obavljam sve što mogu iz udobnosti svoga doma. | 3 | 11 | 12 | 22 | 21 | 31 |
| Smatram da je online kupovina brža, lakša i da se online kupovinom uštedi više vremena. | 3 | 8 | 10 | 12 | 33 | 34 |

## ZAKLJUČCI

Digitalna revolucija i pojava interneta promijenila je svakodnevni život i dovela do inovacija koje su podstakle razvoj kompjutera i algoritmima. Kako čovjek nije u mogućnosti da prihvati tolike informacije u kratkom vremenu, predviđa se da će razvoj računara i mašina nadmašiti postojeću ljudsku inteligenciju i da će jednog dana biti u mogućnosti da ima ljudska osjećanja. Ovakav brz razvoj i potreba za vještačkom inteligencijom, koja je sada pristupačnija kompanijama, čini je izuzetnim alatom za trgovce i stručnjake u digitalnom marketingu. Danas se pojavila nova vrsta potrošača koja je brza i informisana sa velikim očekivanjima. Potrošači očekuju da će dobiti vrijednost robe i prije nego što je kupe. Oni žele osjetiti da je brendu stalo do njih, žele da brend zna šta potrošači žele i prije nego što se odluče na kupovinu, potrebni su im prijedlozi, savjeti i odgovori. Ove potrebe neće nestati, nego će se vremenom povećavati pa je zbog toga vještačka inteligencija jedini način na koji firme mogu držati korak sa sve većom tražnjom i očekivanjima kupaca. Donošenje odluke o kupovini puno su kompleksnije nego što se inače misli jer na njih utiču brojni faktori. Zato je proces donošenja odluke o kupovini specifičan za svakog pojedinca, kao i njihove kupovne navike pa će u tom području vještačka inteligencija i mogućnost personalizacije koju ona pruža imati glavnu ulogu. Na kraju se mogu vidjeti rezultati koji ukazuju na uticaj vještačke inteligencije na kupovne navike ispitanika. Anketiranje je bilo podijeljeno u tri sekcije od kojih je svaka zastupala jednu hipotezu. Sve su hipoteze djelimično ili u potpunosti potvrđene.

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# ARTIFICIAL INTELLIGENCE IN DIGITAL MARKETING

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**ABSTRACT**

The aim of this paper is to investigate the impact of artificial intelligence on consumers, the familiarity of consumers with artificial intelligence, as well as the interaction of consumers with tools that use artificial intelligence in their work. The main conclusions of the research indicate that marketing is increasingly changing and adapting to new trends, and that artificial intelligence with its methods will become an indispensable part of marketing. Modern consumers like to check product information, take a good look at all the offers and finally decide to buy. In this process, artificial intelligence can create an excellent personalized environment for the user to feel invited to make a purchase. Modern marketing incorporates artificial intelligence methods to more easily profile customers and create personalized content. In addition to the use of artificial intelligence for profiling and easier selection of relevant information, modern marketing introduces modern advertising methods so that brands can get closer to their consumers. Therefore, lately, more attention has been paid to marketing on social networks, mobile marketing, as well as e-mail marketing. In the end, it can be concluded that artificial intelligence has an impact on the buying habits of consumers. The survey was divided into three parts, each of which represented one hypothesis. All hypotheses were partially or fully confirmed.

**Keywords**: artificial intelligence, mobile marketing, digital marketing, modern advertising.

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# FACTORS BEHIND THE INCREASING POPULARITY OF LOCALLY PRODUCED FOOD – INSIGHTS FROM A REPRESENTATIVE STUDY ON CONSUMER MOTIVATIONS

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## ABSTRACT

The interest in locally sourced food products is on the rise. Alongside their impact on the local economy and rural development, attention is drawn to their ecological advantages and their present or potential contribution to the growth of rural tourism. Gaining a thorough understanding of consumer preferences and habits is vital for effective marketing efforts, ultimately fortifying the market position of these products. This study unveils partial findings from a representative survey focusing on the incentives behind the consumption of local food products. The creation and widespread promotion of local goods can serve as a catalyst for rural tourism, gastronomy, and overall rural development. Hence, it is crucial to comprehend the motivations and factors that prompt potential consumers to opt for locally produced food, whether it be on an occasional or regular basis.

**Keywords**: local products, local food, consumer motivation, rural tourism.

## INTRODUCTION

There is a trend towards an increasing importance of local products in domestic food consumption. While in the past the industrialisation and globalisation of agri-food supply chains has increased the distance between producers and consumers, today there is a clear process of convergence. As the world's food supply is moving in two opposite directions – towards industrialisation on the one hand and small-scale production on the other – this contrast has become typical also in Hungary. This thinking has led to new (counter)trends among food consumers. Among them, health-consciousness, the demand for safe food, preservative-free, traditional flavours stand out. Local and seasonal products are appreciated, and the traditional knowledge of their production – passed on from generation to generation – and the role of traditional cooking methods have become more important (Sarmento et al., 2017). At the same time, alternative food supply systems are being constructed (Neulinger et al., 2020). The creation, widespread marketing and promotion of local products can become a driving force for tourism and gastronomy, as well as for rural development.

In the present study, we draw on the results of a nationally representative questionnaire survey to investigate the reasons for the perceived increase in consumer interest. We also investigate what motivates consumers of local products to include the purchase of local products in their food purchases, either occasionally or regularly. In the literature review section of the paper, we will discuss the different definitions of local products, the interpretation of the term, EU and national regulatory practice, the impact of local products on rural development and society, and changes in consumer behaviour. It is a widely accepted view that local food and local gastronomy, successfully integrated with local food, can contribute to the economic, environmental and social sustainability of a place, while increasing its visibility, popularity and competitiveness (Rinaldi, 2017). After presenting the research methodology, we present our research findings, which provide insights into the motivations that drive consumers to turn to local products.

## LITERATURE REVIEW

According to trend researchers, every major trend will sooner or later have its counter-trend (Törőcsik, 2011). This is also the case with globalisation, where a significant group of consumers are turning to local options as a counter-trend (Gonda et al., 2022). Consumption of local food was taken for granted until the 1960s. In the European Economic Community (EEC) countries, the spread of American-style retail chains in the 1960s led to an over-concentration of trade. Simultaneously, a large number of small local trading outlets were closed down and local foodstuffs were displaced. In contrast, the 1980s saw a resurgence in demand for fresh, reliable local food among urban populations. The growth in demand for local food was significantly influenced by the 1990s food safety scandals that eroded consumer confidence in food produced with industrial methods. As a result of the numerous scandals, it was recognised that food safety issues needed to be regulated and managed at Community level within a new framework, both in terms of legislation and institutions.

Despite the fact that the subject is a fashionable area for researchers, there are different approaches to the definition of local product and there is no single definition to date. It is also difficult to interpret the category because some producers define food as local even if some of its ingredients are imported but the food is produced locally. A narrower interpretation is that a local product is only local if it contains exclusively local ingredients. The most common definition is that of geographical distance (Eriksen, 2013), whereby the distance between production and consumption determines whether a product is local (Morrison et al., 2011). However, there is considerable variation in the definition of specific distance. In Europe, the range of 40-100 km is used to define the production and marketing area of local products, while in the US it is defined in the 100-mile scale. In the geographical approach, a product produced within a country or region is considered as local. Another way of defining a local product is to focus on the cultural heritage value that the product carries or its importance to a particular community. Fonte (2008) assessed local products from three approaches: economic, social and environmental. From a social point of view, the collective effort involved in the production of local products is important, as it activates and unites actors within the community. Related to this, Martinez et al. (2010) define local products as food produced, processed and distributed within a geographical boundary that consumers associate with their own community. The environmental dimension looks at the specific characteristics of the area: in addition to local plant and animal species, other value-adding attributes that affect the products from the perspective of the area. Brunori (2007) links local food to compliance with the following 5 criteria:

- functional category: health impact and specific taste
- ecological category: landscape, biodiversity, food landscapes
- aesthetic category: diversity versus standardisation
- ethical category: credibility, identity, authenticity, solidarity
- political category: changing power relations in the food chain, orienting production and consumption patterns.

Products with a designation of origin represent a specific category of local foods. They are inextricably linked to the place where they are produced and have specific quality characteristics linked to their geographical indication, which makes them easy to identify. These typical local products are therefore defined by their geographical location, history and cultural environment. “The historical dimension refers to the cognitive content, which is knowledge and know-how that has been consolidated over time.” (D’Amico 2004, p.794). In Hungary, “Hungaricums” have a distinctive role, among which a considerable number of local foods are also found (Tőzsér, 2021).

In Hungary, several regulatory decisions on local production have been applied in the last two decades. Based on EU directives, the Government supports the development of local farmers’ markets and small-scale production, which is regulated by Regulation (EC) No 852/2004 on food hygiene and Decree 52/2010 of the Ministry of Agriculture and Rural Development (MARD). In the period 2014-2020, the Rural Development Programme and the Operational Programme for Spatial and Urban Development have supported measures to promote the market penetration of

local products. However, consumers still dominantly buy cheap imported products (Benedek, & Fertő, 2015), as the development and implementation of measures to raise consumer awareness has been lagging behind.

The impact of locally produced and high quality food on the local economy and local society has already been mentioned above. It can be concluded that these products play a significant role in both local marketing and local branding (Berg, & Sevón, 2014). Their use for tourism is not new, but its importance has been enhanced (Henderson, 2009; Nagy et al., 2021), Other supply elements related to local foods can be the basis for the development of creative tourism (Richards, 2014) and can be a great complement to other tourist attractions (Gászné Bősz, 2019; Madarász et al., 2021). The impact of making local products on the local economy has been demonstrated by several authors (Szente et al., 2021). This, combined with socio-cultural traditions, ensures quality and increases consumer confidence (Wiskerke, 2009). Local goods production offers a more environmentally sustainable option, in line with the principles of climate change and the circular economy (Mezőfi, & Németh, 2022). The indisputable advantage of frequent personal selling of local products is the direct contact between buyer and seller. Seen from a different perspective and dimension, local products are indirectly nothing more than a tool for

- job creation and job retention,
- maintaining, preserving and revitalising traditions,
- the creation and maintenance of a liveable countryside, and
- enriching and diversifying the touristic supply (Gonda et al., 2018).

Consumer interest in local products is steadily increasing, with a parallel rise in the number of scientific articles examining consumer attitudes (Feldmann, & Hamm, 2015; Szente et al. 2014). A common finding of research on this topic is that, unlike organic food, consumers do not perceive local foods as expensive. They are willing to pay more for them than for conventional foods. Consumers believe that locally produced products are of better quality (Spiller, & Anke-Mellin, 2007), fresher, more nutritious, tastier and safer than food produced by the food industry (Seyfang, 2006). There is also a new trend in consumer behaviour whereby food is no longer seen as a simple agricultural product, but is now seen as a cultural element.

There is a significant tradition and extensive literature on the study of consumer behaviour in Hungary (Törőcsik, 2016). The study of consumer trends and the impact of these trends on tourism is also a popular research area (Törőcsik, & Csapó, 2018). Törőcsik (2011) describes the trend of experience-seeking among consumer expectations and the search for authenticity as a countertrend. Consumers expect experiential shopping circumstances, they demand spectacular and special things. However, in addition to experience, consumers also demand authenticity, competence and reliability.

Hungary's Medium and Long-Term Food Industry Development Strategy, published in 2015, is a strategic document that reviews the current situation of the Hungarian food industry. The Strategy states that "Hungarian society shows a duality as regards domestic and high-quality food. On the one hand, there is a strong food cult, many regions or towns have become famous in Hungary specifically because of the food or food raw materials produced there, and the strong and complex relationship of the national culture to food is a fundamental determinant of the national identity of the Hungarian people. At the same time, a significant proportion of consumers are not sufficiently prepared, able or knowledgeable to assess the quality of food. Part of the reason for this is the homogeneous quality and limited range of items that were prevalent in the decades of socialism, in an environment where it was difficult to consider the possibilities of quality differentiation. This disadvantage has been exacerbated by the increasing sensitivity to price, partly artificially induced by the retail chains, after the regime change".

## METHODOLOGY

With our primary research, our main objective was to find out what motivates local food consumers to include local products in their food purchases, either occasionally or regularly. In order to generalise our findings to the Hungarian population, we conducted an online survey of

1,000 people with the involvement of a market research company, which is considered representative of the Hungarian population aged 18 to 65 years old by gender, age cohort and region of residence. In addition to general questions on the consumption and purchase of local food products, our questionnaire included a block of 30 statements to explore the motivations for consuming such products. On a five-point Likert scale, we asked respondents to rate their level of agreement with each statement. The question preceding the statements was worded as follows in the questionnaire: "Please rate on a scale of 1 to 5 how much you agree with each statement. A score of 1 means you strongly disagree and a score of 5 means you strongly agree. I eat local food products because..."

In order to avoid bias, respondents were also given the option to omit statements if they were unsure of the meaning or the extent to which they agreed. The statements and the motivational factors they address were developed through discussions among several researchers. Finally, the motivations to consume local food products were examined along a total of 8 different possible motivational factors, namely quality, taste, local patriotism, fashion, personal relationships, origin, environmental protection, and health. To measure each motivational factor, we used groups of statements rather than single questions, because they are psychometric instruments that can only be accepted in this way because of their complexity.

We are aware that in order to find out how motivational statements, based on the primary results, move together and how much they measure one single factor, an exploratory factor analysis (EFA) and a confirmatory factor analysis (CFA) are needed. However, the aim of this study is not to validate the scale in this direction, as in the process statements that are difficult to classify into factors are deleted, despite the fact that they may have important meaning. Instead, as a first step in our larger research on the motivations for consuming local food products, in this paper we report the descriptive statistical results of the responses to all statements to avoid loss of meaning. For this reason, the validation process and its results will only be reported as a next step in a later publication. Accordingly, in the following we present the frequencies and means of the responses to each of our questions, where we used IBM SPSS 28 software for their detection and Microsoft Excel 2021 software for their visualisation. In presenting the results, we will put the whole of our research in context, focusing first on the more general issues, and only then turn specifically to the part related to motivation.

## RESEARCH FINDINGS

The research findings show that more than 20% of the Hungarian population buy local food regularly (at least weekly). A further 21.7% reported buying more than once in a month. This means that almost half of the consumers (42.9%) are more or less regular buyers of local food. The growing popularity of local products is reflected in the relatively low level of rejection, with only 14.6% of respondents saying they never buy local food (Figure 1).

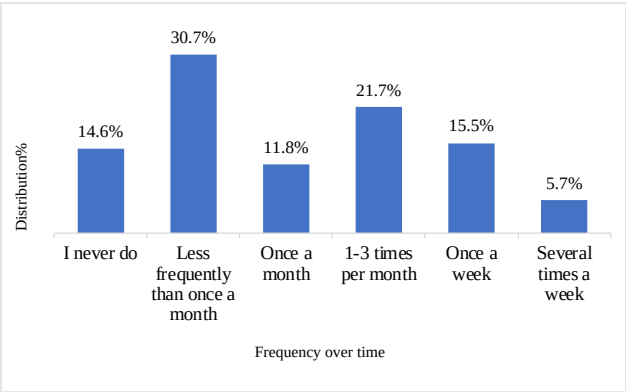


Figure 1. Frequency of buying local food products from farmers/smallholders (n=1000).

A deeper analysis of consumer attitudes reveals that the majority of consumers prefer these products over other products in the food industry when shopping. Slightly more than 50% said that they give priority to local products in most cases, while a further 26.4% said that they give priority to local products only for certain products (Figure 2).

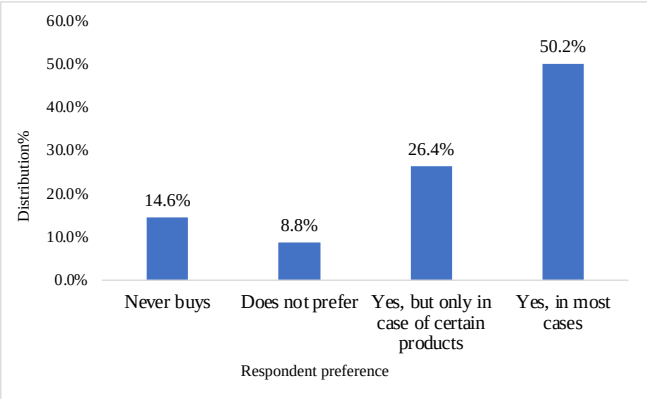


Figure 2. Percentage of preference for locally produced food (n=1000).

We consider it an important issue for the analysis of consumer behaviour to identify information on where to buy. As expected, the most popular locations are farmers' and traditional markets specialising in local products. From Figure 3, the underrepresentation of classical tourism service providers (tourist offices, restaurants, accommodations) is striking, although the role of local products in tourism is also of growing importance (Gonda et al., 2021a; Gonda et al., 2021b) and restaurants are also visited by the local population. Thus, with more outlets and a larger supply, they could play a much greater role in the marketing of local food than they do now. A good practice in this respect is the Almalomb restaurant in Hosszúhetény, which was awarded the Michelin Green Star in 2022 for its focus on local food and sustainable gastronomy.

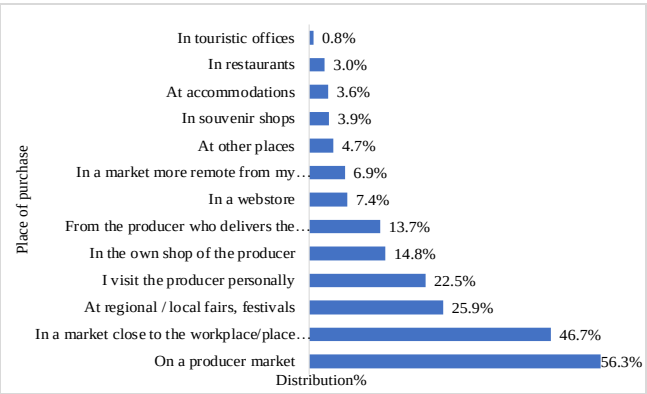


Figure 3. Locations of purchase of local /farmers/smallholders food products (n=854, those who buy them with some regularity).

The main aim of our research was to find out what motivates consumers to choose local products and what aspects they consider most when making a purchase. As mentioned in the methodological subsection above, a total of 30 motivation statements were randomly ordered in the questionnaire, asking respondents to indicate the importance they attach to each criterion on a 5-point Likert scale. The names of the delimited areas of investigation and the number of statements associated with them were as follows:

- quality (3 statements)

- taste (4 statements)
- local patriotism (4 statements)
- fashion (4 statements)
- origin (3 statements)
- personal connections (4 statements)
- environmental protection (5 statements)
- health consciousness (3 statements).

In the following, the results of the responses to the statements are presented, broken down by topic. Figure 4 shows the frequency of responses related to quality as a motivational factor. The results of our 3 different formulations differ only slightly, so that we can conclude that for consumers of Hungarian local products an important motivating factor for consumption (for all 3 statements, the markings of the 4 and 5 are similarly high) is that local products are of a basically high quality and that this quality level is reliably maintained. At this point, it is important to underline that quality was deliberately not defined separately in the questionnaire for respondents in order to measure their subjective impression, as it is this general subjective perception of quality that influences their decisions in practice.

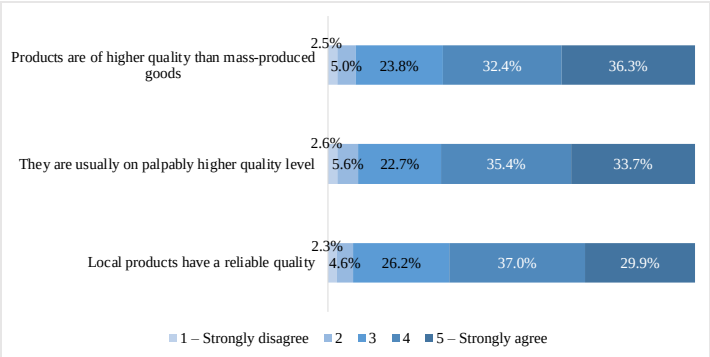


Figure 4. Quality as a motivation for consuming local products (n=854).

Figure 5 summarises our findings on taste as a motivational factor. For 3 out of our 4 hypotheses, the level of agreement was very high, also in relation to all the statements we tested. This suggests that one of the leading motivators in the consumption of local products is that consumers value these types of food products as fresher and tastier than their mass-produced counterparts. In addition, the fact that Hungarian consumers of local products in general perceive traditional local flavours as more delicious also plays a significant role. It is interesting to note that, in comparison, they are less likely to consume local products because they are closer to their tastes than their mass-produced counterparts.

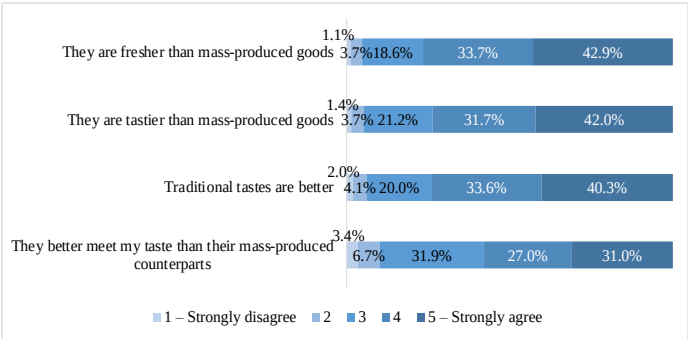


Figure 5. Taste as a motivation for consuming local products (n=854).

In our research, we also investigated the extent to which local patriotism can be a motivation for consuming local products, and our results are summarised in Figure 6. The second highest agreement rate in our overall questionnaire was achieved related to this statement. This is that one of the biggest motivators for consuming local products is that through their consumption people can support local producers and smallholders. In addition, a significant motivation is that consumers of such products know that the price of the products they buy is the producer's income, that they are helping to develop the local economy and that they want to help the local economy by buying them.

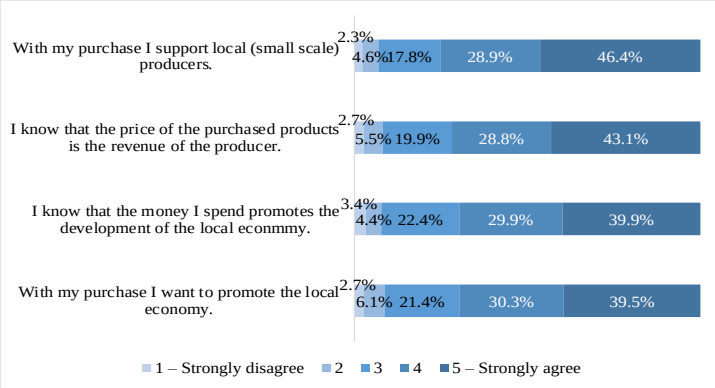


Figure 6. Local patriotism as a motivation for consuming local products (n=854).

Our research revealed that fashion is clearly the least important of the motivational factors (Figure 7). For each of the 4 statements we used, the agreement rate was generally low compared to the other statements we examined. This suggests that the motivation to consume local products is less motivated by the fact that one's friends consume them or that it is generally popular to consume local products than by quality, taste or local patriotism as described above. The statement with the lowest agreement rate in our questionnaire was also related to the topic of fashion, that someone is motivated to consume local products because it is fashionable. However, this statement should be treated with reservations, as it may have been heavily biased by the fact that often respondents are reluctant to admit to themselves that they would do something because it is fashionable rather than because of rationally explainable reasons.

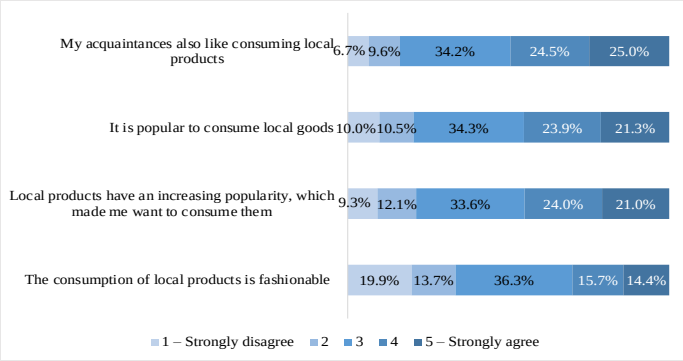


Figure 7. Fashion as a motivation for consuming local products (n=854).

In our research, we also examined the issue of product origin as a motivating factor (Figure 8). The three statements of ours related to this performed differently. Our statement "because products are of Hungarian origin" achieved the highest agreement rate of all our questionnaires, indicating that the fact that consumers can choose products that are domestic plays a significant role in the consumption of local products. This confirms what we found for the theme of local patriotism. Within the theme of origin, it is somewhat lower than this, but still a high proportion of

respondents would consume such products because they know where they come from. Of the 3 definitions, the one that was clearly agreed upon least by consumers of local products was that they would be motivated to consume such products by the fact that their origin is known precisely.

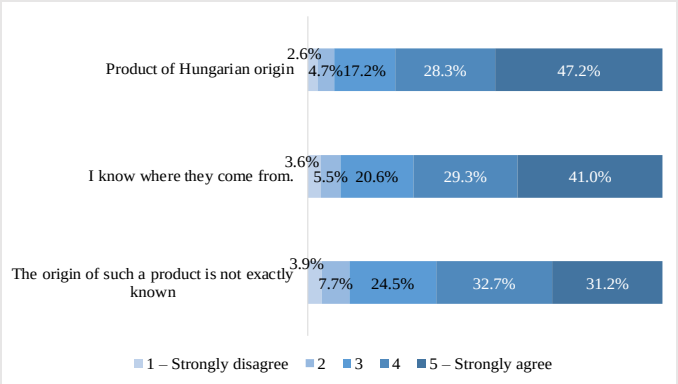


Figure 8. Origin as a motivation for consuming local products (n=854).

Another interesting issue in our research was to investigate the extent to which personal relationships can be an incentive to consume local products, and we found mixed results. As shown in Figure 9, people are more motivated by the feeling of buying directly from the producer/producer in person than by the feeling of being able to talk to them or having a good relationship with them.

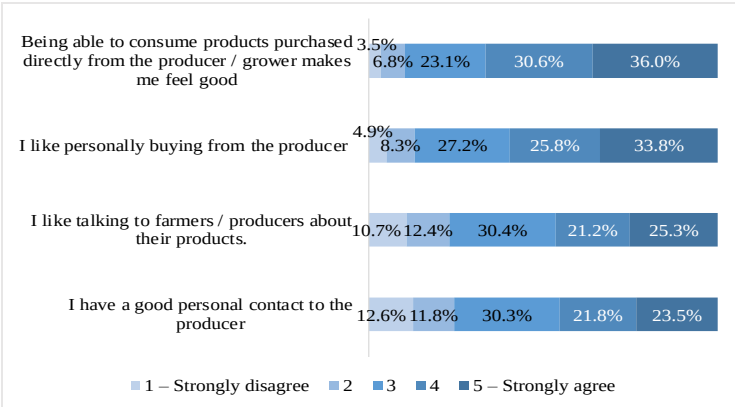


Figure 9. Personal relationships as a motivation for consuming local products (n=854).

Environmental protection is a complex issue that can influence the motivation to consume local products in several ways. Unsurprisingly, this topic was the one with the highest number of statements, with a total of 5 different statements (Figure 10). Of these, respondents agreed most strongly that they consume local products because they are not transported far from where they are produced, and therefore are less damaging to the environment. This is a very important point, as it was the 3rd highest agreement rate of all our 30 statements. In comparison, the agreement rate was lower for the statement that one would consume local products because they are more environmentally friendly than their mass-produced counterparts. Respondents were least likely to agree that they would be motivated by the fact that local product producers take care of and protect the environment.

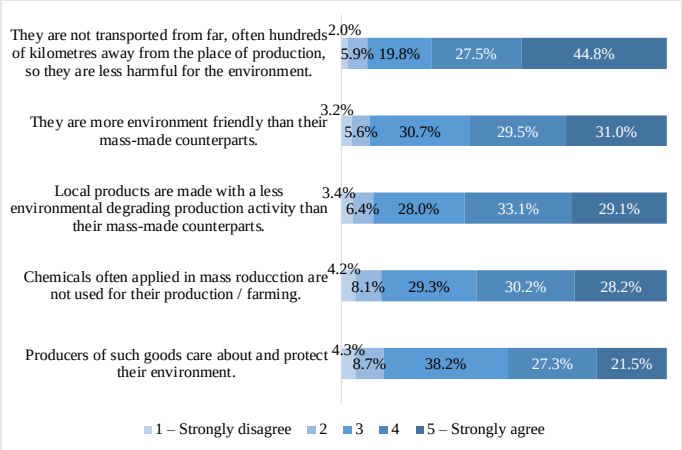


Figure 10. Environmental protection as a motivation for consuming local products (n=854).

In our study we also looked at health consciousness as a possible motivating factor. Our results show that the fact that local products do not contain unnecessary additives, flavour enhancers or are perceived as healthier by respondents is more motivating than the fact that they do not contain substances that could harm the human body. Our latter statement presumably had a lower agreement rate because officially, mass-produced food products cannot contain substances that are harmful to health, either. Health consciousness as a motivating factor did not score strongly in any of the ratios compared to the other parameters, i.e. it is a motivating factor for consuming local products, but it is not among the leading motivating factors.

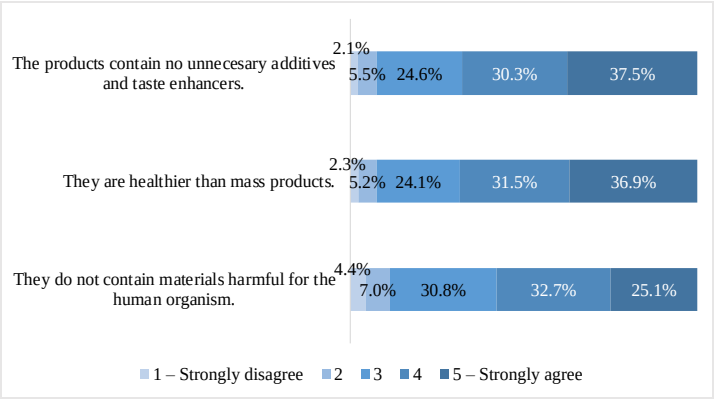


Figure 11. Health consciousness as a motivation to consume local products (n=854).

## SUMMARY, POSSIBLE RESEARCH DIRECTIONS

If we look at the average of the scores for the different statements in the above results, we believe that we can draw the right conclusions about the motivation of consumers to consume local food products. From our initial analysis, we can see that the 3 most important aspects were local patriotism, taste and origin. All these indicate conscious consumer behaviour. They are aware of the very positive impact of local products on the local economy and society and associate high quality and outstanding taste with local food. The least important purchasing criteria are fashion and the personal relationship that can be made with the producer. A somewhat surprising result is that health and environmental aspects are slightly lower in respondents' preferences than expected.

Further analysis is needed to explore deeper correlations. We believe that factor analysis could be a good method for this purpose, and that the baseline survey provides an opportunity for this. In order to increase the consumption of local products and thus the production of local products, it is important to have a better understanding of consumers' motivations and decision criteria. It is hoped that the results of the present research can make a useful contribution to both product development and marketing.

## ACKNOWLEDGEMENT

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# ANALIZA UTICAJA TROŠKOVA REKLAME NA PRIHODE PREDUZEĆA

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## SAŽETAK

Kreiranje poslovnih aktivnosti na bazi marketing koncepta predstavlja izgradnju odgovarajućeg odnosa između uloženog napora i ostvarenog rezultata. To znači da je sposobnost ostvarivanja pozitivnih poslovnih aktivnosti povezana sa sa upravljačkim sistemom preduzeća, reagovanjem ciljne javnosti i ostvarenih rezultata. Zbog toga se pred rukovodioce stalno nameće potreba upoređivanja ostvarenih poslovnih rezultata i doprinosa marketing aktivnosti. Pribavljanjem i obradom primarnih i sekundarnih podataka utvrđuje se uticaj samog marketinga, odnosno provjerava opravdanost marketing koncepta. Koliki je značaj i doprinos marketing koncepta ili pojedinih marketing aktivnosti moguće je utvrditi analizom odnosa ostvarenih troškova i ključnih poslovnih perfomansi. Istraživanje marketing troškova i efekata izraženih u odabranim parametrima je pouzdan osnov za ocjenu nivoa prihvatljivosti marketing koncepta u poslovanju preduzeća. Predmet istraživanja ovog rada je statističko-finansijska analiza uticaja troškova reklame na ukupan prihod preduzeća. Troškovi reklame predstavljaju troškove koji nastaju na osnovu strategijskog plana u cilju promovisanja preduzeća, odnosno određenog proizvoda. Na koji način povećanje ili smanjenje troškova marketinga utiče na ukupne prihode prikazano je kroz međuzavisnost troškova i ukupnog prihoda.

**Ključne riječi**: reklama, troškovi, marketing, prihodi.

## UVOD

Sa ekonmskog aspekta savremene oglašivačke aktivnost usko su povezane sa razvojem modernog industrijskog društva orijentisanog prema proizvodnji dobara ili usluga kao i plasiranju istih na tržište. Sam pojam tržišta ovdje predstavlja ključan termin, jer predstavlja onu vrstu masovne komunikacije zasnovane na ekonomskom principu ponuda i tražnja kao osnovi savremenog društvenog života. Snažan industrijski razvoj savremenog društva, uslovio je i brz razvoj potrošačkog društva, u kojem su zakoni tržišta kao osnova življena uopšte, uveliko determinišu i sve ostale društvene odnose. Sa razvojem industrije i globalnog tržišta, usljed sve većeg i raznovrsnijeg razvoja i proizvodnje roba i usluga, akumulira se i višak proizvoda i usluga koje je potrebno plasirati, na zasićenom potrošačkom tržištu. To je u ekonomiji stvorilo idealan prostor za razvoj reklame industrije. Osnovni pristup u kreiranju poslovnih aktivnosti baziran na marketing konceptu jeste uspostavljanje adekvatnog odnosa između uloženog napora i ostvarenog rezultata. Uspješnost realizovanih poslovnih aktivnosti sa stanovišta marketinga se može posmatrati i razumjeti kao veza između perfomansi preduzeća, reakcije kupaca i ostvarenih rezultata. Upoređivanjem ostvarenih poslovnih ciljeva i doprinosa marketing aktivnosti menadžeri stalno provjeravaju svrhovitost marketing koncepta. Doprinos pojedinih marketing aktivnosti moguće je utvrditi odnosom ostvarenih troškova i ključnih poslovnih perfomansi. Istraživanje marketing troškova i efekata izraženih u odabranim parametrima je pouzdan osnov za ocjenu nivoa prihvatljivosti marketing koncepta u poslovanju preduzeća. Upravljanje troškovima poseban je način upravljanja preduzećem i vođenja poslovanja koji najveću važnost u postizanju ciljeva organizacije poklanja optimizaciji troškova (Jakovčević, 2008). Na dobar poslovni rezultat utiče odnos između ukupnih ulaganja i ukupnih učinaka i poboljšanjem ovog odnosa želi se uticati na ulazne veličine u poslovni proces. Poslovni rezultatu zahtjevaju od menadžmenta organizacije primjenu različitih metoda i modela upravljanja troškovima. Za tu svrhu razvijene su metode i

postupci, odnosno brojni modeli, koji menadžmentu organizacije osiguravaju kritičnu masu informacija neophodnih za donošenje odluka u cilju optimizacije troškova, na temelju činjenica:

- model tradicionalnog upravljanja proizvodnim troškovima,
- model upravljanja troškovima temeljenih na procesima,
- model upravljanja troškovima baziranih na aktivnosti,
- model ciljnih troškova,
- budžetiranje temeljeno na aktivnostima,
- model bilansa postignuća,
- "Kaizen" troškovi,
- analiza vrijednosti,
- model upravljanja troškovima kvaliteta i drugi menadžerski koncepti kao odrednice uticaja na razvoj modela informacijskog sistema za upravljanje poslovnim procesima, odnosno cjelokupnim sistemom upravljanja organizacije.

Optimizacija troškova omogućuje da se troškovi minimaliziraju uz željeni rezultat. Pri tom željeni rezultat nije samo količinski izraz ili mjera poslovnih aktivnosti nego je to i subjektivan osjećaj zadovoljstva kupaca (Cingula i Klačmer, 2003). Ono što je svakako bitno jeste sagledati opravdanost troškova koji su nastali u toku poslovnog procesa, odnosno pri realizaciji planova i ostvarivanja ciljeva. Sagledavanje troškova omogućeno je kroz savremene informacijske sisteme koji omogućavaju menadžmentu donošenje odluka i sagledavanju dosadašnjih rezultata.

## PRIHODI KAO KLJUČNI INDIKATOR POSLOVNOG USPJEHA

Uspješnost poslovanja se obično definiše kao sposobnost ostvarivanja određenih ciljeva. Najčešći cilj koji preduzeća žele da ostvare jeste profitabilnost. Da li preduzeće posluje profitabilno i u kojoj mjeri, može se vidjeti iz izvještaja koji se zove bilans uspjeha. Bilans uspjeha je finansijski izvještaj koji predstavlja pregled prihoda, rashoda i finansijski rezultat ostvaren u određenom vremenskom periodu. Posmatrano kroz analizu bilansa, uspješnost poslovanja se najčešće manifestuje preko ostvarenog finansijskog rezultata, koji predstavlja kontrolu uspješnosti. Menadžeri imaju veoma značajnu odluku u procesu predviđanja uspješnosti poslovanja, jer mogu uticati na brojne činioce kvaliteta dobitka (Stevanović i Marinković, 2017).

Prema Međunarodnim standardima finansijskog izvještavanja prihodi se posmatraju kao: povećanje ekonomske koristi u toku obračunskog perioda u obliku priliva ili povećanje sredstava, a smanjenja obaveza, što ima za posljedicu povećanje kapitala, osim povećanja koja se odnose na doprinose vlasnika kapitala (na primjer dodatna ulaganja kapitala). Cilj svakog poslovnog subjekta je opstanak i razvoj, a ostvarenje tog cilja postiže se kroz odvijanje poslovnih aktivnosti i stvaranje novih upotrebnih vrijednosti. Tržišna vrijednost realizovanih učinaka, predstavlja prihod. Prihodi predstavljaju pozitivnu komponentu rezultata poslovanja, koji nastaje u fazi realizacije. Najznačajniji dio prihoda svakog preduzeća je prihod koji je ostvaren prodajom proizvoda, roba i usluga. Prihodi su detaljno regulisani Međunarodnim računovodstvenim standardom i obavezna su osnova finansijskog izvještavanja.

Prihodi nastaju u fazi realizacije, kod kojih se javlja problem razlikovanja prihoda i primanja novca, kao i problem vrednovanja odnosno procjenjivanja prihoda. Prihode ne možemo izjedanačiti sa primanjem novca u preduzeću, a rashode ne možemo izjednačiti sa izdavanjem novca iz preduzeća. Temeljna odrednica prihoda jeste povećanje imovine ili smanjenja obaveza, ali u onom dijelu koji ima uticaj na povećanje neto imovine (kapitala). Može doći do sledećih situacija: prihod prethodi primanju (prodaja na kredit), primanje prethodi prihodu (prodaja uz avans) i prihod i primanja nastaju zajedno (prodaja za gotovinu). Praćenjem prihoda i rashoda utvrđuje se uspješnost poslovanja.

Prihodi se procjenjuju na osnovu tri principa:

- Princip na bazi prodatih učinaka (sistem fakturisane realizacije)
- Princip naplate prodatih učinaka (sistem naplaćene realizacije)
- Princip na bazi proizvedenih učinaka (u suprotnosti je sa principom realizacije.

Pri datim nabavnim cijenama, definisanom obimu proizvodnje i utroščima materijala, usluga i rada, visina troškova zavisna je od načina obračuna amortizacije, otpisa sitnog inventara i načina obračuna utošenog materijala. Zavisno od načina obračuna amortizacije, ako se vrši primjena gdje se više obara neotpisanu vrijednost osnovnih sredstava, to direktno utiče na povećanje troškove i obrnuto. Sve metode koje se baziraju na otpisu sitnog inventara koje više obara njegovu neotpisanu vrijednost utiče i na povećavaju troškove i obrnuto. Metode bazirane na obračunu troškova materijala koje više obaraju vrijednost zaliha materijala, isto utiču na povećavanje troškova i obrnuto.

U teoriji su za obračun troškova poznati sledeći sistemi: sistem obračuna ukupnih troškova, sistem obračuna proizvodnih troškova i sistem obračuna varijabilnih troškova. Ovi sistemi mogu da budu izvedeni na osnovu: stvarnih troškova, stvarnih i planskih troškova, stvarnih i standardnih troškova. Na finansijski rezultat utiče: sistema obračuna stvarnih ukupnih troškova, sistema obračuna stvarnih proizvodnih troškova i sistema obračuna stvarnih varijabilnih troškova.

Analiza finansijskog rezultata podrazumijeva analizu na osnovu prostornog i vremenskog poređenja. Vremensko poređenje pokazuje razvoj, napredovanje preduzeća u ostvarivanju finansijskog rezultata. Ukoliko se prilikom poređenja analizira više uzastupnih obračunskih perioda, jasnije se uočavaju tendencije ostvarivanja finansijskog rezultata i obrnuto. Koliko se uzastupnih godina uzima za analizu i upoređivanje finansijskih rezultata zavisi od cilja analize. Prostorno poređenje je važno radi ocjene pozicije preduzeće u odnosu na konkurenciju. Kao uporedno preduzeće uzima se ili najbolje konkurentno preduzeće ili se poređenje vrši sa svim konkurentnim preduzećima, opet zavisno od cilja analize.

Analiza strukture ukupnog prihoda daje informaciju o tome po osnovu čega i koliko je ostvareno prihoda, dok raspored ukupnog prihoda pokazuje opterećenje prihoda na osnovu pojedinih vrsta rashoda, kao i udio finansijskog rezultata u ukupnom prihodu.

Analiza podataka bavi se analiziranjem i proučavanjem informacija koji za cilj imaju dobiti zaključke koji omogućuju preduzeću donošenje odluke. Analizom podataka vrši se se ispitivanje i tumačenje baze podataka radi dobijanja statističkih pokazatelja. Za analizu podataka koriste se različite metode iz područja statistike, ekonometrije ili matematike.

Predmet statističkog istraživanja su masovne pojave. Masovna pojava predstavlja skup elemenata koji se odlikuju nizom nizom zajedničkih ali varirajućih obilježja. Statistika se bavi prikupljanjem obradom i analiziranjem podataka o masovnim pojavama. Bazira se na podacima koji su prikupljeni u prošlosti, ali se na osnovu tih podataka može predvidjeti i ponašanje masovnih pojava u budućnosti. Kod istraživanja masovnih pojava primjenjuju se razni statistički metodi, koji se mogu podjeliti u dvije osnovne grupe. U prvu grupu se svrstavaju metodi koji se koriste za statističko posmatranje (prikupljanje, grupisanje, sređivanje i prikazivanje statističkih podataka). U drugu grupu svrstavaju se metodi statističke analize, koji se koriste za razna izračunavanja, objašnjenja i zaključivanje o karakteristikama osnovnog skupa na osnovu uzorka. Prvi metodi pripadaju deskriptivnoj analizi, a drugi metodi statističkoj analizi.

Deskriptivna statistika je najčešće prvi korak za analizu podataka i služi da bi se opisali prikupljeni podatci. Najčešće koristi grafičko i tabelarno prikazivanje podataka. Obično prethodi statističkom zaključivanju i predviđanju, ali može biti i krajnji cilj statističke analize.

Aritmetička sredina - Srednja vrjednost pokazuje, reprezentuje cijelu statističku masu , tj. ona je ta vrjednost koja zamjenjuje svako drugo obilježje u seriji koju posmatramo. Srednje vrijednosti su vrijednosti koje jednom brojčanom vrjednošću karakterišu statističku masu u cjelini. Medijana je srednja vrjednost obilježja po položaju koja deli numeričku seriju na dva dijela, pod uslovom da su vrjednosti obilježja poređane u rastući niz. Modus je vrjednost numeričkog obilježja koje se najčešće pojavljuje, tj. vrjednost koje ima najveću učestalost. Standardna devijacija pokazuje srednju mjeru odstupanja pojedinačnih vrjednosti obilježja od aritmetičke sredine. Izračunava se uvijek u apsolutnim vrjednostima. Mjeri se u jedinici mjere u kojem je izraženo obilježje. Regresiona analiza je skup statističkih metoda u istraživanju gdje se posmatraju pojave i analiziraju veze, oblik i smjer između tih veza.

Regresiona analiza je u suštini metod kojim se ispituje zavisnost dvije ili više pojava. Najprostiji oblik regresione krive predstavlja linearna regresija izražena funkcijom: $Y = a + Bx$. Ona se

primjenjuje kada postoji direktna ili obrnuto proporcionalna veza između nezavisnih i zavisnih promjenljivih. U svojoj osnovi, regresiona analiza uključuje dvije ili više varijabli koje su međusobno u nekakvoj vezi.

Korelaciona analiza je skup statističkih metoda pri istraživanju pojava pri čemu je moguće ispitati stepen saglasnosti posmatranih pojava i na osnovu toga izvesti zaključak o njihovoj zavisnosti. Numerički pokazatelj kojim se izražava stepen slaganja pojava naziva se koeficijent korelacije pojava. Postoji više različitih postupaka za ispitivanje zavisnosti. Korelacioni koeficijenti su mjere jačine (stepena) i smjera povezanosti između dvije promjenjive veličine.

Cilj korelacione analize je mjerenje intenziteta povezanosti opservirane izmedju bilo kojeg para varijabli i testiranje iskaza da li je intenzitet veći no što bi se očekivalo samo na osno vu slučajnosti. Jednom ustanovljena povezanost ne znači kauzalnost odnosa među varijablama. Tu povezanost možda najbolje opisuju različita strukturna objašnjenja korelacije izmedju varijabli Y1 i Y2. Utvrdjivanje značajne korelacije ne ukazuje nam koji je od ovih strukturalnih modela odgovarajući (Šošić, 2006). Dakle, korelacija ne podrazumeva uzročnost. Čak i vrlo jaka korelacija ne znači uzročnu povezanost izmeu varijabli X i Y. imamo različite vrste koralacija (Grafen, & Hails, 2002).

## UTICAJ REKLAME NA VISINU FIKSNIH TROŠKOVA

Kod proizvodne funkciju uglavnom se razmatra nivo fiksnih troškova povezan sa kreiranim proizvodnim kapacitetima. Međutim, i druge funkcije u preduzeću generišu fiksne troškove, tako da se na fiksne troškove nastale u proizvodnoj funkciji dodaju fiksni troškovi nabavke, izlazne logistike, marketinga, finansija, ljudskih resursa i sl. Potrebno je još dodati fiksne troškove nastale kreiranjem kapaciteta za rad korporativne centrale.

Analiza prelomne tačke (tačke pokrića) je veoma pogodan instrument koji je dostupan menadžerskoj strukturi preduzeća za upravljanje poslovnim rezultatom (Janjić et al., 2010). Prelomna tačka korišćenjem kontribucione marže pokazuje koliki je obim prodaje potreban da bi se pokrili ovako nastali ukupno fiksnih troškovi. Tek nakon prelomne tačke rentabilnosti, kad se svi troškovi uzmu u obzir, počinje da se ostvaruje profit preduzeća. Ukoliko se prodaja ne ostvari na nivou višem od prelomne tačke, preduzeće će poslovati nerentabilno. Viši nivo fiksnih troškova znači i da je viši rizik poslovanja preduzeća.

Kada preduzeće ima dugoročno planirani nivo proizvodnje, moguće je definisati potrebne kapacitete unutar svake funkcije u preduzeću i to tako da, funkcionalni nivo fiksnih troškova bude optimalan za planiranu proizvodnju i očekivane oscilacije u odnosu na ovaj nivo. Ovi troškovi su fiksni sa stanovišta godišnjeg obima proizvodnje, odnosno prodaje. Fiksni troškovi nastaju i generisanjem kapaciteta za obavljanje aktivnosti marketing funkcije. Za obavljanje aktivnosti unutar marketing funkcije, potrebno je prvo obezbijediti osoblje i sredstva za realizaciju marketing aktivnosti, (plate, računari, baze podataka, softvere, kancelarijski prostor, opremu i održavanje, i sl.). Sve navedeno dovodi do troškova amortizacije, troškova održavanja, plaćanja licenci i sl. (Atkinson et al., 2007). Svi navedeni troškovi su uglavnom fiksnog karaktera. Unutar svakog od sektora generišu se resursi i kapaciteti za obavljanje aktivnosti za koje je taj sektor i obrazovan. Postepeno se dodaju fiksni troškovi funkcije marketinga, a time i preduzeća. Dio tih troškova su opšti troškovi funkcije marketinga poput plate izvršnog direktora za marketing.

Ukupni fiksni troškovi marketinga su zbir generisanih kapaciteta za rad pojedinih departmana u funkciji marketinga kao i kancelarije izvršnog direktora za marketing. Ako postoje organizacione cjeline u marketingu, onda se kapaciteti i sa njima povezani fiksni troškovi mogu pratiti i po pojedinim elementima marketing strategije. Npr. troškovi brenda i sa njima blisko povezani troškovi reklame su i diskrecionog i fiksnog karaktera. Menadžment donosi odluku o njihovoj vrijednosti na osnovu procjene. Često su ovi troškovi procenat od planiranog nivoa prodaje, definisan na osnovu procjene, pa se označavaju kao varijabilni. Troškova reklamiranja ili izgradnje brenda često se zasnivaju na očekivanoj efikasnosti reklamne kampanje po pitanju generisanja prodaje. Menadžment na osnovu iskustva daje procjenu koliko je novca potrebno za reklamiranje da bi se ostvario planirani nivo prodaje. Međutim, nivo efikasnosti reklamiranja je nepromijenjen kada je mjeren troškovima reklamiranja u ostvarenoj prodaji. Isto tako, moguće je da se za isti nivo

troškova generiše viši, ali i niži nivo prihoda od iskustvenog u zavisnosti od stvarno ostvarenog nivoa efikasnosti reklamiranja. Ne treba zanemariti i da se reklamni efekti prenose iz godine u godinu. Na osnovu toga, troškovi reklame mogu biti fiksni i diskrecioni u godini za koju su utvrđeni.

Fiksni troškovi ne nastaju samo tokom proizvodnje proizvoda. Mogu se javiti i kao potreba marketing strategije za istraživanje i razvoj novog proizvoda ili poboljšanje već postojećeg proizvoda. Zavisno od ciljnog tržišta, aktivnosti distributivnih kanala mogu generisati troškove nastale na osnovu podrške u vidu suncobrana, obezbjeđivanje i brendirananja određenih predmeta, odnosno sredstava za rad i sl., označene kao prateće usluge kupcima. Ne znači da će svi marketing troškovi biti isključivo fiksnog karaktera sa stanovišta obima proizvodnje/prodaje ali svakako da troškovi marketinga mogu značajno doprinijeti generisanju fiksnih troškova poslovanja. Varijabilni troškovi marketinga po jedinici proizvoda mogu biti troškovi naljepnica, reklamne knjižice koja se daje uz svaki proizvod, procentualne nadoknade po jedinici proizvoda za iznajmljivanje brenda i sl. Varijabilni troškovi marketinga najčešće nemaju značajno učešće u ukupnim ili ukupnim varijabilnim troškovima. Uticaj marketinga na povećanje ukupnog rizika poslovanja moguće je iskazati sledećom formulom: Prelomna tačka poslovanja = fiksni troškovi centrale preduzeća+fiksni troškovi drugih funkcija +fiksni troškovi marketinga / kontribuciona marža Koliko je povećanje prodaje potrebno za pokriće fiksnih troškova nastalih radom marketing funkcije moguće je tačno ustanoviti ukoliko formulu predstavimo i na sledeći način: Prelomna tačka poslovanja = fiksni troškovi centrale preduzeća i drugih funkcija / kontribuciona marža +(fiksni troškovi marketing funkcije)/kontribuciona marža Takođe, varijabilni marketing troškovi uticaće simultano na smanjenje vrijednosti kontribucione marže. Obe vrijednosti pokazuju strateški uticaj strukture troškova marketinga na rizik poslovanja preduzeća mjeren nivoom prjelomne tačke rentabilnosti. Samo ako je marketing generisao viši nivo prodaje od onog u drugom razlomku, ostvario je i pozitivan uticaj na pad rizika u poslovanju preduzeća. Ako je dodatno generisao i adekvatnu prodaju za pokriće ukupnih fiksnih troškova i ostvarenje ciljnog dobitka ili još i veću, njegov uticaj je pozitivan i u domenu ostvarenja ukupnog godišnjeg rezultata poslovanja. Dobijeni pokazatelji pomažu menadžerskom timu u sagledavanju i analizi međusobne povezanosti troškova, prihoda i rezultata preduzeća i njegovih organizacionih segmenata i donošenje racionalnih poslovnih odluka o tome koje proizvode proizvoditi, po kojim cijenama prodavati proizvode, koja marketing strategija treba da se primjeni, kao i koja struktura troškova je najpovoljnija za konkretno preduzeće (Janjić et al., 2010). Može se zaključiti da marketing funkcija doprinosi rastu rizika poslovanja preko povećanja nivoa fiksnih troškova, odnosno povećanjem nivoa prelomne tačke koji treba dostići. Međutim, marketing strategija kroz resurse obezbijeđene u obliku kapaciteta koji su nosioci fiksnih troškova istovremeno doprinosi i generisanju prihoda koji obavezno mora pokriti, ne samo marketinške, već sve fiksne troškove preduzeća i dodatno obezbediti adekvatan profit. Važnost obračuna profita po elementima marketing strategije se može vidjeti i iz jednog od osnovnih zadataka finansijske strategije - alokacije resursa na profitabilne upotrebe. Sredstva je potrebno alocirati na one elemente marketing strategije koji obezbjeđuju viši prinos od drugih elemenata. Obračun profita po elementima marketing strategije je od posebne važnosti. Iz navedenih razloga, neophodno je naći načine za obračun profita povezanog sa marketing strategijom u cjelini i/ili njenim relevantnim elementima. Pored analize po proizvodu koja je najvažnija treba istovremeno uraditi i analize po kupcima, tržištima, distribucionim kanalima u cilju definisanja sadašnjih i predviđanja budućih kontribucija. Prema P. Drakeru, kao elemenat marketing strategije, može se još dodati i brend po kome je moguće obračunati ostvareni doprinos profitu, koji se drugačije naziva i kontribucija. Kontribucija ostvarena po pojedinom elementu marketing strategije je razlika između prihoda ostvarenih po tom elementu marketing strategije i troškova nastalih po tom istom elementu marketing strategije. Njen obračun treba da bude tako organizovan da je moguće ustanoviti vrstu i razloge nastanka pojedinih troškova, povezanih sa elementom marketing strategije (Drucker, 1963). Kontribucija se koristi sa ciljem pokazivanja koliko je pojedini element marketing strategije direktno doprinio prihodima i troškovima preduzeća, što omogućava dalje upravljanje ovim elementom u cilju ostvarivanja još višeg rezultata. Posebno korisna informacija je definisanje razloga zašto su pojedini segmenti

poslovanja profitabilni na obračunatom nivou. Obračun ostvarene kontribucije po pojedinim elementima marketing strategije zapravo definiše relevantne izvore profita u preduzeću - kupce, proizvode, brendove, tržišne segmente, nacionalna tržišta, distributere preko kojih se prodaju proizvodi. Njima je sada moguće upravljati, jer je obračun kontribucije otkrio razloge nivoa ostvarenog profita po svakom. Sa druge strane, nedostatak informacije o ostvarenom doprinosu profitu može izazvati čitav niz problema: budžet marketinga je previsok za pojedine proizvode, što rezultira u opadajućim prinosima – odnosno smanjenje izdataka bi vodilo rastu profita, budžet marketinga je prenizak i povećanje izdataka za proizvod bi vodilo povećanom prinosu, marketing miks je neefikasan sa neadekvatnim iznosom i neadekvatnim iznosom potrošenim na njegove pojedine djelove, ili, marketing napor je pogrešno alociran između proizvoda odnosno njegova bolja alokacija bi vodila ukupno višem rezultatu. Kao i za proizvode, slični argumenti se mogu primijeniti i za prodajne teritorije ili grupe kupaca. Da bi obračun doprinosa profitu bio moguć po pojedinim segmentima poslovanja, neophodno je da se oni sastoje od srodnih nosilaca prihoda i troškova. Zato je upravljačko računovodstvo segmente poslovanja povezane sa marketingom upravo i oblikovalo prema elementima marketing strategije za koje je moguće obračunati prihode i troškove. Upravo su elementi marketing strategije istovremeno nosioci prihoda i troškova. U organizaciji marketinga često postoje menadžeri koji odgovaraju direktno za proizvode, grupe proizvoda, kupce, grupe kupaca, tržišne segmente, distributivne kanale ili tipove distributivnih kanala, odnosno individualne ili kišobran brendove. Ovi menadžeri odgovaraju za individualne ili grupe elemenata marketing strategije (Wilson, 1999). Individualni marketing menadžer direktno, po principu kontrolabilnosti prihoda i troškova, odgovara za prihode i troškove po elementu marketing strategije. Zato i kontribucija obračunata po pojedinom elementu strategije pokazuje rezultat njegovog rada. U marketingu je moguće obračunati samo kontribuciju uvažavanjem uzročno posljedičnih veza između troškova i elementa marketing strategije, a ne i nivo neto profita po elementima marketing strategije.

Kontribucija kao pojam podrazumijeva razliku između prihoda i varijabilnih troškova. Rečeno je, da je većina troškova marketinga fiksnog karaktera sa stanovišta obima proizvodnje. Međutim, troškovi ne moraju biti varijabilni samo u odnosu na obim proizvodnje ili prometa. Mogu biti varijabilni u odnosu na aktivnosti u marketing odjeljenju koje se bavi određenim elementom marketing strategije. Kako fiksni troškovi po pojedinim elementima marketing strategije nastaju sa ciljem da se kreiraju kapaciteti za obavljanje aktivnosti povezanih sa tim elementom, moguće je obračunati kontribuciju po pojedinim elementima marketing strategije kao razliku prihoda i varijabilnih troškova. Kontribucija po individualnom elementu marketing strategije se dobija kao razlika prihoda po tom elementu marketing strategije i varijabilnih troškova aktivnosti po izazivaču troška, inače povezanim sa tim individualnim elementom marketing strategije (Ward, 1993). Za obračunu kontribucije po individualnom elementu marketing strategije važno je i da se koriste direktni troškovi po pojedinom elementu marketing strategije, kao nosiocu troškova. Na primjer, trošak reklamiranja je preko reklamne kampanje povezan sa brendom na koji se kampanja odnosi, što predstavlja direktnu veza između elementa marketing strategije i njegovih troškova. Trošak po aktivnosti je i varijabilan, jer koliko puta se ponovi reklamiranje toliko puta će adekvatan trošak, uz uvažavanje uzročno posljedičnih veza, biti dodjeljen kupcu, odnosno brendu, koji ga je izazvao. Navedeni elementi obračuna kontribucije omogućuju da se u obračun kontribucije po pojedinim elementima marketing strategije kreira situacija u kojoj su njegovi troškovi istovremeno i varijabilni i direktni, što je sa stanovišta obračuna troškova – najbolja moguća situacija. Funkcija marketinga može biti organizovana samo po proizvodima ili kupcima. Ako je matično organizovana, onda je organizovana uglavnom samo po dva elementa (po proizvodima i distributivnim kanalima). Razni su prijedlozi o tome kako je moguće obračunati kontribuciju funkcije marketinga. Jedan predlog je da se prvo od prihoda oduzmu varijabilni troškovi povezani sa cijenom koštanja ili nabavnom vrijednošću prodate robe. Ovu veličinu zovu proizvodnom kontribucijom. Kada se ova veličina dalje umanji za varijabilne direktne marketing troškove, dobija se varijabilna kontribucija marketinga. Ista se dalje umanjuje za fiksne direktne troškove marketinga da bi se dobila kontribucija marketinga. Obračun dalje do neto profita stiže umanjenjem kontribucije marketinga za indirektne i fiksne proizvodne troškove. Iako ovakav

prijedlog obračuna ima svojih prednosti, moguće je da bi jednostavniji obračun bio od veće koristi. Alterantivni prijedlog obračuna, mogao bi se definisati na sledeći način: Kontribucija marketinga = Neto prihod (prihod nakon popusta) – Troškovi marketinga. Na ovaj način se izbjegavaju ili bar umanjuju dileme povezane sa obračunom cijene koštanja proizvoda, njenim varijabilnim i fiksnim odnosno direktnim i indirektnim komponentama. Ako je neki od troškova koji ulaze u cijenu koštanja proizvoda marketinškog karaktera, jednostavno ga treba klasifikovati u smislu prethodne formule kao trošak marketinga. Istovremeno, cjelokupni menadžment se navodi da precizno definiše troškove marketinga umjesto da ih koristi kao nedovoljno definisanu kategoriju – što upravo otežava mjerenje performansi marketinga. Ovakve dileme je potrebno rješiti u skladu sa uslovima poslovanja svakog preduzeća. Nakon takvog definisanja, postaje lakše pratiti kontribuciju marketinga kao razliku koju funkcija marketinga ostvaruje između prihoda, čiji je nastanak pod njenim jakim uticajem, i troškova pod njenom nadležnošću koje je generisala za njihovo ostvarenje (Wilson, & Gilligan, 2005).

## ZAKLJUČCI

Preduzeće je osnovni stub privrednog sistema svake zemlje, pa stabilnost poslovanja i konkurentnost utiču i na ostale poslovne i društvene subjekte. Sam značaj poslovnog uspjeha bilo kog preduzeća povlači za sobom i potrebu za analitičkim aktivnostima koje ukazuju na realne kvantitativne mjere njegovog uspjeha. Aktivnosti za praćenja poslovnog uspjeha su pokazatelj napretka ili stagnacije određenog poslovanja. Ekonomičnost i sigurnost investiranja i drugi pokazatelj poslovanja, daju informacije koje su potrebne za sagledavanje uspjeha, stabilnosti i perspektive preduzeća. Redovno praćenje, kao i preispitivanje i analiziranje pokazatelja uspješnosti poslovanja u odnosu na prethodni period, i u odnosu na druga preduzeća, rezultiraju uspješnim upravljanjem i tržišnom opstanku preduzeća. Kao problem koji se javlja i na čijem rješavanju treba raditi, jeste precizno definisanje troškova marketinga koje otežava mjerenje aktivnosti marketinga, odnosno ostavrenih ciljeva. Postoje brojni instrumenti koji dopriose jednostavnim, bržim i efikasnijim informisanju preduzeća. Analizom dobijenih rezultata od pomoći je rukovodstvu preduzeća da procjeni uticaj strukture troškova na stabilnost poslovnog rezultata. S obzirom da je upravljanje troškovima složen proces on zahtijeva i primjenu suvremenih metoda. Razumijevanje ovih relacija je od velike važnosti za razvoj uspješnih poslovnih strategija i planiranje budućih poslovnih aktivnosti.

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# ANALYSIS OF THE INFLUENCE OF ADVERTISING COSTS ON COMPANY INCOME

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**ABSTRACT**

The creation of business activities based on the concept of marketing represents the construction of an appropriate relationship between the effort invested and the achieved result. This means that the ability to achieve positive business activities is related to the management system of the company, the response of the target public and the achieved results. For this reason managers are constantly faced with the need to compare the achieved business results and the contribution of marketing activities. By obtaining and processing primary and secondary data, the impact of marketing itself is determined, that is, the justification of the marketing concept is checked. The importance and contribution of the marketing concept or individual marketing activities can be determined by analyzing the relationship between realized costs and key business performances. The research of marketing costs and effects expressed in selected parameters is a reliable basis for evaluating the level of acceptability of the marketing concept in the company's operations. The subject of research in this paper is the statistical-financial analysis of the impact of advertising costs on the total revenue of the company. Advertising costs represent costs incurred on the basis of a strategic plan in order to promote a company, that is, a specific product. How marketing costs affects total revenue is shown through the interdependence of costs and total revenue.

**Keywords**: advertising, costs, marketing, income.

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# ADVERTISING ON SOCIAL NETWORKS THROUGH THE PRISM OF ETHICS

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## ABSTRACT

In recent years, advertising on social networks has become one of the important factors for the survival of companies on the market. It seems that there is more and more advertising and less and less ethics. Precisely because of this, the paper pointed out the importance of ethics when advertising on social networks. Also, the results of the research conducted to determine the views of respondents who use social networks on the ethics of advertising and to identify the key problems and challenges they face during advertising are presented. The data used were collected using a survey questionnaire and processed using the statistical program IBM SPSS Statistics. 350 respondents who use social networks for private, business, or combined (private and business) participated in the research. The authors point to the importance of developing ethical guidelines and regulations for advertising on social networks to ensure fair and transparent practices that protect users' interests and promote advertisers' integrity.

**Keywords:** social networks, advertising, ethics, information, and communication technologies.

JEL classification: D12, D18, L82, M14, Z13

## INTRODUCTION

Advertising on social networks has become indispensable in modern business. Especially after the COVID-19 pandemic, there is a small number of business organizations that do not advertise through social networks or do not use them in some way for promotional purposes. The number of users of social networks is increasing day by day, and therefore the market is getting bigger and more informed. Users of social networks are not only individuals but also business entities. Given that, it can be assumed that ethics are questioned, as well as that legal regulations are very sketchy and superficial for this type of advertising.

The paper highlights the opinion that social networks represent an excellent tool for communication through which organizations promote their products and services. However, the question arises of the ethics of the ways advertisers use when advertising on these platforms.

Philip Kotler and Gary Armstrong (2020) believe that advertising can be defined as any form of paid presentation and promotion of ideas, products, or services by a sponsor who must be named. Advertisements can be found in traditional media, and the presence of ads in modern media, ie media that use digital technology, is increasing. The goal of advertising is to provide persuasive messages about a product or service to attract consumers and convert them into customers. We can say that advertising is a marketing activity that is used more and more every day. Žanetić (2014) states that today's marketing experts and other theoreticians of the field are aware that advertising is not only a tool to increase sales, but at the same time, it is also a tool that enables sales in general. So, it can be said that it is unthinkable that any product or service can achieve sales success without advertising.

The research was conducted to determine the views of respondents who use social networks on the ethics of advertising and compare their views depending on whether they use social networks for private, business, or combined purposes. We tried to establish whether there is an evident difference in the attitudes of respondents of different age groups, than respondents who

post on social networks, and to determine the difference between the attitudes of those who use social networks only privately, only for business, and those who combine presence in both ways.

## LITERATURE REVIEW

How advertising is carried out on social networks should be such that it will not endanger the consumer himself, as well as society as a whole and the environment. According to Singh (2014), ethics is one of the most important characteristics of advertising industries. Ethics in advertising has an increasing value in the business world, striving to respect human dignity, honesty, and truthfulness. Advertising has always caused a lot of public criticism and numerous studies have been done on the impact of unethical advertising on consumers. Studies have shown that consumers believe that advertising often violates broad ethical norms (Treise et al., 1994). Some argue that the issue of ethics in advertising is an oxymoron (Beltramini, 2003).

All the developments and changes in the business that are directed by marketing do not come without a price. Some scholars argue that advertising can support ethical issues (Kerr, & Richard, 2021; Desimpelaere et al., 2023; Drumwright, 2009; Tinarbuko, 2002; Kunkel et al., 2004). These ethical issues include the exploitation of women, subliminal perception, i. e. hidden advertising, advertising directed at children, misleading advertising, and other issues that can lead to the moral deterioration of society (Shabbir, & Thwaites, 2007; Murphy, 1998). It is a fact that potentially unethical advertisements reach the market, and accordingly, it has been stated that current methods of evaluating advertisements may be insufficient for some of today's controversial or innovative campaigns (Bush, & Bush, 1994).

The authors define business ethics in different ways. According to Krkač (2007), business ethics is a type of applied ethics, that is, the application of general ethical principles to a special area of life - business. According to Miljević (2014), business ethics studies the application of personal moral norms to the activities (processes and relationships) and goals of organizations in the world of work. Successful organizations understand the importance of business ethics in the competitive arena, which enables them to grow and develop faster, and increase efficiency, and productivity. Aleksić (2007) states that those organizations that do not separate ethics from profitability, but successfully harmonize them in their operations, will be successful.

According to Spence and Heekeren (2005), ethics can be defined as a set of prescribed rules, principles, values, and virtues of character that inform and direct interpersonal and intrapersonal behavior. Schlegelmilch (2010) claims that ethics is difficult to define because it cannot be directly measured and that it arises from many influences such as internal and external environmental influences.

There is extensive research on business ethics in general (Hartman et al., 2020; Arnold, & Hartman, 2003; Bowie, 1999). Research in the field of business ethics includes all functions of business, and therefore also the field of advertising and promotion. Because advertising causes ethical controversies, there are numerous studies from different perspectives to understand this phenomenon (Nebenzahl, & Jaffe, 1998; Fam, Waller, & Erdogan, 2004). Many scholars and experts argue that evolving marketing practices, particularly in the digital and social media realms, require marketers to be equipped with ethical awareness, knowledge, and skills. As marketing practices continue to evolve, professionals are faced with new challenges and ethical considerations related to data privacy, online targeting, transparency, and the influence of social media influencers, among other areas. This necessitates a continuous emphasis on ethics training and a more nuanced understanding of professionalism and virtuous behavior within the marketing discipline. New marketing practices should increase the need for more training on ethics and more sophisticated perspectives on professionalism and virtuous behavior (Solomon, 2019; Laczniak, & Murphy, 2019; Solomon et al., 2020). Also, many authors have discussed advertising on social networks from an ethical perspective and conducted significant research (Zimmer, & Proferes, 2014; Van Dijck, 2014; Tadajewski, & Kjeldgaard, 2017; Dobele et al., 2016; Wirtz et al., 2018; Li, & Zhang, 2020; Sorensen, & Prasad, 2020).

## METHODS OF WORK

The research was conducted to identify the views of users of social networks on the ethics of advertising on social networks. The attitudes of respondents who use social networks only privately, only for business, and combined private and business were analyzed. In addition to the above, the research was also conducted to determine whether respondents who use social networks only for business have a better image of the ethics of advertising on social networks than those who use social networks only for private purposes or for private and business purposes combined.

At the beginning of the research, it was assumed that respondents of different age structures have different attitudes about ethics in advertising. Based on that, their attitudes about the use of social networks were analyzed. Furthermore, the views on how much respondents pay attention to ads on social networks were also considered, to get a picture of which age population trusts the information that is marketed through social networks. In addition, the authors compared the time spent on social networks among respondents who answered affirmatively that they regularly post on social networks, with those who said that they do not post or rarely post on social networks.

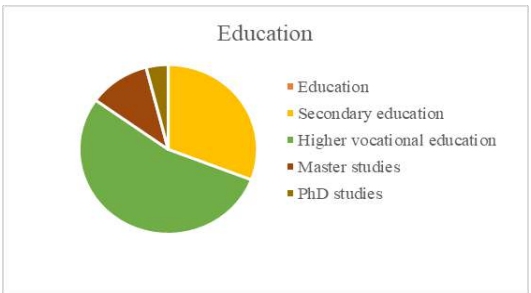
The research was conducted using a survey questionnaire that was delivered electronically (via e-mail) to respondents in Bosnia and Herzegovina. The survey questionnaire consisted of 10 closed-ended questions, with the first four questions referring to the demographic structure of the respondents. The survey lasted three months and was carried out in the period from February 1, 2023, to April 30, 2023. On that occasion, 386 completed questionnaires were collected, but only 350 respondents (90.7% of total respondents) who filled out the questionnaire were analyzed. The collected data were sorted and analyzed using the statistical software IBM SPSS Statistics Version 26. The obtained results are given in the continuation of the paper.

## RESULTS AND DISCUSSION

As already mentioned, the research was conducted to determine whether different age categories use social networks for different purposes. In addition, the research was conducted to identify the views of social network users on the ethics of advertising. 350 validly completed questionnaires were collected using the survey questionnaire that was delivered to respondents electronically. Their analysis led to significant conclusions about the views of social network users on the ethics of advertising in modern business conditions.

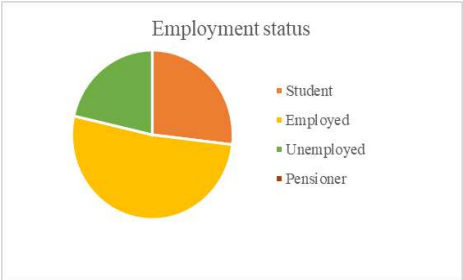
350 respondents participated in the research, of which 218 (62.29%) were female, and the remaining 132 (37.71%) were male. The largest number of respondents, 114 or 32.57% of the total number of respondents, are between 18 and 28 years old, followed by respondents who are between 29 and 39 years old (98 respondents, i.e. 28.0%) and respondents aged 40 to 50 years. (76 respondents, or 21.71%), and the least are over 51 years old (62, or 17.71% of respondents).

The survey questionnaire contained questions related to the level of education and work status of the respondents. The obtained results show that the largest number of respondents have a university degree (189 of them, i.e. 54%), followed by respondents with completed high school education (108 respondents, i.e. 30.86%) and completed master's studies (39 or 11.14%), and the fewest respondents completed doctoral studies (only 14, i.e. 4.00%). Graph 1 shows the level of education of the respondents.




Graph 1. Level of education of respondents.

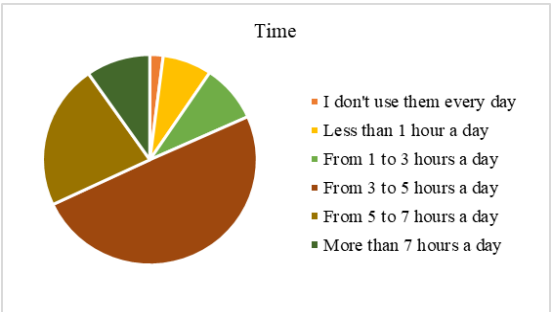
Furthermore, the work status of the respondents was analyzed. The obtained results are presented in Graph 2. The obtained results show that the largest number of respondents are employed (181, i.e. 51.71%), students (94, i.e. 26.86%), and unemployed (75, i.e. 21.43%), are approximately equal, and there are no pensioners.




Graph 2. Work status of the respondents.

After demographic questions about the respondents, the time spent by the respondents on social networks was analyzed. The obtained results are presented in Graph 3. The obtained results show that there is a very small number of respondents who do not use social networks every day (7 respondents, or 2%). They are followed by respondents who spend less than an hour a day on social networks (26, i.e. 7.43%), from one to three hours a day (31, i.e. 8.86%) or more than seven hours a day (34, i.e. 9 .71%).

The largest number of respondents, 174 of them (49.71%) spend between three and five hours a day on social networks, and 78 respondents (22.29%) spend between five and seven hours a day on social networks.




Graph 3. Time spent on social networks.

Based on the above, it can be concluded that half of the respondents spend almost a quarter of the day on social networks, while approximately a quarter of the respondents spend almost a third of the day on social networks. This fact is acceptable only if the respondents use social networks for business, and if they use them only for fun, the situation is quite worrying. Accordingly, it was analyzed why respondents use social networks. The obtained results are shown in Graph 4.

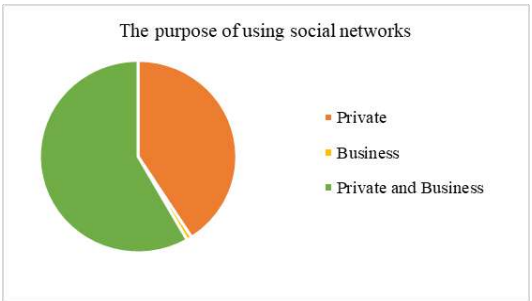



Chart 4. Purpose of using social networks.

The obtained results show that the largest number of respondents who use social networks privately and for business is almost 60% of them (more precisely, 204, or 58.28%). Next come respondents who use social networks only privately /143 respondents, or 40.86%), and there are almost no respondents who use social networks only for work (less than 1% of respondents).

Through further analysis, it was determined that respondents who use social networks both privately and for business generally spend between three and seven hours on social networks. The analysis showed that students mostly spend between three and five hours on social networks, while more than seven hours are spent mainly by employees, so the authors assume that the respondents are involved in marketing and advertising.

The objective of the research was to analyze whether and how often respondents publish content on social networks. The obtained results are shown in Graph 5.

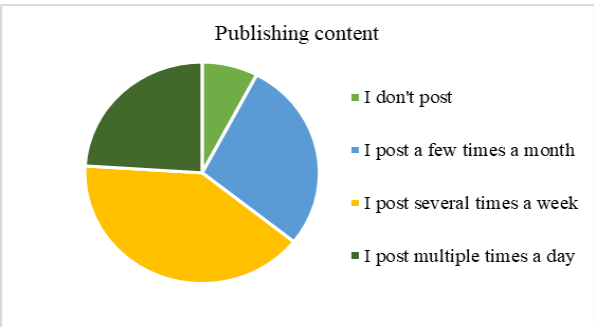


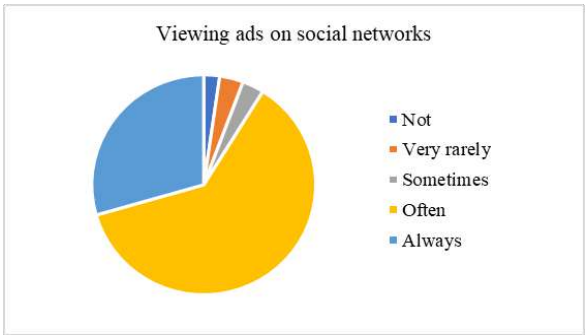

Chart 5. Frequency of posting on social networks.

The presented results show that the smallest number of respondents are those who do not publish any content on social networks (less than 8% of respondents), and the most are those who post more than once a week (141 respondents, or 40.29%). The participation of those who publish content several times a month (98 respondents, or 28%), as well as those who do it several times a day (84 respondents, or 24%), is significant.

It is also interesting to mention the fact that most younger respondents (up to 28 years of age) post content several times during the day or the week, while those over 50 years old generally do not post on social networks. In addition to the above, the analysis showed that mostly employed respondents who use social networks both privately and professionally publish content several times a day.

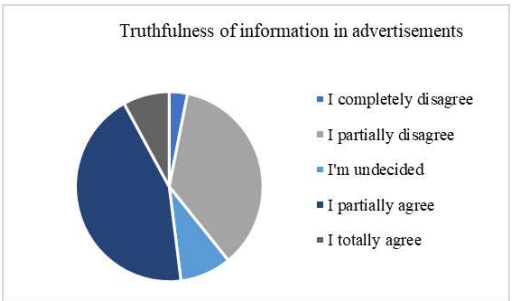
The research was conducted to examine the attitudes of the participants on whether they pay attention to ads on social networks and how much they believe in the truth of the information that has been published.

When analyzing the views of respondents on whether and how often they pay attention to the ads they see on social networks, it was observed that more than 60% of the total number of respondents do so very often. Graph 6 presents the views of respondents on this basis.




Graph 6. Viewing ads on social networks.

It was also checked whether the respondents believed in the truth of the information provided in the advertisements placed through social networks. The obtained results are presented in Graph 7 and show that there is an almost equal number of those who partially agree (154 respondents, i.e. 44%) and partially disagree (126 respondents, i.e. 36%) with the statement that they believe in the truth of the information stated in ads on social networks. 11 respondents (3.14%) disagree with this statement, 31 of them (8.86%) are undecided, and 28 respondents (8%) completely agree.




Graph 7. The truthfulness of information placed in ads on social networks.

It is interesting to point out the fact that people under the age of 39 generally do not believe in the truth of the information from advertisements on social networks, while people over the age of 40 stated that they partially or fully believe the information posted. The last question from the questionnaire referred to the ethics of advertising and compliance of this process with legal regulations. The obtained results are presented in Graph 8.

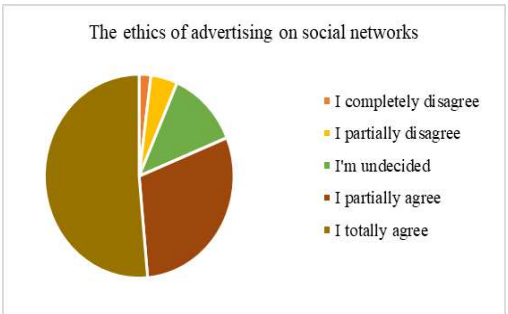



Chart 8. Respect for ethics and legal regulations during advertising.

When analyzing the opinions of respondents, that is, their agreement with the statement that advertising on social networks is not always ethical, and by legal regulations, it was concluded that more than 80% of respondents agree with the above. There is a small number of those who do not agree with this statement at all (only 7 respondents, or 2%) or partially disagree (16 respondents, or

4.57%). In this case, 43 respondents, or 12.29%, were undecided. Furthermore, 104 (29.71%) respondents partially agreed with the stated statement, while 180 (51.43%) respondents fully agreed with the stated statement.

After the conducted research, it can be concluded that advertising on social networks represents a growing segment of marketing activities, but it faces challenges related to ethics. According to a survey conducted on a sample of 350 respondents, more than 80% of them agree with the statement that advertising on social networks is not always ethical and follows legal regulations. These results point to the importance of respecting ethics when advertising on social networks.

Accordingly, it is important to emphasize that social networks have become an integral part of the daily life of a large number of people. Users are exposed to a large number of advertisements, which creates a need for transparency, correct presentation of information, and respect for user privacy. Marketing professionals must be aware that their actions on social networks can have a direct impact on people and their perception of brands, products, or services.

Ethics in social media advertising include many aspects, such as properly labeling sponsored content, protecting user privacy, truthfully representing products or services, and avoiding manipulative marketing techniques. These questions are important because bad ethical practices can lead to a loss of user trust and a negative impact on the reputation of brands.

Relevant literature confirms the importance of respecting ethical principles in advertising on social networks, and the results of conducted research show that users increasingly rely on feedback from other users and that negative experiences with unethical advertising can have long-term consequences for companies that advertise their products and/or services. To promote ethical advertising on social networks, marketers should apply transparent advertising methods, provide users with relevant and useful information, and comply with legal guidelines. In addition, continuous education of marketing experts on ethical standards and regular monitoring of changes in legislation are key elements in ensuring ethical advertising on social networks.

The results of this research indicate the need to respect ethical principles when advertising on social networks. This aspect of advertising has a profound impact on consumer perception and brand reputation. Promoting transparency, protecting user privacy, and correctly representing products or services should be central guidelines for marketing professionals to maintain ethical practices in this ubiquitous form of advertising.

## CONCLUSIONS

In today's age of digital communication, social media advertising is becoming ubiquitous and inevitable. However, as this form of advertising gains in popularity, so does the need for greater attention to ethical principles and norms. In this paper, we investigated the importance of ethics in advertising on social networks and identified the harmful consequences resulting from an unethical approach to this type of advertising. We also proposed concrete measures to increase the ethics of those who advertise on social networks.

Ethics is a key factor that determines the quality and sustainability of advertising on social networks. When advertisers adhere to ethical principles, trust is built between the brand and the consumer. Transparency, honesty, and respect for user privacy become the foundations of a successful campaign. Consumers are increasingly aware of and demanding ethical advertising, and brands that do not adhere to these principles face loss of trust, negative reputations, and possible legal consequences.

Unethical advertising on social media can have serious adverse consequences. Manipulative techniques, such as fake news, disinformation, and targeted diversion, can lead to increased polarization of society, decreased trust in the media, and distortion of public opinion. Also, violation of user privacy, misuse of their data, and invasive monitoring can lead to a negative brand experience and refusal of users to engage with the advertiser.

To increase the ethicality of advertising on social networks, we suggest several measures that can be useful. First, clear guidelines and codes of conduct for social media advertisers need to be established. These guidelines should cover the protection of user privacy, the prohibition of false

information and manipulation, and transparency regarding paid content. Mechanisms for efficient monitoring and punishment of unethical advertising should also be developed.

Another measure is education. Advertisers should be aware of the ethical challenges they face and be trained to make morally responsible decisions. Education on the ethics of social media advertising should be included in the formal and informal education of marketers.

Furthermore, social networks themselves have an important role in promoting ethics. They should develop and apply algorithms and technologies aimed at detecting unethical advertising and filtering false information. Also, social networks must establish transparency regarding advertising, allowing users to clearly distinguish paid content from organic content.

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# *LAW SECTION*
# *PRAVO*

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# ZLOUPOTREBA POLOŽAJA I OVLAŠTENJA U BANKARSKOM SEKTORU KROZ KRIVIČNOPRAVNI KONSTRUKT

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## SAŽETAK

Gotovo je neizbježno da se u sektoru bankarstva ne otkriju slučajevi zloupotrebe položaja i ovlaštenja od strane bankarskih službenika. Kroz samo istraživanje u radu će biti elaborirani načini takve vrste zloupotreba kao što su kreiranje kreditne dokumentacije sa lažnim ispravama, a nakon toga i odobrenja novčane pozajmnice ili kredita do momenta isplate istog. Pored navedenog u radu će biti analizirani i okvirni parametri unutrašnjih pravilnika o radu bankarskih službenika i njihovog djelovanja kao i zakonska legislativa koja se odnosi na cjelokupni bankarski sistem u BiH, u odnosu na pomenuti segment zloupotreba. S tog gledišta treba se istaknuti da bi zloupotreba položaja bila predmet istrage u krivičnopravnom smislu mora se pored ostalih obilježja utvrditi i postupanje izvršioca kroz institut umišljaja (lat.dolus) kao subjektivnog elementa bića krivičnog djela.

**Ključne riječi:** Zloupotreba položaja i ovlaštenja, kreditna dokumentacija, lažne isprave, zakonska legislativa, institut umišljaja.

## UVOD

Krivični zakon Federacije BiH u članu 383. (Krivični zakon Federacije Bosne i Hercegovine [KZFBiH], 2017), Krivični Zakon Republike Srpske u članu 315. (Krivični zakonik Republike Srpske [KZRS], 2021), i Krivični zakon Brčko distrikta u članu 377. precizira kroz stav 1 (Krivični zakon Brčko distrikta Bosne i Hercegovine [KZBD], 2020), da se radnja krivičnog djela Zloupotreba položaja ili ovlašćenja manifestira kroz iskorištavanje službenog položaja i prekoračenje granica službenog ovlaštenja.

Dakle, eksplicitno, radnja učinjenja krivičnog djela je osnovni element u samom pojmu krivičnog djela, gdje se poduzimanjem iste izvršava krivično djelo. Analizirajući odredbe u našim krivičnim zakonima jasno je da se ovo krivično djelo može počiniti samo direktnim umišljajem kao oblikom krivice. U tom kontekstu Bačić (1980, 235) ističe da je kriv onaj učinilac koji je uračunljiv, a djelo je ostvario s umišljajem ili iz nehata, pri čemu je svjestan ili je morao biti svjestan protupravnosti svog djela. Krivica predstavlja kompleks subjektivnih pretpostavki da bi se jedno protivpravno djelo stavilo na teret učiniocu, a čime je intelektualna i voluntaristička komponenta, odnosno svijest i volja učinioca. U ovom slučaju svijest učinioca mora obuhvatiti sve elemente zloupotrebe položaja ili ovlaštenja. Dakle, učinilac mora biti svjestan vlastitog svojstva, radnje i posljedice. Najveći broj teoretičara smatra da se ovo krivično djelo može počiniti samo umišljajem (Petrović, Jovašević i Ferhatović, 2016; Tomić, 2007; Mrvić-Petrović, 2006; Stojanović i Perić, 2009), ne precizirajući da li se radi o direktnom ili eventualnom umišljaju, niti analizirajući navedeno.

Subjektivnu stranu djela čini direktni umišljaj. Učinilac treba da je svjestan da iskorištava svoj službeni položaj, prekoračuje svoje ovlaštenje ili da ne vrši svoju službenu dužnost, kao i toga da na taj način pribavlja za sebe ili drugoga kakvu korist, drugom nanosi kakvu štetu (Babić i Marković, 2005; Tahović, 1961) ili teže povređuje prava drugog (Tulić i sar., 2019, 65). Pored umišljaja potrebna je i namjera karakteristična za ovo djelo. Namjera mora obuhvatiti kako svijest o tome da se iskorištava položaj ili ovlast, prekoračuju granice ovlasti ili ne obavlja dužnost, tako i svijest da se prouzročuje šteta (Novoselac, 2002; prema Tulić i sar., 2019). Prema tome, u svakom se slučaju traži direktni umišljaj (dolus directus), pa eventualni umišljaj (dolus eventualis) nije dovoljan (Novoselec, 2002).

Poduzimanjem radnje koja je suprotna poslovanju subjekta, odnosno banke generira se Zloupotreba službenog položaja od strane službenika banke, gdje isti ciljeve i interese banke zanemaruje i zamjenjuje svojim ličnim tj. sopstvenim interesima.

Kod utvrđivanja činjeničnog stanja za preciznije otkrivanje i dokazivanje krivičnog djela, kod preduzimanja radnje potrebno je razlikovati položaj službene osobe kao i njeno ovlaštenje. Sam položaj određuje šta je dopušteno kroz djelovanje, a šta je zabranjeno, dok ovlaštenje predstavlja mogućnost obavljanja pravnih poslova za drugog.

U praksi se često pojavljuju dileme oko toga ima li neka osoba svojstvo službene ili odgovorne osobe. S obzirom na to da je svojstvo učinitelja konstitutivni element u biću krivičnog djela, zadatak tužilaštva je, prije svega, da ponudi dovoljno dokaza, najprije, da je optužena osoba imala svojstvo službene ili odgovorne osobe, dok je zadatak suda da na osnovu ponuđenih dokaza to i utvrdi (Ferhatović, 2016).

Šire posmatrano položaj možemo okarakterisati kao skup ovlaštenja koje bankarski službenik ima na raspolaganju, a koja su vezana za njegov položaj unutar banke kada je i samo izvršenje djela vezano za banku, dok zloupotreba može proizaći upravo iz tog ovlaštenja. S tim u vezi implicira da zloupotreba položaja koristi jedinstven položaj koji bankarski službenik posjeduje u okviru svog položaja u banci poduzimajući određene radnje kako bi djelujući protivno poslovanju banke ostvario svoj interes. Do same zloupotrebe dolazi tako što se ne postupa u skladu sa procedurama poslovanja banke. Ono što treba apostrofirati jeste da se radnjom zloupotrebe položaja postupa suprotno poslovanju banke i da je vlastiti interes izvršioca u konkretnom slučaju bankarskog službenika, iznad pravilnika poslovanja banke, gdje je konačno izvršenjem krivičnog djela pribavljena korist. Suštinski, potrebno je da se radi o osobi koja je na takvom položaju ili koja ima ovlasti donositi odluke koje mogu imati za posljedicu pribavljanje koristi sebi ili drugom. S druge strane službena osoba može učiniti ovo krivično djelo i kada preduzme neku djelatnost koja nema karakter službene radnje ako je učinjena korištenjem službenog položaja ili ovlasti. U samom postupku potrebno je utvrditi i dokazati uzročno-posljedičnu vezu između radnje izvršenja i posljedice.

**Zloupotreba položaja i ovlaštenja kroz odobravanje fiktivnog kredita u bankama**

Zloupotreba položaja i ovlaštenja sa aspekta krivičnopravne odgovornosti se smatra tradicionalno koruptivnim krivičnih djelom kako u našoj državi tako i zemljama regiona. Uvriježeni fenomen kao što je korupcija (lat. coruptio - pokvarenost) u našem društvu sadržava pored podmićivanja i davanja mita u užem smislu i širi dijapazon kriminalnih djelatnosti, koje po pravilu predstavljaju različite vrste zloupotreba u službi (Tulić i sar., 2019).

Prema međunarodnim konvencijama, i to: Ujedinjenih Nacija protiv korupcije – (Konvencija Ujedinjenih Nacija protiv korupcije [KUNPK], 2006), zatim Krivičnopravnoj konvenciji protiv korupcije - Criminal Law Convention on Corruption, (Konvencija Krivičnopravna protiv korupcije [KKPK], 2001) i Građanskopravnoj konvenciji protiv korupcije - Civil Law Convention on Corruption (Konvencija Građanskopravna protiv korupcije [KGPK], 2001), državama članicama je ostavljeno da kroz svoje nacionalno zakonodavstvo propišu kažnjiva ponašanja koja, pored klasičnog primanja mita, obuhvataju i druge postupke preduzete u javnoj ili privatnoj službi sa ciljem pribavljanja koristi sebi ili drugom, dok prouzrokovanje štete pojedinačno nije navedeno kao nužan dio dispozicije krivičnog djela kao posljedica (Sarajlija, 2018).

Za potrebe rada izdvojiti će se primjer zloupotrebe položaja i ovlaštenja, gdje optužnica tereti lice N.N. Poštujući Zakon o zaštiti ličnih podataka BiH (Zakon o zaštiti ličnih podataka BiH [ZOZLP], 2011), neće se navoditi decidni podaci o pravnim, fizičkim licima kao i tačnom vremenskom periodu dešavanja samog događaja, da je kao bankarski službenik filijale jedne od banaka u Kantonu Sarajevo u prostorijama iste filijale zloupotrijebio svoj položaj i prekoračio granice istog, tako što je zloupotrijebio lične podatke i dokumentaciju postojećeg klijenta na način da je izvršio odobrenje i isplatu kredita u iznosu od 10.000,00 KM, sa ciljem da sebi pribavi protupravnu imovinsku korist ne vodeći računa o interesu Banke, klijenta i radnih kolega već o svom vlastitom interesu, znajući da mu je kao odgovornoj osobi zabranjeno vođenje i organizovanje posla u sopstvenu korist. Tom prilikom bankarski službenik se na kreditnu

dokumentaciju potpisao vlastoručnim potpisom u ime klijenta, zatim kreditnu dokumentaciju ovjerio pečatom Banke, gdje je na taj način iskoristio povjerenje Direktora filijale koji je potpisao ugovornu dokumentaciju za kredit i potpisao nalog za isplatu. U ime klijenta izvršena je isplata odobrenog kredita kod službenika na šalteru filijale sa obrazloženjem da se klijentu žuri i da ne može da čeka u redu, gdje je bankarski službenik N.N. isplaćeni novac sebi prisvojio i na taj način sebi pribavio protupravnu imovinsku korist oštetivši Banku za pomenuti iznos, gdje je ujedno doprinjeo povredu radne obaveze drugih službenika koji su izvršili navedene radnje po nalogu bankarskog službenika N.N.

Bankarski službenik N.N. je u ovoj situaciji zanemario granice službenog položaja i jasno utvrđenih ovlaštenja. Pomenuto proizilazi iz propisa kojima su ista utvrđena ugovorom o radu kao i internom pravilniku o poslovanju Banke gdje se jasno propisuju prava i obaveze službenika. Na taj način bankarski službenik N.N. je zloupotrijebio granice svojih ovlaštenja i time je preduzeta i izvršena radnja postala predmet krivičnog djela.

Općenito posmatrano postoje različite percepcije po pitanju dovršenja predmetnog krivičnog djela. Sarajlija (2018:12, prema Tomić, 2007) ističe da preovladava teorija po kojoj se smatra da je krivično djelo izvršeno u pokušaju ako je preduzeta radnja izvršenja, ali je izostala posljedica (pribavljena korist, nastupila šteta ili teže povrijeđena prava drugog). Nadalje se navodi da u slučajevima gdje nije nastupila posljedica, treba imati na umu opću odredbu o pokušaju, koja propisuje kažnjivost za počinioca koji s umišljajem započne činjenje krivičnog djela, ali ga ne dovrši – ako se radi o krivičnom djelu za koje se može izreći kazna zatvora od tri godine ili teža kazna, a za pokušaj drugog krivičnog djela – kad zakon izričito propisuje kažnjavanje i za pokušaj. Dakle, iako u samoj inkriminaciji krivičnog djela zloupotrebe nije propisano kažnjavanje za pokušaj, pokušaj će biti kažnjiv zbog propisane visine kazne za ovo krivično djelo. Kod odlučivanja o tome radi li se o kažnjivom pokušaju, potrebno je uzeti u obzir da je obilježje krivičnog djela pribavljanje koristi, koja ne mora nužno biti imovinska, kao ni šteta.

**Sprovođenje mjera vezanih za interne kontrole u bankama kao oblik preventivnih aktivnosti u vršenju krivičnih djela**

Analizirajući krivično djelo zloupotrebe položaja i ovlaštenja u praksi je primijećeno da se kao jedan od načina saznanja ovih krivičnih djela javljaju prijave oštećenih, organa zaduženih za upravljanje društvom i anonimne prijave. Drugi način saznanja su izvještaji policijskih agencija, iz sredstava javnog informisanja ili saznanja proisteklih iz drugih predmeta, gdje su postojeći dokazi nerijetko nedovoljni za finaliziranje i pokretanje postupka podnošenjem krivične prijave.

Kao jedna od mnogobrojnih specifičnosti pri dokazivanju učinjenja ovog krivičnog djela karakteristično je i samo provođenje finansijskog vještačenja. Propisi nalažu da su Tužioci obavezni da vještake određuju sa liste sudskih vještaka. Na toj listi se nalaze i vještaci ekonomske struke, ali je njihovo znanje često nedovoljno specijalizirano za pojedine predmete, dok su usluge nekih stručnjaka teže dostupne zbog ograničenja u iznosima naknada za vještake (Sarajlija, 2018).

Također, autorica Sarajlija (2018) u prethodnom kontekstu navodi da se u praksi pokazalo da pojedini vještaci nisu neovisni, da nisu dovoljno stručni, da su nesigurni na sudu kad dođu u poziciju da su podvrgnuti unakrsnom ispitivanju, da relativiziraju svoje zaključke, mijenjaju ih zbog pojavljivanja novih dokaza koje je odbrana činila nedostupnim tužiocu do te faze postupka. Zbog toga je za utvrđivanje istine na sudu presudna posvećenost, profesionalnost i stručnost tužioca, a ponekad ni sve to neće biti dovoljno za osuđujuću presudu zbog ranije navedenih okolnosti, na koje tužilac nije mogao utjecati u fazi istrage.

Kada je riječ o bankarskim subjektima (Zakon o bankama Federacije BiH [ZOBFBiH], 2017), u odjeljku C i članu 82. predviđa sistem internih kontrola, a u članu 84. decidno obrazlaže šta banka kao subjekt treba poduzeti u organizacijskom djelu kod uspostavljanja strukture kontrolnih funkcija: „Banka je dužna uspostaviti stalne i efikasne kontrolne funkcije s odgovarajućim ovlastima nezavisne o poslovnim procesima i aktivnostima u kojima rizik nastaje, odnosno koje kontrolne funkcije prate i nadziru, srazmjerno svojoj veličini te vrsti, obimu i složenosti poslova u skladu sa svojim profilom rizičnosti, kao i da pojedina kontrolna funkcija ne može biti organizovana u sklopu druge kontrolne funkcije“ [ZOBFBiH], 2017.

Sukladno tomu, Odluka o sistemu internih kontrola u banci[1], u članu 2. kroz nadležnosti nadzornog odbora i uprave banke propisuje između ostalog i održavanje i unapređenje efikasnog sistema internih kontrola u bankama[2] (Odluka o sistemu internih kontrola u banci [OSIKB], 2017). Pored toga u članu 4. stav 1. i 2. tačka a), b), c) i d), se ističe da se od strane banke, odnosno nadzornog odbora kroz internu kontrolu mora uspostaviti jasan nivo i linije nadležnosti i odgovornosti u upravljanju, nadzoru i rukovođenju. Osim toga u navedenim tačkama se propisuje da se kroz akte o unutrašnjoj organizaciji i sistematizaciji mora provoditi takva kadrovska politika koja zaposlenike zapošljava na radna mjesta koja odgovaraju njihovim stručnim kvalifikacijama, sposobnostima i odgovarajućem radnom iskustvu (OSIKB, 2017).[3] U praksi je primjetno da to nije slučaj, kao što je također primjetno da se ne provodi sveobuhvatna, kontinuirana i uspješna obuka zaposlenika banke kao i kontinuirana kontrola i ocjena kvaliteta poslova izvršenih od strane svakog zaposlenika banke (OSIKB, 2017; član 4. stav 2. tačka c i d).

Nadalje, kroz Odluku o sistemu internih kontrola u banci je propisano u članu 5. stav 3 da sistemi internih kontrola moraju osigurati da niti jedan službenik zaposlen u banci ne može biti u poziciji da učini značajne greške[4]. Smatra se da je ovdje ključ prevencije i suzbijanja svih radnji koji bi se mogli dovesti u vezu sa planiranjem i izvršenjem krivičnih djela iz sfere bankarskog djelovanja. Dakle, sama podjela aktivnosti pri poslovanju, ne smije dati poziciju službeniku banke da učini značajne greške ili počini prekršaje koji su propisani zakonskim regulativama u bankarskom sektoru, u konačnici i krivičnim zakonodavstvom. Jedan od načina kako se to može preduprijediti jeste permanentna i kontinuirana kontrola i nadzor službenika prvenstveno u sferi transakcija novca, kako je to dijelom i propisano u članu 6.stav 2. tačka b), koji se odnosi na administrativne i računovodstvene kontrole - kontrola procedura i evidencija vezanih za procese donošenja odluka o odobravanju poslovnih transakcija banke, kao i samom primjenom člana 7. stav 2. tačka f) kroz procedure za zaštitu aktive banke gdje se praktično nedovoljno primjenjuju procedure i sve specifičnosti u vezi zapošljavanja osoba u bankama, odnosno procedurama za zaštitu aktive banke - procedure za zapošljavanje osoblja koje, posebno za specifična radna mjesta u banci, moraju da uključe obaveznu prethodnu provjeru pouzdanosti i stručnosti.

Odobravanje različitih zajmova klijentima, je još jedna od bankarskih usluga gdje postoji mogućnost zbivanja zloupotrebe položaja i ovlaštenja. Temeljni oblik bankovnog zajma za klijenta jeste Ugovor o kreditu (Vedriš i Klarić, 2004). Ugovor o kreditu takav je oblik Ugovora o zajmu kod kojeg je objekt prestacije isključivo novac i kao takav oblik mora biti sklopljen u pisanom obliku.

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[1] Upravni odbor Agencije za bankarstvo Federacije Bosne i Hercegovine, donosi Odluku na sjednici održanoj 13.10.2017. godine.

[2] (1) Nadzorni odbor je odgovoran da, na osnovu prijedloga uprave banke, donese odluku o uspostavi, održavanju i unapređenju efikasnog sistema internih kontrola u banci i osigura da uprava banke osigura uslove za njihovo provođenje, odnosno da uprava banke i drugi zaposlenici u banci uspostavljaju i provode detaljne procedure i postupke vezane za adekvatnu kontrolu rizika, praćenje efikasnosti i djelotvornosti poslovanja banke, pouzdanosti njenih finansijskih i ostalih informacija i usklađenosti sa propisima, internim aktima, standardima i kodeksima.

[3] Član 4. *Organizaciona struktura i kultura*;

(1) Plan organizacione strukture banke, donesen od strane nadzornog odbora, mora uspostaviti jasne nivoe i linije nadležnosti kao i odgovornosti sa jasnim razgraničenjima između funkcija upravljanja, nadzora i rukovođenja u banci.

(2) Po pitanju organizacione strukture banke, sistemi internih kontrola, kao minimum, trebaju osigurati da:

a) su ovlaštenja i ograničenja zaposlenika banke jasno i precizno utvrđena u aktu o unutrašnjoj organizaciji i sistematizaciji poslova banke donesenom od strane nadzornog odbora;

b) se u banci provodi kadrovska politika na način da se zaposlenici zapošljavaju na radna mjesta koja odgovaraju njihovim stručnim kvalifikacijama, sposobnostima i odgovarajućem radnom iskustvu;

[4] Član 5. Kontrolne funkcije banke- (stav 3.) Sistemi internih kontrola moraju osigurati da ni jedno lice zaposleno u banci ne može biti u poziciji da učini značajne greške ili počini prekršaje utvrđene zakonom, drugim propisima i internim aktima banke, a koji se u kratkom roku ne mogu otkriti.

Uopšteno, postoji više podjela kredita. Krediti prema samom subjektu mogu biti bankovni i komercijalni krediti, prema predmetu kreditiranja robni i novčani, prema roku tj. ekonomskoj funkciji kratkoročni i dugoročni, zatim prema svrsi proizvođački i potrošački, prema namjeni investicijski i za obrtna sredstva, i na kraju prema osiguranju otvoreni i pokriveni (Kandžija i Živko, 2004).

Iznos kredita može biti u domaćoj valuti ili devizni uz valutnu klauzulu vezanu na dan transakcije. Nenamjenski krediti su uvijek gotovinski krediti koji se isplaćuju na račun korisnika, dok su namjenski krediti uvijek vezani uz određenu namjenu i imaju složeniji postupak odobrenja sredstava. Pored navedenog važno je istaći da postoje različiti oblici osiguranja kredita. Kamber (2008) u tom smislu ističe da je moguće osiguranje putem jemaca, sudužnika, garancija drugih banaka, fizičkih ili pravnih osoba, tijela državne vlasti ili lokalne i regionalne samouprave, različitim gotovinskim instrumentima naplate kao što su mjenice i zadužnice, založnim pravom i fiducijem (Leksikografski zavod Miroslav Krleža, 2023), odnosno prijenosom prava vlasništva radi osiguranja novčane tražbine, novčanim depozitima i zalogom različitih vrijednosnih papira. Pomenuti autor nadalje navodi da prilikom sklapanja Ugovora o kreditu banke pribavljaju različite podatke o klijentima korisnicima kredita i svim drugim činjenicama koje su vezane uz neki od oblika osiguranja kredita. Pomenuti podaci se mogu razlikovati kao lični i i poslovni podaci. Na temelju njih banke stvaraju vrijednosne sudove i odlučuju o plasmanu svojih sredstava. U zavisnosti od unutrašnjeg ustrojstva banke postoje različita tijela koja odlučuju o odobravanju sredstava na ime kredita za pojedine klijente, a to su po defaultu kreditni odbori.

Obzirom na bankarske poslove, banke pribavljaju i obrađuju slijedeće podatke (Kamber, 2008, a prema Manning, George, A., op. cit., str. 390. – 392):

- podaci o transakcijskim računima – periodične obavijesti o stanju računa, potvrde o uplati, poništeni čekovi, potpisni kartoni, dugovni i kreditni podaci, podaci o deponiranim sredstvima,
- podaci o štednim i depozitnim računima – periodični podaci o promjenama stanja na računu, podaci o deponiranim sredstvima, podaci o transferu sredstava, podaci o povlačenju sredstava, poništeni čekovi, potpisni kartoni, dugovni i kreditni podaci, obavijesti o kamatama,
- podaci o kreditima – saldo kredita, otplatni plan, poništena zaduženja, potpisne kartone, zahtjev za kredit i popratna dokumentacija, financijski podaci, podaci pravnih osoba koje prate kretanje obveza po kreditima za pojedinog korisnika,
- podaci o kreditnim karticama – periodična izvješća, podatke o kupnji i prodaji dobara i usluga, kamate na promet, zahtjev za izdavanje kartice, podatke o financijskom stanju i kretanju obveza po kreditnim karticama,
- podaci o uslugama sefa – zahtjev za otvaranje, ulazni podaci, potpisni karton,
- podaci u svezi ostalih bankovnih poslova – ugovori, izjave, knjigovodstveni podaci, garancije, nalozi za novčane uplate i isplate, ostala financijska korespondencija klijenata i trećih osoba koja se obavljala preko banke.

**Fiktivna odobrenja kredita i nezakoniti transferi novca- primjeri iz prakse**

Iz ugla bosanskohercegovačkog zakonodavstva kao i regije, najzastupljenija krivična djela koja se dovode u vezu sa nezakonitim djelovanjem unutar bankarskog spektra djelovanja su:

Organizovani kriminal (KZFBiH, 2017, član 342) u vezi sa krivičnim djelima zloupotreba položaja ili ovlaštenja (KZFBiH, 2017, član 383), zloupotreba ovlaštenja u privredi u vezi krivičnog djela pranje novca (KZFBiH, 2017, član 272), falsifikovanje ili uništavanje službene isprave (KZFBiH, 2017, član 389), neprijavljivanje krivičnog djela (KZFBiH, 2017, član 345), falsifikovanje ili uništavanje poslovnih ili trgovačkih knjiga ili isprava (KZFBiH, 2017, član 261), ali u posljednjih nekoliko godina i pojavljivanje krivičnog djela finansiranje terorističkih aktivnosti (KZFBiH, 2017, član 202) zbog određenih propusta kao i nedostatne obrade finansijskih zahtjeva klijenata od strane bankarskih službenika.

Posmatrajući širi dijapazon nezakonitih radnji koji se mogu dovesti u vezu užeg ili šireg konteksta djelovanja službenika bankarskih subjekata trebalo bi kao vid preporuke u budućnosti

intenzivnije i detaljnije uključiti i druge sektore u samoj kontroli i nadzoru djelovanja banke i to: sektor upravljanja rizicima, sektor finansijske analize, sektor praćenja, naplate i likvidacije kredita kao i sektor upravljanja dodjelom kredita koji trebaju biti pod hijerarhijskom linijom odgovornosti i izvještavanja Uprave nadležne za rizike. Navedeni sektori u bankarskom subjektu, obavljaju određene poslovne aktivnosti u cilju provođenja pravila efikasnog upravljanja rizicima kako to predviđa član 87 (ZOBFBiH, 2017), gdje je Banka dužna da funkciju praćenja usklađenosti poslovanja uspostavi i razvija na način koji osigurava:

- praćenje usklađenosti poslovanja banke sa ovim zakonom, propisima Agencije i drugim propisima i standardima opreznog bankarskog poslovanja, procedurama o sprečavanju pranja novca i finansiranja terorističkih aktivnosti, kao i drugim aktima kojima se uređuje poslovanje banke,
- identifikovanje propusta i procjenu rizika kao posljedice neusklađenosti poslovanja banke sa zakonom i drugim propisima, posebno rizika od provođenja nadzornih mjera i sankcija Agencije i drugih nadležnih organa, finansijskih gubitaka, kao i reputacioni rizik,
- savjetovanje uprave i drugih odgovornih lica o načinu primjene relevantnih zakona, standarda i pravila, uključujući i informacije o aktuelnostima iz tih područja,
- procjenu efekata koje će na poslovanje banke imati izmjena relevantnih propisa.

Organizaciona jedinica zadužena za praćenje usklađenosti poslovanja banke dužna je da sačini program praćenja usklađenosti poslovanja banke, koji posebno sadrži metodologiju rada te organizacione jedinice, planirane aktivnosti, način i rokove izrade izvještaja, način provjere usklađenosti, kao i plan obuke zaposlenih.

Nadalje, istaći će se primjeri iz sudske prakse unazad nekoliko godina u Bosni i Hercegovini u kojima su bila uključena nekolicina lica, kao i primjer iz Crne Gore u kojoj je bilo uključeno jedno lice procesuirano od strane nadležnih institucija:

Akcija Lavina iz 2016. godine preduzeta po nalogu Tužilaštva Bosne i Hercegovine, a kao rezultat višemjesečne detaljne istrage, gdje je uhapšeno deset osoba koji se sumnjiče za zloupotrebu položaja ili ovlaštenja, zloupotrebu ovlaštenja u privredi, pranje novca, falsifikovanje ili uništavanje službene isprave, neprijavljivanje pripremanja krivičnog djela i falsifikovanje ili uništavanje poslovnih ili trgovačkih knjiga ili isprava. Prema navodima Tužilaštva Bosne i Hercegovine uhapšeni se sumnjiče da su davali kredite preduzećima i privrednim subjektima koji su povezani ili su suvlasnici Bobar banke znajući da neće moći naplatiti potraživanja. Znali su da će prouzrokovati stečaj Bobar banke i ozbiljno uzdrmati bankarski sistem Bosne i Hercegovine. Uhapšene osobe osumnjičene su da su kao grupa pripadnika međusobno povezanog i organizovanog zločinačkog udruženja, djelujući u međusobnom dogovoru, počinili niz nezakonitosti u poslovanju Bobar banke, prvenstveno u dodjeli kredita u višemilionskim iznosima, kao i nezakonitih bankarskih garancija za razne poslove, uz kršenja procedura i garancija propisanih Zakonom o bankama Republike Srpske, te su na taj način nanijeli štetu i omogućili sticanje nezakonite imovinske koristi u iznosu od oko 123 miliona konvertibilnih maraka gdje su takve kriminalne aktivnosti nanijele i veliku štetu kreditnom rejtingu Bosne i Hercegovine u cijelosti.

Njihova djela su dovela i do toga da se Međunarodni monetarni fond (MMF) aktivno uključi u analizu dešavanja u bankarskom sektoru. Osim toga važno je istaći da su ovakvim aktivnostima ugroženi depoziti različitih pravnih i fizičkih osoba, koji su bili deponovani u Bobar banci, uključujući sredstva gradova, opština, preduzeća, zdravstevnih zavoda, PIO fondova, elektroprivreda, fizičkih osoba te je nanesena višemilionska šteta Agenciji za osiguranje depozita BiH.

Osobe lišene slobode osumnjičene su za krivična djela: organizirani kriminal iz člana 383.a stav 3. u vezi sa kaznenim djelom zloupotreba ovlaštenja u privredi iz člana 263. stav 1. tačka 5. [KZRS]; organizirani kriminal iz člana 383.a stav 3. u vezi sa kaznenim djelom zloupotreba službenog položaja ili ovlaštenja iz člana 347. stav 4. [KZRS]; pranje novca iz člana 280. [KZRS]; falsifikovanje ili uništavanje službene isprave iz člana 379. stav 1. [KZRS].

Akcija Bankar iz 2019 godine po naredbama Kantonalnog suda u Sarajevu i Tužilaštva Kantona Sarajevo, a kao rezultat višemjesečne detaljne istrage uhapšene su tri osobe, koji se sumnjiče za udruživanje radi činjenja krivičnog djela, zloupotreba položaja i ovlaštenja i pranje novca.

Prilikom realizacije operativne akcije policijski službenici Državne agencija za istrage i zaštitu pretresli su stambene objekte na tri lokacije i lišili slobode tri lica zbog postojanja osnova sumnje da su počinila krivično djelo iz člana 340. Udruživanje radi činjenja krivičnog djela, u vezi sa krivičnim djelom iz člana 383. Zloupotreba položaja i ovlaštenja, a sve u vezi sa krivičnim djelom iz člana 272. Pranje novca [KZFBiH], 2017. Lica su uhapšena zbog postojanja osnova sumnje da su kao uposlenici Sberbanke u Bosni i Hercegovini u periodu od početka 2016. do početka 2019. godine, zloupotrebom službenog položaja, iskoristivši svoj službeni položaj i prekoračivši granice službenih ovlaštenja, za lični račun vršili elektronsku kupoprodaju stranih valuta po kursnoj listi koja nije bila uobičajena za period od početka 2016. godine do marta mjeseca 2019. godine, odnosno prema onim vrijednostima deviznih kurseva koje su osumnjičeni prije prodaje, nezakonito i sistematski višestruko uvećavali, odnosno sistemski mijenjali paritet valuta prije transfera na svoje račune otvorene u različitim poslovnim bankama u Bosni i Hercegovini s ciljem prikrivanja, da bi tako stečen novac za koji su znali da je pribavljen učinjenjem krivičnih djela, ubacivali u platni sistem Bosne i Hercegovine koristeći ga na različite načine, te su na taj način stekli protivpravnu imovinsku korist preko milion konvertibilnih maraka.

Rukovoditeljka filijale kao odgovorna osoba jedne banke u Baru (Crna Gora) u 2022. godini je zloupotrijebila svoj položaj i povjerenje koje joj je dato u pogledu raspolaganja imovinom banke i njenih klijenata.

Prema navodima policijskih agencija u Crnoj Gori, zbog zloupotrebe službenog položaja u privrednom poslovanju Policija je Osnovnom državnom tužilaštvu u Baru podnijela krivičnu prijavu protiv M.M. rukovoditeljke filijale jedne banke u tom gradu. Osoba inicijala M.M. se sumnjiči da je zloupotrijebila službeni položaj u privrednom poslovanju (Krivični zakonik Crne Gore [KZCG], 2020, član 272). Ona je u svojstvu odgovornog lica ovog privrednog društva, u tri navrata tokom 2020. i 2021. godine, zloupotrijebila svoj položaj i povjerenje koje joj je dato u pogledu raspolaganja imovinom banke i njenih klijenata. Kako se sumnja, M.M. je neovlašćeno, bez prisustva i ovlašćenja klijenata banke pristupila bazi podataka klijenata i po sopstvenom izboru iz baze izdvojila klijente, zatim, također na osnovu neovlašćeno pribavljenih ličnih podataka i bez ličnog prisustva klijenata, zahtijevala kreiranje kreditne dokumentacije sa lažnim ispravama u pogledu ovlašćenih podnosilaca zahtjeva za dobijanje kredita, u stvarnosti klijenata banke.

Također, neovlašćeno je davala odobrenja kredita, te je, ponovo zloupotrijebivši svoj položaj i prekoračivši ovlašćenja u odnosu na hijerarhijski određene, zahtijevala procesuiranje navedenih lažnih kredita do momenta isplate.

Na kraju lažno kreiranog procesa odobravanja fiktivnog kredita, kako se sumnja, M.M. je podizala novac u odobrenim iznosima i to 10.08.2020. godine sa računa jednog deponenta banke iznos od 50.000 eura, 06.12.2020. godine sa računa drugog deponenta banke iznos od 72.000 eura, te tokom 2021. godine, u više navrata, sa računa još jednog deponenta banke podigla ukupno 11.408 eura. Osoba M.M. je na ovaj način pribavila protivpravnu imovinsku korist u iznosu od 133.408 eura, te je banci u kojoj je zaposlena i klijentima banke nanijela imovinsku štetu u pomenutom iznosu.

## ZAKLJUČNA RAZMATRANJA

Kod krivičnog djela zloupotreba položaja i ovlaštenja potrebno je utvrditi svojstvo počinioca, odnosno da li se radi o službenoj ili odgovornoj osobi, imajući u vidu krivično djelo koje mogu počiniti samo osobe kojima je posjeduju određeno svojstvo tj. da im se u okviru položaja ili ovlasti koje obnašaju daju u zadatak određeni poslovi, radne funkcije, a u konačnici neposredno odlučivanje. Posmatrajući opisne narative krivičnog djela zloupotrebe položaja i ovlaštenja ustanoviti će se da se radi o krivičnom djelu koje ima blanketni karakter obzirom na to da zakonom nisu propisane granice ovlasti koje mogu biti predmet zloupotrebe. Nadalje, nije decidirano niti

kada će i pod kojim uslovima izvršilac krivičnog djela iskoristiti svoj položaj ili ovlasti ili će ih prekoračiti u određenom trenutku.

Okvirni obrasci ovlaštenja mogu biti definisani pravilnicima o radu, statutima subjekta, ugovorima o radu, odlukama kao i zakonskim i podzakonskim aktima i propisima.

Bankarski subjekti sistemski trebaju prikupljati i obrađivati sve podatke koji su u vezi s njihovim poslovanjem. Na takvim podacima se moraju zasnivati vrijednosni sudovi koji se mogu potvrđivati ili osporavati drugim činjenicama, ali svakako predstavljaju dragocjen izvor otkrivanja i daljnjeg usmjeravanja kriminalističkog istraživanja kada je riječ o nezakonitim radnjama i djelovanjima pri pružanju bankarskih usluga.

Također, prilikom pribavljanja bankovnih podataka potrebno je unaprijed planirati izvore iz kojih se oni pribavljaju. Dakako, takvi izvori unutar same banke mogu biti različiti. Njihovo sistemsko planiranje znači stavljanje u odnos i prosudbu vjerovatne spoznaje i očekivane informacije. To se može odrediti i kao optimalno djelovanje. Svaka znatnija razlika može imati negativan utjecaj na daljnje istraživanje. Vrlo je važno da se svi prikupljeni bankovni podaci kompariraju međusobno uključujući i podatke iz drugih izvora, prethodnih saznanja i informacija. Za podatke koji se prikupe potrebno je osigurati pohranu koja će onemogućiti zloupotrebu, gubitak istih, posebno ako se radi o nedovoljno istraženom ili spornom materijalu koji mora proći dodatne provjere ili ekspertizu. Pohranu podataka potrebno je organizovati prema subjektu ili prema odnosu iz kojeg su nastali, ali i istovremeno omogućiti jasno međusobno razlikovanje prikupljenih podataka gdje bi se isti objedinili i dalje koristili kao zaključci, procjene ili u konačnici predviđanja kako u pravnim tako i krivičnopravnim stvarima.

Razmatrajući pojedinosti u vezi davanja određenih preporuka kada je zloupotreba položaja i ovlaštenja u bankarskom sektoru u pitanju izdvojiti će se sama Odluka o sistemu internih kontrola u banci, tačnije član 5. gdje se ističe da sistemi internih kontrola moraju osigurati da niti jedan službenik zaposlen u banci ne može biti u poziciji da učini značajne greške. Na taj način podjelom aktivnosti pri poslovanju, permanentnom kontrolom i nadzorom bi onemogućila službenika da učini značajnije greške ili pak dala šansu da počini takve vrste prekršaja koji bi ga doveli u položaj da mora krivično odgovarati. Pretpostavka u širem smislu da se ovdje krije ključni segment preventivnih aktivnosti i mjera u suzbijanju svih radnji koji bi se mogli dovesti u vezu sa planiranjem i izvršenjem krivičnih djela iz sfere bankarskog djelovanja.

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# THE ABUSE OF POSITION AND AUTHORITY IN THE BANKING SECTOR THROUGH A CRIMINAL LEGAL CONSTRUCT

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**ABSTRACT**

It is almost unavoidable not to find cases of abuse of position and authority perpetrated by bank clerks in the banking sector. Through the research itself, different types of misuses will be elaborated in this paper, such as creating loan documentation with false documents and subsequently approving the monetary loan or credit until the moment of payment. In addition to the above mentioned, in this paper we will analyse the general parameters of the internal work directives of bank clerks and their effect, as well as the legal legislation which refers to the whole banking system in B&H, in regards to the mentioned segment of misuse. From that standpoint, it should be emphasized that for abuse of position to be the subject of a criminal investigation, in addition to other characteristics, the conduct of the perpetrator through the institution of intent (lat. dolus) as a subjective element of the commission of a criminal offense must also be determined.

**Keywords:** Abuse of position and authority, credit documentation, false documents, legal legislation, institution of intent.

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# DEEPFAKE KAO NOVI OBLIK KRIMINALITETA

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## SAŽETAK

Laži nisu nepoznanica čovečanstvu, stare su koliko i ono samo, ali dimenzije posledica koje danas laž može da dosegne, upotrebom savremenih tehnologija, daleko su se uvećale. U poslednje vreme upotrebom savremenih tehnologija stvoreno je još jedno sredstvo na osnovu kojeg može doći do bržeg i lakšeg, kako sačinjavanja, tako i rasprostranjivanja lažnih sadržaja koji mogu poslužiti da podrivanje osnovnih ljudskih prava. To sredstvo poznato je pod nazivom Deepfake i koristi se za označavanje fotografija, audio i video zapisa na kojima se nalazi sadržaj koji se u realnosti nikada nije dogodio. U nastavku rada autori obrazlažu pojavne oblike deepfake-a. Pojedine međunarodne organizacije, poput Evropske unije i Svetske organizacije za intelektualnu svojinu, su prepoznale neophodnost reakcija na ovaj fenomen. Nakon analize pravnih dokumenata međunarodnih organizacija autori se okreću predstavljanju normativnih rešenja u pogledu inkriminacije deepfake-a u pojedinim državama. Poslednji deo rada posvećen je tome da li se po postojećem zakonodavstvu Republike Srbije deepfake može podvesti pod krivično delo.

**Ključne reči:** deepfake, kriminalitet, Republika Srbija.

## UVOD

Kontinuirani razvitak savremenih tehnologija je omogućio nastanak tehnike za kreiranje video zapisa i drugog sadržaja čija je suština u lažnom predstavljanju ljudi i događaja. Naime, tri napretka u razvoju tehnologije omogućila su stvaranje tzv. Deepfake-a. Prvi napredak ogledao se u tome da su stručnjaci za kompjuterski vid razvili algoritam čija se suština odnosi da mogućnost automatskog mapiranja orijenata lica na slikama, poput položaja obrva i nosa, što rezultira stvaranjem tehnike prepoznavanja lica. Uspon i široka upotreba interneta, naročito platformi za razmeni video klipova u fotogafija, doveo je do dostupnosti velikih količina audio-vizuelnih podataka. Povećanje kapaciteta forenzike slike, što predstavlja treći ključni napredak u stvaranju deepfake, učinio je mogućim automatsko otkrivanje falsifikata. Na osnovu navedenog stvoreni su uslovi da veštačka inteligencija može da uči tako što otkriva obrasce u velikim skupovima podataka (European Parliamentary Research Service, 2021).

Iako pomenuta tehnologija predstavlja napredak u svetu savremenih tehnologija i nije osmišljena s ciljem prouzrokovanja štete, jer je njena primena moguća u filmskoj i muzičkoj industriji, kao i za kreiranje umetnosti, ljudska genijalnost, nažalost, nije se ograničila na primenu iste samo u blagotvornom smislu. U praksi su već poznate brojne zloupotrebe, a o štetnim posledicama i malicioznim načinima korišćenja može se samo nagađati. U konkretnom slučaju problem je nastao jer su brojne aplikacije (Zao, DeepFace Lab, FaceApp, Face Svap i uklonjeni DeepNude jer je služila za generisanje lažnih slika nagih žena) koje koriste AI tehnologiju postale dostupne u formi jednostavnoj za upotrebu čak i početnicima u smislu tehnologije (Johnson, 2021).

Nakon predstavljanja preduslova za razvoj deepfake-a okrenućemo se određenju pojma deepfake. Suština ove tehnologije, nazvane po korisniku veb sajta u vidu foruma Reddita, koji je doprineo njenoj popularizaciji, ogleda se u korišćenju veštačke inteligencije za prepoznavanje i zamenu lica na slikama i video zapisima. Drugim rečima, deepfake na početku analizira fotografije ili video zapise određene osobe nakon čega veštačka inteligencija kreira odgovarajući algoritam za manipulisanje tim licem, pri čemu dolazi do mapiranja datog lica u video zapisu (Dodge, 2021). Kako su mogućnosti zloupotrebe deepfake-a ogromne i Evropska unija je počela da se bavi sprečavanjem njegovog korišenja radi nanošenja štete drugim licima (Johnson, 2021). Savremene

tehnologije su omogućile da se prošire i oblici viktimizacije žena. Naime, jedna od tendencija poslednjih godina jeste upotreba tzv. deepfake kako bi se osobe ženskog pola dodatno viktimizirale. Rad će biti posvećan pojmovnom određenju termina deepfake, njegovim načinima (zlo)upotrebe, kao i njegovim posledicama. Na kraju rada biće analiziran normativni okvir radi utvrđivanja da li postojeća zakonska rešenja omogućavaju adekvatni zaštitu od upotrebe deepfake.

**Određenje pojma deepfake i njegovi pojavni oblici**

Deepfake jeste naziv koji se koristi za fotografije, audio I video zapise na kojima se nalazi sadržaj koji se u realnosti nikada nije dogodio. Pojam "deepfake" (deep – duboko; fake – lažno) nastao je iz naziva osnovne tehnologije "deep learning" koja se koristi za izradu "deepfake" materijala. Tehnologija je bazirana na vrsti algoritma (Al) koji u svom radu koriste duboku neuronsku mrežu autoenkodera – inteligentnog programa sa dubokim učenjem koji vrši zamenu lica, a koji ima zadatak da prouči video snimak koji mu je dat, usvoji informaciju o tome kako lice ciljne osobe izgleda iz različitih uglova i u različitim okolnostima, a zatim prikupljene podatke primeni na odabranu podlogu – drugu fotografiju ili video zapis. Tehnici dobijanja lažnih fotografija i video snimaka dodaje se i vrsta mašinskog učenja – Generativne adversarne mreže (GAN), koja otkriva i poboljšava nedostatke u "dubokom lažranju", čime otežava otkrivanje lažnih snimaka jer se kombinacijom navedenih tehnika dobijaju izuzetno ubedljivi rezultati (Johnson, 2021).

Tehnologija je osmišljena u leto 2017. godine od strane tima informatičara sa Univerziteta u Vašingtonu (Chesney, & Citron, 2019). Tom prilikom oni su, u cilju demonstracije tehnologije, kreirali klip bivšeg američkog predsednika Baraka Obame na kojem on izgovara rečenice koje u stvarnosti (javnosti) nije nikada izgovorio (Washington post, 2021; Langston, 2017). Nakon što su mediji počeli da izveštavaju o novoj tehnologiji i lažnim video klipovima američkog predsednika, na sajtu www.reddit.com, novembra meseca 2017. godine, pojavili su se video zapisi kreirani od strane korisnika koji je sebe nazvao deepfake, a koji su sadržali lica poznatih ličnosti postavljena na lica glumaca i glumica iz pornografske industrije (Tseng, 2018), a zatim i brojni video zapisi humorističnog i satiričnog karaktera. Već naredne godine stvoren je sintetički video o tome kako tada aktuelni američki predsednik Donald Tramp (Donald Trump) ohrabruje Vladu Belgije da preduzme odlučne korake u borbi za klimatske promene. Najgore je prošla poznata američka glumica Skarlet Johanson (Scarlett Johansson) kojoj je lice utisnuto u porno snimak (Center for digital society, 2021). Na osnovu primera glumice Skarlet Johanson možemo videti sve mogućnosti korišćenja ove tehnologije, čime se stvara potencijalna situacija da bilo koja osoba, naročito ženskog pola, bude predmet ovakve zloupotrebe. Stoga su neki od najpopularnijih porno sajtova, poput Pornhaba (Pornhub), zabranili kačenje ovakvih snimaka na njihove sajtove. Ipak, to ne znači da ne postoje alternativna mesta na kojima korisnici interneta mogu naći snimke izmenjenje korišćenjem deepfake tehnologije.

Deepfake se može javiti u dva oblika. Naime, prvi oblik, poznat pod nazivom: Generativne adversarne mreže (Generative Adversarial Networks - GAN), jeste algoritam mašinskog učenja koji na osnovu postojećih slika stvara nove slike uporedivog nivoa kvaliteta (Shen et al., 2018). Drugim rečima, GAN radi tako što na osnovu prethodnih podataka stvara nešto novo. Njegov način funkcionisanja se ogleda u tome da se dve neuronske mreže, generator (generator) i diskriminator (discriminator), postavljaju jedna nasuprot drugoj, pri čemu generator stvara novu sliku, a diskriminator određuje da li je reč o pravoj ili lažnoj slici. Generator i diskriminator su u stalnoj interakciji na taj način da generator uči da stvori sliku toliko vernu originalu da je diskriminator prihvati kao stvarnu, dok diskriminator uči kako da prepozna lažnu sliku, a time da ne bude prevaren. Iako su neki programi, poput Fotošopa (Photoshop), mogli da stvore potpuno novu sliku, postojale su više nego vidljiva ograničenja. Veliki skok napravljen je stvaranjem GAN-a 2014. godine. Već u naredne tri godine došlo je do njegove šire upotrebe (Cvision lab, 2021).

Drugi oblik se naziva autoenkoderi (Autoencoders). On radi tako što izvlači informacije o crtama lica iz slika i koristi ih za pravljenje slika sa drugačijim izrazom lica. Iako opšta javnost smatra da se najčešće za pravljenje deepfake materijala koristi GAN, treba napomenuti da se autoenkoder znatno više koristi prilikom kreiranja sintetičkih slika i video klipova. Naime,

autoenkoder je posebna vrsta algoritma deepfake koji obavlja dva zadatka. Prvi zadatak ogleda se u kodiranju ulazne slike u mali skup numeričkih vrednosti, pri čemu se kodiranje vrši kroz niz slojeva koji počinju sa mnogo promenljivih i postepeno postaju sve manji dok dođu do sloja „uskog grla“ (“bottleneck” layer) u kome se nalazi ciljni broj promenljivih. Drugi zadatak odnosi se na dekodiranje podataka u sloju uskog grla i ponovnom stvaranju originalne slike. Drugim rečima, autoenkoder isporučuje niz slika, pri čemu je težnja da se parametri podese tako da izlazna slika bude što sličnija ulaznoj (Tech talks, 2021).

Do sada poznati vidovi zloupotrebe jesu ucene, pornografija iz osvete, manipulacija i iznuđivanje. Ono što treba da zabrine društvo je to da štetne posledice ne mora da trpi samo pojedinac, već pretnja postoji i kad su u pitanju pravna lica, organizacije, pa čak I samo državno uređenje, poverenje u institucije i potiranje demokratije (Adee, 2020). Vrlo je moguće da će i novinarska industrija morati da se suoči sa pitanjem poverenja potrošača zbog lažnih fotografija i video snimaka (CNBC, 2019). Težnja da se pobedi u trci za video snimak incidenta koji je snimio svedok jeste cilj novinara koji im može pružiti prednost nad konkurencijom, gde upravo usled postojanja lažnih snimaka ovo može predstavljati opasnost. Tako je tokom napetosti između Indije i Pakistana 2019. godine Rojters (novinarska agencija sa sedištem u Londonu) otkrio 30 lažnih video snimaka o incidentu, koji su bili uglavnom stari video snimci drugih događaja, objavljeni sa novim natpisima (DIGIDAY, 2019). Vlade u svetu zabrinute su i da bi lažni materijal dobijen upotrebom navedenih aplikacija mogao da se koristi za ugrožavanje nacionalne bezbednosti, širenje političkih propaganda i ometanje izbornih kampanja. Stvaranje lažnih snimaka na kojima politički kandidati izgovaraju rasističke komentare, uzimaju mito, priznaju da su učestvovali u nekom zločinu, nalaze se u kompromitujućoj situaciji ili otkrivaju navodni tajni plan, mogu lako iskriviti mišljenje birača I uticati na rezultate izbora (Westerlund, 2019). Takođe, i korporacije su ukazale na pretnju koju predstalja deepfake materijal jer bi se isti mogao koristiti za manipulisanje tržištem i akcijama kroz prikazivanje izvršnih direktora kako govore o bankrotstvu firme, nepostojećim spajanjima sa drugim preduzećima, i td (Forbes, 2019). Osim toga, deepfake tehnologija omogućava predstavljanje izvršnih direktora u realnom vremenu, te zaposleni mogu biti obmanuti I na način da se od njih traži da izvrše transfer novca ili pruže poverljive informacije (PCMag, 2019). Pored ovih opasnosti, a kako tehnologija omogućava kreiranje lažnih identiteta, potrebno je zabrinuti se i u pogledu veće mogućnosti pedofiličara da stupe u kontakt sa decom (Fox News, 2019).

**Normativni okvir međunarodnih organizacija u pogledu deepfake**

Proučavajući na ovu temu, autori rada uvideli su da su u Evropi i svetu počele da se preduzimaju mere u cilju otkrivanja lažnih vesti i materijala, ograničavanja upotrebe aplikacija koje u svom radu koriste Al I GAN tehnologije i usvajanja normativnih okvira u cilju inkriminisanja zloupotrebe deepfake-a, ali i da naša država u tome daleko zaostaje za svetom jer deepfake još uvek nije proučavan i ne prepoznaje se kao rastuća opasnost.

Sve veća prisutnost deepfake-a naterala je zvaničnike Evropske unije da preduzmu korake u jedinstvenom načinu reakcije na pojavu veštačke inteligencije. Tako je 2016. godine doneta Opšta uredba o zaštiti podataka (General Data Protection Regulation - GDPR). Deepfake često podrazumeva upotrebu ličnih podataka. Ukoliko je u deepfake prikazano fizičko lice možemo ga posmatrati ličnim podatkom, jer se odnosi na identifikovanu osobu ili osobu koja se može identifikovati. Lični podaci mogu se obrađivati, kako je to u Uredbi naglašeno, pod tačno određenim uslovima, jer svaki pojedinac ima pravo na privatnost i zaštitu ličnih podataka. Tako se pod obradom podrazumevaju svi mogući načini upotrebe ličnih podataka u toku nastajanja deepfake-a. Budući da se lični podaci mogu koristiti ne samo za stvaranje deepfake, već i obuku softvera, koji se upotrebljava za kreiranje sintetičkih slika i video klipova, možemo videti značaj širokog pojmovnog određenja termina obrada. Shodno tome, Uredbom se štite lični podaci, koji se koriste za deepfake od strane aplikacije poput TikTok i FaceApp. Stvaranje deepfake zahteva na osnovu člana 84 Uredbe izvođenja procene uticaja na zaštitu podataka (Data Protection Impact Assessment - DPIA). Iako postoji šest mogućih pravnih osnova za obradu ličnih podataka, ako bismo ove osnove posmatrali kroz prizmu deepfake moglu bismo da zaključimo da samo

informisana saglasnost (informed consent) i legitimni interesi (legitimate interests) mogu se primeniti za stvaranje deepfake bez posledica po autora. Tako, na primer, kreator deepfake se može pozvati na legitimni interes kada je prikazao poznatu osobu na ironičan način, te bi na taj način njegovi interesi nadjačali interese subjekta obrade ličnih podataka, jer bi se kreator mogao pozvati na slobodu izražavanja radi satire ili političkog komentara. Ukoliko ne postoje legitimni interesi za stvaranje i širenje deepfake mora postojati informisanu pristanaka subjekata obrade. Pod time se podrazumeva saglasnost ne samo osobe koja se pojavljuje u deepfake sadržaju, već i od osobe koja postoji u originalnoj slici ili video zapisu. Nepostojanje saglasnosti dovodi autore deepfake u opasnost da krše odredbe Uredbe. Jedan od izuzetaka kada se ne zahteva postojanje saglasnosti jeste kada je subjekt obrade ličnih podataka preminuli pojedinac, poput istorijske ličnosti (član 27 Uredbe). Ipak, istim članom ostavljena je mogućnost državama članicama EU da donesu posebne zakone kojima bi se zahtevala saglasnot naslednika preminule osobe pre obrade ličnih podataka. Sa druge strane treba napomenuti da iako žrtve imaju pravo da isprave netačne podatke, pri čemu mogu tražiti da se deepfake izbriše, treba napomenuti da pravni put može imati dosta poteškoća bez obzira što je predviđena obaveza postojanja u svakoj državi članici najmanje jednog nezavisnog nadzornog tela odgovornog za primenu pravila propisana Uredbom. Kao problem može se javiti nemogućnost identifikacije kreatora deepfake, ali i nepostojanje dovoljnih finansijskih sredstava na strain žrtve da pokrene odgovarajući sudski postupak (Johnson, 2021).

Pored Opšte uredbe o zaštiti podataka, Evropska unija je 2000. godine donela Direktivu o elektronskoj trgovini (Directive on electronic commerce) koja je poznatija pod nazivom Direktiva o e-trgovini (e-Commerce Directive). Osnovni cilj donošenja ovog dokumenta jeste uzdržavanje od nametanja preteranih regulatornih zahteva kako bi se olakšao ekonomski procvat pružalaca usluga. Posmatranjem sadržaja Direktive kroz prizmu deepfake možemo zaključiti da posrednički pružaoci usluga ne podležu bilo kakvoj obavezi u pogledu nadgledanja informacija koje teku njihovim kanalima. Ujedno, njome je predviđeno da se neće vršiti ex ante procena sadržaja. Ipak, Direktiva propisuje obavezu provajdera da ukloni nelegalni sadržaj čim sazna za njegovo postojanje. Prevedeno na jezik deepfake, to znači da Direktiva predviđa obavezu uklanjanja deepfake (Johnson, 2021). Kako je Direktiva doneta još na samom početku razvoja digitalnog sveta treba napomenuti da postoji potreba za reformom normativnog okvira uspostavljenog njenim donošenjem (Waldemarsson, 2020). Evropska unija je svesna neophodnosti inoviranja postojećeg normativnog okvira. Tako je Evropska Komisija najavila usklađivanje pravila o odgovornosti i moderiranja sadržaja u pogledu digitalnih platforma, usluga i proizvoda. Cilj normativne reforme jeste zamena Direktive o e-trgovini. Reforma bi se ogledala u donošenju tzv. Zakona o digitalnim uslugama (Digital Services Act) i Zakona o digitalnim tržištima (Digital Markets Act). Tako bi pomenutim zakonima bila predviđena obaveza platforma društvenih medija da procene rizike od zloupotrebe svojih usluga za širenje nezakonitih sadržaja, uz stvaranje mogućnosti da se ilegalni sadržaj prijavi i isti ukloni. Isto tako, mora biti predviđena procedura pomoću koje bi se oni pogođeni nelegalnim sadržajem žalili na bilo kakvo blokiranje, uz navođenje razloga blokiranja (European Parliament, 2021).

Ujedno, treba spomenuti i Evropski parlament i njegovu aktivnost u borbi protiv deepfake. Naime, Evropski parlament je 15. juna 2017. godine doneo Rezoluciju o onlajn platformama i jedinstvenom digitalnom tržištu (Resolution on online platforms and the digital single market) čime je pozvao Evropsku komisiju da usvoji stroga regulatorna sredstva o sprečavanju širenja lažnih vesti, što neminovno znači reviziju već spomenute Direktive o e-trgovini. Trećeg maja naredne godine usvojena je rezolucija pod nazivom Medijski pluralizam i medijske slobode u Evropskoj uniji (Media pluralism and media freedom in the European Union). Iako se neposredno ne odnosi na fenomen deepfake, treba istaći da rešenjima poput pune transparentnosti u korišćenju algoritama (br. 25), važnost nezavisnih i nepristrasnih sertifikovanih nezavisnih organizacija za proveru činjenica (br. 32 i 33); obaveze i instrumenti u vezi sa verifikacijom izvora (br. 32); omogućavanje korisnicima da prijave i označe potencijalne dezinformacije (br. 33) i prikazivanje i etiketiranje dezinformacija koje su otkrivene kao takve da bi se stimulisala javna debata i sprečilo ponovno pojavljivanje sadržaja, stvara dobru osnovu za dalju debatu o deepfake. Evropski parlament je nastavio sa aktivnostima koji se odnose na rešavanje problema deepfake. Tako je, na

primer, 12. februara 2019. godine doneta Rezolucija o sveobuhvatnoj evropskoj industrijskoj politici o veštačkoj inteligenciji i robotici (Resolution on a comprehensive European industrial policy on artificial intelligence and robotics) kojom se poziva Evropska komisija da uvede zahtev za označavanje proizvođača deepfake. Kako deepfake može uticati na rezultate izbora Evropski parlament je našao za shodno da se pozabavi i ovom problematikom donošenjem Preporuke od 13. marta 2019. godine Savetu i potpredsedniku Komisije/visokom predstavniku Unije za spoljnu politiku i bezbednost u vezi sa sagledavanjem aktivnosti koje je EEAS preduzela dve godine nakon izveštaja EP o strateškim pitanjima EU komunikacija kako bi se suprotstavila propagandi trećih strana (Recommendation of 13 March 2019 to the Council and the Vice- President of the Commission / High Representative of the Union for Foreign Affairs and Security Policy concerning taking stock of the follow-up taken by the EEAS two years after the EP report on EU strategic communication to counteract propaganda against it by third parties). Dvadesetog oktobra 2020. godine Evropski parlament je usvojio Izveštaj o pravima intelektualne svojine za razvoj veštačke inteligencije (Report on intellectual property rights for the development of artificial intelligence technologies). U pomenutom dokumentu naglašena je potreba podizvanja svesti i medijske pismenosti zarad smanjivanja mogućnosti manipulacije putem upotrebe deepfake. Poslednji korak u vezi načina na koji se treba boriti protiv deepfake napravljen je 19. maja 2021. godine usvajanjem Rezolucije o veštačkoj inteligenciji u obrazovanju, kulturi i audiovizuelnom sektoru (Resolution on artificial intelligence in education, culture and the audiovisual sector). Njome je kao cilj propagirano podizanje svesti o rizicima deepfake i poboljšanja digitalne pismenosti (br. 90), rešavanje sve veće teškoće u otkrivanju i označavanju lažnog i izmanipulisanog sadržaja tehnološkim sredstvima (br. 91). Ujedno, Evropska komisija je pozvana da uvede odgovarajuće pravne okvire za regulisanje stvaranja, proizvodnje ili distribucije deepfake-a u zlonamerne svrhe (br. 91). Isto tako, neophodno je raditi da daljem razvoju sposobnosti detekcije (br. 92) kao i poboljšanju transparentnosti u pogledu sadržaja koji se prikazuje korisnicima platforme i davanje im veće slobode da odluče da li i koje informacije žele da primaju (br. 93) (Johnson, 2021).

Iako nije vezana direktno za Evropsku uniju, neophodno je spomenuti Evropski Sud za ljudska prava u Strazburu i njegovu praksu koja može biti relevantna u pogledu sankcionisanja fenomena poput deepfake. Sud je napravio pionirski poduhvat donošenjem presude u slučaju von Hannover v. Germany (no. 2) iz 2009. godine (European Court of Human Rights, 2008). Naime, Sud je u presudi istakao da pravo na zaštitu imidža jedna od bitnih komponenti ličnog razvoja i pretpostavlja pravo na kontrolu upotrebe te slike. Isto tako, Sud je podvukao da sloboda izražavanja uključuje objavljivanje fotografija, ali ovo je ipak područje u kojem zaštita prava i ugleda drugih ima posebnu važnost, jer fotografije mogu sadržati vrlo lične ili čak intimne podatke o pojedincu ili njegovom ili njenoj porodici.

Naredna međunarodna organizacija, koja će biti predmet naše analize, je Svetska organizacija za intelektualnu svojinu (World Intellectual Property Organization WIPO). Iako je reč u organizaciji na svetskom nivou, razmatranje dokumenata na nivou njenih organa je vršeno nakon donošenja već navedene Uredbe od strane Evropske unije. Svetska organizacija za intelektualnu svojinu je decembra 2019. godine objavila Nacrt pitanja o politici intelektualne svojine i veštačkoj inteligenciji (Draft Issues Paper On Intellectual Property Policy And Artificial Intelligence). U Nacrtu su istaknuti određeni problemi u pogledu deepfake. Prvi problem ogleda se u tome da li deepfake može biti predmet autorskih prava i ako mogu kome pripadaju autorska prava, dok se drugi problem odnosi na postojanju eventualnog sistema pravične naknade za osobe čije se ličnosti koriste za kreiranje deepfake sadržaja. S tim u vezi Svetska organizacija za intelektualnu svojinu ističe da deepfake može rezultirati kršenjem ljudskih prava, prava na privatnost, prava na zaštitu ličnih podataka. Polazeći od ovih činjenica opravdano se postavlja pitanje da li kreatorima deepfake treba da se priznaju autorska prava ili pak autorska prava treba da se priznaju osobi čije lice je korišćeno za stvaranje sintetičke slike, odnosno video klipa. Zaključak je da ako je deepfake tako stvoren da je u potpunosti u suprotnosti sa životom žrtve ne treba biti predmet zaštite autorskih prava. Ako sa druge strane deepfake nije u potpunoj suprotnosti sa životom osobe čije je lice korišćeno, autorska prava treba da pripadaju kreatoru sintetičke slike ili video klipa. Na osnovu

navedenog možemo zaključiti da autorska prava ne treba da budu primarno oružje, jer žrtva nema nikakvo vlasništvo nad sintetičkom slikom ili klipom. Ipak, treba istaći da žrtva deepfake može uživati pravo na zaštitu ličnih podataka na osnovu člana 5 (1) već analizirane Opšte uredbe o zaštiti podataka. Naime, u pomenutom članu je napisano da lični podaci moraju biti tačni i, po potrebi, ažurirani; moraju se preduzeti svi razumni koraci kako bi se osiguralo da se lični podaci koji su netačni, s obzirom na svrhe u koje se obrađuju, izbrišu ili isprave bez odlaganja („tačnost"). Ako pažljivo analiiramo sadržaj navedenog člana možemo videti da ako je deepfake irelevantan, netačan ili lažan, neophodno ga je izbrisati ili ispraviti bez odlaganja. Čak iako je deepfake istinit ili tačan, subjekt podataka, drugim rečima žrtva, može se koristiti pravom propisanim članom 17 Uredbe (tzv. pravo na zaborav). To znači da subjekt podataka ima pravo da od kontrolora zatraži brisanje ličnih podataka bez odlaganja, dok kontrolor ima obavezi da to uradi bez odlaganja (Institute for Internet & Just Society, 2021).

**Normativni okvir deepfake u pojedinim državama**

Sjedinjene Američke Države su napravile prvi korak ka inkriminaciji deepfake. Naime, pojedine savezne države, poput Kalifornije (California) i Teksasa (Texas), su donele prve zakonske tekstove o ovom fenomenu. Tako je guverner Kalifornije Gavin Njusom (Gavin Newsom) tokom 2019. godine potpisao dva zakona u nastojanju da se bori protiv rastuće distribucije političkih i pornografskih deepfake sadržaja. Jedan od tih normativnih akata pod oznakom Skupštinski zakon 602 – Duboki lažni i seksualno eksplicitni materijal (Assembly Bill 602 – Deepfakes and Sexually Explicit Material) stvara pravnu osnovu za privatnu tužbu protiv osobe koja kreira i namerno otkriva seksualno eksplicitan materijal gde ta osoba zna ili je razumno trebalo da zna da prikazana osoba nije pristala na stvaranje ili otkrivanje. Druga mogućnost je kada se namerno otkriva seksualno eksplicitni materijal koji ta osoba nije kreirala i osoba zna da prikazana osoba nije pristala na stvaranje materijala. „Prikazani pojedinac" je pojedinac koji kao rezultat digitalizacije izvodi performans koji zapravo nije izveo ili da izvodi u izmenjenom prikazu. Stvaralac deepfake materijala će biti izuzet od odgovornosti ako je materijal otkriven u pravnom postupku, ako se prijavi nezakonita aktivnost ili ako je materijal predmet legitimnog javnog interesa, političko ili delo vredno vesti, ili je na drugi način zaštićen ustavima Kalifornije ili SAD. Drugi zakonski tekst, donet od strane kalifornijskog zakonodavca, označen je pod nazivom Zakon Kalifornije 730 (California Assembly Bill 730). Njime je izvršena dopuna Izbornog zakona ove savezne države (California Elections Code) čime je zakonodavac zabranio licu, odboru ili drugom licu da distribuira sa stvarnom zlobom u roku od 60 dana od izbora materijalno obmanjujućih audio ili vizuelnih medija kandidata na glasačkom listiću, pri čemu postoji namera da se naruši ugled kandidata ili da se prevari birač da glasa za ili protiv kandidata. Ujedno, zakonodavac je odredio šta se podrazumeva pod materijalno obmanjujućim audio ili vizuelnim medijima. Naime, ovaj materijal uključuje namerno manipulisanu sliku, audio ili video snimak kandidata koji bi razumnoj osobi lažno izgledao kao autentičan i koji bi prouzrokovao da razumna osoba ima suštinski drugačije razumevanje ili utisak ekspresivnog sadržaja nego što bi ta osoba imala da čuje ili vidi nepromenjenu, originalnu verziju sadržaja. Kao i kod prvog pomenutog zakona, i kod ovog postoje određeni izuzeci. Tako mediji nisu odgovorni ukoliko stave obaveštenje o tome da materijal nije autentičan. Drugi izuzetak odnosi se na situaciju kada je materijal distribuiran u svrhe izveštavanja, pod uslovom da oni koji distribuiraju kontekst priznaju da je njegova autentičnost dovedena u pitanje ili da ne predstavlja tačno govor ili ponašanje kandidata. Poslednji izuzetak se odnosi na materijale koji predstavljaju satiru ili parodiju (Lexology, 2021).

Naredna savezna država, koja je donela zakonske tekstove o inkriminaciji deepfake, je Teksas. Zakon pod oznakom 751 (Texas Senate Bill 751), donet 2019. godine, odnosi se na dopunu izbornog zakonodavstva ove savezne države u smislu uvođenja krivičnog dela pod nazivom stvaranje obmanjujućeg video snimka sa namerom da utiče na ishod izbora. Biće ovog krivičnog dela podrazumeva da svako ko stvori obmanjujući video s namerom da utiče na ishod izbora može biti optužen za prekršaj klase A, što podrazumeva kaznu od godinu dana zatvora u okružnoj penitencijarnoj ustanovi i novčanu kaznu do 4.000 dolara (KRW Lawyers, 2021).

Ubrzo je donet zakonski tekst na federalnom nivou koji se odnosi na deepfake. Tadašnji predsednik Donald Tramp (Donald Trump) je 20. decembra 2019. godine potpisao Zakon o nacionalnoj odbrani za fiskalnu 2020. godinu (National Defense Authorization Act) čiji se jedan deo odnosi na deepfake. Ovim zakonskim tekstom se zahteva sastavljanje sveobuhvatnog izveštaja o korišćenju deepfake-a kao vrste oružja od strane drugih država. Isto tako, zahteva se od američke Vlade da obavesti Kongres o stranim aktivnostima u vezi deepfake-a u pogledu dezinformacija koje su usmerene na izbore u SAD-u. Poslednji zahtev odnosi se na uspostavljanje takmičenja pod nazivom „Deepfakes Prize“ kako bi podstaklo istraživanje ili komercijalizaciju tehnologija za otkrivanje deepfake (JDSUPRA, 2021). Pored ovog zakonskog teksta, vredan pomena je i Zakon o identifikaciji rezultata generativnih suparničkih mreža (Identifying Outputs of Generative Adversarial Networks Act - IOGAN Act). Cilj donošenja ovog normativnog akta je pomoć ka boljem razumevanju deepfake radi sprečavanja širenja lažnih vesti, prevara i drugih štetnih primena tehnologije video manipulacije (Millennial action project, 2019).

Naredna država, koja će biti predmet naše analize u pogledu zakonskih rešenja u vezi deepfake jeste Narodna Republika Kina. Naime, kineska regulatorna tela su objavila nova pravila kojima se zabranjuje objavljivanje i distribucija lažnih vesti kreiranih tehnologijama kao što su veštačka inteligencija i virtuelna stvarnost na osnovu Zakona o sajber bezbednosti (Cybersecurity Act). Kineska uprava za sajber prostor (Cyberspace Administration of China) je nadležna da vodi računa o upotrebi deepfake-a. S tim u vezi istaknuto je od strane Uprave da svaka upotreba veštačke inteligencije ili virtuelne stvarnosti takođe mora biti jasno označena na uočljiv način. Ukoliko se ovo pravilo ne poštuje dolazi do izvršenja krivičnog dela. Ova inkriminacija je stupila na snagu 1. januara 2020. godine (First post, 2021). Takođe, zakonom je predviđena obaveza da se korisnici moraju registrovati na platformama sa informacijama koje mogu da se identifikuju kao što su lične karte ili brojevi mobilnih telefona. Isto tako, internet platforme treba da uspostave načine ulaganja žalbi koji su laki za korišćenje. U pogledu audio i vizuelnih usluga treba ispuniti industrijske standarde, pri čemu nadležni državni organi moraju da organizuju redovne inspekcije kako bi osigurale da platforme regulišu onlajn audio i video u skladu sa ugovorima o uslugama. Na ovaj način kineske vlasti smatraju da deepfake, koji može ugroziti nacionalnu bezbednost, poremetiti društvenu stabilnost, poremetiti društveni poredak i narušiti legitimna prava i interese drugih, može biti kontrolisan kako bi se sprečilo vršenje eventualnih krivičnih dela od strane 759 miliona korisnika onlajn video platformi (Tech node, 2019).

Iako države poput Tajvana nemaju normativini okvir, koji se odnosi na inkriminaciju deepfake-a, treba posebno analizirati korake koje Tajvan preduzima kako bi smanjio njihov štetni uticaj. Ovo je naročito važno ako se štetni uticaj deepfake-a posmatra kroz prizmu težnje Narodne Republike Kine da povrati suverenitet nad ostrvom. S tim u vezi vlasti su preduzele aktivnosti protiv Kine na taj način što su zabranili upotrebu medijskih platformi, kao što su iKIII (Baidu-ova video platforma) i Tencent video. Razlog zabrane leži u činjenici da su kineske vlasti koristile ove platforme za širenje dezinformancija u vezi predsedničkih izbora održanih u januaru 2020. godine. Nosioci borbe protiv dezinformacija i deepfake-a su organizacije civilnog društva kao što su Tajvanski centar za proveru činjenica (The Taiwan FactCheck Center) ili Čistač lažnih vesti (The Fakenews Cleaner) (Army University Press, 2021). Poslednji slučaj u vezi zloupotrebe deepfake-a odnosi se na člana tajvanskog parlamenta Kao Čiaju (Kao Chia-yu) i gradskog odbornika Huang Jia (Huang Jie) čija lica su korišćena za lažne pornografske snimke. Ova afera će nesumnjivo ubrzati napore tajvanskog parlamenta da donese odgovarajuće normativne akte u vezi deepfake-a. Prema postojaćem zakonodavnom okviru tvorci deepfake u konkretnom slučaju bi snosili više nego simboličnu kaznu od 9.000 NT$ (280 evra) za javnu uvredu, dok bi distribueri mogli biti osuđeni na kaznu zatvora od dve godine koja se može pretvoriti u ili joj se dodati novčana kazna od 90.000 NT$ (2800 evra). Stoga je napravljen predlog za izmenu tamošnjeg krivičnog zakonodavstva. Prema postojećem predlogu za distribuciju intimnog sadržaja bez pristanka osobe predviđena je maksimalna kazna od sedam godina, a još teža zatvorska kazna ako postoji namera da se sadržaj iskoristi za profit (Focus Taiwan, 2021).

Još jedna azijska zemlja napravila je korake ka inkriminaciji deepfake-a. Naime, Južna Koreja je visoko razvijena zemlja sa svim blagodetima savremenog društva. Međutim, ti blagodeti

nose sa sobom opasnosti u vezi zloupotrebe deefake-a. Bilo je više skandala u kojima su se slike poznatih ličnosti upotrebljavale za kreiranje lažnih pornografskih snimaka. Nakon peticije građana da se ovaj fenomenom inkriminiše, vlasti su preduzele izmene krivičnog zakonodavstva čime je uvedeno krivično delo kojim je zabranjena zloupotreba deepfake-a uz kaznu do pet godina zatvora ili novčanu kaznu do 50 miliona vona (47.420 evra). Ako je krivično delo učinjeno radi imovinske koristi, zatvorska kazna se može povećati na sedam godina (Deutsche Welle, 2021).

Poslednji, ali ne i najmanje značajni primer ne predstavlja normativno rešenje, ali svakako jeste primer dobre prakse i jedno od rešenja kontrolisane upotrebe deepfake-a. U Amsterdamu, počev od 2018. godine, postoji Deeptrace – kompanija za sajberbezbednost, koja se bavi proučavanjem deepfake materijala, te radi na osmišljavanju programa za prepoznavanje i onlajn praćenje veštačkih medija. Cilj kompanije jeste zaštita pojedinaca i organizacija od potencijalnih štetnih uticaja koje mogu da izazovu veštački mediji. U te svrhe kompanija izdaje nedeljni časopis i iznosi stručni pregled trenutnog stanja, podatke o najnovijim deepfake sadržajima i ukazuje na novonastale sajber pretnje koje mogu da utiču na stvarnost (Ajder et al., 2019).

**Analiza pozitivnog zakonodavsta u Republici Srbiji u pogledu deepfake**

Nakon predstavljanja normativnih rešenja u vezi inkriminacije deepfake-a u pojedinim državama u prethodnom delu rada, neophodno je izvršiti analizu postojećih normativnih rešenja u Republici Srbiji kako bi se ustanovilo da li postoji potreba da zakonodavac preduzima određene korake s ciljem zaštite od zloupotrebe deepfake-a. S tim u vezi analizu normativnih rešenja u Republici Srbiji počećemo od Krivičnog zakonika (Krivični zakonik [KZ], 2019). Naime, u okviru glave XVIII KZ pod nazivom krivična dela protiv polne slobode inkriminisano je krivično delo prikazivanje, pribavljanje i posedovanje pornografskog materijala i iskorišćavanje maloletnog lica za pornografiju. Prvi oblik ovog krivičnog dela glasi da lice koje maloletniku proda, prikaže ili javnim izlaganjem ili na drugi način učini dostupnim tekstove, slike, audio-vizuelne ili druge predmete pornografske sadržine ili mu prikaže pornografsku predstavu, kazniće se novčanom kaznom ili zatvorom do šest meseci (stav 1 člana 185). Kod prvog oblika ovog krivičnog dela je nesporno da se njime ne pruža nikakva zaštita od zloupotrebe deepfake-a.

Međutim, drugi oblik može da stvori osnov za delimičnu inkriminaciju deepfake-a. Biće drugog oblika ovog krivičnog dela odnosi se na situaciju da lice koje iskoristi maloletnika za proizvodnju slika, audio-vizuelnih ili drugih predmeta pornografske sadržine ili za pornografsku predstavu, kazniće se zatvorom od šest meseci do pet godina (stav 2 člana 185). Kako bismo doneli pravi zaključak o tome da li je drugim oblikom ovog krivičnog dela pružena krivičnopravna zaštita maloletniku u pogledu zloupotrebe deepfake-a neophodno je analizirati sve elemente bića krivičnog dela. Nesporno je da je predmet ovog krivičnog dela tzv. pornografski predmeti pod čime se podrazumevaju spisi, slike, audio-vizuelni i drugi predmeti čija se sadržina odnosi na seksualni život (Lazarević, 2006). Drugim rečima, i sam zakonodavac je odredio šta se smatra predmetima pornografske sadržine. Tako se predmetima pornografske sadržine nastalim iskorišćavanjem maloletnog lica (dečija pornografija) smatra svaki materijal koji vizuelno prikazuje maloletno lice koje se bavi stvarnim ili simuliranim seksualno eksplicitnim ponašanjem, kao i svako prikazivanje polnih organa deteta u seksualne svrhe (stav 6 člana 185). Na osnovu ovoga možemo zaključiti da bi se deepfake, koji se odnosi na pornografski sadržaj, mogao podvesti pod predmet ovog krivičnog dela, čime bi bila pružena krivičnopravna zaštita maloletniku. Međutim, istovremeno možemo zaključiti da znatno veća kategorija ljudi ne uživa krivičnopravnu zaštitu od zloupotrebe deepfake-a.

Isto tako, naredni oblik ovog krivičnog dela, koji glasi da ako je krivično delo izvršeno prema detetu, učinilac će se kazniti zatvorom od jedne do osam godina (stav 3 člana 185). Međutim, postavlja se pitanje koja bi bila motivacija kreatora deepfake-a da koriste resurse kako bi stvorili generisanu sliku ili video snimak sa likom deteta, osim ako je u pitanju dete nekog poznatnog para ili je samo dete poznato. Uvek motivacija može imati seksualnu konotaciju ali bitno je napomenuti da živimo u dobu kada se uz veću kompjutersku pismenost lako može doći do dečije pornografije.

Zakonodac je u stavu 4 člana 185 inkriminisano pribavljanje za sebe ili drugog, posedovanje, prodaju, prikazivanje, javno izlaganje ili elektronski ili na drugi način činjenje dostupnim slike, audio-vizuelne ili druge predmete pornografske sadržine nastale iskorišćavanjem maloletnog lica, pri čemu je propisana kazna zatvora od tri meseca do tri godine. Na taj način bi se sprečila dalja distribucija deepfake materijala kod kojih su žrtve maloletna lica.

Borba protiv deepfake-a kod kojih su viktimizirana maloletna lica pojačana je postojanjem petog oblika ovog krivičnog dela. Naime, u stavu 5 člana 185 propisano je da ko pomoću sredstava informacionih tehnologija svesno pristupi slikama, audio-vizuelnim ili drugim predmetima pornografske sadržine nastalim iskorišćavanjem maloletnog lica, kazniće se novčanom kaznom ili zatvorom do šest meseci. Time bi bilo sprečeno da druga lica pristupaju deepfake materijalu nastalom iskorišćavanjem maloletnog lica.

Pored maloletnih lica, žrtve deepfake su najčešće osobe ženskog pola, ali su zabeleženi slučajevi da su žrtve i muškarci. S tim u vezi neophodno je izvršiti analizu postojećeg zakonodavstva kako bi se ustanovilo da li postojeće inkriminacije pružaju ženama bilo kakav vid zaštite zloupotrebom njihovog lika u vidu deepfake-a.

U glavi XIX KZ pod nazivom krivična dela protiv braka i porodice inkrimisano je u članu 194 krivično delo nasilja u porodici. Analizom svih oblika krivičnog dela nasilja u porodici možemo zaključiti da ne postoji osnov po kojem bi moglo doći do kažnjavanja lica odgovornog za kreiranje deepfake-a u pornografske ili bilo koje duge svrhe, a s ciljem vršenja nasilja.

Kako je praksa pokazala da deepfake može da se koristi i kao sredstvo za obračun sa političkim protivnicima, postavlja se pitanje da li je zakonodavac u glavi XV pod nazivom krivična dela protiv izbornih prava predvideo osnov za njegovu inkriminaciju. Analizom krivičnih dela predviđenih u ovog glavi nameće se zaključak da ne postoji nijedno od krivičnih dela u kojima postoji inkriminacija deepfake-a.

Slična je situacija i kod glave XVII pod nazivom krivična dela protiv časti i ugleda. Ni krivično delo uvreda, propisano članom 170 KZ, ni krivično delo iznošenje ličnih i porodičnih prilika, propisano članom 172 KZ, ne predstavljaju osnov kojim se deepfake zabranjuje. Kako deepfake nastaje upotrebom kompjuterskih programa neophodno je izvršiti uvid i u krivična dela iz glave XXVII pod nazivom krivična dela protiv bezbednosti računarskih podataka. Kod krivičnog dela oštećenje računarskih podataka i programa iz člana 298 KZ možda može da postoji osnov za inkriminaciju deepfake-a. Naime, ko neovlašćeno izbriše, izmeni, ošteti, prikrije ili na drugi način učini neupotrebljivim računarski podatak ili program, kazniće se novčanom kaznom ili zatvorom do jedne godine.

Da bismo uvideli da li se pod ovim krivičnim delom može podvesti zloupotreba deepfake-a moramo ustanoviti šta se podrazumeva pod terminom računarski podatak. Tako se pod računarskim podatkom, kako je to predvideo zakonodavac u stavu 17 člana 112 KZ, podrazumeva svako predstavljanje činjenica, informacija ili koncepta u obliku koji je podesan za njihovu obradu u računarskom sistemu, uključujući i odgovarajući program na osnovu koga računarski sistem obavlja svoju funkciju. Drugim rečima, ključno pitanje je da li se slika i video klip mogu smatrati računarskim podatkom. Konsultovanjem stručne literature iz oblasti informatike možemo doneti zaključak da slika i video klip predstavljaju nenumerički podatak koji sadrži neku informaciju koja se u spoljnom svetu ne može predstaviti brojevima (Računarstvo i informatika, 2021). Kako smo otklonili sumnju da li se slika može smatrati raučunarskim podatkom, neophodno je izvršiti analizu elemenata bića ovog krivičnog dela. Radnja izvršenja ogleda se u brisanju, izmeni, oštećivanju, prikrivanju ili na drugi način činjenjem neupotrebljivim računarski podatak ili program. Deepfake podrazumeva izmenu postojećih slika ili video klipova upotrebnom drugih slika. To znači da se jedna od radnja izvršenja ovog krivičnog dela, a to je izmena, može navesti kao osnov za stvaranje deepfake materijala. Još jedna dilema u vezi toga da li se ovo krivično delo može koristiti kao osnov za inkriminaciju deepfake-a jeste i šta se podrazumeva pod posledicom njegovog izvršenja kako je to predviđeno u članu 298 KZ. Naime, posledica izvršenja ovog krivičnog dela ogleda se u činjenju neupotrebljivim računarski podatak ili program. Drugim rečima, činjenje neupotrebljivim odnosi se na situaciju kada je računarski podatak doveden u takvo stanje da za određeno vreme ne može da služi svojoj nameni (Jovašević, 2003). Kako deepfake nema za posledicu neupotrebljivost

slike ne može se reći da postoji istovetnost posledica. Posmatrajući posledicu izvršenja ovog krivičnog dela možemo zaključiti da se deepfake ne može podvesti pod krivično delo oštećenje računarskih podataka i programa iz člana 298 KZ.

Ukoliko bismo izvršili uvid u druge zakonske tekstove, poput Zakona o zaštiti podataka o ličnosti (Zakon o zaštiti podataka o ličnosti [ZZPL], 2018), Zakona o izboru narodnih poslanika (Zakon o izboru narodnih poslanika [ZINP], 2020) i Zakon o lokalnim izborima (Zakon o lokalnim izborima [ZLZ], 2020), mogli bismo da donesemo isti zaključak. Nigde nije inkriminisana zloupotreba deepfake-a.

Na osnovu svega navedenog neophodno je u što kraćem periodu inkriminisati deepfake, jer njegova zloupotreba može dovesti do katastrofalnih posledica o kojima je bilo reči u prethodnom delu rada. Na taj način bi zakonodavac išao u korak sa vremenom i pružio dodatnu krivičnopravnu zaštitu licima čije su slike iskorišćenje generisanje lažnih slika i snimaka čime može doći do narušavanja njihovog ugleda. Kako se deepfake može koristiti sa različitom motivacijom potrebno je predložiti dve nove izmene. Naime, deefake se može koristiti kao jedan od oblika nasilja, pri čemu bi nova inkriminacija glasila: "Ko iskoristi sliku nekog lica za stvaranje obmanjujuće slike, audio ili video snimka sa namerom da utiče na njegov ugled, kazniće se kaznom zatvora od godinu dana do pet godina." Međutim, ako bi motivacija bila uticanje na rezultate izbora predlog kako bi inkriminacija deepfake-a mogla da glasi je sledeća: "Ko iskoristi sliku nekog lica za stvaranje obmanjujuće slike, audio ili video snimka sa namerom da utiče na ishod izbora, kazniće se kaznom zatvora od godinu dana do pet godina." Ovime bi se pružila adekvatna inkriminacija, pri čemu bi zakonodavac pratio trendove u krivičnopravnoj teoriji i praksi i zaštitio sve ljude od situacije da se njihova slika ili lik zloupotrebljavaju.

## ZAKLJUČCI

Deepfake kao generisana slika ili snimak stvorio je potpuno novo polje na osnovu kojeg je moguće uticati na nečiji ugled i reputaciju. Najčešće žrtve deepfake su žene predstavljenje u kompromitujućim snimcima čime su muškarci, kao njegovi najčešći kreatori, samo povećali načine na osnovu kojih je moguće vršiti nasilje nad ženama. Bitno je naglasiti da su zabeleženi slučajevi zloupotrebe deepfake kao vid političkog obračuna sa neistomišljenicima. Navedeni primeri zloupotrebe deepfake-a nam ukazuju na javljanje jednog sasvim novog fenomena na koje države širom sveta nemaju adekvatan odgovor.

Evropska unija je najdalje odmakla u stvaranju normativnih akata kojima se bori protiv deepfake-a. Još jedino Svetska organizacija za intelektualnu svojinu je prepoznala potrebu donošenja odgovarajućih akata. Pored međunarodnih organizacija pojedine države su napravile prve korake ka inkriminaciji deepfake-a. Najviše u tome su odmakle Sjedinjene Američke Države. Još neke države su napravile slične korake. Očekuje se u budućnosti da i druge države širom sveta počnu da zabranjuju deepfake dok se ne dogodi neka kritična situacija sa njegovom zloupotrebom.

Analiza krivičnog zakonodavstva Republike Srbije pokazuje da jedino krivično delo prikazivanje, pribavljanje i posedovanje pornografskog materijala i iskorišćavanje maloletnog lica za pornografiju može da obezbedi parcijalnu zaštitu od zloupotrebe deepfake-a, što je svakako nedovoljno kako bi se sprečile sve eventualne mogućnosti njegove zloupotrebe. Stoga je neophodno što pre da zakonodavac izvrši izmene krivičnog zakonodavstva u pravcu inkriminacije deepfake-a. Na taj način bi Republika Srbija išla u korak sa vremenom čime bi se obezbedila adekvatna krivičnopravna zaštita svih njenih građana.

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# DEEPFAKE AS A NEW FORM OF CRIMINALITY

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**ABSTRACT**

Lies are not unknown to humanity, they are as old as humanity itself, but the dimensions of the consequences that lies can reach today, with the use of modern technologies, have greatly increased. Recently, the use of modern technologies has created another means on the basis of which it is possible to create and distribute false content faster and easier, which can be used to undermine basic human rights. This tool is known as Deepfake and is used to tag photos, audio and video recordings that contain content that never happened in reality. In the continuation of the work, the authors explain the appearance of deepfakes. Certain international organizations, such as the European Union and the World Intellectual Property Organization, have recognized the necessity of reactions to this phenomenon. After analyzing the legal documents of international organizations, the authors turn to the presentation of normative solutions regarding the incrimination of deepfake in certain countries. The last part of the paper is dedicated to whether, according to the existing legislation of the Republic of Serbia, deepfake can be classified as a criminal offense.

**Keywords**: deepfake, criminality, Republic of Serbia.

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# BEZBJEDNOSNI IZAZOVI I PRIJETNJE U LOKALNOJ ZAJEDNICI - STUDIJA SLUČAJA OPŠTINA FOČA

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## SAŽETAK

Interes ljudi oduvijek je bio da budu bezbjedni i da mjesto u kojem žive i rade ima visok stepen bezbjednosti. Bezbjedna lokalna zajednica preduslov je razvoja i opstanka, a posebno u današnje vrijeme koje karakteriše veliki broj različtih bezbjednosni izazova i prijetnji. Prioritet ljudi je da u lokalnoj zajednici u kojoj žive mogu da zadovolje svoje potrebe i ostvare svoja prava i interese. Svaki oblik ugrožavanja bezbjednosti u lokalnoj zajednici budi interesovanje građana, što je svojevrstan alarm za lokalnu samoupravu, ali i organe bezbjednosti. Organi lokalne samouprave u lokalnoj zajednici u obavezi su da se bave pitanjima koja su od značaja za njihove građane i da pitanja koja su u nadležnosti drugih organa i službi iniciraju da se ona pravovremeno rješavaju. Pitanje bezbjednosti u lokalnoj zajednici je u nadležnosti lokalne policije, koja takođe ima za cilj da lična i imovinska bezbjednost građana bude na najvećem mogućem nivou. Različiti su bezbjednosni izazovi i prijetnje koje ugrožavaju građane u lokalnoj zajednici i oni se prvenstveno razlikuju u odnosu na specifičnosti same lokalne zajednice, prije svih geografske, demografske, kulturološke, etičke, etničke, industrijske, socijalne i sl. Ovaj rad ima za cilj ne samo da ukaže na pojmovno određenje lokalne zajednice i bezbjednosnih izazova i prijetnji, nego i da ukaže na sam značaj bezbjednog ambijenta u kome ljudi žive. Takođe, u radu će se prikazati percepcija različitih bezbjednosni prijetnji, kao i njihovo rangiranje po stepenu opasnosti od strane građana u opštini Foča.

**Ključne riječi**: bezbjednost, bezbjednosni izazov, bezbjednosna prijetnja, lokalna zajednica, lokalna samouprava.

## UVOD

Čovjek kroz svoj razvojni ciklus, od davne prošlosti pa evo i sada, neprestano iskazuje potrebu za bezbjednošću. Ta potreba za bezbjednošću podjednako je usmjerena kako na njegovu ličnu, tako i na njegovu imovinsku bezbjednost. Mjesto gdje čovjek živi i najdirektnije ostvaruje svoja prava i interese je lokalna zajednica. Na tom nivou organizovanja ljudi, najbolje se može ostvariti i sam uvid u stanje bezbjednosti. Bezbjedan ambijent, je preduslov ne samo razvoja, nego i opstanka uopšte. Vrijeme u kojem živimo, kao i vrijeme koje je pred nama prepuno je različitih bezbjednosnih izazova i prijetnji koje su sa aspekta bezbjednosti veoma bitne. Te bezbjednosne prijetnje nisu iste na nivou lokalne zajednice i na nivou države, a niti su bezbjednosne prijetnje identične u različitim lokalnim zaajednicama. Tako, uglavnom su bezbjednosni prioblemi povezani sa samim specifičnostima lokalnih zajednica, a te specifinosti mogu biti geografske, demografske, industrijske, etičke, etničke, kulturološke, socijalne, ekonomske i druge prirode. Najednostavnije rečeno, ono što jednu lokalnu zajednicu ugrožava, ne mora da znači da će ugrožavati i drugu (npr. lokalne zajednice koje graniče sa državnom granicom predpostavlja se da će imati problema sa prekograničnim kriminalom, krijumčarenjem, dok te probleme neće imati lokalne zajednice u dubini države, koje nemaju granicu koja je neposredno uz njenu teritoriju i sl.). Za bezbjedan ambijent na nivou lokalne zajednice zaduženi su subjekti bezbjednosti, pre svih policija i pravosudni organi. Međutim, veoma bitnu ulogu igraju i drugi suplementarni subjekti bezbjednosti, koji se isključivo ne bave samo bezbjednošću, nego oni kroz svoj rad i djelovanje na ovom nivou organizovanja ljudi doprinose ostvarivanju funkcije bezbjednosti. Tu se prije svega misli na

lokalnu samoupravu, njene inspekcijske organe, medije, vjerske zajednice, privredne subjekte, nevladine organizacije i sl. Kako navodi Marinković lokalna samouprava predstavlja „Ustavom i zakonom zajamčeno pravo građana da u jedinicama lokalne samouprave neposredno i preko svojih demokratskih izabranih organa, samostalno upravljaju određenom vrstom javnih poslova“ (Marinković, 1998, str. 16). Lokalna samuprava kroz svoje djelovanje, kroz lokalni parlament, ali i preko svojih organa i službi veliki dio stvari uređuje na nivou lokalne zajednice. Rad lokalnih organa, preduzeća koji pružaju usluge, kao i drugih stručnih organa, utiče i na kvalitet života građana, a što se odražava i na samu bezbjednost. Nezadovoljstvo građana stepenom dobijenih usluga i kvalitetom zadovoljenja svojih potreba i ostvarivanju svojih prava mogu da proizvedu određene bezbjednosne izazove i prijetnje koje se ogledaju kroz različite oblike građanske neposlušnosti, građanske proteste i nemire, različite oblike nedoličnog i nedozvoljenog ponašanju u vidu činjenja prekršaja, a ponekad i krivičnih djela. Najjednostavnije rečeno, bezbjednost na nivou lokalne zajednice ne može se posmatrati odvojeno od aktivnosti lokalne samouprave, od spečifičnosti lokalne zajenice, ali i od stepena zadovoljenja elemetranih životnih potreba ljudi i ostvarivanju njihovih prava i interesa.

## BEZBJEDNOST U LOKALNOJ ZAJEDNICI

Danas se u javnom diskursu mnogo govori i piše o bezbjednosti. O njoj govore ne samo ljudi koji se bave bezbjednošću, nego i drugi koji se najdirektnije ne bave bezbjednošću kao što su ekonomisti, sportisti, pisci, pravnici, kao i ljudi uopšte. Bezbjednost posebno dobija na značaju danas u savremenom globalizovanom svijetu. Sa aspekta ostvarenja nivoa bezbjednosti možda se to najbolje može predstaviti na nivou same lokalne zajednice, kao uređene teritorijalne jedinice koja se veže za geografski prostor. U kontekstu navedenog vrijedno je viđenje Musabegovića i dr. koji smatraju da „termin „lokalna“ u određenju zajednice ukazuje na egzistenciju u fizičkom prostoru, čija veličina može biti različita, mada u odnosu na teritorij na kome je konstituirana država mora biti mnogo manji“ (Musabegović i sar., 1999, str. 12-13). Isti autori navode da u pojmovnom određenju lokalne zajednice „neophodno je poći od toga da je to takva ne samo teritorijalna nego i socijalna zajednica koja predstavlja najniži nivo na kome se rađaju zajedničke potrebe individua koje tu žive i to one koje nije moguće zadovoljiti bez zajedničke akcije ljudi“ (Musabegović i sar., 1999). Za razliku od ovih autora, nešto drugačije određenje i samo viđenje daje Pusić i Pejanović. Prema Pusiću „značenje lokalnih zajednica ne proizilazi iz onog što one danas jesu, nego iz onog što bi ljudi htjeli da one budu, iz uloga koje im se namjenjuju i zadataka koji im se pripremaju. Voluntaristička, teološka metoda otvara ovdje plodniju perspektivu od empirijske. Lokalna je zajednica, u neku ruku, „sve i ništa“, u njoj se krije zametak svega mogućeg u društvenom pogledu i u tom svom bogatstvu mogućnosti ona je beskonačno privlačna za socijalnu sekulaciju” (Pusić, 1963, str. 37). U samom određenju lokalne zajednice Pejanović i Sadiković navode da u savremenoj sociološkoj teoriji „lokalna zajednica se definiše kao određena teritorijalna cjelina u kojoj građani posredstvom vlastitih i zajedničkih resursa, zadovoljavaju najveći dio svojih potreba. Lokalna zajednica je oblik udruživanja ljudi - koji okupljajući se oko zajedničkih problema, interesa, potreba i vrijednosti - stupaju u različite socijalne interakcije, razvijajući svijest o pripadnosti toj zajednici“ (Pejanović i Sadiković, 2010, str. 14). Dalje, prema ovim autorima „brojne teorije i naučne studije na različite načine definišu samu bit lokalne zajednice oslanjajući se na različita društvena rješenja, te stoga dolazi i do različitih shvatanja o lokalnoj zajednici, odnosno do različitih shvatanja o ulozi i perspektivi lokalnih zajednica u savremenom svijetu“ (Pejanović i Sadiković, 2010). Iz ovih definicija u vezi lokalne zajednice vidljivo je da se ovdje prvenstveno govori o jednoj vrsti elemenata koji čine lokalnu zajednicu, ka što su prostor, odnosno teritoriji, ljudima koji tu žive, kao i potrebama i i nteresima koje oni zadovoljavaju i ostvaruju. Kako kaže Musabegović i dr. evidentno je da su jedan od konstitutivnih elemenata lokalne zajednice ljudi koji naseljavanjem određene teritorije formiraju naselje kao društvenu zajednicu gdje žive, rade i stanuju iz čega proizilazi da je “lokalna zajednica životni prostor u kome njeni članovi zadovoljavaju svoje egzistencijalne potrebe” (Musabegović i sar., 1999, str. 15). Lokalna vlast na nivou lokalne zajednice igra posebnu ulogu i kada je bezbjednost u pitanju. Tako prema mišljenju Erkića „predstavnici lokalnih vlasti posljednjih decenija igraju

važnu ulogu u razvoju društvene bezbjednosti u zemljama širom svijeta te i sami počinju sagledavati bezbjednost svojih područja kao temeljno pravo građana i kao jedan od najvažnijih aspekata u kvaliteti života. Građani od lokalnih vlasti očekuju inicijativu i odgovornost u rješavanju ključnih problema zajednice s obzirom na to da su nosioci lokalne vlasti najbliži nivo vlasti samim građanima zbog čega su u najboljoj poziciji za neposredan rad s lokalnim grupama s ciljem razvoja učinkovitih programa koji se temelje na potrebama i kapacitetima zajednice. Razvoj takvih programa, temeljenih na potrebama i obilježjima zajednice, je prepoznat kao najuspješniji način rješavanja problema. Pritom se ne smije zaboraviti na nacionalne politike i strategije koje daju okvir i pravac djelovanja. Ali, djelovanje na lokalnom nivou je ključno za planiranje i provedbu aktivnosti koje su usmjerene na izgradnju i održavanje bezbjednije i snažnije lokalne zajednice" (Erkić, 2017, str. 451). Lokalna zajednica u cilju postizanja što veće bezbjednosti mora da preduzima niz aktivnosti. Tako, prema Bjelošu i dr. „da bi zajednica bila bezbjedna, između ostalog, mora:

- razvijati partnerstva aktera zajednice, pri čemu partnerstvo ne samo da sublimira nivo saradnje, već esencijalno utiče na volju aktera zajednice da grade, u okviru svog domena, bezbjednost okruženja, relacije bezrezervnog povjerenja i odgovornosti u poboljšanju bezbjednosti i sigurnosti;
- preventivno pristupiti problemima u zajednici, ustupanjem neophodnih informacija za kreiranje proaktivnih mehanizama i instrumenata sa ciljem prevencije i redukcije;
- problemski orijentisati rad, što znači ostvariti sintezu interaktivnog pristupa više aktera u prepoznavanju i rešavanju konkretnih bezbednosnih problema;
- uspostaviti komunikacijski proces kroz aktivnu razmjenu informacija među akterima, posebno u većim gradovima, gde su takvi subjekti često otuđeni i nepoznati jedni drugima;
- poštovati specifičnosti lokalne zajednice i mogućnost da različite lokalne zajednice imaju specifične potrebe;
- razvijati visok nivo tolerancije između subjekata zajednice, što predstavlja proces koji kreira uslove za razvoj i poboljšanje povjerenja koje ti subjekti imaju međusobno;
- postojati odgovornost svih subjekata zajednice za bezbednosne uslove u zajednici, što se izražava savesnijim pristupom događajima i fenomenima, kao i obavezom učešća u aktivnostima u vezi sa kreiranjem i poboljšanjem boljeg okruženja za život građana" (Bjeloš et al., 2011, str. 7).

Kao što je bitno za lokalnu zajednicu da se ukaže na pojmovno određenje, isto tako bitno je ukazati i na samo određenje bezbjednosti. Danas u stručnoj literaturi nailazimo na mnoga određenja bezbjednosti, međutim, evidentna je jedna vrsta različitosti kod autora, koji se najvećim dijelom određuju u odnosu na objekat ili vrijednost koja se štiti. Još uvijek univerzalne definicije koja određuje bezbjednost nema, ali je potrebno ukazati na neke od njih radi boljeg razumijevanja njenog značaja, posebno značaja na nivou lokalne zajednice. U kontekstu određenja bezbjednosti vrijedno je viđenje Mijalkovića i Keserovića, koji kažu „gotovo da nema riječi kao što je bezbjednost, koja se više koristi u savremenom životu, a da je pojam koji se njome označava istovremeno manje određen i jasan. Ovaj termin podjednako upotrebljavaju teoretičari bezbjednosnih nauka u najširem smislu, ali i političari, predstavnici državnih vlasti, međunarodnih organizacija i nevladinog sektora, industrijalci, poljoprivrednici, medicinari, ekolozi, prosvjetari, pravnici, ekonomisti, meteorolozi, građani..., kao i policajci, vojnici, obavještajci, tužioci, sudije i slične profesije" (Mijalković i Keserović, 2010, str. 38). Za razliku od ovih autora Ejdus je stanovišta da se „pojam bezbjednosti i obogatio, tako da se sada ne razmatra samo sa stanovišta strategijskih studija u cilju „rješavanja problema" već i sa stanovišta filozofije, sociologije, antropologije i drugih društvenih disciplina u cilju kritičkog preispitivanja izvora (ne)bezbednosti" (Ejdus, 2012, str. 55). Dosta korektnu i potpunu definiciju bezbjednosti, uvažavajući pri tome i samo ugrožavanje bezbjednosti, daje Stajić, prema kome se bezbjednost definiše kao „svojstvo nekog realnog društvenog, prirodnog ili tehničkog subjekta (bića, tvorevine ili stvari) ispoljeno kao uspostavljeno, održano ili unapređeno stanje i (ili) vrijednost, a koja se izražava kroz ispunjenost

minimuma određenih (bezbjednosnih) standarda svojstvenih tom subjektu, a koji mu omogućavaju realnu osnovu za opstanak, rast i razvoj bez obzira na nosioca, oblik, vrijeme i mjesto mogućeg ugrožavanja“ (Stajić, 2008, str. 173).

## BEZBJEDNOSNE PRIJETNJE I IZAZOVI - OPŠTINA FOČA

Svaka lokalna zajednica, kao teritorijalno uređena cjelina sureće se pored ostalog i sa bezbjednosnim izazovima i prijetnjama koji su svojstveni njoj. Prvenstveno izazovi i prijetnje bezbjednosti uslovljeni su samim specifičnostima lokalne zajednice koje mogu biti različite. Samo određenje bezbjednosnog izazova i prijetnje, kao i pojam bezbjednosti nije unificirano i jedinstveno. Kako navodi Maksimović „bezbjednosni izazov označava potencijalnu opasnost ili potencijalni oblik ugrožavanja bezbjednosti štićene vrijednosti, odnosno, izazov je stanje koje predhodi prijetnji, a prijetnja je materijalizacija izazova. Riječ je o najnižem nivou opasnosti po objekat bezbjednosti, koji može ali ne mora da bude izvor bezbjednosnih rizika i prijetnji, budući da je početna vrijednost izazova neutralna“ (Maksimović, 2014, str. 133). U kontekstu bezbjednosnih izazova vrijedno je viđenje Mijalkovića i Keserovića koji smatraju da „s obzirom na to da predstavljaju tzv. apstraktnu opasnost, po svojoj prirodi ovi su fenomeni zapravo izvori ugrožavanja bezbjednosti. Tako se često raspravlja o demografskim izazovima, ekološkim izazovima, izazovima siromaštva, izazovima etničkog, vjerskog, rasnog i kulturnog identiteta, izazovima društveno-ekonomskih i političkih tranzicija, izazovima globalizacije, izazovima migracija, izazovima reformi sektora bezbjednosti itd. Činjenica da se od navedenih nivoa ugrožavajućih pojava najsporije razvijaju, ukazuje na to da ih je lakše blagovremeno identifikovati i spriječiti, odnosno kontrolisati“ (Mijalković i Keserović, 2010, str. 111). Za razliku od izazova prijetnja je konkretnija. Tako, prema Lisici prijetnja „predstavlja kombinaciju namjere i sposobnosti protivnika da poduzmu akcije koje mogu biti štetne po imovinu i stanovništvo“ (Lisica, 2011, str. 15). Ipak, prijetnja se može definisati kao „svesna namera uzrokovanja štete nekoj osobi, svojini ili pravu, da bi prinudila objekat pretnje da ispuni nametnuto ponašanje“ (Bajagić, 2007, str. 132). Dakle, može se reći za prijetnju da je „to namera nanošenja konkretne štete ili kazne, naznaka da nešto blisko nepoželjno i neprijatno dolazi, noseći u sebi direktne negativne posledice“ (Bajagić, 2007).

U kontekstu bezbjednosnih izazova i prijetnji rađena je studija slučaja u opštini Foča, na uzorku od 100 ispitanika, korišćena metoda anketiranja, instrument metode je bio anketni upitnik, koji je bio anonimnog karaktera. Ovdje je preliminarnim pregledom popunjenosti anketnih listova, konstatovano da sedam anektnih listova nisu uredno popunjeni, usljed čega oni nisu ni korišćeni u analizi, tako da su preostala 93 anketna upitnika korišćena u analizi dobijenih rezultata. Kada je u pitanju starosna populacija ispitanika iz Foče, osam ispitanika su od 18 – 24 godine starosti, 29 ispitanika su starosti od 25 –39 godina starosti, zatim 36 ispitanika je starosti od 40 do 54 godine, dok je sledeća starosna struktura ispitanika od 55 do 64 godine i ispitanika te starosne populacije je 11. Preko 65 godina je 9 ispitanika. Od ukupnog broja ispitanika iz Foče, 52 ispitanika su ženskog pola, dok je preostali broj ispitanika muškog pola.

Ni jedan ispitanik iz Foče nije naveo da nema završenu osnovnu školu, 12 ispitanika su navela da imaju završenu samo osnovnu školu, 57 ispitanika su naveli da imaju završenu srednju školu, 18 ispitanika su naveli da imaju završeno fakultetsko obrazovanje, te 6 ispitanika su naveli da imaju zvanje magistra ili doktora nauka. Tačno polovina ispitanika iz Foče su bošnjačke nacionalnosti, 29 ih je srpske nacionalnosti, šest ispitanika su hrvatske nacionalnosti, tri ispitanika su crnogorske nacionalnosti, dok ih se preostali dio nije izjasnio u pogledu nacionalne pripadnosti. Kada je u pitanju distribucija ispitanika iz Foče u odnosu na aktuelno mjesto prebivališta, 29 ispitanika iz Foče u sadašnjem mjestu stanovanja živi oduvijek, dok ih 46 u navedenom mjestu prebivališta živi kao povratnik, a preostali broj ispitanika u sadašnjem mjestu prebivališta žive kao raseljena lica. Nešto više od polovine, odnosno 52 ispitanika su izjavila da su zaposleni, dva ispitanika se na ovo pitanje nisu izjasnili, dok su preostali ispitanici iz Foče nezaposleni. Od 52 ispitanika koji su izjavili da su zaposleni, oko tri petine su izjavili da su zaposleni u javnom sektoru. Od ispitanika koji su izjavili da nisu zaposleni, 24 je izjavilo da im je zaposlen uži član porodice, po pet ispitanika su naveli da dobijaju pomoć familije i da primaju penziju, dok su

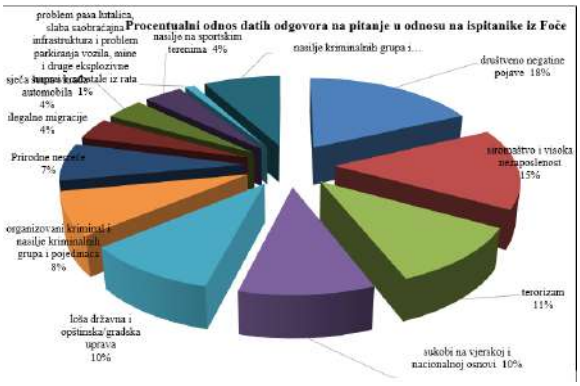
preostali naveli da rade na poljoprivredi ili kao drugi izvor primanja. Pet ispitanika iz Foče su naveli da su sami u domaćinstvu, 19 ispitanika su naveli da žive sa još jednim članom, da ih je troje u domaćinstvu navela su 39 ispitanika, da ih je četvoro u stanu navelo je 24 ispitanika, a preostali dio se izjasnio da ih je više od četvoro u domaćinstvu.

U tabeli br.1 ispitanicima su ponuđene određene bezbjednosne prijetnje, gdje su ispitanici trebali da ih ranigiraju. Pitanje je glasilo: „U ovom pitanju navedene su različite bezbjednosne prijetnje za Vašu opštinu/grad gdje živite“, cilj ovog pitanja je bio da građani (ispitanici) rangiraju bezbjednosne prijetnje po njihovu opštinu/grad gdje žive na skali od 1-14.

Tabela 1. Ponuđene bezbjednosne prijetnje.
Table 1. Offered security threats.

| **U ovom pitanju navedene su različite bezbjednosne prijetnje za Vašu opštinu/grad gdje živite.**<br>**Rangirajte ove prijetnje, prema ličnom stavu, na rang-listi od 1 do 14, tako da je 1 najviša, a 14 najniža prijetnja.**<br>**Prije nego što odredite rang- listu, pažljivo proučite sve prijetnje, a zatim dodajte svakoj prijetnji redni broj na rang-listi.** | **Rang-lista** |
|---|---|
| 1. prirodne nesreće (poplave, klizišta, zemljotresi...) | |
| 2. mine i druge eksplozivne naprave zaostale iz rata | |
| 3. organizovani kriminal i nasilje kriminalnih grupa i pojedinaca | |
| 4. uništavanje životne sredine (zagađenje vode, neuredno odlaganje smeća...) | |
| 5. loša državana i opštinska/gradska uprava, korupcija i zloupotreba vlasti | |
| 6. terorizam | |
| 7. siromaštvo i visoka nezaposlenost (ekonomska i finansijska kriza) | |
| 8. sječa šume i krađe automobila | |
| 9. slaba saobraćajna infrastruktura i problem parkiranja vozila | |
| 10.nesigurnost granica Bosne i Hercegovine (ilegalne migracije) | |
| 11.problem pasa lutalica | |
| 12. društveno negativne pojave (zlupotreba droge, kocka, alkoholizam, vršnjačko nasilje...) | |
| 13. sukobi na vjerskoj i nacionalnoj osnovi | |
| 14. nasilje na sportskim priredbama | |

Vidljivo je da ispitanici iz Foče na prvo mjesto stavljaju društveno negativne pojave na koje otpada oko 18% od ukupnog broja dodijeljenih rangova. Drugo mjesto, po odgovorima ispitanika, jeste siromaštvo i visoka nezaposlenost, na koje otpada oko 15%, pa zatim terorizam sa 11%, te nakon čega dolaze sukobi na vjerskoj i nacionalnoj osnovi i loša državna i opštinska/gradska uprava na koje otpada oko 10% datih rangova, dok po 8% datih rangova otpada na korupciju i zloupotrebu vlasti i organizovani kriminal i nasilje kriminalnih grupa i pojedinaca. Ilegalne migracije, odnosno nesigurnost granica BiH su sledeći bezbjednosni problem za koji se izjasnilo oko 4% ispitanika, za koliko se izjasnilo i za nasilje na sportskim terenima i sječe šuma i krađa automobila. Navedeni odnos prikazan je na grafikonu br. 1.

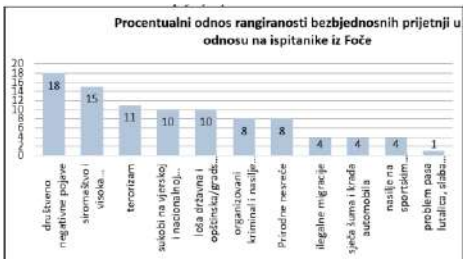



Grafikon 1. Procentualni odnos datih odgovora na ponuđene bezbjednosne prijetnje.
Chart 1. The percentage of responses given to the offered security threats.

Na osnovu dobijenih rezultata anketiranja ispitanika da rangiraju ponuđene bezbjednosne prijetnje za opštinu Foča, rang lista prijetnji bi izgledala ovako:

- Društveno negativne pojave (zloupotreba droge, kocka, alkoholizam, vršnjačko nasilje),
- Siromaštvo i visoka nezaposlenost (ekonomska i finansijska kriza),
- Terorizam,
- Sukobi na vjerskoj i nacionalnoj osnovi,
- Loša državna i opštinska/gradska uprava, korupcija i zloupotreba vlasti,
- Organizovani kriminal i nasilje kriminalnih grupa i pojedinaca,
- Prirodne nesreće (poplave, klizišta, zemljotresi…),
- Nesigurnost granica Bosne i Hercegovine (ilegalne migracije),
- Nasilje na sportskim terenima,
- Sječa šuma i krađa automobila,
- Mine i druge eksplozivne naprave izostale iz rata,
- Slaba saobraćajna infrastruktura i problem parkiranja vozila,
- Uništavanje životne sredine,
- Problem pasa lutalica.

Na osnovu dobijenih rezultata u vezi rangiranosti ponuđenih bezbjednosnih prijetnji u opštini Foča, na grafikonu br. 2 prikazan je brojčani odnos srednje vrijednosti datih odgovora ispitanika.




Grafikon 2. U kojem je prikazan brojčani odnos srednje vrijednosti datih ocjena na bezbjednosne prijetnje ispitanika iz Foče.
Chart 2. In which the numerical ratio of the mean value of the given ratings on security threats of respondents from Foča is shown.

Na sledeće pitanje koje glasi: „Ovdje su navedene pojedine specifičnosti lokalne zajednice (mjesta u kojem živite) koje utiču na bezbjednost!“, ispitanici iz Foče su se trebali izjasniti o uticaju konkretnih specifičnosti na bezbjednost lokalne zajednice u kojoj žive. Na navedeno pitanje je postavljeno osam tvrdnji na koje su ispitanici trebali da se izjasne u pogledu kvantitativnosti slaganja ili neslaganja sa svakom od ponuđenih tvrdnji.

U sledećoj tabeli *(tabela br. 2)* prikazana je frekvencija i procenat datih odgovora ispitanika na svaku od ponuđenih tvrdnji.

Tabela 2. Frekvencija i procenat odgovora na tvrdnje u pitanju za opštinu Foča.
Table 2. Frequency and percentage of responses to the statements in the question for the municipality of Foča.

| Odgovori na pitanje: „Ovdje su navedene pojedine specifičnosti lokalne zajednice (mjesta u kojem živite) koje utiču na bezbjednost!“ *T v r d nj e* | N/% | Odgovor: u potpunosti se slažem | slažem se | niti se slažem, niti se ne slažem | ne slažem se | uopšte se ne slažem | Total |
|---|---|---|---|---|---|---|---|
| Sam geografski položaj mjesta u kojem živite pogoduje razvoju kriminaliteta, prekršaja i ugrožavanju bezbjednosti građana. | N | 31 | 55 | 7 | 5 | 2 | 93 |
| | % | 31% | 55% | 7% | 5% | 2% | 100% |
| Neravnomjerna izgradnja ustanova za razvoj različitih kultura građana u mjestu gdje živite. | N | 25 | 49 | 10 | 7 | 2 | 93 |
| | % | 27% | 53% | 11% | 7% | 2% | 100% |
| Ponašanje ljudi koje nije primjereno moralnim normama u mjestu gdje živite. | N | 26 | 50 | 9 | 7 | 1 | 93 |
| | % | 28% | 54% | 10% | 7% | 1% | 100% |
| Smanjenje broja stanovnika, starenje stanovništva, nejednak reproduktivni život za sve društvene skupine, nejednakost u teritorijalnoj rasprostranjenosti stanovništva i slab razvoj nekih područja. | N | 25 | 49 | 10 | 7 | 2 | 93 |
| | % | 27% | 53% | 11% | 7% | 2% | 100% |
| Postojanje različitosti među stanovništvom u pogledu vjere, jezika i narodnosti, | N | 29 | 49 | 10 | 4 | 1 | 93 |
| | % | 26% | 50% | 14% | 6% | 4% | 100% |
| Materijalna nesigurnost, neizvjesnost u zadovoljenju životnih potreba, neuvažavanje porodične, rodne i međugeneracijske solidarnosti. | N | 25 | 48 | 11 | 6 | 3 | 93 |
| | % | 27% | 52% | 12% | 6% | 3% | 100% |
| Zaposlenost stanovništva i dobar privredni razvoj mjesta u kojem živite. | N | 20 | 46 | 15 | 9 | 3 | 93 |
| | % | 22% | 49% | 16% | 10% | 3% | 100% |
| Saobraćajna infrastruktura i nedovoljna povezanost sa susjednim opštinama i šire. | N | 22 | 46 | 13 | 9 | 3 | 93 |
| | % | 24% | 49% | 14% | 10% | 3% | 100% |

Cilj ovog pitanja bio je da se ispitanici (građani) odrede prema tvrdnjama koje se odnose na stavove građana u pogledu pojedinih specifičnosti lokalnih zajednica koje utiču na bezbjednost. Ponuđene tvrdnje u ovom pitanju i stavovi građana prema njima razložene su na pet mogućih odgovora (kako se vidi u tabeli), od potpunog slaganja sa tvrdnjama do potpunog neslaganja. Na tvrdnju „Sam geografski položaj mjesta u kojem živite pogoduje razvoju kriminaliteta, prekršaja i ugrožavanju bezbjednosti građana“, najmanje je bilo izjašnjenja ispitanika na odgovor „uopšte se ne slažem“ (2/2%), a najviše na odgovor „slažem se“ (55/55%). Sa ovom tvrdnjom na odgovor „ne slažem se“ izjasnilo se (5/5%), a sa odgovorom „u potpunosti se slažem“ (31/31%) ispitanika. Za

neutralni odgovor „niti se slažem, niti se ne slažem“ izjasnilo se (7/7%) ispitanika. Zbrajanjem odgovora u ovoj tvrdnji „u potpunosti se slažem“ i „slažem se“ (31+55)/(31%+55%) izjasnilo se (86/86%) ispitanika, a za odgovore „ne slažem se“ i „uopšte se ne slažem“ (5+2)/(5%+2%) izjasnilo se (7/7%) ispitanika. Na preostale tvrdnje u navedenoj tabeli biće elaborirani samo karakteristični odgovori ispitanika. Na tvrdnju „Neravnomjerna izgradnja ustanova za razvoj različitih kultura građana u mjestu gdje živite“, za odgovor „uopšte se ne slažem“ izjasnilo se (2/2%) ispitanika. U tvrdnji „Ponašanje ljudi koje nije primjereno moralnim normama u mjestu gdje živite“, za odgovor „slažem se“ izjasnio se veliki broj ispitanika (50/54%), a i kod tvrdnje „Smanjenje broja stanovnika, starenje stanovništva, nejednak reproduktivni život za sve društvene skupine, nejednakost u teritorijalnoj rasprostranjenosti stanovništva i slab razvoj nekih područja“, za odgovor „slažem se“ izjasnio se približno veliki broj ispitanika (49/53%). U tvrdnjama „Postojanje različitosti među stanovništvom u pogledu vjere, jezika i narodnosti“, za odgovor „ne slažem se“ opredjelilo se (4/6%) ispitanika, a kod tvrdnje „Materijalna nesigurnost, neizvjesnost u zadovoljenju životnih potreba, neuvažavanje porodične, rodne i međugeneracijske solidarnosti“, za odgovor „u potpunosti se slažem“ izjasnilo se (25/27%) ispitanika. Isti broj ispitanika izjasnio se za odgovor „ne slažem se“ (9/10%) i „uopšte se ne slažem“ (3/3%) na poslednje dvije tvrdnje u ovom pitanju.

Kada je u pitanju srednja vrijednost svih odgovora izražena procentualno na ponuđene tvrdnje u ovom pitanju vidi se da se najveći broj ispitanika izjasnio za odgovor „slažem se“ (52%), a najmanje za odgovor „uopšte se ne slažem“ (3%). Za odgovor „u potpunosti se slažem“, izjasnilo se (26%), a za „ne slažem se“ (8%) ispitanika. Za neutralni odgovor „niti se slažem, niti se ne slažem“, izjasnilo se (11%) ispitanika.

Takođe, pored anketnih upinika u opštini Foča, sprovedeno je i 6 intervjua, na već pripremljena pitanja u vezi bezbjednosnih prijetnji i njihove refleksije na bezbjednost, a intervjuisana su ona lica koja mogu da utiču na društveno-politički život lokalne zajednice (predstavnici lokalne samouprave, bezbjednosnog sektora, zdravstvenog sektora, privrednici, predstavnici vjerskih zajednica i sl.). Rezultati dobijenih odgovora u najvećem dijelu se poklapaju sa dobijenim ukupnim odgovorom kao i kod ova dva pitanja u anketnom upitniku.

## ZAKLJUČCI

Govoreći o bezbjednosti, s pravom se može reći da je ona neodvojiva od čovjeka i da je egzistencijalno pitanje opstanka. S obzirom na to, čovjek, kao pojedinac, želi da živi u bezbjednoj lokalnoj zajednici, a koja je kao takva preduslov ostvarivanja građanskih prava i zadovoljenja životnih potreba. Bezbjednosni izazovi i prijetnje u lokalnim zajednicama nisu univerzalne. Na postavljeno pitanje u pogledu rangiranja bezbjednosnih prijetnji za opštinu Foča, evidentno je da su dati odgovori i bili shodno viđenju samih ispitanika, a koje su potvrdila i intervjuisana lica. S obzirom da svaka lokalna zajednica je specifična za sebe, tako i opština Foča ima određene specifičnosti koje se mogu dovesti u vezu sa bezbjednosnim izazovima i prijetnjama koje utiču na samu bezbjednost. Analizirajući rezultate istraživanja koji su rađeni u opštini Foča evidentno je se u velikom broju, odnosno procentu datih odgovora ispitanici slažu da specifičnosti lokalnih zajednica utiču na samu bezbjednost u lokalnoj zajednici. Takođe, sa tim se slažu i lica koja su intervjuisana, gdje u svojim odgovorima na ponuđena pitanja daju identične odgovore.

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# SECURITY CHALLENGES AND THREATS IN THE LOCAL COMMUNITY - CASE STUDY OF THE MUNICIPALITY OF FOCA

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**ABSTRACT**

People's interest has always been to be safe and that the place where they live and work has a high level of security. A safe local community is a prerequisite for development and survival, especially in today's time, which is characterized by a large number of different security challenges and threats. People's priority is to be able to satisfy their needs and realize their rights and interests in the local community where they live. Any form of threat to security in the local community arouses the interest of citizens, which is a kind of alarm for the local self-government, but also for the security authorities. Local self-government bodies in the local community are obliged to deal with issues that are of importance to their citizens and to initiate issues that are the responsibility of other bodies and services so that they are resolved in a timely manner. The issue of security in the local community is the responsibility of the local police, which also aims to ensure that the personal and property security of citizens is at the highest possible level. There are various security challenges and threats that endanger citizens in the local community and they primarily differ in relation to the specifics of the local community itself, primarily geographic, demographic, cultural, ethical, ethnic, industrial, social, etc. The aim of this paper is not only to indicate the conceptual definition of the local community and security challenges and threats, but also to indicate the very importance of a safe environment in which people live. Also, the paper will present the perception of various security threats, as well as their ranking by degree of danger by citizens in the municipality of Foča.

**Keywords:** security, security challenge, security threat, local community, local self-government.

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# INSTITUT RAZVODA BRAKA SA POSEBNIM OSVRTOM NA SPORAZUMNI RAZVOD KAO NAČIN PRESTANKA BRAKA U PORODIČNOM ZAKONODAVSTVU FEDERACIJE BOSNE I HERCEGOVINE

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## SAŽETAK

Razvod braka jedan je od načina prestanka braka i to odlukom suda za života bračnih partnera. Danas je razvod braka učestala pojava u društvu i poznaju ga gotovo sve kulture širom svijeta. Uticaj katoličke crkve je razlog zbog čega je mogućnost razvoda braka relativno kasno uvedena u pravne sisteme katoličkih zemalja kao što su Italija, Španjolska, Portugal i Irska i što još uvijek ne postoji na Filipinima. U ovom radu govorit ćemo o pravnom uređenju razvoda braka u bosanskohercegovačkom pravnom sistemu s kratkim osvrtom na reguliranje ovog instituta u nekim zemljama Europske unije. U prvom dijelu rada, govorit će se o historijskom razvoju razvoda braka kroz rimsko i kanonsko pravo te brakorazvodnim uzrocima u našem i uporednom pravu. U drugom, glavnom dijelu rada, fokus je stavljen na sam institut razvoda i postupak razvoda braka prema Porodičnom zakonu FBiH sa posebnim osvrtom na sporazumni razvod kao način prestanka braka. Rad bi trebao pokazati da je sporazumni razvod braka lakši i brzi proces, jer se temelji na slobodnoj i saglasnoj volji bračnih partnera da se njihov brak razvede. Također, bit će istaknute brojne prednosti i olakšice postupka sporazumnog razvoda za bračne partnere u odnosu na postupak razvoda braka koji se pokreće putem tužbe.

**Ključne riječi:** razvod braka, sporazumni razvod, brakorazvodni uzroci, postupak za razvod braka.

## UVOD

Razvod braka se ubraja među najstarije pravne institute. Nastao je kao popratna pojava braka i prirodna posljedica poremećaja odnosa zajedničkog života muškarca i žene. U rimskom pravu je vrijedjelo načelo slobodnog razvoda braka. Manus brak se razvodio suprotnim ritualom u odnosu na formu u kojoj je brak bio sklopljen (diffarreatio) ili prostom izjavom o razvodu (repudium) i faktičkim prestankom zajednice života. Ovakvo shvatanje razvoda bilo je posljedica činjenice da se brak u rimskom pravu smatrao faktičkom zajednicom života u kojoj postoji affectio maritalis, što znači da prestankom ovih elemenata braka prestaje i sam brak te nije potrebno predviđati posebne zakonske razloge za razvod braka. Ipak manus brak je mogao biti razveden samo voljom muža ili njegovog i ženinog *paterfamilijasa* (Draškić, 2010).

Do promjene dolazi tek u doba carstva kada imperatori počinju da ograničavaju slobodu razvoda braka, jer su bili pod utjecajem katoličke dogme o nerazriješivosti braka. Uveli su se opravdani razlozi za razvod (ubistvo za muža ili nevjera za ženu), te se počela praviti razlika između opravdanog i neopravdanog razvoda. Ako se brak razvodi iz neopravdanih razloga nastajale su nepovoljne posljedice za onu stranu koja je neopravdano razvela brak (zabrana kasnijeg braka, deportacija ili gubitak miraza).

U doba Justinijana već su bile predviđene sankcije za bračnog partnera koji je kriv za opravdani razvod (*repudium ex iusta causa*) kao i za onoga ko je preduzeo razvod bez opravdanog razloga (*repudium sine causa*). Također je postojao sporazumni razvod braka (*divortium mutu consensu*) i nekažnjivi dopušteni jednostrani razvod bez krivice drugog bračnog duga (*divortium bona gratis*) (Draškić, 2010).

Ovakvo stanje zakonodavstva u vrijeme sve raspusnijeg života rimskog stanovnišva koje se odalo neradu i uživanju, doprinijelo je da razvod postane masovna pojava, a brak izgubi svaki značaj. Brak i porodica su bili uglavnom regulisani običajima, dok je zakon imao manje uticaja na njihovu organizaciju. Zakon se bavio uslovima i posljedicama sklapanja braka dok je za njegovo postojanje i prestanak bio nezainteresiran. Ovo je sve funkcionisalo dok je na snazi bila moć *pater familijasa*. Njegovim slabljenjem, razvod u rimskom pravu je postao jako lagan (Janjić Komar, Korać i Ponjavić, 1996).

**Teorije o razvodu braka**

Postoji više teorija o razvodu braka. Historijski, najranija je teorija o razvodu kao pravnoj sankciji za neispunjavanje bračnih dužnosti. Bračni partner koji je kriv za razvod braka zato što nije ispunjavao bračne dužnosti se, na neki način kažnjava za svoje ponašanje. Ova teorija pretpostavlja utvrđivanje krivice za razvod. Bračni partner koji je kriv često nije imao pravo na pokretanje brakorazvodnog postupka, a brak se razvodio na osnovu nekog posebnog brakorazvidnog uzroka npr. preljube ili napuštanja. Također i posljedice razvoda braka su zavisile od krivice. Savremena porodičnopravna teorija posmatra razvod braka kao izlaz iz poremećenih bračnih odnosa (teorija o razvodu kao pravnom lijeku zbog poremećenosti bračnih odnosa). Za ovu teoriju je karakteristično postojanje opšteg brakorazvodnog uzroka i sporazumnog razvoda. Krivica gubi na značaju te pravo bračnog partnera za pokretanje brakorazvodnog postupka ne zavisi od njegove krivice. Pojam krivice se u potpunosti napušta i ostaje samo u domenu krivičnog prava. Karakteristika savremenih prava o razvodu braka jeste ekspanzija neskrivljenih brakorazvodnih uzroka, uvođenje sporazumnog razvoda te uvođenje postupka posredovanja ili medijacije.

Stoga se pravni sistemi mogu podijeliti u dvije grupe. Na jednoj strani su pravni sistemi u kojima među uzrocima za razvod braka figuriraju, pored uzroka koji ni na koji način ne zavise od krivice bračnih partnera i uzroci koji se zasnivaju na krivici jednog ili oba bračna partnera (mješoviti sistem razvoda braka kao pravnog lijeka). Na drugoj strani se nalaze oni pravni sistemi u kojima se na krivici ne može zasnivati niti jedan uzrok za razvod braka, niti se krivica u brakorazvodnom sporu može utvrđivati (čisti sistem razvoda braka kao pravnog lijeka) (Draškić, 2010).

Mogućnost razvoda braka koji je valjano sklopljen za života bračnih partnera i na zahtjev muža ili žene pojavila se u zakonodavstvima evropskih država počevši od 19. vijeka. Do kraja 20. vijeka u regulisanju instituta razvoda braka dogodile su se tako dramatične promjene da je većina početnih i bitnih obilježja te osnove prestanka braka gotovo potpuno nestala. Od sredine šezdesetih godina u mnogim razvijenim industrijskim zemljama zabilježen je nagli porast stope razvedenih brakova, a sedamdesetih godina u većem broju evropskih država režim razvoda braka znatno je liberaliziran. Glavno obilježje novih propisa je priznavanje neskrivljenih uzroka za razvod te prihvatanje ili pojednostavljivanje propisa za razvod braka na osnovu zajedničkog sporazuma muškarca i žene.

**Uzroci za razvod braka u uporednom pravu**

Razlike koje su tokom historije prava bile upadljive u uporednom pravu, kada je riječ o pravu na razvod braka, sve više isčezavaju u savremenom uporednom pravu. Sa jedne strane, sve je manje pravnih sistema u kojima ne postoji institut razvoda braka, tako da je i pretposljednja država koja nije priznavala pravo na razvod, Republika Irska na referendumu 1995.godine izmijenila svoj Ustav i uvela insitut razvoda 1996.godine. Malta je danas jedina evropska država koja ne priznaje institut razvoda.

Sa druge strane, u savremenom uporednom pravu, rijetkost je i postojanje sistema u kojima je bračnim partnerima dopuštena potpuna sloboda odlučivanja o razvodu braka prostom izjavom volje o otpustu drugog bračnog partnera (u zemljama gdje se primjenjuje šerijatsko pravo).

Mješoviti sistem razvoda kao pravnog lijeka je sve manje zastupljen u pravnim zakonodavstvima. Poznaju ga još uvijek englesko pravo kroz uzrok za razvod braka koji naziva “nepovratni bračni slom”, zatim irsko pravo, italijansko pravo te francusko pravo koje priznaje tri

glavna razloga za razvod braka: razvod po sporazumu bračnih partnera, razvod zbog trajne promjene bračne veze usljed odvojenog života partnera koji je trajao najmanje 2 godine i razvod usljed krivice jednog od bračnih partnera (Draškić, 2010).

U većini evropskih zemalja ipak dominira stanovište da razvod braka predstavlja izlaz iz situacije koja je za bračne partnere postala nepodnošljiva i neodrživa do te mjere da je razvod braka lijek za oslobađanje od takvog odnosa (teorija o razvodu kao pravnom lijeku).

Čisti sistem razvoda kao pravnog lijeka postao je u posljednih petnaestak godina dominantan u savremenim sistemima. Usvojila ga je Austrija, Danska, Njemačka, Holandija, Švajcarska, Švedska i Portugal. Svi ovi sistemi su odustali od brakorazvodnih uzroka, koji se zasnivaju na dokazivanju krivice jednog bračnog partnera. Jedini brakorazvodni uzrok je taj da je brak doživio „slom“, ako je prestao zajednički život bračnih patnera i ne može se očekivati da će biti ponovno uspostavljen (različite države određuju različite vremenske proteke vremena i rokove) (Draškić, 2010).

**Razvod braka u porodičnom zakonodavstvu FBiH**

Novo porodično zakonodavstvo prihvatilo je sistem teške i trajne poremećenosti bračnih odnosa, odnosno sistem razvoda braka kao lijeka. U smislu člana 41. PZ FBiH: "Bračni partner može tražiti razvod braka, ako su bračni odnosi teško i trajno poremećeni". Najnovijim izmjenama Porodičnog zakona FBiH ukinuta je tzv. privremeno ograničenje prava muža da traži razvod braka za vrijeme trudnoće žene ili dok njihovo dijete ne navrši tri godine. Prije pokretanja postupka za razvod braka bračni partner ili oba bračna partnera koji imaju djecu nad kojom ostvaruju roditeljsko staranje, kao i za vrijeme trudnoće žene, dužni su podnijeti zahtjev za posredovanje fizičkom i pravnom licu ovlaštenom za posredovanje (Porodični zakon FBiH, član 45, stav 1). Posredovanje predstavlja jedan od alternativnih načina rješavanja sukoba u porodici, kako bi se na miran način prevazišle sve konfliktne situacije te došlo do sporazuma između partnera (Bubić i Traljić, 2007).

U smislu člana 44. PZ FBiH sud će, na osnovu sporazuma bračnih partnera, razvesti brak:

- ako je od sklapanja braka prošlo 6 mjeseci i
- ako postoji sporazum bračnih partnera, sklopljen u postupku posredovanja, o ostvarivanju roditeljskog staranja, izdržavanju djeteta, uvjetima i načinu održavanja ličnih odnosa i neposrednih kontakata djeteta sa roditeljem koji ne ostvaruje roditeljsko staranje i izdržavanju bračnog partnera.

Republika Srpska je zadržala odredbu da se sporazumno ne mogu razvesti parovi sa maloljetnom djecom, usvojenom djecom ili djecom nad kojoj je produženo roditeljsko staranje. Za takve brakove predviđa zajednički prijedlog za razvod braka gdje se utvrđuje poremećenost bračnih odnosa.

Postupak za razvod braka je jedan od postupaka u bračnim sporovima i normiran je u Porodičnom zakonu FBiH [PZFBiH], 2005 (7. dio - "Postupak pred sudom"), ali se na njega, ako ovim zakonom nije drugačije određeno, primjenjuju i odredbe Zakona o parničnom postupku, Zakona o vanparničnom postupku i Zakona o izvršnom postupku (PZFBiH, član 268. stav 2).

Za sve bračne sporove, pa i za razvod braka, stvarno nadležan je općinski sud (Zakon o sudovima FBiH, član 27. stav 2). Mjesno nadležan je sud na čijem području tuženi bračni partner ima prebivalište ili boravište te sud na kojem su bračni partneri imali posljednje zajedničko prebivalište. Funkcionalna nadležnost je podijeljena tako da u prvom stepenu sudi sudija pojedinac, a u drugom vijeće od 3 sudije od kojih je jedan specializovan za ovu vrstu spora.

**Prednosti i olakšice sporazumnog razvoda braka u odnosu na razvod braka putem tužbe**

Postupak za razvod braka mogu pokrenuti samo bračni partneri lično ili preko punomoćnika. Dakle, inicijalni akt kojim se pokreće brakorazvodna parnica može da ima dva oblika: tužbeni i oblik prijedloga za sporazumni razvod braka (Panov, 2010). Ako tuženi bračni partner do zaključenja glavne rasprave izjavi da ne osporava osnovanost tužbenog zahtjeva, smatrat će se da su partneri podnijeli zahtjev za sporazumni razvod.

Koje su to specifičnosti i olakšice sporazumnog razvoda braka?

Za ovaj postupak, kao i za ostale bračne sporove, važe posebna pravila parničnog postupka. Radnje u postupku se preduzimaju hitno, u kraćim rokovima od onih normiranih u Zakonu o parničnom postupku Zakon o parničnom postupku Federacije BiH [ZPPFBiH], 2015 (član 273. stav 1).

Postoji mogućnost određivanja, po službenoj dužnosti, privremene mjere radi davanja izdržavanja maloljetnoj djeci i radi njihovog smještaja (član 276. stav 1.).

Žalba protiv tog rješenja ne zadržava njegovo izvršenje. Ove mjere se mogu odrediti i u korist bračnog partnera, ali samo po njegovom prijedlogu.

Radi zaštite interesa bračnih partnera, odnosno njihove privatnosti isključena je javnost (član 277.).

Za razliku od redovnog parničnog postupka, u kojem se utvrđuju samo one činjenice koje su stranke iznijele i koje su među strankama sporne, u ovom postupku sud je ovlašten utvrđivati i činjenice koje stranke nisu iznijele, a može dokazivati i one činjenice koje su stranke priznale u postupku, osim ako se zahtijeva sporazumni razvod braka (član 278. stav 4.).

U žalbi se ne mogu iznositi nove činjenice i predlagati novi dokazi, osim ako žalilac dokaže da ih bez svoje krivice nije mogao iznijeti, odnosno predložiti prije zaključenja glavne rasprave i ako se njihovim iznošenjem, odnosno predlaganjem, štite prava i interesi djeteta (član 279.).

Sud o troškovima postupka njima odlučuje slobodno, vodeći računa o okolnostima slučaja i o ishodu postupka.

Kada se u postupku za razvod braka odlučuje o tome s kojim će roditeljem živjeti dijete, o ličnim odnosima i neposrednim kontaktima djeteta sa roditeljem sa kojim ne živi, o izdržavanju djeteta i o drugim sadržajima roditeljskog staranja, sud je obavezan pozvati organ starateljstva da učestvuje u tom postupku radi zaštite interesa djeteta (član 281. stav 1.).

Brakorazvodni postupak se završava donošenjem presude o razvodu braka, ukoliko sud ocijeni da su bračni odnosi teško i trajno poremećeni, odnosno da su ispunjeni uslovi za sporazumni razvod braka. Ova presuda mora sadržati odluku o razvodu braka i ukoliko bračni partneri imaju dijete o kojem se staraju, odluku o tome s kojim će roditeljem živjeti dijete, o načinu održavanja ličnih odnosa i neposrednih kontakata djeteta s roditeljem s kojim ne živi, o izdržavanju djeteta i o drugim sadržajima roditeljskog staranja (za pobijanje presude o razvodu braka donesene po tužbi važe pravila o pobijanju prvostepene presude, žalba se može podnijeti iz svih žalbenih razloga).

## ZAKLJUČCI

Sporazumni razvod izaziva različite reakcije u pravnoj teoriji i zakonodavstvu. Osnovni prigovor je taj što se sporazumnim razvodom umanjuje društveni značaj braka i štite interesi pojedinca. Pravo na sporazumni razvod omogućava raspolaganje pravom na razvod, što je protivno javnom poretku, društvenim dobrim običajima i prinudnim propisima. Također mu se spočitava to što doprinosi neodgovornom, brzopletom i afektivnom prestanku braka, s ciljem unošenja nestabilnosti u porodične odnose.

Međutim, kroz rad smo mogli vidjeti i zaključiti da sporazumni razvod ima i te kakve prednosti u odnosu na razvod braka prema tužbi, prvenstveno što se izbjegava konflikt koji se inače dešava ukoliko je u pitanju razvod tužbom, te postoji nada da će se odnosi razvedenih bračnih partnera lakše i skladnije održavati nakon razvoda. Na ovaj način se ipak štiti dostojanstvo bivših supružnika te pojedinosti intimnog života i razlozi neuspjeha ostaju nedostupni za treća lica. Sporazumni razvod braka, ipak, odgovara slobodi stupanja u brak, kao jednoj od osnovnih ustavnih prava i sloboda čovjeka (Draškić, 2010).

Možemo zaključiti da, u našem pravu, sloboda disponiranja bračnih partnera kod razvoda braka, ipak nije apsolutna. Bračni partneri ipak moraju da podnesu prijedlog za sporazumni razvod u pismenoj formi te moraju predočiti izvještaj sa obavljenog posredovanja ukoliko imaju zajedničku djecu nad kojom ostvaruju zajedničko staranje da su postigli saglasnost o čuvanju, vaspitanju i izdržavanju zajedničke djece kao i o načinu održavanja zajedničkih odnosa s njima (oni koji nemaju zajedničke djece mogu proći postupak posredovanja ali im to nije zakonska

obaveza). Dakle, značajno ograničenje slobode bračnih partnera kod sporazumnog razvoda postoji zbog zaštite najboljeg intreresa njihove maloljetne djece.

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# THE INSTITUTE OF DIVORCE WITH SPECIAL EMPHASIS ON CONSENTUAL DIVORCE AS MEANS OF ENDING A MARIAGE IN FAMILY LAW LEGISLATION OF THE FEDERATION OF BOSNIA AND HERZEGOVINA

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## ABSTRACT

Divorce is one of the means of ending a marriage which is performed by a decision of the court during the life of the marital partners. Today divorce is a frequent occurrence in society and is known by almost all cultures around the world. The influence of the Catholic Church is the reason why the possibility of divorce has been introduced in to the legal systems of catholic states such as Italy, Spain, Portugal and Ireland relatively late. This is also the reason why it still does not exist in the Philippines. This paper will examine the legal ordering of the divorce in the legal system of Bosnia and Herzegovina with a brief examination of the way this legal institute is ordered in some countries of the European Union. In the first part of this paper the historical development of divorce through roman and canon law will be examined as well as divorce causes in our and comparative law. In the second, main part of this paper, the focus will be placed on the very institute of divorce and on the procedure for divorce according to the Family law of FB&H with special emphasis on consensual divorce a means of ending a marriage. The paper should demonstrate that consensual divorce is an easier and quicker process, because it is based on the free and consensual will of the marriage partners aimed at dissolving their marriage. Likewise, numerous advantages and reliefs of the procedure of consensual divorce for the marital partners as opposed to the divorce by means of filing a lawsuit will be indicated.

**Keywords:** divorce, consensual divorce, divorce causes, process for divorce.

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# VANBRAČNA ZAJEDNICA U PORODIČNOM ZAKONODAVSTVU BIH SA POSEBIM OSVRTOM NA NASLJEDNOPRAVNI POLOŽAJ NADŽIVJELOG VANBRAČNOG PARTNERA

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## SAŽETAK

U radu će biti detaljno obrađen institut vanbračne zajednice u porodičnom zakonodavstvu Bosne i Hercegovine, sa posebnim akcentom na položaj vanbračnog partnera kao nasljednika u ostavinskom postupku. Vanbračna zajednica je zajednica života muškarca i žene od kojih ni jedno nije u braku, koja je trajala najmanje tri godine ili kraće, ako je u njoj rođeno zajedničko dijete. Ovako određuju i definišu vanbračnu zajednicu Porodični zakon Federacije i Brčko Distrikta. U Porodičnom zakonu Republike Srpske vanbračna zajednica je zajednica života žene i muškarca (vanbračnih partnera) između kojih nema bračnih smetnji i koja je trajala najmanje dvije godine ili kraće ako je u njoj rođeno dijete. S obzirom na to, i nasljednopravni položaj vanbračnog partnera je u BiH različito regulisan. Nasljednopravni položaj vanbračnih partnera je značajno otežan potrebom dokazivanja postojanja vanbračne zajednice. U rezultatima rada ukazat će se na moguća rješenja ovog problema potrebom registracije vanbračne zajednice. Također, trebalo bi razmisliti o mogućnostima uvođenja određenih oborivih pravnih pretpostavki u korist vanbračnih partnera. Na taj način bi se olakšao položaj vanbračnog partnera u ostavinskom postupku i postiglo prebacivanje tereta dokazivanja sa vanbračnih partnera na nasljednike koji osporavaju postojanje vanbračne zajednice.

**Ključne riječi:** vanbračna zajednica, vanbračni partner, ostavinski postupak, nasljeđivanje vanbračnih partnera.

## UVOD

U nasljednom pravu u Bosni i Hercegovini, vanbračna zajednica je u imovinskopravnom pogledu izjednačena sa bračnom. Porodičnim zakonima određeno je da se imovina, stečena radom u vanbračnoj zajednici, smatra zajedničkom stečevinom. Dakle, pravila o nasljeđivanju između bračnih partnera primjenjuju se i u međusobnom nasljeđivanju vanbračnih partnera, s tim da je nasljednopravni položaj vanbračnih partnera otežan potrebom dokazivanja postojanja vanbračne zajednice. Bračni/vanbračni partneri su zakonski nasljednici prvog nasljednog reda, ukoliko postoje djeca ili drugi potomci ostavioca (unučad, praunučad). Nasljedni dio je jednak nasljednom dijelu djece i zavisi od broja djece (Centar za podršku organizacijama CENSOR, 2019). Ukoliko ostavilac nije imao djece, bračni/vanbračni partner ne može biti jedini nasljednik u prvom nasljednom redu i prelazi u drugi nasljedni red.

U drugom nasljednom redu, neovisno o broju ostalih nasljednika s kojim konkurira za nasljedstvo, bračni/vanbračni partner nasljeđuje pola zaostavštine. Tako nasljeđuje kao zakonski nasljednik ½ nasljedstva, bilo da nasljeđuje u prvom redu, kad postoji samo jedno dijete ostavioca, bilo da nasljeđuje u drugom nasljednom redu.

Međutim, od tog pravila postoje određeni izuzeci. Prvi izuzetak koji omogućuje da partner naslijedi sam u prvom nasljednom redu postoji u situaciji u kojoj imamo djecu ostavioca kao nasljednike prvog reda, koji se odriču svog nasljednog dijela u korist nadživjelog partnera. Tada neće doći do prelaska u drugi nasljedni red, jer je upravo želja ostalih nasljednika prvog reda bila da nadživjeli bračni/vanbračni partner sam naslijedi svu zaostavštinu. Ovo je novina koja je unesena u nove zakone o nasljeđivanju FBiH i BD BiH (Zakon o nasljeđivanju FBiH [ZNFBiH],

2019, čl. 163, st.5, Zakon o nasljeđivanju Brčko Distrikta BiH [ZNBDBiH], 2017, čl. 168, st.5). Zakon o nasljeđivanju RS, ne sadrži ovu odredbu (Zakon o nasljeđivanju RS [ZNRS], 2019).

Međutim, Zakon o nasljeđivanju RS u članu 25. u dijelu koji nosi naziv „Povećanje nasljednog dijela supružnika“ navodi u stavu 1. slijedeće: „Kad je supružnik koji nema nužnih sredstava za život pozvan na nasljeđe sa nasljednicima prvog ili drugog nasljednog reda sud može na zahtjev supružnika odlučiti da supružnik naslijedi i jedan dio onog dijela ostavštine koji bi po zakonu trebalo da naslijede ostali nasljednici, a može odlučiti i da supružnik naslijedi cijelu ostavštinu, ako je ona tako male vrijednosti da bi njenom podjelom, supružnik zapao u oskudicu. U slučaju iz stava 1. ovog člana sud će uzeti u obzir sve okolnosti, a naročito imovinske prilike i sposobnosti, za privređivanje supružnika, trajanje bračne zajednice, imovinske prilike ostalih nasljednika i njihovu sposobnost za privređivanje i vrijednost zaostavštine“. Ovakva određena nalazimo i u Zakonu o nasljeđivanju FBIH u čl. 26. stav 1. i 2. te Zakonu o nasljeđivanju BD (čl. 27 stav 1. i 2.).

Odredbe koje uređuju položaj nadživjelog bračnog partnera u drugom nasljednom redu nisu usklađena sa pravnom stečevinom EU i dovode ga u položaj u kojem on za imovinu svog umrlog bračnog/vanbračnog partnera uglavnom konkurira sa relativno dalekim srodnicima ostavioca (bratićima i sestrićima umrlog).

Pravni položaj bračnih i vanbračnih partnera u pogledu međusobnog nasljeđivanja je u FBiH i BD BiH ojačan jedino uvođenjem ugovora o nasljeđivanju (ZNFBiH, 2019, čl.125.-134., ZNBDBiH, 2017, čl. 130-136), koji je rezervisan upravo samo za partnere iz bračne odnosno vanbračne zajednice i buduće bračne partnere. Moguće ga je kombinirati i sa bračnim ugovorom kojim vanbračni partneri također mogu urediti imovinske odnose i prije zasnivanja vanbračne zajednice te tokom njenog trajanja (Cvejić Jančić, 2009, str. 211). Na taj način je moguće dodatno zaštiti nadživjelog bračnog/vanbračnog partnera, poštivajući pravo nužnih nasljednika na nužni dio. Zakon o nasljeđivanju RS ne odobrava ugovorno nasljeđivanje, što još jednom potvrđuje da bračni/vanbračni partneri kao nasljednici u BiH nisu u istom pravnom položaju za nasljeđivanje.

Raskid vanbračne zajednice najteže pogađa partnera koji mora napustiti porodični dom, zajednički stan/kuću u kojem su živjeli bračni/vanbračni partneri. U porodičnom zakonodavstvu FBiH i BD BiH nema posebnih pravila vezanih za porodični dom. Tako se u određenim konstalacijama odnosa može desiti i da nadživjeli bračni/vanbračni partner izgubi porodični dom i to u odnosu na potomke braće i sestara ostaviočevih, ali naravno i nasljednike prvog nasljednog reda. Radi zaštite nadživjelog partnera bi trebalo predvidjeti pravila koja će garantirati pravo da ostane živjeti u porodičnom domu do kraja života, neovisno o udjelima pojedinih nasljednika u konkretnom slučaju. Institut prava na porodični dom je uveden u novi Porodični zakon RS 2023. godine. Uvođenjem instituta pravo na porodični dom, definisano je da su to nepokretnosti u kojima žive roditelji i njihova maloljetna ili usvojena djeca, a da bračni partner, za vrijeme trajanja braka, ne može otuđiti ili opteretiti porodični dom koji predstavlja zajedničku imovinu, bez saglasnosti drugog bračnog partnera koja se daje u formi notarski obrađene isprave. U slučaju razvoda braka, u porodičnom domu ostaje bračni partner/roditelj kojem je povjereno vršenje roditeljskog prava, odnosno sa kojim dijete živi. Ovo se također odnosi i na vanbračnog partnera.

## VANBRAČNA ZAJEDNICA U PORODIČNOM ZAKONODAVSTVU BOSNE I HERCEGOVINE

Postavlja se pitanje šta je to vanbračna zajednica i koja su njena određenja u porodičnom zakonodavstvu BiH?

Prema Porodičnom zakonu FBiH te Brčko Distrikta vanbračna zajednica je zajednica života muškarca i žene od kojih ni jedno nije u braku, koja je trajala najmanje tri godine ili kraće, ako je u njoj rođeno zajedničko dijete (Porodični zakon FbiH [PZFBiH], 2005, čl.9., Porodični zakon BD BiH [PZFBD], 2007, čl. 5.,).

U Porodičnom zakonu Republike Srpske vanbračna zajednica je zajednica života žene i muškarca (vanbračnih partnera) između kojih nema bračnih smetnji i koja je trajala najmanje dvije godine ili kraće ako je u njoj rođeno dijete. Vanbračna zajednica izjednačena je sa bračnom

zajednicom u pravima i obavezama na međusobno izdržavanje, imovinsko-pravnim odnosima, pod uslovima i na način propisan zakonom (Porodični zakon RS [PZRS], 2023, čl.13.).

Iako je porodičnim zakonima u Bosni i Hercegovini vanbračna zajednica u imovinskopravnom pogledu izjednačena sa bračnom, ovo izjednačenje nije dosljedno provedeno, naročito na području nasljednog prava, pa se ovaj status – brak ili vanbračna zajednica javlja čak i kao osnov direktne, a ne samo indirektne diskriminacije. To se odnosi i na muške i na ženske vanbračne partnere, ali imajući u vidu navedenu praksu da je obično kod nasljeđivanja nekretnina uknjižen samo partner muškog spola, i ovdje negativne posljedice pogađaju uglavnom ženu (Centar za podršku organizacijama [CENSOR], 2019).

Problem koji se javlja u praksi, ukoliko u ostavinu spadaju nekretnine, u pravilu (ali to ne mora biti stalno slučaj) će ta nekretnina biti upisana samo na muškog bračnog partnera, čak i kada ta nekretnina čini bračnu stečevinu. Na taj način će, ukoliko umre suprug, ta nekretnina, koja je upisana na njega ući u ostavinsku masu i nadživjela supruga mora prvo dokazivati da se radi o bračnoj stečevini, pa zahtijevati izdvajanje svog udjela. S druge strane, ako je prvo umrla supruga, a suprug kao nadživjeli bračni partner je uknjižen kao vlasnik nekretnine, to ima za posljedicu da nekretnina neće ni ući u ostavinsku masu. Dakle, ona pripada njemu. Jedino ako nasljednici zahtijevaju izdvajanje udjela supruge, teret dokazivanja pada na njih (Centar za podršku organizacijama CENSOR, 2019).

## NASLJEDNOPRAVNI POLOŽAJ NADŽIVJELOG VANBRAČNOG PARTNERA U PORODIČNOM ZAKONODAVSTVU BOSNE I HERCEGOVINE

Nasljednopravni položaj vanbračnog partnera je u BiH različito regulisan. Iako su 2005. godine Porodičnim zakonom FBiH izjednačena bračna i vanbračna zajednica u imovinskopravnom pogledu, u šta bi trebala spadati i pitanja nasljeđivanja, tek su naknadno novim zakonima o nasljeđivanju u FBiH (2014) i BD BiH (2017) vanbračni partneri uvršteni u krug zakonskih nasljednika po istom principu (ZNFBiH, 2014, čl.4., ZNBDBiH, 2017, čl.4.).

Iako je izvršeno formalnopravno izjednačavanje, nasljednopravni položaj vanbračnih partnera je značajno otežan potrebom dokazivanja postojanja vanbračne zajednice. Dakle, glavni razlog pravne nesigurnosti vanbračnih partnera je u činjenici da će zbog neformalnosti odnosa oni često tek u sudskom postupku moći saznati da li njihova zajednica ima značaj vanbračne, u smislu odredaba porodičnog zakonodavstva. Sud će ponekad teško moći odrediti kad je tačno zasnovana, a kada prestala, između ostalog i zbog toga što se par koji je zasnovao vanbračnu zajednicu ne pojavljuje uvijek na istoj adresi. To se uglavnom odnosi na partnere koji nemaju zajedničke djece. U suprotnom, važna okolnost za sud bi bila činjenica da je partner priznao očinstvo. Tak nakon što sud donese presudu, bivši vanbračni partneri će znati hoće li se ili neće moći pozvati na učinke vanbračne zajednice npr. hoće li jedan od njih u potrebi imati pravo na izdržavanje i sl. (Korać, 2006, str. 145). Registracija vanbračne zajednica kod nadležnog organa bi pomogla riješiti ovaj problem.

U Republici Srpskoj, unatoč reformiranom nasljednom pravu i porodičnom pravu, postoji isti problem.

Pitanjem diskriminacije vanbračnih partnera u odnosu na bračne u pogledu mogućnosti uzajamnog nasljeđivanja se bavio i Ustavni sud BiH u svojoj odluci AP-42017/13, u kojoj je Sud zaključio da su sudovi na području FBiH primjenjujući stari Zakon o nasljeđivanju BiH, koji nije uvrštavao vanbračne partnere u krug zakonskih nasljednika, bez uvažavanja izjednačavanja bračne i vanbračne zajednice učinjenog Porodičnim zakonom, i odbijajući zahtjev apelanta da mu se prizna status zakonskog nasljednika, prekršili zabranu diskriminacije. Ova odluka može imati reperkusije i na položaj vanbračnih partnera kao zakonskih nasljednika (Centar za podršku organizacijama CENSOR, 2019).

Također, u zakonodavnoj aktivnosti je prošlo više godina dok vanbračni partner nije uvršten među članove porodice umrlog osiguranika u oblasti penzijskog i invalidskog osiguranja. Tako je odredbama člana 4. Zakona o izmjenama i dopunama Zakona o penzijskom i invalidskom osiguranju (Službene novine Federacije BiH, broj 19/22 od 11. 3. 2022. godine - u daljem tekstu: Zakon o PIO) vanbračnom partneru priznato pravo na porodičnu penziju, čime je konačno izvršena

međusobna pravna harmonizacija između člana 3. PZFBiH i člana 69. Zakona o PIO. Naime, u članu 69. tačka a) istog zakona kod nabrajanja članova porodice umrlog osiguranika, odnosno korisnika penzije dodate su riječi "i vanbračni partner" (pored postojećih riječi "bračni supružnik (udovica, odnosno udovac)". Bitno je napomenuti da je iza stava (1) člana 69. Zakona o PIO zakonodavac dodao novi stav (2), koji glasi: "Vanbračni partner iz stava (1) ovog člana smatra se lice koje je kao takvo definisano Porodičnim zakonom Federacije Bosne i Hercegovine, a koje je svoj status utvrdilo u odgovarajućem sudskom postupku"(Oslobođenje, 2022, Prava vanbračnog partnera – nasljeđivanje i porodična penzija). U Republici Srpskoj, vanbračni partner ima pravo na porodičnu penziju, ako mu je pravosnažnom presudom suda dosuđeno pravo na izdržavanje prema važećem zakonu (čl. 71. i 72. Zakona o PIO RS).

Dakle, u pogledu zahtjeva vanbračnog partnera na izdvajanje udjela u vanbračnoj stečevini vrijedi sve ono što je prethodno izneseno za bračnu stečevinu. Međutim, položaj vanbračnog partnera koji nije uknjižen kod nasljeđivanja nekretnena je uveliko teži, obzirom na obavezu dokazivanja postojanja vanbračne zajednice koja pada na teret vanbračnog partnera.

## ZAKLJUČCI

Uprkos zakonima koji formalnopravno izjednačavaju prava i obaveze vanbračnih i bračnih partnera u Bosni i Hercegovini, vanbračna zajednica mora se dokazivati sudskim putem, što je i uvjet za ostvarivanje prava nadživjelog vanbračnog partnera.

Vanbračna zajednica dokazuje se, u parničnom postupku, pred osnovnim sudovima u RS i općinskim u Federaciji BiH, i to iskazima svjedoka i materijalnim dokazima (prijava mjesta boravka, dokazi u smislu adrese, razglednice i paketi koji su stizali, zdravstvana knjižica na tu adresu, izjave komšija, ostali svjedoci, datirane slike da se može sabrati koliko je trajala zajednica).

Teret dokazivanja je, prema dosadašnjim nasljednopravnim rješenjima u FBiH, RS i BD, uvijek na nadživjelom vanbračnom partneru. Na njemu je teret da u parničnom postupku dokaže da je s ostaviocem bio u vanbračnoj zajednici i da je ona dovoljno dugo trajala, (minimalno tri godine u FBIH i BD te minimlno dvije godine u RS), sve do ostaviočeve smrti. Pri tome, dokazuje da se njegova zajednica s ostaviocem razlikovala od braka samo u činjenici da je brak zaključen, odnosno po svojoj neformalnosti. Sve teškoće u ostvarivanju statusa zakonskog nasljednika za vanbračnog partnera proizlaze upravo iz te neformalnosti. Teret dokazivanja postojanja takvih zajednica se javlja kao jedan vid „kazne"zbog (navodne) neformalnosti zajedničkog života. Ista ta neformalnost, s druge pak strane, ostavlja prostora mogućim zloupotrebama, odnosno ostvarivanju nasljednopravnih dejstava kod fiktivnih vanbračnih zajednica.

Zato bi, svakako, ipak trebalo razmotriti o mogućnosti uvođenja nekog oblika registracije vanbračne zajednice u bosanskohercegovačkom nasljenom pravu.

Preporuka je da, ukoliko dođe do neslaganja po pitanju njegovih prava između vanbračnog partnera i ostalih nasljednika kako bi se postiglo prebacivanje tereta dokazivanja sa nadživjelog vanbračnog partnera na nasljednike koji osporavaju postojanje vanbračne zajednice.

Preporuka je da bračni/vanbračni partneri regulišu svoje međusobne odnose u pogledu bračne stečevine, primjerice sklapanjem bračnog ugovora, a također i u pogledu nasljeđivanja korištenjem ugovora o nasljeđivanju, jer će se na opisani način izbjeći eventualni nesporazumi i sukobi vezani uz pitanje nasljeđivanja. Ugovor o nasljeđivanju prema Zakonu u nasljeđivanju RS nije dopušten u Republici Srpskoj., dok je u Federaciji i Distriktu Brčko dopušten.

Također, odredbe nasljednog prava u BiH dovode bračnog/vanbračnog partnera u položaj u kojem on za imovinu svog umrlog bračnog/vanbračnog partnera konkurira sa relativno dalekim srodnicima ostavioca (bratićima i sestrićima umrlog).

U budućim promjenama nasljednog zakonodavstva preporuka da bi se trebalo zalagati za rješenje da ukoliko iza umrlog nisu ostali živi roditelji, nadživjeli bračni/vanbračni partner nasljeđuje sam i ne konkurira sa braćom i sestrama ostavioca, niti njihovim potomcima.

Također, preporuka da nasljednici slijedećih nasljednih redova, primjerice braća i sestre ostavioca i njihovi potomci, nasljeđuju samo ako ostavioc nije imao bračnog/vanbračnog partnera.

Uzimajući u obzir sve navedeno, ne može se govoriti o potpunoj ravnopravnosti vanbračnih partnera sa partnerima koji su u braku. Postignut je značajan napredak da se vanbračni partneri i

njihova prava iz vanbračne zajednice izjednače sa bračnim uvrštavanjem vanbračnih partnera u krug zakonskih nasljednika. Na taj način im je recimo olakšano ostvartivanje prava na porodičnu penziju. Mnogo je toga urađeno, prvenstveno od strane Ustavnog suda BiH kako bi se olakšao i u potpunosti izjednačio pravni položaj vanbračnih partnera sa bračnim.

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# EXTRAMARITAL UNION IN B&H FAMILY LAW WITH SPECIAL REFERENCE TO THE INHERITANCE POSITION OF THE SURVIVING EXTRAMARITAL UNION PARTNER

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## ABSTRACT

The institute of the extramarital union in family law of Bosnia and Herzegovina will be examined in detail in the paper, with special emphasis to the position of the extramarital union partner as inheritor in the inheritance proceedings. The extramarital union is a union of a man and a woman of which neither is married, that has lasted for at least three years, or less if it produced a child by the participants. This is how the extramarital union is defined and determined in the Family law of the Federation and of Brčko District. In Family law of Republic Srpska the extramarital union is defined as being a union of a man and a woman (extramarital union partners) between which there are no marital obstacles and which has lasted at least two years or less if it had produced a child. Given this fact, the inheritance position of the extramarital union partner is differently regulated in B&H. The inheritance position of the extramarital union partners is significantly made more difficult by the need to prove the existence of the extramarital union. In the results of the paper possible solution to this problem will be indicated in the form of the need to register the extramarital unions. Likewise, a thought will be given to the possibility of introducing certain rebuttable legal presumptions to benefit the extramarital union partners. In this way the position of the extramarital union partner in inheritance proceedings would be enhanced and the shifting of the burden of proof from the extramarital union partners to the inheritors disputing the existence of the extramarital union would be achieved.

**Keywords**: extramarital union, extramarital union partner, inheritance proceedings, inheritance by extramarital union partners.

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# NEVAŽEĆI UGOVORI U OBLIGACIONOM PRAVU REPUBLIKE SRPSKE

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## SAŽETAK

Da bi jedan obligacioni ugovor proizvodio pravno dejstvo potrebno je da se ispune uslovi koje zakon predviđa za njegov nastanak i punovažnost. Izostanak nekog od ovih uslova čini ugovor pravno nevaljanim. Zakon o obligacionim odnosima Republike Srpske uglavnom je prihvatio dvojnu podjelu nevažećih pravnih poslova, time i ugovora, dijeleći ih na ništave i rušljive ili relativno ništave, iako jedan dio naše pravne teorije ovoj podjeli pridružuje i kategoriju tzv. nepostojećih ugovora.

Dugogodišnja sudska praksa nije bila dovoljna da se odredi precizna razlika uslova koji trebaju biti ispunjeni da bi ugovor bio ništav ili rušljiv. U radu se razmatraju teorijski i praktični aspekti razlikovanja ništavih i rušljivih ugovora kao i njihovog pravnog dejstva, posljedice koje iz tih razlika proizilaze kao i pretpostavke za konverziju i konvalidaciju pravno manjkavih ugovora.

**Ključne riječi**: nevaljanost, ništavost, nepostojeći ugovor, konverzija, konvalidacija.

## UVOD

Od nastanka civilizacije ljudi su kao društvena bića u sociološkom, kulturološkom, ekonomskom i svakom drugom segmentu svog bivstvovanja upućeni jedni jedni na druge. Ovo se prije svega odnosi na njihove materijalne, egzistencijalne potrebe. U početku ljudi sami proizvode dobra samo za svoje potrebe. Usavršavanjem proizvodnih vještina i sredstava za proizvodnju dolazi do stvaranja viška materijalnih dobara koje proizvođači razmjenjuju (trampe) sa drugim proizvođačima. Potrebe društva za većim količinama i raznovrsnijim proizvodima zahtijevalo je postepeno potiskivanje razmjene i uvođenje novca kao univerzalnog platežnog sredstva. Ovo je usko povezano sa razvojem tržišta pa novac postaje glavno platežno sredstvo za prodaju i kupovinu proizvoda koji na tržištu predstavljaju robu. Razvijaju se i drugi imovinskopravni odnosi između ljudi, roba i novac se daju u zajam, materijalna dobra na poslugu, objekti i sredstva za rad daju se u zakup itd. Razvojem nauke, tehnike i ekonomije veći značaj dobija i privatna svojina i svi oblici njenog prometa što je pratilo unapređenje obligacionih odnosa i pravnih normi koje ih regulišu. Sporazumi, kovencije, ugovori ili dogovori - kakav god naziv nosili, imaju istu ekonomsku osnovu i vremenom sve više dobijaju na značaju.

Demokratizacijom društva i sazrijevanjem ideja o slobodi volje strana u imovinskim odnosima raste težnja progresivnih snaga da se ovi odnosi regulišu tako da niko ne dobije prava koja mu ne pripadaju niti da ispunjava obaveze koje nije preuzeo niti prouzrokovao.

Ova težnja prisutana još u starom vijeku sažeta je u latinskoj maksimi koja odražava opšta pravna načela: *„Honeste vivere, alterum non laedere, suum quique tribuere.“* – Pošteno živjeti, drugoga ne povrijediti, svakome dati što mu pripada.

Jedan od osnovnih alata kojima se ova maksima ostvarivala u slobodnom raspolaganju građana svojom imovinom su ugovori. Sklapanjem ugovora teži se jasnom definisanju volja ugovarača, njihovih namjera, kao i eliminisanju mogućih nesporazuma. Tema pravne valjanosti ugovora teorijski se počinje oblikovati pojavom teorije o pravnim poslovima koju u pravni život uvodi njemački profesor Arnold Hajse, dok njen klasični izraz oblikuje znameniti njemački pravni teoretičar Savinji početkom XIX vijeka (Stojanović i Antić, 2004, str. 310).

Obzirom na viševiekovni razvoj teorijske misli o pravnim poslovima među kojim su ugovori najznačajniji, postavlja se pitanje zašto je pitanje valjanosti ugovora i dalje aktuelno?

Ma koliko se ugovarači trudili da svoju volju jasno i nedvosmisleno iskažu, praksa je pokazala da uvijek postoji mogućnost da ta volja ne bude ugovorom pravilno određena, ili da se ugovara nešto što se protivi zakonima, javnom poretku ili moralnim normama.

Ugovorne strane ponekad samo prividno zaključuju određeni ugovor koji je pravno dozvoljen, ali u stvari tim ugovorom žele prikriti neki drugi ugovor koji pravo ne dozvoljava. Tako npr. nije dozvoljeno ugovaranje trgovine ljudima, narkoticima, zelenaški ugovori i slično, ma kakvom formom pravnog posla bili skriveni. Ovi ugovori ne samo da ne smiju postati sastavni dio pravnog prometa, nego je neophodno spriječiti da oni proizvedu bilo kakvo pravno dejstvo; oni jednostavno moraju biti eliminisani iz pravnog poretka.

Nekada ugovorne strane iz neznanja ili nepažnje zaključuju dozvoljen ugovor, a u stvari njihova namjera je zaključenje drugog pravno prihvatljivog ugovora, pa je pitanje koji ugovor je u stvari zaključen? Takođe ugovori mogu biti zaključeni i sa tzv. manama volje, odnosno pod zabludom, prinudom ili prijetnjom. Postoji mogućnost i nesporazuma kada ugovorne strane zaključuju jednu vrstu ugovora pogrešno držeći da se radi o drugoj vrsti ugovora, a u ovoj zabludi može biti jedna ili obje ugovorne strane. Dakle ovo pitanje je i danas aktuelno kako u uporednom tako i u domaćem pravu.

U domaćem pravu oblast ugovora reugulisana je Zakon o obligacionim odnosima SFRJ iz 1978, godine koji je uz određene korekcije i dopune u najvećem dijelu preuzet u pozitivno pravo zemalja nastalih disolucijom bivše socijalističke Jugoslavije (Zakon o obligacionim odnosima SFRJ [ZOOSFRJ], 1978). I pored gotovo pola vijeka primjene navedenih obligacionih normi, neke dileme u pogledu važnosti ugovora, pravnih posljedica nevažećih ili manjkavih ugovora i danas često zadaju glavobolju ugovornim stranama, a naročito sudijama, advokatima, notarima i drugim licima koji ova pitanja rješavaju u praksi. Cilj ovog rada je ukazati još jednom na navedeni problem i dati skroman doprinos boljem sagledavanju i osvjetljavanju ovog složenog pitanja i u sadašnjem vrijemenu.

## USLOVI ZA NASTANAK I PUNOVAŽNOST UGOVORA

Da bi se raspravljalo o punovažnosti ugovora, kao i njegovim posljedicama neophodno je prije svega utvrditi da je konkretni pravni posao (ugovor) nastao. U najopštijem smislu u pravnoj teoriji ugovor je saglasna izjava volja ugovornih strana kojima pravni poredak priznaje pravno dejstvo koje se sastoji u promjeni subjektrivnih građanskih prava. Zakon o obligacionim odnosima Republike Srpske (Zakon o obligacionim odnosima Republike Srpske [ZOORS], 2004, član 26 ZOO), zemalja regiona, ali i važnije građanske kodifikacije određuje da je ugovor zaključen kad se ugovorne strane saglase o njegovim bitnim sastojcima Zakon ne definiše posebnom odredbom bitne elemente (sastojke) ugovora (*essentialia negotii*). U teoriji se bitni sastojci ugovora dijele na objektivno i subjektivno bitne. Objektivno bitni sastojci određuju se pravnim propisom, odnosno zakonom (npr. prema čl. 454. ZOORS, predmet i cijena su bitni sastojci ugovora o prodaji). Subjektivno bitni elementi ugovora određuju se voljom stranaka. To su oni sastojci ugovora koji generalno ne predstavljaju uslov nastanka ugovora. Međutim, za jednu od ugovornih strana ti uslovi mogu predstavljati važan sastojak, bez kojeg ta strana ne želi zaključiti ugovor. Ovdje je bitno da se o tim uslovima ugovarači slože i da ih kao bitne ugovore. U slučaju spora samo se objektivno bitni sastojci ugovora ne dokazuju, dok postojanje subjektivno bitnih sastojaka ugovora mora dokazati ona strana koja se na njih poziva.

Pozitivno obligaciono pravo Republike Srpske, Federacije BiH kao i uporedna zakonodavstva zemalja regiona, kao i većine evropskih zemalja za nastanak pravno valjanog ugovora zahtijevaju postojanje nekoliko elemenata:

- sposobnost ugovaranja,
- saglasnost volja,
- dozvoljen pravni osnov (kauzu),
- predmet ugovora,
- određenu formu (samo kod formalnih ugovora).

Sposobnost ugovaranja, saglasnost volja, kauza i predmet ugovora predstavljaju bitne sastojke bez kojih ugovor ne bi bio pravno valjan. Za određenu vrstu ugovora neophodna je

posebna forma (zakonska ili ugovorena) da bi proizveli pravno dejstvo, što je izuzetak, dok je opšte pravilo da forma nije uslov nastanka ugovora.

Za zaključenje ugovora neophodno je da ugovorne strane, ugovarači imaju sposobnost ugovaranja. Pravno lice može zaključiti ugovore u pravnom prometu u okviru svoje pravne sposobnosti. Ugovor zaključen izvan okvira pravne sposobnosti pravnog lica nema pravno dejstvo, a savjesna strana može zahtijevati naknadu štete koju je pretrpjela uslijed zaključenja ugovora koji nema pravno dejstvo. (čl. 54 ZOO) Zakon reguliše da je za zaključenje punovažnog ugovora potrebno da ugovarač ima poslovnu sposobnost koja se traži za zaključivanje tog ugovora. Ograničeno poslovno sposobno lice može bez odobrenja svog zakonskog zastupnika zaključivati samo one ugovore čije mu je zaključivanje zakonom dozvoljeno (čl. 56 ZOO) Ostali ugovori tih lica ako su zaključeni bez odobrenja zakonskog zastupnika rušljivi su, ali mogu biti osnaženi njegovim naknadnim odobrenjem.

Uočljivo je da zakonske odredbe preciziraju da pravno lice može zaključiti ugovor u okviru svoje pravne sposobnosnosti koja je po prirodi stvari uža od pravne sposobnosti fizičkih lica (pravna lica npr. ne mogu imati porodična prava, obligaciona prava koja proizilaze iz srodstva kao i lična prava koja se vežu za ljudsku individualnost). Pri tome Zakon određuje poslovnu sposobnost ugovarača kao uslov za punovažnost ugovora, koja je neophodna i za pravna i fizička lica. Poslovna sposobnost pravnih lica je u direktnoj vezi sa pravnom sposobnošću. Pravna i poslovna sposobnost fizičkog lica nije uređena odredbama građanskog prava kao što je to slučaj u važnijim evropskim kodifikovanim građanskim zakonicima.

Uopštavanja o pravnoj sposobnosti fizičkih lica naša pravna nauka zasniva na analizi važećih propisa predratnih zakona i uporednog zakonodavstva i prakse, što je posljedica normativne razuđenosti i nesistematičnosti odredbi koji uređuju ovu oblast. Poslovna sposobnost kao atribut fizičkog lica uređena je propisima o braku i bračnim odnosima, a materijalno pravni propisi o proglašenju nestalog lica umrlim Zakonom o vanparničnom postupku. Kad je u pitanju obligaciono pravo, za valjanost ugovora koje zaključuje ugovarač kao fizičko lice neophodno je da to lice posjeduje poslovnu sposobnost. Poslovna sposobnost je sposobnost da se izjavama sopstvene volje prouzrokuju pravne posljedice, dakle steknu, izmijene, ugase ili prenesu građanska subjektivna prava. Teorijski poslovnu sposobnost je nemoguće zamisliti bez pravne sposobnosti, za sticanje prava neohodna je prethodna mogućnost - upšte imati prava i obaveze. Obrnuto je moguće, odnosno pravnu sposobnost imaju i lica koja nemaju poslovnu sposobnost. Pravna sposobnost je statička, a poslovna sposobnost dinamična komponenta pravnog subjektiviteta (Stojanović i Antić, 2004, str. 142).

Ugovor je zaključen kad su se ugovorne strane saglasile o bitnim sastojcima ugovora (čl. 26. ZOO). Saglasnost volja kao opšti uslov za nastanak ugovora, proizilazi iz samog pojma ugovora u kome se za razliku od jednostranog pravnog posla javljaju dvije volje iz čije podudarnosti i koegzistencije nastaju prava i obaveze. Saglasnost se, dakle ostvaruje susretom volje ugovornika. U pravnoj teoriji se ističe da volja ugovornika prije svega treba biti na shodan i dozvoljen način izjavljena, kao i da jedna od njih uvijek ima obilježja inicijative i prijedloga (ponude) a druga obilježja prihavatanja ponude. I najzad izjavljene volje u smislu punovažnog ugovora, ne smiju imati nedostatke odnosno mane, kao što je npr. prijetnja ili zabluda (Perović i sar. 1980, str. 184-185).

U svim savremenim pravnim sistemima dopuštena je sloboda ugovornog uređenja odnosa, ali je predviđena i granica do koje se ta sloboda može prostirati. Sloboda ugovaranja omeđena je opštim pravilima društvenog poretka čija sadržina i okvir zavise od prirode i karaktera osnovnih principa na kojima je zasnovan taj pravni sistem. Sloboda ugovaranja može se ograničiti zakonom i to tako što se za pojedine ugovore predviđa pismena forma, kao npr., za ugovor o građenju (čl. 630. st. 2. ZOO) ili ugovor o licenci (čl. 687. ZOO).

Uporednopravni pregled važnijih građanskopravnih kodifikacija evropskih zemalja ukazuje na izvjesnu razliku pojmova i izraza kojima se na opšti način ograničava sloboda ugovaranja. Tako npr. u francuskom Građanskom zakoniku i švajcarskom Zakonu o obligacijama se govori o javnom poretku i dobrim običajima, a njemački i austrijski Građanski zakonik poznaje samo dobre običaje. (Perović i sar. 1980, str. 26) Zakon o obligacionim odnosima RS, predviđa da su strane u

obligacionim odnosima slobodne da svoje odnose urede po svojoj volji, ali u granicama prinudnih propisa, javnog poretka i dobrih običaja. (čl. 10 ZOO) Ovo je proizvod teorije o javnom poretku kojim se ograničenje slobode ugovaranja određuje jednom normom po uzoru na francuski Građanski zakonik koji je prvi prihvatio taj izraz, pa se teorija o javnom poretku najviše razvila u francuskoj doktrini.

Opšte ograničenje slobode ugovaranja predviđeno domaćim obligacionim zakonodavstvom našlo je konkretnu primjenu u odredbama posvećenim predmetu i osnovu ugovorne obaveze. Sam predmet ugovora je ono na šta se ugovor odnosi, odnosno ono „o čemu je ugovor" kako predviđa Crnogorski Opšti imovinski zakonik. (čl. 513) U praksi je čest slučaj izjednačavanja predmeta i objekta ugovora što nije prihvatljivo sa stanovišta nauke. Tako npr. predmet zakupa nije stan kao nepokretnost, nego obligacije koje nastaju za ugovorne strane, odnosno obaveza zakupodavca da preda stan zakupcu na korišćenje i obaveza zakupca za to plaća zakupninu i stan vrati zakupodavcu u ugovorenom roku. Stan je dakle objekat ugovora, a ne predmet ugovora. Predmet, odnosno ugovorna obaveza, može se sastojati u davanju, činjenju, nečinjenju ili trpljenju (*dare, facere, non facere i pati*). Obaveza je nedopuštena ako je protivna prinudnim propisima, javnom poretku ili dobrim običajima. (čl. 49 ZOO) Da bi predmet obaveze bio punovažan potrebno je da on bude moguć, dopušten i određen odnosno odrediv (čl. 46 ZOO), a sankcija za neki od navedenih nedostataka u pogledu predmeta je ništavost ugovora. (čl. 47. ZOO)

Svaka ugovorna obaveza mora imati dopušten pravni osnov, a osnov je nedopušten ako je protivan prinudnim propisima, javnom poretku ili dobrim običajima. (čl. 51 ZOO) Pravni osnov (kauza) daje odgovor na pitanje zašto se ugovorna strana obavezuje ugovorom (*cur debitur*). Postoje različita shvatanja teorijskog pojma kauze, a kreću se od glorifikovanja do negacije klauzule (Stojanović i Antić, 2004, str. 322). Brojne teorije o ovom pitanju mogu se svrstati u tri osnovna pravca: klasično shvatanje kauze, negacija kauze i novija shvatanja kauze u okviru kojih se ističu subjektivno, objektivno i mješovito poimanje kauze. Ne upuštajući se dublje u torijsku genezu razvoja kauze kao bitnog elementa ugovora, možemo konstatovati da Zakon o obligacionim odnosima u osnovi prihvata teoriju o mješovitom poimanju kauze. Uvedena je oboriva pretpostavka da svaki ugovor, uključujući tu i apstraktne ugovore (kod kojih kauza nije vidljiva za treća lica), mora da sadrži dozvoljen pravni osnov. Normativno je definisan odnos motiva i kauze, na način da pobude iz kojih je zaključen ugovor ne utiču na njegovu punovažnost, ali ako je nedopuštena pobuda bitno uticala na odluku jednog od ugovarač da zaključi ugovor i ako je drugi ugovarač to znao ili morao znati ugovor će biti bez dejstva (Stojanović i Antić, 2004, str. 322).

Zaključenje ugovora ne podliježe nikakvoj formi, osim ako je zakonom drugačije određeno. (čl. 67. st.1) Odredbama ovog člana Zakon proklamuje princip savremenog ugovornog prava prema kome se ugovori zaključuju prostom saglasnošću volja (*solus concesensus obligat*), bez ispunjenja unaprijed predviđenih formi (Perović i sar. 1980, str. 273). Savremeno pravo prati snažan razvoj i primjena informacionih tehnologija i u obligacionom pravu (unificirani obrasci pojedinih tipskih ugovora, njihovo zaključenje on line, elektronski potpis i dr), kao i sve češčih oblika specifičnih ugovora za pojedine društvene i privredne oblasti. Stoga je osjetna tendencija povećanja novih vrsta i elemenata formalnih ugovora.

Formalni ugovori su, kao što i sam naziv govori, oni ugovori za čiju punovažnost zakon zahtijeva da izjava volje bude data u odgovarajućoj formi. Elementi forme razlikuju se od posla do posla: pismena forma, forma javne isprave, predaja stvari ili prisustvo svjedoka. Ugovorne strane se mogu sporazumjeti da posebna forma bude uslov punovažnosti njihovih ugovora. Ugovor za čije je zaključenje ugovorena posebna forma može biti raskinut, dopunjen ili na drugi način izmijenjen i neformalnim sporazumom. Ako su ugovorne strane predvidjele posebnu formu samo da osiguraju dokaz svoga ugovora, ili da postignu što drugo, ugovor je zaključen kad je postignuta saglasnost o njegovoj sadržini, a za ugovarače je u isto vrijeme nastala obaveza da ugovoru daju predviđenu formu. (član 69 ZOO) Ugovor koji nije zaključen u propisanoj formi nema pravno dejstvo ukoliko iz cilja propisa kojim je određena forma ne poizilazi šta drugo. Ugovor koji nije zaključen u ugovorenoj formi nema pravno dejstvo ukoliko su stranke punovažnost ugovora uslovile posebnom formom. (čl. 70 ZOO) Forma *ad solemnitatem* – bitna forma, dakle forma je bitan uslov za

punovažnost ugovora. Nepoštovanje ove forme ima za posljedicu ništavost ugovora. Forma *ad probationem* - dokazna forma nije bitan uslov za punovažnost ugovora i njeno nepoštovanje nema za posljedicu ništavost nego nemogućnost da se u postupku pred sudom dokaže postojanje ugovora na drugim način osim tom formom. Konsensualizam je pravilo modernog građanskog prava, ali pravilo koje, najčešće iz razloga pravne sigurnosti i izvjesnosti namirenja fiskalnih obaveza, trpi brojne izuzetke (Stojanović i Antić, 2004, str. 330-331). Kod nekih ugovora je obavezna forma odavno našla svoje mjesto u domaćem i uporednom pravu. Tako je kod kupoprodaje nekretnina forma bitan sastojak ugovora i u domaćem i uporednom pravu. Ovo je slučaj i sa njemačkim zakonodavstvom, koje regulište da kupoprodajni ugovori za nekretnine imaju snagu samo ako su ovjereni kod notara. Usmeni kupoprodajni ugovor za imovinu je nedjelotvoran od samog početka. Prema § 125 BGB, pravni posao je ništav ako nije u zakonom propisanom obliku. U novije vrijeme dakle, primjetna je tendencija povećanja pravnih poslova za koji se propisuje posebna forma.

## NEVALJANI UGOVORI U POZITIVNOM PRAVU I SUDSKOJ PRAKSI

Zakon o obligacionim odnosima sve ugovore kojima nedostaje neki od elemenata neophodnih za njihovu valjanost svrstava u kategoriju nevažećih ugovora. U suštini Zakon prihvata dvojnu podjelu nevažećih ugovora te ih svrstava u ništave i rušljive.

Usko tumačeći ovaj naziv mogli bismo zaključiti da su svi ugovori koji nisu perfektni, odnosno koji imaju nedostatak u nekom od uslova za njihovu valjanost nisu važeći. Stoga ovaj termin nije najadekvatniji za njihovo objašnjenje. U teoriji se za ništave ugovore koristi i termin apsolutno ništavi, a za rušljive relativno ništavi ugovori. Naime u nevažeće ugovore ne bi spadali rušljivi, jer oni "važe" (proizvode dejstvo) sve dok ne budu poništeni. Za razliku od njih u nevažeće možemo uvrstiti ništave, nepostojeće i poništene (rušljive koji više ne važe).

Termin nepunovažni obuhvatao bi i ništave i rušljive, dok nepostojeći nisu ni nastali pa se ne bi moglo govoriti o njihovoj punovažnosti. Smatramo da bi termin „pravno nevaljani ugovor" najadekvatnije održavao ugovore koji su nepostojeći ili ništavi ili rušljivi. Pod ništavim ugovorima porazumijevaju se oni ugovori koji su protivni prinudnim propisima, javnom poretku i dobrim običajima (čl. 103. ZOO). Ovi ugovori su ništavi samo ako cilj povrijeđenog pravila ne upućuje na neku drugu sankciju, ili ako zakon o određenom slučaju ne propisuje što drugo. Ništavi ugovori su zabranjeni, odnosno nezakoniti i/ili nemoralni pravni poslovi. Pošto vrijeđaju javne interese, na njih se mogu pozivati sva zainteresovana lica. Ovo je jedan od osnovnih principa poznat joj u rismskom pravu: „O*no što je od početka nevaljano, ne može protekom vremena ojačati*..." (Digesta, 1958) ili kako to Valtazar Bogišić narodnim jezikom kaže: *„Što se grbo rodi vrijeme ne ispravi* [...]*"* (Bogišić, 1888, čl. 1006).

U prvobitnom tekstu Zakona o obligacionim odnosima član 103 st. 1, bilo je navedeno da je ništav ugovor koji je u suprotnosti sa „ustavom utvrđenim načelima društvenog uređenja, prinudnim propisima ili moralom socijalističkog samoupravnog društva...". Kasnijim izmjenama zakona izbačen je dio o ustavnim načelima i moralu i zamijenjen je dijelom koji govori o javnom poretku i dobrim običajima. Zakon o obligacionim odnosima Federacije BiH je izmjenu predmetnog člana izvršio tako što „ustavom utvrđena načela(...)"zamjenjuje tekstom "Ustavu (…), prinudnim propisima te moralu društva" izbacivši tako ideološku i političku odrednicu ranijeg društvenog uređenja, a sačuvavši suštinu prvobitne odredbe. Međutim, mnogo je teže odrediti kada je jedan ugovor suprotan moralnim normama, nego kad je ugovor protivan imperativnoj normi. Postoje primjeddbe u pravnoj teoriji da su pojmovi morala i moralna shvatanja promjenjive i pravno neprecizne kategorije. Ono što je za jedno društvo na određenom stupenu razvoja nemoralno, u nekom drugom to ne mora biti. Međutim, slična primjedba bi mogla da se stavi i na dobre običaje koje možemo posmatrati u užem i širem kontekstu. U užem smislu oni bi obuhvatali nepisana pravila ponašanja koja su duboko ukorijenjena u jednom društvu. U širem smislu ova pravila obuhvataju i moralne principe na šta i njihov naziv upućuje i „dobri običaji". Moral i dobri običaji se djelimično preklapaju, a oba pojma su usko vezana za načelom savjesnosti i poštenja kao univerzalnom načelom građanskog prava. U konačnici ostavljeno je sudskoj praksi da u konkretnim slučajevima procjenjuje koje ponašanje je povrede morala, odnosno dobrih običaja.

Tako je npr. Okružni sud u Subotici zaključio da lice koje da na zajam drugom novac radi kocke i isti se u tu svrhu upotrijebi, nema pravo tužbom da traži povraćaj duga. Ovakav ugovor je protivan moralu [...] pa je zbog toga ništav (Presude Okružni Sud Subotica Gž. 1885/91). Kad stranke zaključe fiktivan pravni posao označavajući ga kao ugovor o poklonu, u namjeri da na taj način obezbijede jednoj ugovornoj strani ostvarenje pravo na dječiji dodatak, onda je u takvom pravnom poslu ispoljena nesavjesnost oba ugovarača, pa je takav pravni posao apsolutno ništav jer je protivzakonit i protivan moralu (...).(Presuda Saveznog Vrhovnog Suda Rev. 2291/60) Nije ništav ugovor o doživotnom izdržavanju iako je zaključen kratko vrijeme prije smrti primaoca izdržavanja, ako davalac izdržavanja nije bio svjestan da zbog prirode bolesti predstoji skora smrt primaoca izdržavanja (Presuda Vrhovnog suda FBiH, Rev. 105/99, od 02.09. 1999).

Najkarakterističniji slučajevi ništavog ugovora u našem pravu su: zelenaški ugovor, ugovor sa nemogućim obavezama, ugovori potpuno nesposobnog lica i pravni poslovi koje preduzme pravno lice van okvira svoje pravne sposobnosti. Bez obzira na činjenični osnov istaknut u tužbi, ako sud utvrdi da je osporeni pravni posao ništav on će ga poništiti, jer na ništavost sud pazi po službenoj dužnosti (Presuda Vrhovnog suda Vojvodine Rev. 211/89).

Djelimična ništavost postoji kad su ništave samo pojedine odredbe a ne i ugovor u cjelini. Pravilo da ništavost jedne manje važne ugovorne odredbe ne povlači i ništavost cijelog ugovora prihvaćeno je u svim značajnijim kodifikacijama. (§ 139 BGB, član 20. Švajcarskog zakona o obligacijama, član 1419 Italijanskog građanskog zakonika i dr.). Domaća sudska praksa staje na stanovište da je npr. ništava odredba ugovora prema kojoj su stranke saglasne da zajmodavac stekne pravo svojine na nekretnini zajmoprimca ukoliko zajmoprimac u roku utvrđenom ugovorom ne vrati pozajmljena sredstva. U ostalom dijelu ugovor ostaje na snazi (Presude Vrhovnog suda Srbije, 19/94).

Zakon o obligacionim odnosima određuje da je ugovor rušljiv kad ga je zaključila ograničeno poslovno sposobna strana, kad je pri njegovom zaključenju bilo mana u pogledu volje kao i kad je to Zakonom ili posebnim propisom određeno (čl. 111). Rušljivi ugovori su oni ugovori kojima se prevashodno vrijeđaju privatni interesi stranaka. Za razliku od ništavih ugovora, oni proizvode pravna dejstva, ali mogu biti poništeni na zahtjev ovlašćenog lica u zakonom predviđenom roku. Dakle rušljivi ili tzv. oborivi ugovori spadaju u nepunovažne, ali ne može se reći da su nevažeći. Strana u čijem je interesu rušljivost ustanovljena može podići tužbu za poništaj u subjektivnom roku od godinu i objektivnom roku od tri godine. Pravo da se zahtijeva poništaj je preobražajno pravo, rok za poništaj je prekluzivan, a sudska odluka ima konstitutivno dejstvo.

Rušljivi ugovori su ugovori zaključeni: u zabludi; pod prevarom; pod prijetnjom; od strane ograničeno poslovno sposobnog lica i lezionarni ugovor. Sudska praksa ima zadatak da razgraniči ništavost i rušljivost ugovora prema konkretnom slučaju. Tako se u presudi Saveznog suda Jugoslavije ističe da budući da jedna pravila važe za ništave, a druga za rušljive ugovore sud je dužan razgraničiti da li se radi o ugovoru zaključenom pod pritiskom radi iseljenja koji bi bio protivan prinudnim propisima, pa samim tim i apslolutno ništav, ili pak o ugovoru zaključenom sa manom u volji prodavca (relativno ništavom ugovoru) (Presude Saveznog suda Jugoslavije, Gzs 14/95 od 29. VI 1995).

Poništaj dejstvuje retroaktivno što ima negativan uticaj na stečeno pravo vlasništva pribavioca i trećeg lica jer predstavlja udar na sigurnost pravnog prometa. Zato od navedenog pravila postoje izuzeci, a oni su ustanovljeni zbog sigurnosti pravnog prometa. Prvi izuzetak postoji u slučaju kada se na strani sticaoca kao trećeg lica ispune uslovi za sticanje prava vlasništva po osnovu održaja, *usucapio* što je predviđeno odredbama Zakona o vlasničko-pravnim odnosima Federacije BiH (Zakona o vlasničko-pravnim odnosima Federacije BiH [ZOVOFBiH, 1998]) ( čl. 32. st. 1.). Drugi izuzetak je sticanje prava vlasništva od nevlasnika. Ovo sticanje vlasništva je jedan od načina originarnog sticanja vlasništva na pokretnim stvarima ( čl. 36. ZOVO).

Osim ništavih i rušljivih ugovora, u teoriji su prisutni i tzv. nepostojeći ugovori, a ovi ugovori se posredno pominju i u Zakonu o obligacionim odnosima u dijelu koji se odnosi na nesporazum strana (čl. 63). Nepostojeći ugovori ne ispunjavaju uslove koji su neophodni za nastanak ugovora uopšte. U ovom slučaju postoji samo privid ugovora koji za razliku od ništavih poslova koji postoje, ali ne proizvode pravno dejstvo, nisu ni nastali. U našem pravu u nepostojeće pravne

poslove uključujući i ugovore svrstavaju se: fiktivni ugovori; simulovani ugovori i ugovori kod kojih postoji zabluda o prirodi, predmetu ili kauzi ugovora. Ugovor nije fiktivan samo po tome što su ga stranke nazvale jednim imenom, a trebalo je da ga nazovu drugim imenom i zbog toga što su stranke ugovor ocijenile kao pravni posao jedne vrste, a to je pravni posao druge vrste (Presuda Saveznog vrhovnog suda Jugoslavije, Rev. 2291/60). Simulovani ugovor o kupoprodaji stvari može se konverzijom preobraziti u ugovor o obezbjeđenju potraživanja zalogom (Vrhovni Sud Srbije, Rev, 3900/95, 19. 09. 1995) Vrhovni sud Hrvatske zauzeo je stav da „u određenom slučaju ugovor o zajmu [...] nema učinka među ugovornim stranama jer je utvrđeno da se radi o simulovanom poslu koji prikriva neki drugi ugovor [...] iznos naveden u ugovoru o zajmu bi bio dug iz poslovanja tvrtki stranaka“ (Vrhovni sud Hrvatske Rev. 862/2006-2 od 4. 4. 2007).

Kad je u pitanju poslovna sposobnost ugovarnika sudska praksa zauzima stav da je ništav ugovor koji sačini lice potpuno poslovno nesposobno, a ugovor koji zaključi strana ograničeno poslovno sposobna je rušljiv. Ugovorna strana u čijem je interesu rušljivost ustanovljena može tražiti da se ugovor poništi (Presude Okružnog suda Subotica, Gž 1885/91). Takođe, ništav je ugovor koji je zaključilo lice koje nije bilo sposobno za rasuđivanje u vrijeme zaključenja ugovora bez obzira što mu poslovna sposobnost nije bila oduzeta sudskom odlukom u smislu člana 103. Zakon o obligacionim odnosima Republike Srbije (Zakon o obligacionim odnosima Republike Srbije [ZOORS], 2020), (Presuda Okružnog suda Zrenjanin, Gž 234/96, 25. 02. 1988). Ako jedna strana izazove zabludu kod druge strane ili je održava u zabludi u namjeri da je time navede na zaključenje ugovora, druga strana može zahtijevati poništaj ugovora i onda kad zabluda nije bitna. (Vrhovni Sud Srbije, Rev. 1291/97 od 3. VI 1997) Ugovori starijih maloljetnika zaključeni bez saglasnosti zakonskog zastupnika su *hramajući* pravni poslovi, jer ne proizvode pravno dejstvo dok ne dobiju saglasnost, dok rušljivi ugovori proizvode pravno dejstvo od trenutka nastanka. I u njemačkom Građanskom zakoniku (BGB) ništavi ugovori uključuju i tzv. neefikasne pravne poslove na čekanju, koji, međutim, mogu stupiti na snagu kasnije izjavom. Ovo uključuje ugovore sa *osobama sa ograničenom poslovnom sposobnošću* (maloletnici od 7 do 17 godina) bez prethodnog pristanka zakonskog zastupnika. (§ 107 BGB) Takvi ugovori stupaju na snagu tek nakon punoletstva ili uz naknadnu saglasnost zakonskog zastupnika, a u izuzetnim slučajevima i kroz određene implicitne radnje zakonskog zastupnika koje zakon tretira kao prihvat ugovora maloljetnika (§108 BGB).

Neodređen ili neodrediv predmet ugovora razlog je za ništavost pravnog posla. Tako Vrhovni sud Republike Srpske zauzima stav da je ništav ugovor o poklonu nekretnina koje nisu tačno određene ili odredive (Vrhovni Sud R. Srpske, 710P26100022 rev, 2023).

Kao što je navedeno bitan sastojak ugovora je i kauza odnosno dopušten osnov obaveze. Svaka ugovorna obaveza mora imati dopušten osnov, a ako nije dopušten ugovor je ništav. (Vrhvoni Sud Srbije, 6276/98 od 01. 10. 1999) Pobuda da se učini poklon ulazi u sam osnov ugovora o poklonu, pa kad pobuda otpadne, onda otpada i sam osnov ugovora, što vodi ništavosti ugovora (Vrhovni Sud Srbije, Rev. 4409/99, od 20.10.1999).

Za razliku od ništavih ugovora nepostojeći ugovori, kako ih pojedini teoretičari kod nas kvalifikuju (Perović, 1976) su sporni od samog naziva pa do njihove suštine. Sam termin je pravno neprecizan ili bolje reći neadekvatan. Naime, neki pravni posao je ugovor ili nije, ali svakako ne može biti ugovor koji ne postoji. Preciznije bi bilo govoriti o situaciji “nepostojanja ugovora” ili o “ugovoru u nastajanju” ili o “pokušaju nastajanja ugovora”.

Ovakvi dvostrani, ili višestrani akti samo stvaraju privid pravnog posla odnosno ugovora. Nastali su Francuskoj u XIX vijeku u bračnom pravu. U XX vijeku teorija nepostojanja je proširena i na druge oblasti prava pa su pristalice teorije nepostojanja zastupale stav o potrebi proširenja sankcije nepostojanja na sve pravne akte i uspostavile razliku između poništivih i nepostojećih akata.

Kod nepostojećih ugovora govorimo o pokušaju zaključenja ugovora kojem nedostaje neki suštinski element pri čijem nastajanju nisu bili ispunjeni svi bitni uslovi. On ne samo da ne proizvodi pravno dejstvo, nego i više od toga, ugovor nije ni nastao. O nepostojanju bi trebalo raspravljati u okviru uslova za nastanak pravnog posla, a ne njegove nepunovažnosti.

Pojam nepostojećih pravnih poslova nije opšteprihvaćen. Postoje mišljenja da bi trebalo ostati na bipartitnoj podeli na ništave i rušljive pravne poslove. U francuskoj teoriji zastupa se stav da suprotno onome što se ponekad vjeruje, pravni režim nepostojanja ugovora nije teško objasniti pa čak i teorijski odbraniti. Nepostojeći ugovor ima dva važna elementa: prvi koji se odnosi na uslove za određenje nepostojećim. Drugi se odnosi na posljedice proglašenja ugovora nepostojećim.

Prvo, kao i tužba za apsolutnu ništavost, pa čak i *a fortiori*, tužba za nepostojanje je dozvoljena svakom licu koje ima legitiman interes za nju. Tužba dakle, nije rezervisana za određeno lice kao što je slučaj sa relativnom ništavosti koju "može zahtijevati samo strana koju zakon namjerava zaštititi". Dakle, kada se situacija nepostojanja ugovora tiče javnog poretka, javni tužilac mora biti u mogućnosti da izvrši ovu pravnu radnju. Slično tome, treća lica moraju imati mogućnost da se oslone ne samo na postojanje ugovora nego i suprotno na njegovo nepostojanje (Goût, 2018)

Za ništave ugovore smo prethodno rekli da su zabranjeni ugovori, bilo zakonski, ili su u suprotnosti sa javnim poretkom ili moralom (npr. trgovinom ljudima, prodaja narkotika, obećanje nagrade za slučaj da se izvrši neka nedopuštena radnja, ugovor kojim se određuje kraći ili duži rok zastarelosti, kupovina “mlade” i sl.).

Zelenaški ugovor je nemoralan i nezakonit pa tako ZOO regulište ništavost ugovora kojim neko, koristeći se stanjem nužde ili teškim materijalnim stanjem drugog, njegovim nedovoljnim iskustvom, lakomislenošću ili zavisnišću, ugovori za sebe ili za nekog trećeg korist koja je u očiglednoj nesrazmjeri sa onim što je on drugom dao ili učinio. I njemački Građanski zakonik (§ 138 BGB) reguliše ništavost ugovora u slučaju nemoralnog postupanja ugovarača, iskorištavanja kakve nevolje, neiskustva, nedostatka u rasuđivanju ili značajne slabosti volje nekog lica. Ovo podrazumijeva i pribavljanje novčane koristi koja je upadljivo nesrazmjerna sa pruženom uslugom ili uslugom koja će se pružiti. Nemoral se prvenstveno odnosi na trgovačke običaje. Tako su npr. primjer iskorišćavanja neprilika u vezi sa lihvarenjem cijena kada neko proda litar benzina za 10 eura nekom drugom kome se vozilo pokvarilo zbog nedostatka goriva. Ovaj kupoprodajni ugovor je ništav. Drugi primjer je prodaja radar detektora. Ovo je takođe kršenje § 138 BGB. (Presuda Saveznog suda pravde (Njemačke), VIII ZR 129/04 od 23. 02. 2005.)

## PRAVNO DEJSTVO I POSLJEDICE PRAVNO NEVALJANIH UGOVORA

Poređenje karakeristika ništavog i rušljivog ugovora najbolje ilustruje njihove razlike kao i pravne posljedice.

Tabela 1. Karakteristike, sličnosti i razlike ništavog i rušljivog ugovora.
Table 1. Characteristics, similarities and differences of a void and voidable contract.

| | | |
|---|---|---|
| Terminologija - značenje | Ugovor je neprovodiv i nema pravnih posljedica | Smatra se valjanim i prestaje samo kada se utvrdi njegova nevaljanost |
| Ovlaštena lica za pobijanje | Sva zainteresovana lica | Samo ugovarač u čijem je interesu rušljivost utvrđena |
| Sud pazi po sl. dužnosti | Da | Ne |
| Dejstvo | Nikad ne vrijedi | Vrijedi do prestanka |
| Uslovi za nastanak | Nisu ispunjeni | Postoje nedostaci, ali samo u međ. odnosu ugovornih stana |
| Valjanost *ab-initio* | Nevaljan – ništav od početka | Kasnije postaje ništav |
| Odluka suda o valjanosti | Deklaratorna | Konstitutivna |
| Posljedice | Ne proizvodi pravne posljedice | Proizvodi pravne posljedice do poništenja |
| Konvalidacija | Nije dozvoljena | Moguća konvalidacija |
| Zastarijevanje osoporavanja pravne valjanosti | Ne | Da |

Pravilno uočavanje karakeristika i međusobnih razlika između ništavih i rušljivih ugovora je od naročite važnosti kod odlučivanja u sudskim sporovima koji za predmet imaju ovo pitanje.

Naime ugovarači svoja prava i obaveze vežu za ove posljedice i svakako će se sudbina ugovora odraziti na njihova prava i obaveze ili imovinu, pa je jasno razlikovanje ove dvije vrste ugovora od suštinske važnosti.

Na osnovu do sada navedenog možemo konstatovati da su najvažnije karakteristike ništavih ugovora sljedeće:

- ugovori su nastali, ali ne proizvode pravna dejstva,
- sud o ništavosti vodi računa po službenoj dužnosti, a eventualna sudska odluka je deklarativna, što će reći da sud samo konstatuje da je ugovor ništav,
- strane ne mogu sudskim putem biti prinuđene na izvršenje, što je i logično jer ovakvi ugovori ne mogu proizvoditi međusobna prava i obaveze.
- prava i obaveze ne nastaju ni kao civilne ni kao prirodne (naturalne).

Posljedice ništavih ugovora su:

- obaveza na povraćaj onoga što je primljeno,
- sud može odbiti zahtjev nesavjesne strane za povrat datog,
- sud može odlučiti da strana koja je primila nešto na osnovu zabranjenog ugovora preda to opštini.

Dakle očigledno je zakonodavac želio istaći poništenje svih posljedica ovakvog ugovora, a na kraju i sankciju predaje stečenog po osnovu nezakonitog ugovora opštini (koja je doduše primjerenija sankciji iz krivičnog zakonodavstva).

Rušljivi ugovori za razliku od ništavih predstavljaju ugovore koji svoju osnovu za eventualno poništenje imaju u odnosu samih ugovornih strana.

Oni proizvode pravno dejstvo sve do trenutka dok ne budu poništeni (ukoliko uopšte budu poništeni). Dakle njihova je sudbina neizvesna od trenutka kada nastanu do trenutka kada budu poništeni ili konvalidirani. Proizvode dejstvo od samog početka, uprkos nedostatku koji imaju, stvaraju prava i obaveze. Čest slučaj rušljivosti ugovora je u postojanju mana volje kod ugovornih strana. ZOO uzroke nesporazuma smešta u mane volje; u pitanju nisu zablude kao mane volje, već tzv. zablude-smetnje, odnosno zablude-prepreke. Zablude-mane volje ne sprečavaju nastanak ugovora već dovode do njegove rušljivosti, dok zablude-prepreke sprečavaju nastanak ugovora, jer su se volje mimoišle.

Zablude-prepreke su u suštini razlozi za ništavost ugovora, a odnose se na:

- zabludu o prirodi ugovora (*error in negotio*) – npr, jedan ugovarač misli da je zaključio ugovor o prodaji, a drugi misli da je stvar dobio na poklon ili zajam.
- zabluda o objektu (*error in corpore*), ovdje se radi o zabludi u objektu ispunjenja, kupac misli da je naručio uređaj ajfon, a prodavac misli da se radi o mobilnom komjuteru iste marke.
- zabluda o kauzi (*error in causam*), postoji npr. kada neko nadoknadi štetu jer pogrešno mislio da je on prouzrokovao.

Zablude-mane volje koje ne dovode do ništavosti nego rušljivosti:

- bitna zabluda, koja se može odnositi na svojstva predmeta, zabludi o pobudi kod dobročinih poslova, zabludi o odlučnim okolnostima ili o zabluda o ličnosti (*error in personae*) kod ličnih ugovora (*intuiti personae*)
- prevari - kojom se jedna ugovorna strana koristila da bi druga zaključila s njom ugovor
- prinudi - dakle kada jedna strana prinudi drugu na zaključenje ugovora koji ta druga strana ne želi.

Zakon razlikuje i prijetnju kao psihičku prinudu i fizičku prinudu. Za prvu predviđa posljedicu rušljivost ugovora, a za drugu ništavost.

Ovo su bitne razlike koje imaju potpuno drugačije pravne posljedice, odnosno mogućnosti ili nemogućnosti konverzije ili konvalidacije, što i jeste najčešći uzrok sporova i različitog tumačenja valjanosti i posljedica ovako zaključenih ugovora.

Kada govorimo o konverziji?

Kada ništav ugovor ispunjava uslove za punovažnost nekog drugog ugovora, onda će među ugovaračima važiti taj drugi ugovor, ako bi to bilo u saglasnosti sa ciljem koji su ugovarači imali u vidu kad su ugovor zaključili i ako se može uzeti da bi oni zaključili taj ugovor da su znali za ništavost svog ugovora.

U teoriji je široko prihvaćen stav da bi konverziju trebalo dovoditi isključivo u vezu s nepostojećim ugovorima. Prva potvrda upravo navedenog u shvatanju (apsolutno) ništavih ugovora kao zabranjenih, bilo pravom, bilo moralom, pa kada je nešto u tom smislu zabranjeno, ne može nikako preći u polje punovažnog. Drugu potvrdu nalazimo u onome što vremenski prethodi konverziji, a naime „stranke zbog svoje neobaviještenosti (...) ili nevještosti (...) sačine ugovor tako da ne obezbijede sve bitne bitne uslove za njegovo zaključenje“ (Dolović, 2011).

Rušljivi ugovori su pravilo. Ovo iz razloga što pravni poredak nastoji da u što većoj mjeri ispoštuje volje ugovornih strana. Tako da ugovori koji nemaju nedostatke koji povlače ništavost mogu vremenom ili postupkom ugovornih strana biti osnaženi i postati pravno valjani – konvalidirati.

Konvalidacija kao naknadno osnaženje rušljivog ugovora ima za posljedicu da:

- ugovor postaje punovažan
- ugovor se ne može više poništiti;
- pravna dejstva opstaju, “učvršćuju se”.

Ugovor može konvalidirati:

- voljnom konvalidacijom – kada se strana koja ima pravo da zahtijeva poništaj odrekne tog svog prava ili se ugovor izvrši.
- zakonskom konvalidacijom – kada ona nastupa po sili zakona istekom roka u kojem je poništaj mogao da se zahtijeva.
- izjašnjenjem pozvane ugovorne strane da ostaje pri ugovoru (kod vansudskog poništenja).

Zakon o obligacionim odnosima pravi izuzetak od pravila da ništavi i neposrojeći ugovori ne mogu konvalidirati. Konvalidacija ništavog ugovora moguća je kod ugovora koji su zaključeni iako je postojala zabrana ako je zabrana bila manjeg značaja, a ugovor je izvršen (čl. 107 st. 2 ZOO).

Zakon o obligacionim odnosima pravi još jedan izuzetak, a odnosi se na ugovor za čije se zaključenje zahteva pismena forma a ona prilikom zaključenja ugovora nije ispoštovana. Ovaj ugovor može konvalidirati ako su ugovorne strane izvršile, u cjelini ili u pretežnom dijelu, obaveze koje iz njega nastaju, osim ako iz cilja zbog koga je forma propisana očigledno ne proizlazi nešto drugo (čl.73 ZOO).

## ZAKLJUČCI

Sklapanjem ugovora teži se ostvarenju određenih ciljeva ugovarača za što je neophodno jasno definisanje njihovih volja, namjera, kao i eliminisanje mogućih nesporazuma. Da bi jedan ugovor bio valjan, odnosno proizvodio pravne učinke, potrebno je da se ispune određene pretpostavke vezane za saglasnost volja ugovarača, njihovu poslovnu sposobnost, valjanost predmeta i dopuštenost pravne osnove. Ponekad se za punovažnost ugovora traži i određena forma. Ukoliko jedna neka od navedenih pretpostavki nedostaje u momentu zaključenja ugovora, tada taj ugovor ne proizvodi pravna dejstva. Takvi ugovori su pravno nevaljani, a Zakon o obligacionim odnosima naziva ih nevažećim. Svaki od navedenih nedostataka ne proizvodi uvijek istu građanskopravnu sankciju. Određeni nedostaci vode ništavosti, a drugi rušljivosti (oborivosti) ugovora. Tako i Zakon o obligacionim odnosima prihvata dvojnu podjelu nevažećih ugovora dijeleći ih na ništave i rušljive uz samo posredno pominjanje tzv. nepostojećih ugovora. Sudska praksa pokazuje da se kao čest razlog ništavosti kod nas ogleda u suprotnosti sadržaja ugovora sa propisom imperativne prirode, ali i u suprotnosti sa dobrim običajima. Svakako su prisutni i drugi razlozi ništavosti, i to: poslovna nesposobnost stranaka, nesporazum prilikom izjave volje, nemogućnost, nedopuštenost i neodređenost, odnosno neodredivost predmeta obaveze (činidbe), nedopuštenost i nepostojanje osnove, a pod izvjesnim uslovima i nepostojanje određene forme. Na ništavost ugovora mogu se

pozvati sva zainteresirana lica. Osim toga, i sud, po službenoj dužnosti (*ex oficio*), pazi na ništavost. Pozivanje na ništavost ne zastarijeva. Kod ništavosti se smatra da ugovor nije ni nastao i da njegova ništavost postoji od početka (*ex tunc*). Pravne posljedice ništavosti očituju se prije svega u tome što svaka ugovorna strana mora vratiti drugoj strani sve ono što je primila na osnovu ništavog ugovora, uz rijetke izuzetke predviđene zakonom. Pored restitucije, savjesna strana ima pravo i na naknadu štete. Rušljivi ugovori su takvi ugovori koji proizvode pravna dejstva, ali se na zahtjev zainteresiranih lica mogu poništiti. Ovi ugovori sadrže određeni nedostatak kojim se ne vrijeđa opšti interes, zbog čega se samo ugovoraču u čijem je interesu rušljivost predviđena, daje pravo da traži poništenje ugovora. Kao razlozi rušljivosti u Zakonu su navedeni:ograničena poslovna sposobnost ugovarača, mane volje (zabluda, prijetnja i prevara), prekomjerno oštećenje i pravne radnje dužnika preduzete na štetu povjerioca. Pravo na zahtjev za poništenje rušljivog ugovora vezano je za određeni subjektivni rok (jedna godina) i objektivni rok (tri godine). Rušljiv ugovor proizvodi pravna dejstva i to sve dotle dok on ne bude poništen. Protekom određenog vremena ovaj će ugovor konvalidirati i više se ne neće moći pozivati na njegovo poništenje. Pravne posljedice poništenja rušljivog ugovora su takve da taj ugovor prestaje važiti i to od njegovog zaključenja, tj. *ex tunc*. To znači da ugovarači nisu dužni ispuniti obaveze koje su preuzeli zaključenjem tog ugovora. Isto kao i kod ništavog ugovora ako su ugovarači ispunili u cijelosti ili djelimično svoje obaveze, dužni su da međusobno uspostave onakvo stanje kakvo je bilo prije zaključenja ugovora, tj. da vrate ono što su jedan od drugoga primili. Takođe kao i kod ništavog ugovora pored restitucije primljenog, posljedica rušljivog ugovora može biti i pravo na naknadu štete. Pravni poredak nastoji da dozvoljeno raspolaganje strana u ugovoru i njihova volja budu maksimalno ispoštovane, te je upravo iz tih razloga predvidio i konverziju i konvalidaciju ugovora. Iako djeluje da su zakonske odredbe u pogledu razgraničenja ništavih i rušljivih ugovora jasne i nedvosmislene u praksi se pokazalo da je nekada tanka granica između ove dvije vrste ugovora. Posebno kada je neophodno utvrditi pravu volju ugovornih strana, zatim postojanje savjesnosti i dobre vjere (*bone fides*) kod jednog ili oba ugovarača, postojanje dozvoljenog pravnog osnova, određenosti predmeta i dr. Zadatak pravne nauke je da na bazi dosadašnjih saznanja i sveobuhvatne analize uporednog prava i prakse pruži kvalitetnu teorijske podlogu za odgovor na pitanja i dileme oko nevaljanosti ugovora i njihovog razgraničenja. Ovo je od vitalne važnosti sudijama za boje razumijevanje cilja i svrhe instututa ništavosti i rušljivosti ugovora i primjene zakonskih odredbi uz uvažavanje specifičnosti svakog slučaju posebno. Neophodno je imati u vidu sve aspekte, pa i neke naoko manje važne detalje, koji mogu imati uticaja na konačnu odluku u rješenju dileme kod nevaljanih ugovora - ništavost ili rušljivost, zbog njihovog različitog pravnog dejstva i posljedica.

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# INVALID CONTRACTS IN THE LAW OF OBLIGATIONS OF THE REPUBLIC OF SRPSKA

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**ABSTRACT**

In order for an obligation contract to produce a legal effect, it is necessary to fulfill the conditions stipulated by the law for its creation and validity. The absence of any of these conditions renders the contract legally invalid. The Law on Obligations of the Republika Srpska mostly accepted the dual division of invalid legal transactions, and thus contracts, dividing them into void and relatively void, although one part of our legal theory adds to this division the category of the so-called non existent contracts. Long-standing judicial practice have not been sufficient to determine the precise difference between the conditions that must be met for a contract to be void or voidable. The paper discusses the theoretical and practical aspects of the distinction between void and voidable contracts as well as their legal effects, the consequences arising from these differences as well as the assumptions for the conversion and convalidation of invalid contracts.

**Keywords**: contract invalidity, non-existent contracts, conversion, convalidation.

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# PRAVO TREĆE GENERACIJE - PRAVO NA ZDRAVU ŽIVOTNU SREDINU

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## APSTRAKT

Većina savremeih ustava sadrži odredbe o zaštiti životne sredine, te tako i Ustav Republike Srpske u svom članu 35. proklamuje da čovjek ima pravo na zdravu životnu sredinu, te da je svako u skladu sa zakonom dužan da je u okviru svojih mogućnosti štiti i unapređuje. Akteri u ostvarivanju ovog prava čine kako organi javne uprave tako i svi građani, a sve u cilju obezbjeđivanja što zdravijih uslova života i stalnog poboljšanja njegovog kvaliteta.

U tom smislu smo svi podjednako odgovorni za kvalitet okruženja u kojem živimo i zbog toga moramo biti podjednako svjesni posljedica svojih aktivnosti koje se odražavaju na životnu sredinu, te istrajati u nastojanjima da u što većoj mjeri umanjimo naša negativna djelovanja u pogledu zagađivanja životne sredine.

Zato je potreban veći angažman javne uprave, podizanje ekološke svijesti građana kao i izdvajanje većih budžetskih sredstava za ovu namjenu, kako bi se izbjeglo nastajanje ekoloških problema.

Na taj način ćemo obezbjediti i omogućiti dostojanstven život i zdravlje, kako za sadašnju, tako i za buduće generacije.

**Ključne riječi:** pravo, ustav, životna sredina, ekologija, prava III generacije.

## UVOD

U poslednjih par decenija zaštita životne sredine je postala predmet pravnog regulisanja na svim nivoima, od državnog preko regionalng do međunarodnog nivoa. Opštoj zaštiti ljudskih prava, koja su zaštićena međunarodnim ugovorima, pridruženo je i pravo na zdravu životnu sredinu koje je usko povezano sa pravima prve i druge generacije: pravo na život, pravo na zdravlje, pravo na odgovarajući životni standard, pravo na privatnost i zaštitu doma i porodice (Lilić, 2014; Nastić, 2011).

Na području bivše Jugoslavije Ustav SFRJ iz 1963. godine je svojim amandmanom po prvi put regulisao zašitu čovjekove okoline (Usatav SFRJ, amandman 30, 1971). Zapravo, nametnula se potreba o donošenju skupa pravnih normi kojima se uređuje kontrola zagađenja i upravljanjem industrijskim otpadom, upravljanje vodama, zaštita vazduha, zaštita od buke i vibracija, zaštita prirode, životinja i biodiverziteta, kao i sprječavanje posljedica klimatskih promjena. Opšte zagađenje životne sredine nametnulo je međunarodnu saradnju u zaštiti voda, vazduha, zemljišta, zaštitu od industrijskih zagađenja, upravljanjem otpadom, hemikalijama i sl (Čavoški, 2007; Vuruna, 2012).

Na pomenutu temu donesen je čitav niz zakona: Zakon o zaštiti životne sredine, Zakon o srateškoj procjeni uticaja na životnu sredinu, Zakonski okvir koji uređuje krivičnopravnu odgovornost za zaštitu životne sredine, te zakonski okvir koji uređuje naknadu ekološke štete. Ovi zakoni, sa ekološkim predznakom pridonijeli su razvoju ekološkog prava, koje ima neraskidivu vezu sa međunarodnim, ustavnim, upravnim, građanskim, krivičnim i finansijskim pravom (Nikolić, 2009).

Karkter međunarodnog prava i njegovi principi primjenjuju se i u ekološkom pravo, koje se ogleda u: saradnji država, suverenosti država u raspolaganju prirodnim bogatstvima, procjenu

uticaja na životnu sredinu, razmjena informacija i konsultacije o stanju životne sredine, dobre volje i susjedstva, hitnog obavještavanja, sardanje i pomoći u slučajevima iznenadnih opasnosti za životnu sredinu, mirnog rješavanja sporova, odgovornost država za štete počinjene živonoj sredini, suverenost nad prirodnim dobrima i obaveze da se ne nanosi šteta životnoj sredini drugih država ili oblasti van nacionalnih jurisdikcija, što se naglašava u Štokholmskoj deklaraciji, princip 21/72: „Države imaju suvereno pravo da, u skladu sa poveljom Ujedinjenih Nacija i principima međunarodnog prava, eksploatišu svoje resurse u skladu sa sopstvenim ekološkim politikama i odgovornost da obebjede da aktivnosti u okviru njihov jurisdikcije ii kontrole ne nanose štetu životnoj sredini drugih država ili oblasti izvan nacionalnih jurisdikcija“ (Štokholmska deklaracija, proncip 21/72, 1972).

Kao negativan primjer nepštovanja odredbi Štokholmske deklaracije se može navesti aktuelan problem u odnosu Republika Hrvatska - Republika Srpska/BiH: Republika Hrvatska je donijela odluku o odlaganju radioaktivnog otpada na Trgovskoj Gori, koja je na samoj granici prema Republici Srpskoj/BiH, bez bilateralnog sporazuma, te je Narodna skupština Republike Srpske – Parlamentarni odbor za zaštitu životne sredine zatražila od zvaničnih institucija u BiH informacije u vezi s tim.

## ZAŠTITA ŽIVOTNE SREDINE U REPUBLICI SRPSKOJ KROZ NORMATIVNU AKTIVNOST

Zašitita životne sredine u Republici Srpskoj je normativno obrađena kroz Zakono o zaštiti životne sredine Republike Srpske koji u okviru zaštite komponenti životne sredine navodi zaštitu: zemljišta, voda, vazduha, biosferu, očuvanje izgrađene životne sredine, od šetnih uticaja od opasnih supstanci i tehnologije, otpada, buke i vibracija, radijacije. Propisuje informisanje, edukaciju, obuku i kulturu u sferi zašite životne sredine, unos podataka u druge registre, istraživanje i tehnički razvoj i aktivno pružanje informacija o zašiti životne sredine (Zakon o zaštiti životne sredine [ZZŽS], 2020).

Nadležnost Narodne skupštine Republike Srpske se ogleda kroz sprovođenje interesa zaštite životne sredine kroz donošenje zakona, usvanja strategije zaštite životne sredine, utvrđuje nadležnost Vlade i organa lokalne samouprave u vezi sa ovom oblašću, te odobrava i kontroliše korišćenje sredstava.

Aktivnosti ili postrojenja koja ugrožavju životnu sredinu stavljaju se u režim kontrole koja se sprovodi putem posebnih obaveza i uslova propisanih za dobijanje ekoloških dozvola.

Posebnim zakonom u Republici Srpskoj se reguliše zaštita i upravljanje kvalitetom vazduha i određuju mjere, način organizovanja i kontrola sprovođenja zaštite i poboljšanja kvalitrta vazduha kao prirodnog dobra od opšteg interesa koje uživa posebnu zaštitu (Zakon o zaštiti vazduha [ZZV], 2011).

### Zakoni i podzakonski akti

Veliki je broj Zakona koje je donijela Narodna skupština Republike Srpske, kao i podzakonskih akata, na osnovu tih zakona, koji se odnose na oblast zaštite životne sredine u Republici Srpskoj, kao što su: Zakon o izmjenama i dopuni Zakona o upravljanju otpadom, Zakon o izmjenama i dopunama Zakona o zaštiti životne sredine, Zakon o Nacionalnom parku Drina, Zakon o izmjenama i dopunama Zakona o zaštiti vazduha, Zakon o izmjenama i dopunama Zakona o Fondu i finansiranju zaštite životne sredine Republike Srpske, Zakon o izmjenama i dopunama Zakona o zaštiti životne sredine, Zakon o zaštiti životne sredine, Zakon o Fondu i finansiranju životne sredine, Zakon o zaštiti vazduha, Zakon o Nacionalnom parku "Kozara", Zakon o Nacionalnom parku "Sutjeska"; Pravilnik o izmjenama Pravilnika o uslovima za obavljanje djelatnosti iz oblasti zaštite životne sredine, Pravilnik o izmjeni i dopunama Pravilnika o uslovima i načinu polaganja stručnog ispita za obavljanje djelatnosti iz oblasti zaštite životne sredine, Pravilnik o izmjenama i dopunama Pravilnika o mjerama za sprečavanje i smanjenje zagađivanja vazduha i poboljšanje kvaliteta vazduha, Pravilnik o izmjeni i dopunama Pravilnika o postupku revizije i obnavljanja ekoloških dozvola, Odluka o izmjeni Odluke o jedinačnim naknadama za

zagađivanje životne sredine za motorna vozila, Odluka o jedinačnim naknadama za zagađivanje životne sredine za motorna vozila, Pravilnik o graničnim i remedijacionim vrijednostima zagađujućih, štetnih i opasnih materija u zemljištu, Pravilnik o izmjeni i dopuni Pravilnika o načinu obilježavanja zaštićenih područja, Pravilnik o sadržaju projekta remedijacije i rekultivacije, Uredba o postupanju sa supstancama koje oštećuju ozonski omotač i zamjenskim supstancama, Pravilnik o izmjenama i dopunama pravilnika o uslovima za obavljanje djelatnosti iz oblasti zaštite životne sredine, Pravilnik o uslovima za izdavanje dozvole za monitoring kvaliteta vazduha, Pravilnik o uslovima i načinu polaganja stručnog ispita za obavljanje djelatnosti iz oblasti zaštite životne sredine, Pravilnik o izmjeni Pravilnika o mjerama za sprečavanje i smanjenje zagađivanja vazduha i poboljšanje kvaliteta vazduha, Uredba o visini naknade za troškove izdavanja licenci iz oblasti zaštite životne sredine, Pravilnik o izmjenama i dopunama Pravilnika o mjerama za sprečavanje i smanjenje zagađivanja vazduha i poboljšanje kvaliteta vazduha, Uredba o vrijednostima kvaliteta vazduha, Uredba o uspostavljanju republičke mreže mjernih stanica i mjernih mjesta, Uredba o uslovima za monitoring kvaliteta vazduha, Pravilnik o mjerama za sprečavanje i smanjenje zagađivanja vazduha i poboljšanje kvaliteta vazduha i Obrazac Izvještaja o mjerenju emisija zagađujućih materija u vazduh, Pravilnik o postupku revizije i obnavljanja ekoloških dozvola, Pravilnik o postrojenjima koja mogu biti izgrađena i puštena u rad samo ukoliko imaju ekološku dozvolu, Pravilnik o projektima za koje se sprovodi procena uticaja na životnu sredinu i kriterijumima za odlučivanje o obavezi sprovođenja i obimu procjene uticaja na životnu sredinu, Pravilnik o uslovima za obavljanje djelatnosti iz oblasti zaštite životne sredine, Uputstvo o sadržaju studije uticaja na životnu sredinu, Pravilnik o aktivnostima i načinu izrade najboljih raspoloživih tehnika, Pravilnik o sadržini i načinu vođenja ragistra izdatih ekoloških dozvola, Pravilnik o eko-oznakama i o načinu upravljanja eko-oznakama, Pravilnik o kriterijumima za odlučivanje o potrebi sprovođenja strateške procjene uticaja na životnu sredinu, Pravilnik o sadržaju izvještaja o strateškoj procjeni uticaja na životnu sredinu, Pravilnik o emisiji isparljivih organskih jedinjenja, Pravilnik o sistemu praćenja namjernog držanja i ubijanja zaštićenih životinja, Pravilnik o načinu uspostavljanja i upravljanja informativnim sistemom za zaštitu prirode i sistemu praćenja, Pravilnik o metodologiji i načinu vođenja registra postrojenja i zagađivača.

## PROJEKTI I PROGRMI ZAŠTITE ŽIVOTNE SREDINE U REPUBLICI SRPSKOJ

U okviru rada Ministarstva za prostorno uređenje, građevinarstvo i ekologiju Republike Srpske obavljaja se integralna zaštita i unapređenje životne sredine, zaštitu i očuvanje prirode i upravljanje otpadom. U saradnji sa drugim institucijama i relevantnim akterima, unapređuje se pravni i institucionalni okvir uz učešće u procesima evropskih integracija kroz projekte i programe finansiranja, između ostalog i u oblasti prostornog planiranja, građevinarstva i ekologije. Istovremeno je kreiralo pravni okvir i uslove za održivi planski razvoj i unapređenje građevinarstva uz racionalno korišćenje prostora i energije, te zaštitu životne sredine na socijalnim, ekonomskim i ekološkim principima definisanim strateškim dokumentima prostornog uređenja Republike Srpske. Tendencija je i stalno unapređujenje pravnog i regulatornog okvira, kao i stvaranje uslova za zaštitu životne sredine.

Osim saradnje sa ostalim državnim organima i institucijama sarađuje i sa nizom međunarodnih institucija: Evropska komisija, Svjetska Banka, Globalnim fondom za zaštitu životne sredine, Regionalnim centrom za zaštitu životne sredine jugoistočne Evrope, nevladinim sektorom i dr. U Ministarstvu se trenutno implementiraju sljedeći projekti:

**Drugi projekat za upravljanje čvrstim otpadom** (Odluka Narodne Skupštine Republike Srpske, 2009)

Opšti razvojni cilj Projekta je unapređenje dostupnosti, kvaliteta, ekološke adekvatnosti i finansijske stabilnosti usluga upravljanja čvrstim otpadom u regijama koje učestvuju u Projektu koji realizuju preduzeća za upravljanje regionalnim deponijama, a Ministarstvo za prostorno uređenje, građevinarstvo i ekologiju, putem Jedinice za upravljanje projektom, obezbjeđuje

podršku u realizaciji Projekta. Osnovnim sporazumom predviđen je prenos dijela sredstava komunalnim preduzećima koja učestvuju u implementaciji projekta. U skladu sa Ugovorom o kreditu/zajmu za Drugi projekat za upravljanje čvrstim otpadom, regije mogu učestvovati u programu ako ispune uslove i to: da su minimalno tri opštine iskazale interes za saradnju za rješavanje pitanja u oblasti upravljanja otpadom, da opštine imaju najmanje 100.000 stanovnika, da postoji potpisan međuopštinski sporazum, da je izabrana lokacija deponije, da je formirano zajedničko preduzeće, da su opštine kreditno sposobne, odnosno da mogu obezbijediti garancije za obezbjeđenje kredita.

IPA 2010 - rehabilitacija i izgradnja deponije u Ramićima Evropska komisija odobrila je donaciju iz IPA fonda za 2010. godinu u iznosu od 2.854.000 EUR, a Ministarstvo vrši praćenje i kontrolu svih aktivnosti, odnosno građevinske radove na rehabilitaciji Regionalne deponije Ramići, izgradnja sanitarne ćelije za zbrinjavanje otpada i izgradnja sistema za prikupljanje gasa, kao i nadzor nad tim radovima. Da bi se Iz IPA granta je u 2014. godini za pomenute poslove još uložilo 1.337.631,14 KM.

**Projekat „Energetska efikasnost u BiH“ (BEEP)**

Vlada Republike Srpske je u februaru 2014. godine usvojila Odluku o prihvatanju zaduženja za Projekat „Energetska efikasnost u BiH“ koji će se finansirati iz sredstava Svjetske banke – Međunarodna asocijacija za razvoj (IDA), a potom je istu Odluku usvojila i Narodna skupština Republike Srpske na sjednici održanoj 29. 04. 2014. godine. Zbog djelomične izmjene uslova kreditiranja od strane Svjetske banke (povećana je kamatna stopa za 0,15% za jedan dio sredstava) i Narodna skupština Republike Srpske je 18. 02. 2015. godine usvojila Izmjenu odluke o prihvatanju zaduženja. Republika Srpska je potpisala kreditni sporazum sa Svjetskom bankom - Međunarodnom asocijacijom za razvoj 18. 03. 2015. godine. Vrijednost Projekta iznosi 12,8 miliona USD za Republiku Srpsku (40%).

Odlukom Vlade Republike Srpske Ministarstvo za prostorno uređenje, građevinarstvo i ekologiju, Ministarstvo prosvjete i kulture, Ministarstvo zdravlja i socijalne zaštite, Ministarstvo finansija i Ministarstvo industrije, energetike i rudarstva (član) zadužuju se za realizaciju Projekta energetske efikasnosti u Republici Srpskoj, te je 2015. godine Svjetska banka je i zvanično proglasila projekat efektivnim, te su time ispunjeni svi uslovi da se u narednom periodu započne sa realizacijom aktivnosti planiranih prema projektu.

**Regionalni projekat energetske efikasnosti (REEP) - EBRD**

Evropska banka za obnovu i razvoj (EBRD) provodi regionalni projekat energetske efikasnosti (REEP) u koji su uključene zemlje Zapadnog Balkana, a koji obuhvata pružanje tehničke pomoći za stvaranje uslova za izgradnju ESCO tržišta, usvajanje regulative i jačanje kapaciteta. Ministarstvo je učestvovalo u realizaciji kroz učešće u radnoj grupi formiranoj u skladu sa Odlukom Vlade Republike Srpske od 06. 02. 2014. godine.
U saradnji sa Evropskom bankom za obnovu i razvoj, Ministarstvo za prostorno uređenje, građevinarstvo i ekologiju Republike Srpske je organizovalo radionicu na temu „Implementacija ESCO modela u javnom sektoru u Republici Srpskoj“, koja je održana 19. 01. 2015. godine u Banjoj Luci. U sklopu projektnih aktivnosti, konsultantska firma „Economic Consulting Associates“ iz Londona razvila je prijedlog ESCO modela za Republiku Srpsku koji je predočen na pomenutoj radionici i otvorena je diskusija sa privrednim subjektima, bankama, javnim institucijama i drugim potencijalnim učesnicima o prednostima i nedostacima samog modela, kao i mogućnostima njegove primjene u praksi.

U okviru REEP-a, EBRD će obezbijediti tehničku pomoć Republici Srpskoj u smislu davanja preporuka za izradu i usklađivanje programa (softverskog alata) prema potrebama vršenja obračuna energetskih karakteristika zgrada zadovoljavajući zahtjeve planirane metodologijom za obračun energetskih karakteristika zgrada Republike Srpske definisane Pravilnikom zvanično usvojenim u aprilu mjesecu 2015. godine („Službeni glasnik Republike Srpske, broj 30/15).

**GIZ Projekat EE**

Ministarstvo učestvuje u realizaciji Projekta "Savjetovanje u oblasti energetske efikasnosti u BiH", koji se finansira na osnovu Sporazuma o tehničkoj saradnji između vlada SR Njemačke i BiH, a Projekat implementira Njemačko društvo za međunarodnu saradnju (GIZ). Cilj Projekta je pružanje tehničke pomoći pri izradi zakonodavnog okvira u oblasti energetske efikasnosti i uspostavljanje sveobuhvatnog, transparentnog i efikasnog internetskog informacionog sistema za energetsku efikasnost u Republici Srpskoj. Uz finansijsku i tehničku podršku u okviru ovog projekta izrađena su tri pravilnika Republike Srpske koja regulišu energetsku efikasnost u zgradama i stupaju na snagu 01. 01. 2016. godine, jer je neophodno obezbijediti vrijeme za organizovanje obuka i sticanje potrebnih licenci.

U okviru ovog projekta izrađeno je i jedno od najznačajnijih istraživanja na temu energetske efikasnosti i fonda stambenih objekata u Bosni i Hercegovini, a rezultat istraživanja je Tipologija stambenih zgrada Bosne i Hercegovine, koju možete preuzeti ispod.

**LIFE - Projekat za treće zemlje "Jačanje kapaciteta za primjenu integralne prevencije i kontrole zagađenja u BiH"**

Ovaj projekat je zapravo integralna kontrola i prevencija zagađivanja u prehrambenoj industriji u kojoj su naznačena tehnička uputstva o najboljim raspoloživim tehnikama u proizvodnji I preradi mlijeka, preradi mesa, proizvodnji piva, uzgoju I preradi ribe, te preradi voća.

Strategija iz „Zelene agende"[5] za Zapadni Balkan potpisana je 2019. godine, a trebala bi Evropski kontinent učiniti prvim klimatski neutralnim kontinentom do 2050. godine. U skladu s njom, BiH mora ispuniti pet osnovnih ciljeva agende. Potpisivanjem Sofijske deklaracije o Zelenoj agendi za Zapadni Balkan, zemlje regiona obavezale su se na niz konkretnih akcija, uključujući uvođenje takse na emisije ugljen-dioksida i tržišnih modela za podsticanje obnovljivih izvora energije, kao i postupno ukidanje subvencija za ugalj. Neke od mjera su: usklađivanje sa klimatskim zakonom Evrposke unije nakon njegovog usvajanja čiji je cilja da Evropska unija bude klimatski neutralna do 2050; definisanje energetskih i klimatskih ciljeva do 2030. u skladu sa pravnim okvirom Energetske zajednice i pravnom tekovinom EU, kao i razvoj i primjena Nacionalnih energetskih i klimatskih planova sa jasnim mjerama za smanjenje emisija gasova sa efektom staklene bašte; nastavak usklađivanja sa Sistemom za trgovanje emisijama EU (EU ETS), kao i uvođenje drugih modela za oporezivanje emisija, kako bi se promovisala dekarbonizacija u regionu; analiza i revidiranje svih propisa koji podržavaju progresivnu dekarbonizaciju energetskog sektora i njihova potpuna primjena, prije svega kroz Energetsku zajednicu; saradnja u pripremi procjene socio-ekonomskog uticaja dekarbonizacije na svaku zemlju i na nivou regiona u cilju pravedne tranzicije; davanje prioriteta energetskoj efikasnosti i njeno poboljšanje u svim sektorima; povećanje udjela obnovljivih izvora energije i obezbeđivanje neophodnih uslova za investiranje, u skladu sa pravnim tekovinama EU i Energetske zajednice; smanjiti i postepeno ukinuti subvencije za ugalj, strogo poštujući pravila državne pomoći; aktivno učestvovati u inicijativi Regioni uglja u tranziciji za Zapadni Balkan.

## KONFERENCIJA RIO DE ŽANEIRO 1992. GODINE

Konferencija Ujedinjenih Nacija o zaštiti životne sredine i razvoju (UNCED), održana juna 1992. godine u Rio de Žaneiru (Brazil) bila je najveća od svih ikad održanih konferencija Ujedinjenijh nacija. Iako učesnicima samita nije pošlo za rukom da dodju do rješenja i saglasnosti po mnogim pitanjima sa različitim ekonomskim interesima. Samit je ipak generalno uspio, s obzirom da je po prvi put povezao pitanja razvoja i zaštite životne sredine. Osim toga, rezultat predstavlja i potpisivanje i usvajanje nekoliko važnih dokumenata, među kojima je:

- Deklaracija o životnoj sredini i razvoju - poznatija kao „Rio deklaracija",
- Konvencija o promjeni klime,
- Konvencija o biološkoj raznolikosti,

[5] „Sofijska deklaracija", Zelena agenda za Zapadni Balkan, Sofija, Bugarska, 10.11.2019. godine

- Princip o upravljanju, zaštiti i održivom razvoju svih tipova šuma,
- Akcioni plan održivog razvoja u 21. vijeku nazvan „Agenda 21“,
- Lokal Agenda 21.

Jedno od poglavlja Agende 21 je i poglavlje o ulozi lokalnih vlasti koja radi u skladu sa principima Lokal Agende. Svaki od procesa ima svoje karakteristike, obilježen je lokalnim uslovima, uključujući tu i javno mnjenje, geografske uslove, urbane i ruralne oblasti, koji se uzimaju u obzir pri donošenju odluka, što važi i za političke stavove, kao i za probleme resursa.

## ZAKLJUČCI

Iz gore navedenih zakonskih rješenja vidljivo je da je zaštita životne sredine i/ili ekološka prava u Republici Srpskoj gotovo u potpunosti normirana, u skladu sa međunarodnim konvencijama UN, Savjeta Evrope i principima ekološke politike Evropske unije.

Potrebno je razlikovati zaštitu životne sredine i ekologije prema njihovom fokusu, kao naučnih oblasti. Zaštita životne sredine zasniva se odnosu ljudi sa različitim aspektima životne sredine, uticajem ljudi na životnu sredinu i mogućnostima njenog učuvanja, dok ekologija proučava zakonitosti koji se odvijaju u odnosima u prirodi, te sve ukupno normirati.

S obzirom da je zaštita životne sredine mlada grana prava, koja se razvija tek krajem 20. vijeka, nije se u tom smislu mogla formirati obimnija sudska praksa, pa je pravnim subjektima snalaženje u parničnim, u vezi sa upravnim, prekršajnim i krivičnim postupcima u vezi zašite životne sredine, dosta otežan. Potrebno je više iskustva u poznavanju gore navedenih propisa, kao i međunarodnih konvencija, propisa Evropske unije, kako eventualni sporovi ne bi donijeli veliku štetu čitavoj zajednici.

Iako životnu sredinu različito tumači svako od nas pojedinačno, takođe i grupe, kao idruštvo, poznavanje elemenata i faktora životne sredine i njene zaštite, analiziranjem uzročno posljedičnih veza svih faktora, ali i usvajanjem saznanja, opažanjem i učenjem, naše životno okruženje može se oplemeniti i odbraniti od negativnih uticaja.

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# THE RIGHT OF THE THIRD GENERATION - THE RIGHT TO A HEALTHY ENVIRONMENT

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**ABSTRACT**

Most modern constitutions contain provisions on the protection of the environment, so the Constitution of the Republic of Srpska in its Article 35 proclaims that man has the right to a healthy environment, and that everyone, in accordance with the law, is obliged to protect and improve it within his capabilities. Actors in the realization of this right are both public authorities and all citizens, all with the aim of ensuring the healthiest living conditions and constant improvement of its quality.

In this sense, we are all equally responsible for the quality of the environment in which we live, and therefore we must be equally aware of the consequences of our activities that are reflected on the environment, and persevere in our efforts to minimize our negative actions in terms of environmental pollution as much as possible.

That is why there is a need for greater engagement of the public authorities, raising the environmental awareness of citizens, as well as the allocation of larger budget funds for this purpose, in order to avoid the emergence of environmental problems.

In this way, we will ensure and enable a dignified life and health, both for the present and future generations.

**Keywords:** law, constitution, environment, ecology, the rights of the third generation.

# *IT SECTION*
# *IT SEKCIJA*

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# DEFENSE-IN-DEPTH MODERNIH RADIO SISTEMA

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## SAŽETAK

Ovaj rad prezentuje Defense-in-depth strategiju zaštite informacionog sistema, u konkretnom slučaju modernih radio sistema. S tim u vezi, u radu će posebno biti objašnjeni osnovni pojmovi modernih radio sistema kao i način na koji se ostvaruje zaštita istih. Rad će prikazati i osnovne koncepte radio komunikacionih sistema, koncepte mobilne radio i mobilne GSM komunikacije.

**Ključne riječi**: Defense-in-depth, TETRA sistem, DMR, Private LTE i 5G.

## UVOD

Defense-in-depth je sigurnosna strategija koja uključuje implementaciju više slojeva sigurnosnih kontrola na različitim tačkama sistema ili mreže. Ideja je stvoriti više barijera koje napadač mora savladati kako bi uspješno kompromitovao sistem. Ova strategija se zasniva na principu da se napadaču otežа uspješno zaobilaženje svih sigurnosnih kontrola, a u slučaju da neka kontrola „padne“ tj. bude kompromitovana, ostale će i dalje biti na mjestu da pružaju zaštitu.

Cilj strategije Defense-in-depth je da se napadaču što je više moguće otežа kompromitovanje sistema i da se smanji uticaj uspješnog napada. Ovo se može postići kombinacijom tehničkih kontrola, kao što su firewall-i i sistemi za otkrivanje upada, kao i netehničkih kontrola, poput obuka za podizanje svijesti zaposlenih i izradom sigurnosnih politika.

Dakle, Defense-in-depth strategija odbrane važan je dio sveobuhvatnog sigurnosnog programa jer pomaže u zaštiti od širokog spektra prijetnji i ranjivosti.

## MODERNI RADIO SISTEMI

Moderni radio sistemi su uređaji koji omogućavaju prijenos i prijem radio signala, koji se koriste za prijenos informacija kao što su zvuk, podaci i slike. Radio sistemi se obično sastoje od radio predajnika i radio prijemnika povezanih antenom.

Radio predajnik je dio radio sistema koji generiše i šalje radio signale. Uglavnom se sastoji od oscilatora koji proizvodi naizmjeničnu struju visoke frekvencije i pojačala koje pojačava snagu signala. Predajnik uključuje i modulator za kodiranje informacije koja se prenosi u radio signal te antenu koja šalje radio signal u zrak.

Radio prijemnik je dio radio sistema koji prima i dekodira dolazne radio signale. Njega čine antena koja hvata radio signale, demodulator koji izdvaja kodirane informacije iz radio signala i pojačalo koje pojačava jačinu signala. Prijemnik također podrazumijeva zvučnik ili drugi izlazni uređaj, koji prevodi dekodirane informacije u oblik razumljiv za korisnika.

Moderni radio sistemi se mogu naći u širokom spektru uređaja, uključujući mobilne telefone, radio, televizore i satelitske sisteme. Koriste se za širok spektar aplikacija što obuhvata komunikaciju, zabavu, navigaciju i sl.

Radio sistem za komunikaciju

Radio audio sistemi se odnose na tehnologiju koja se koristi za prijenos i prijem audio signala preko radiofrekventnog spektra. Ovi sistemi se mogu koristiti u različite svrhe, kao što je emitovanje muzike i drugog audio sadržaja, prenošenje glasovne komunikacije i pružanje hitnih upozorenja.

Kroz istoriju je postojalo mnogo različitih radio audio sistema. Neki od ranih primjera uključuju Markonijev bežični telegrafski sistem, koji se koristio za prijenos poruka Morzeove

azbuke i AM (amplitudna modulacija) radio, koji je razvijen početkom 20. vijeka i još uvijek se koristi za emitovanje muzike i drugog audio sadržaja. Također, u 20. vijeku razvijen je i FM (frekvencijska modulacija) radio koji se danas uobičajeno koristi za muziku i za glasovnu komunikaciju (Wicks, & Kemerling, 2003).

Analogni radio sistem je vrsta radio komunikacionog sistema koji koristi analognu tehnologiju za prijenos i prijem audio signala preko radiofrekventnog spektra. U analognom radio sistemu, audio signal je predstavljen kao kontinuirano varijabilni talasni oblik, koji se zatim modulira (modifikuje) na signal nosioca za prijenos.

Analogni radio sistemi su u upotrebi dugi niz godina i još uvijek se koriste u raznim aplikacijama kao što su AM i FM radio emitovanje, dvosmjerna radio komunikacija i radio u opsegu građana. Neke od glavnih prednosti analognih radio sistema uključuju njihovu jednostavnost i nisku cijenu, kao i njihovu široku dostupnost i kompatibilnost sa nizom uređaja. Međutim, oni su u velikoj mjeri zamijenjeni novijim digitalnim radio sistemima u mnogim aplikacijama zbog poboljšanih performansi i dodatnih karakteristika koje nudi digitalna tehnologija.

Dakle, mobilni analogni radio sistemi imaju niz ograničenja i nedostataka u odnosu na novije digitalne sisteme. Neki od glavnih nedostataka mobilnih analognih radio sistema uključuju:

Loš kvalitet zvuka: Analogni radio sistemi mogu patiti od statičkog elektriciteta, smetnji i drugih vrsta buke koje mogu degradirati kvalitet audio signala. Ovo dalje može otežati razumijevanje govora ili drugog audio sadržaja koji se prenosi preko sistema;

Ograničeni kapacitet: Analogni radio sistemi imaju ograničen kapacitet, jer su u mogućnosti da istovremeno prenose samo jedan kanal zvuka. To znači da mogu postati zagušeni i nesposobni za rad sa velikim brojem korisnika u datom području;

Nedostatak funkcija: Analogni radio sistemi nemaju iste napredne karakteristike i mogućnosti kao noviji digitalni sistemi pod kojim se u prvom redu podrazumijeva mogućnost prijenosa podataka zajedno sa audio signalom, podrška za enkripciju ali i druge napredne funkcije;

Ranjivost na smetnje: Analogni radio sistemi su osjetljivi na smetnje od drugih radio signala i elektronskih uređaja, koji mogu poremetiti prijenos audio signala;

Veoma jednostavno prisluškivanje i snimanje tuđih razgovora putem upada u komunikaciju, tačnije frekvenciju.

Pored analognih radio sistema, postoje i digitalni radio sistemi koji koriste digitalnu tehnologiju za prijenos i prijem audio signala. Neki primjeri digitalnih radio sistema uključuju satelitski radio, digitalno audio emitovanje (DAB) i digitalni mobilni radio (DMR). Ovi sistemi nude poboljšani kvalitet zvuka i dodatne karakteristike kao što je mogućnost prijenosa podataka zajedno sa audio signalom.

**Mobilni sistemi komunikacije**

Mobilni komunikacioni sistemi omogućavaju ljudima da međusobno komuniciraju koristeći mobilne uređaje kao što su pametni telefoni i tableti. Ovi sistemi koriste različite tehnologije kako bi omogućili komunikaciju na širokom području, poput mobilne mreže, satelitske mreže i bežične lokalne mreže (WLAN). Mobilni komunikacioni sistemi koriste se za širok spektar namjena, uključujući glasovne pozive, razmjenu tekstualnih poruka i pristup internetu. Oni su suštinski dio modernog života i revolucionirali su način na koji komuniciramo jedni s drugima.

Istorija mobilnih komunikacionih sistema datira još od ranog 20. vijeka, kada su razvijeni mobilni radio sistemi za upotrebu u vozilima. Ovi rani sistemi su bili ograničenog dometa i mogli su se koristiti samo za komunikaciju između vozila i fiksnih baznih stanica. Sedamdesetih godina prošlog vijeka uvedene su prve mobilne (*cellular*) mreže, koje su koristile sistem međusobno povezanih ćelija (*cells*) da bi obezbijedile pokrivenost na širokom području. Svaku ćeliju (*cells*) u mobilnoj (*cellular*) mreži opslužuje bazna stanica, a kako se mobilni uređaj kreće od jedne ćelije do druge, prenosi se s jedne bazne stanice na drugu, omogućavajući mu da održi kontinuiranu vezu.

Od tog vremena su mobilni komunikacioni sistemi značajno evoluirali uvođenjem novih tehnologija kao što su digitalne mobilne mreže, satelitske mreže i bežične lokalne mreže (WLAN).

Ovaj napredak doveo je do širokog usvajanja mobilnih uređaja i učinio mobilnu komunikaciju sastavnim dijelom svakodnevnog života milijardi ljudi širom svijeta.

GSM (*Global System for Mobile Communications*) je digitalna mobilna mreža koja je razvijena da zamijeni analogne telefonske mreže. Prvi put je predstavljena ranih 1990-ih godina i danas se koristi u većini zemalja širom svijeta. GSM koristi višestruki pristup s vremenskom podjelom (TDMA) kako bi omogućio više korisnika da dijele isti frekvencijski opseg podjelom signala na vremenske slotove.

Druga generacija poznata kao 2G je klasifikacija za mobilne komunikacione sisteme koji se odnose na GSM i njegove nasljednike, gdje spadaju *General Packet Radio Service* (GPRS) i *Enhanced Data rates for GSM Evolution* (EDGE). Ovi sistemi su omogućili poboljšane brzine prijenosa podataka i podršku za pristup internetu, kao i slanje tekstualnih poruka.

Treća generacija tj. 3G je klasifikacija za mobilne komunikacione sisteme koji pružaju veće brzine prijenosa podataka i podršku za napredne usluge kao što su video pozivi i mobilni širokopojasni pristup internetu. Takvi sistemi koriste tehnologije poput CDMA (višestruki pristup s kodnom podjelom) i WCDMA (širokopojasni višestruki pristup s podjelom koda) za povećanje kapaciteta i poboljšanje brzine podataka (Priya et al., 2022).

Četvrta i peta generacija odnosno 4G i 5G su najnovije generacije mobilnih komunikacionih sistema. One pružaju još veće brzine prijenosa podataka i podršku za širok spektar naprednih usluga, uključujući video streaming visoke definicije i virtuelnu stvarnost. Sistemi četvrte i pete generacije koriste tehnologije kao što su LTE (*Long-Term Evolution*) i milimetarski talas (*mmWave*) za povećanje kapaciteta i poboljšanje brzine prijenosa podataka.

GPS (*Global Positioning System*) je satelitski navigacijski sistem koji omogućava mobilnim uređajima da odrede svoju preciznu lokaciju i vrijeme. GPS je razvila američka vojska 1970-ih, ali se danas široko koristi za razne civilne aplikacije, između ostalog za mapiranje i usluge zasnovane na lokaciji.

Mobilni komunikacioni sistemi, poput mobilne mreže i bežične lokalne mreže (WLAN), mogu se koristiti zajedno sa GPS-om za pružanje usluga zasnovanih na lokaciji. Na primjer, pametni telefon s GPS-om i mobilnom vezom može koristiti svoju lokaciju za pružanje navigacije skretanje po skretanje, prikaz obližnjih zanimljivih mjesta ili prijavu na lokaciji na platformi društvenih medija (Alber et al., 2000).

GPS se često upotrebljava u kombinaciji sa drugim tehnologijama, kao što su inercijski navigacioni sistemi (INS) i mrtvo računanje, kako bi se poboljšala tačnost i pouzdanost. Neki mobilni uređaji osim GPS-a koriste i druge satelitske navigacijske sisteme, npr. ruski GLONASS ili kineski BeiDou.

Postoji nekoliko potencijalnih nedostataka vezanih za sigurnost mobilnih komunikacionih sistema:

Mobilni uređaji su osjetljivi na fizičke sigurnosne prijetnje, kao što su krađa i neovlašteni pristup. Ako je uređaj ukraden ili kompromitovan, napadač može biti u mogućnosti pristupiti osjetljivim podacima ili koristiti uređaj u zlonamjerne svrhe;

Sistemi mobilne komunikacije oslanjaju se na bežične mreže, koje su osjetljive na cyber napade poput hack-ovanja i prisluškivanja. Napadači mogu biti u mogućnosti presresti ili manipulisati podacima koji se prenose preko mreže;

Mobilni uređaji i mreže su također osjetljivi na zlonamjerni softver i druge vrste cyber prijetnji, gdje u prvom redu spadaju virusi, trojanci i ransomware. Ove prijetnje mogu ugroziti sigurnost uređaja ili mreže i omogućiti napadačima da pristupe osjetljivim podacima ili preuzmu kontrolu nad uređajem;

Mobilni uređaji i mreže često pohranjuju i prenose velike količine osjetljivih podataka, kao što su finansijske informacije, lične poruke i password za prijavu. Ako ovi podaci nisu pravilno zaštićeni, mogu postati meta neovlaštenog pristupa ili zloupotrebe (Kizza, 2012);

Sistemi mobilnih komunikacija podliježu različitim regulatornim zahtjevima koji se odnose na zaštitu podataka i privatnost. U slučaju da navedeni zahtjevi nisu ispunjeni, može doći do pravnih i finansijskih posljedica za pogođene strane.

I u pogledu sigurnosti GPS-a moguće je prepoznati određene nedostatke koji se ogledaju u sljedećem:

GPS signali se prenose putem radio talasa, koji se mogu presresti i potencijalno ometati ili lažirati. Ovo može otežati oslanjanje na GPS za kritične aplikacije kao što su vojne operacije ili avijacija;

GPS je također, osjetljiv na cyber napade, poput hack-ovanja i lažiranja. Napadači mogu biti u mogućnosti da manipulišu GPS podacima ili stvore lažne signale, što dovodi do netačnih informacija o lokaciji;

Neki GPS prijemnici nisu sigurni i mogu biti podložni neovlaštenom pristupu. Ovo omogućava napadačima da dobiju pristup osjetljivim podacima ili da manipulišu uređajem u zlonamjerne svrhe;

GPS podaci mogu sadržavati osjetljive informacije o lokaciji i kretanju pojedinca, što može predstavljati problem privatnosti u slučaju njihovog otkrivanja odnosno pristupanja ili korištenja bez znanja ili pristanka pojedinca.

## PRAKTIČNI PRIMJER DEFENSE-IN-DEPTH STRATEGIJE NA MOBILNIM SISTEMIMA

U poglavlju koje slijedi biće dati jasni prijedlozi koji su bazirani na Defense-in-Depth strategiji koristeći nove tehnologije i mogućnosti.

TETRA mobilni komunikacioni sistemi

TETRA sistem (*Terrestrial Trunked Radio*) je vrsta profesionalnog mobilnog radio sistema (PMR) koji se upotrebljava za komunikaciju u različitim industrijama kao što su javna sigurnost, transport i komunalne usluge. To je digitalni sistem koji koristi tehnologiju višestrukog pristupa s vremenskom podjelom (TDMA) za pružanje visokokvalitetne glasovne i podatkovne komunikacije.

TETRA sistem može imati dvojak način rada. U prvom slučaju TETRA sistem koristi trunking način rada, primjenom mrežnih resursa, dok se u drugom slučaju radi o direktnom načinu rada (*Direct Mode Operation – DMO*) tokom kojeg se realizuje direktna komunikacija između mobilnih/ručnih stanica. Prednosti DMO načina podrazumijevaju stvaranje mogućnosti direktne komunikacije čak i van dometa područja koje pokriva mrežna infrastruktura, obezbijeđivanje dopunskog kapaciteta u situacijama kada dođe do opterećenja mrežnih resursa kao i omogućavanje ostvarivanja komunikacije u slučajevima nedostupnosti mreže, npr. u vanrednim situacijama. Primjenom ovog sistema obezbijeđuje se komunikacija između korisnika koji nisu u dometu baznih stanica što je i najvažnija karakteristika TETRA sistema. Osim upravljanja govornom komunikacijom koja obuhvata dodjelu prioritetnog poziva, zadržavanje poziva, naknadno uključivanje u postojeći poziv i sl., TETRA sistem nudi i mogućnosti podatkovne komunikacije, te prijenosa slike ili audio-video snimke (Kujavić et al., 2011).

TETRA sisteme naširoko koriste organizacije javne sigurnosti u prvom redu policija i vatrogasne službe, kao i transportne kompanije, komunalne usluge i druge organizacije koje zahtijevaju pouzdanu i sigurnu komunikaciju (Babaev, & Simonina, 2018).

Dakle, TETRA je digitalni trunked radio standard koji se koristi za profesionalne mobilne radio komunikacije, a čije prednosti uključuju:

Visokokvalitetnu govornu i podatkovnu komunikaciju: TETRA pruža jasnu, pouzdanu glasovnu i podatkovnu komunikaciju, čak i u izazovnim okruženjima kao što su urbana područja ili unutrašnjost objekata;

Široku pokrivenost: TETRA mreže mogu pokriti velike površine, što ih čini pogodnim za upotrebu u širokim aplikacijama poput javne sigurnosti i transporta;

Efikasno korištenje spektra: TETRA koristi trunking radio sistem, koji omogućava višestrukim korisnicima da efikasno dijele ograničen broj radio kanala;

Podršku za više aplikacija: TETRA podržava širok spektar aplikacija, uključujući usluge glasa, podataka i multimedija;

Interoperabilnost: TETRA sistemi su dizajnirani da budu interoperabilni, omogućavajući različitim agencijama i organizacijama da međusobno komuniciraju neprimjetno;

Sigurnost: TETRA sistemi uključuju ugrađene sigurnosne funkcije kao što su šifrovanje i autentifikacija, koje pomažu u zaštiti od neovlaštenog pristupa.

Prateći Defense-in-depth strategiju može se reći da je pravilno održavanje od suštinske važnosti kako bi se osigurala pouzdanost i performanse TETRA sistema. U tom smislu, neke od opših smjernica za održavanje TETRA sistema podrazumijevaju:

Redovne inspekcije: Redovne inspekcije TETRA opreme i infrastrukture treba obavljati da bi se na vrijeme identifikovali i riješili problemi. To može uključivati inspekcije baznih stanica, repetitora i mobilnih radija;

Ažuriranja firmware-a: Održavanje TETRA opreme i softvera ažurnim sa najnovijim firmware-om je važno kako bi se osiguralo da sistem radi optimalno i da bi se popravili svi poznati problemi;

Održavanje baterija: Pravilno održavanje baterija je ključno u pogledu rada TETRA uređaja u potrebnom vremenskom trajanju i može uključivati redovno punjenje i zamjenu baterija po potrebi;

Backup sistema: Važno je redovno praviti sigurnosnu kopiju TETRA sistema zbog mogućnosti povraćaja podaka i konfiguracija u slučaju kvara ili katastrofe;

Obuka: Pružanje obuke za TETRA korisnike o pravilnom korištenju i održavanju sistema može pomoći da se osigura što bolje i efikasnije korištenje sistema;

Popravka i zamjena: Kada TETRA oprema ili infrastruktura otkaže ili se ošteti, treba je po potrebi, popraviti ili zamijeniti da bi se održale performanse sistema.

**DMR – Digital Mobile Radio**

DMR (*Digital Mobile Radio*) ubraja se u PMR standarde napravljene za profesionalnu upotrebu. Publikovan je 2004. godine od strane Evropskog instituta za telekomunikacijske standarde (*European Telecommunications Standards Institute – ETSI*) sa glavnim ciljem da profesionalni bežični komunikacioni sistem učini dostupnijim odnosno jeftinijim te manje komplikovanim u pogledu instaliranja opreme i održavanja (Digital Mobile Radio, 2004).

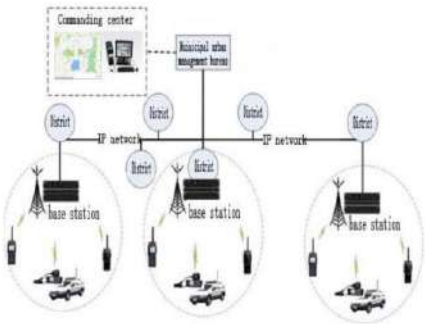
DMR standard podrazumijeva sljedeća tri sloja:

Prvi sloj je prilagođen za opštu, širu upotrebu te se u skladu sa postavljenim ciljem za njega ne mora platiti licenca. Također, podupire tzv. trunking sistem zbog čega je pogodan i u profesionalnom okruženju. Navedeni sistem je važan jer omogućava dinamičko dijeljenje ograničenog broja komunikacionih kanala između više korisnika;

Drugi sloj se koristi za standardnu komunikaciju, a zasnovan je na dvo-slotnoj TDMA tehnologiji koja je namijenjana za profesionalno tržište; i

Treći sloj se primarno koristi za trunking i paralelno odašiljanje radijskog signala, temelji se na istoj tehnologiji kao i prethodni sloj i posebno podupire aplikacije vezane za mrežni menadžment (Digital Mobile Radio).

U odnosnu na analognu tehnologiju, digitalna tehnologija ostvaruje veći spektar frekvencija, više funkcija, efikasniju komunikaciju i veću bezbijednost. DMR također podržava GPS tehnologiju što se obično koristi u svrhu kontrole pozicije radija i odašiljanje kratkih GPS poruka.




Slika 1. Prikaz DMR mreže (Qaddus, 2016).
Figure 1. View of the DMR network (Qaddus, 2016).

Defense-in-depth za digitalni mobilni radio (DMR) odnosi se na implementaciju više slojeva sigurnosnih kontrola za zaštitu DMR komunikacija od neovlaštenog pristupa ili smetnji. Ovo može uključivati mjere kao što su enkripcija, kontrola pristupa i segmentacija mreže kako bi se spriječio neovlašteni pristup DMR mreži. Pored toga, redovno praćenje i otkrivanje prijetnji se mogu koristiti za brzo identifikovanje i reagovanje na sve potencijalne povrede bezbijednosti. Uopšteno, Defense-in-depth je važan aspekt osiguranja bezbijednosti i pouzdanosti DMR komunikacija.

Upotreba Private LTE i 5G mreža

Privatni LTE (*Long-Term Evolution*) sistemi su bežične mreže koje koriste organizacije da obezbjede sigurnu i posvećenu komunikaciju za svoje zaposlene ili članove. Privatne LTE sisteme obično postavljaju preduzeća, agencije za javnu bezbjednost i druge organizacije koje moraju da obezbjede dostupnost i pouzdanost svojih komunikacionih mreža.

Privatni LTE sistemi bazirani su na istoj tehnologiji kao i komercijalne LTE mreže, koje koriste kompanije mobilne telefonije za pružanje mobilnih podataka i govornih usluga svojim korisnicima. Međutim, privatni LTE sistemi su u vlasništvu i njima upravljaju organizacije koje ih koriste, a ne komercijalni provajderi usluga. Ovo omogućava organizacijama da imaju potpunu kontrolu nad svojom mrežom, uključujući mogućnost da je prilagode svojim specifičnim potrebama i zahtjevima.

Privatni LTE sistemi se obično sastoje od mreže baznih stanica, koje su povezane na centralni mrežni server i brojnih korisničkih uređaja, poput pametnih telefona i tableta, koji mogu pristupiti mreži. Bazne stanice su odgovorne za odašiljanje i prijem radio signala sa korisničkih uređaja, kao i za povezivanje sa centralnim serverom. Korisnički uređaji su opremljeni LTE radijima, koji im omogućavaju komunikaciju sa baznim stanicama i pristup mreži (Joglekar et al., 2022).

Privatni LTE sistemi nude nekoliko prednosti u odnosu na druge vrste bežičnih mreža. Oni pružaju visokokvalitetnu glasovnu i podatkovnu komunikaciju, s funkcijama kao što su full-duplex rad, šifrovanje i funkcionalnost grupnih poziva. Oni također nude visoku pouzdanost i dostupnost, sa funkcijama poput redundantnosti i prioriteta mreže. Pored toga, privatni LTE sistemi su često sigurniji od komercijalnih mreža, jer se mogu prilagoditi i konfigurisati da osiguraju dodatne bezbjednosne mjere.

Privatni 5G odnosi se na korištenje 5G mobilne mreže koja je u vlasništvu i kojom upravlja jedan entitet, umjesto javne mreže kojom upravlja telekomunikaciona kompanija. Ovu vrstu mreže obično koriste kompanije ili organizacije za poboljšanje komunikacije i mrežne povezanosti unutar određene lokacije ili okruženja kampusa. Može pružiti veće brzine i manje kašnjenje od tradicionalnih LTE mreža, a također može podržati više uređaja i veći kapacitet. Međutim, ograničena je na specifično područje u kojem je mreža raspoređena i nije dostupna široj javnosti (Casetti, 2022).

U svrhu boljeg, lakšeg i preciznijeg korištenja lokacije klijenta Google je razvio VPS (*Visual Positioning System*) standard.

VPS koristi algoritme kompjuterskog vida za analizu slika snimljenih kamerom uređaja, kao što je detekcija i uparivanje karakteristika, kako bi se slike uskladile sa unaprijed mapiranim slikama. VPS sistem također koristi podatke senzora sa drugih senzora kao što su akcelerometar, žiroskop i magnetometar za fino podešavanje položaja i orijentacije (Kim et al., 2022).

VPS tehnologija je još uvijek u ranoj fazi, ali ima potencijal da revolucionira način na koji se krećemo i komuniciramo s našim okruženjem. Primjenjiva je u raznim poljima kao što su robotika, autonomna vozila i pametni gradovi.

Predviđanja su da će u bliskoj budućnosti VPS u potpunosti zamijeniti GPS standard.

Prednosti korištenja privatnih LTE i 5G mreža su:

Sigurnost: Privatne mreže nude viši nivo sigurnosti od javnih mreža, jer se mogu dizajnirati sa specifičnim sigurnosnim protokolima i kontrolama radi zaštite od neovlaštenog pristupa i kršenja podataka;

Nadzor: Organizacije imaju veću kontrolu nad svojom mrežnom infrastrukturom i mogu je prilagoditi svojim specifičnim potrebama;

Pouzdanost: Privatne mreže mogu biti dizajnirane tako da imaju visok nivo pouzdanosti i dostupnosti, što je važno za kritične aplikacije i usluge;

Niska latencija: Privatne mreže mogu ponuditi nisko kašnjenje i visoku propusnost, što je korisno za aplikacije kao što su industrijska automatizacija i udaljena hirurgija;

Uštede: Organizacije ostvaruju uštedu na troškovima komunikacije jer se ne oslanjaju na javne mreže i infrastrukturu;

Mogućnost korištenja nelicenciranog spektra: Privatne mreže mogu koristiti nelicencirani spektar za rad, što nije moguće na javnim mrežama;

Besprijekorna integracija: Privatne mreže se mogu integrisati sa postojećim IT sistemima i uređajima, omogućavajući besprijekorni i efikasniji rad.

Defense-in-depth kao sigurnosna strategija koja uključuje implementaciju više slojeva sigurnosnih kontrola za zaštitu od različitih vrsta prijetnji može se primijeniti na privatne LTE i 5G mreže kako bi se obezbijedila sigurnost i integritet mreže i podataka koje ona nosi.

Neki primjeri mjera Defense-in-depth koje se mogu koristiti za privatne LTE i 5G mreže uključuju:

Segmentaciju mreže: Podjela mreže na manje segmente, svaki sa vlastitim skupom sigurnosnih kontrola, može pomoći u sprječavanju širenja zlonamjernog softvera i drugih prijetnji;

Kontrole pristupa: Implementacija jakih mjera provjere autentičnosti i autorizacije, kao što je višefaktorska autentifikacija, može pomoći da se osigura da samo ovlašteni korisnici i uređaji mogu pristupiti mreži;

Nadgledanje mreže i odgovor na incidente: Nadgledanje mreže zbog sumnjivih aktivnosti i postojanje plana za reagovanje na sigurnosne incidente može pomoći u brzom otkrivanju prijetnji i odgovoru na njih;

Šifrovanje - enkripciju: Korištenje enkripcije za zaštitu osjetljivih podataka dok putuju mrežom može pomoći u sprječavanju neovlaštenog pristupa i krađe podataka;

Firewall: Firewall se može koristiti za osiguranje perimetra mreže i zaštitu mreže od vanjskih prijetnji;

Redovna ažuriranja i zakrpe softvera: Ažuriranje svih softvera i uređaja sa najnovijim sigurnosnim ažuriranjima i zakrpama može pomoći u zaštiti od poznatih ranjivosti;

Sigurnosnu reviziju i usklađenost: Redovna revizija sigurnosti mreže i usklađenosti sa sigurnosnim standardima poput NIST ili ISO pomože u osiguravanju ukupne sigurnosti mreže.

## ZAKLJUČCI

Ovaj rad daje teorijske osnove modernih radio sistema i prijedlog njihove zaštite koristeći mjere zaštite sadržane u Defense-in-depth startegiji.

Defense-in-depth je koncept koji se odnosi na implementaciju višeslojne zaštite da bi se obezbijedila sigurnost informacionih sistema. To uključuje korištenje različitih kontrola sigurnosti kako bi se osiguralo da ako jedan sloj sigurnosti ne uspije odbraniti, drugi slojevi i dalje ostaju u funkciji. Ova metoda se koristi u cilju smanjenja rizika od neovlaštenog pristupa ili kompromitovanja informacionih sistema. Slojevi zaštite mogu uključivati tehničke kontrole kao što su enkripcija, kontrole pristupa i segmentacija mreže, kao i administrativne i fizičke kontrole poput pravila i procedura, obuke i nadzora.

U prvom dijelu rada objašnjeni su radio i mobilni sistemi kao polazne tačke dok su u drugom poglavlju prikazani moderni radio sistemi bazirani na TETRA, DMR i Private LTE i 5G sistemima.

Na konkretnim primjerima date su i preporuke primjene Defense-in-depth strategije koja pokušava na što bolji način zaštititi navedene sisteme.

Živimo u eri automatike i početku nastanka robota, naprednih komunikacionih sistema, koji koriste umjetnu inteligenciju (AI - Artificial Intelligence) i mašinsko učenje (ML - Machine Learning) gdje se u pozadini koristi Defense-in-depth strategija kao osnovni stub sigurnosti.

Praktična primjena modernih radio sistema je široko rasprostranjena u svakodnevnim aktivnostima, a pretenduje da postane glavni instrument u funkcionisanju budućih modernih sigurnih radio – mobilnih komunikacionih sistema. Da bismo postigli zavidan nivo sigurnosti

Defense-in-depth strategija postaje jedna od osnovnih integrisanih komponenti modenih radio sistema.

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# DEFENSE-IN-DEPTH OF MODERN RADIO SYSTEMS

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## ABSTRACT

A purpose of this paper is to present the Defense-in-depth strategy for the protection of the information system, in this case of modern radio systems. It will explain the basic terms and systems of modern radio systems and how to implement them. Also, this paper will explain the basic concepts of radio communication systems, concepts of mobile radio and mobile GSM communication.

**Keywords**: Defense-in-depth, TETRA system, DMR, Private LTE and 5G.

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# MODELS OF SOFTWARE SYSTEMS DEVELOPMENT AND DESIGN

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## ABSTRACT

The software development model involves the use of one or more traditional approaches to software development, agile methodologies, or a combination of both approaches to obtain the most efficient and effective software. The differences between these approaches are very significant and the paper will show when and which approach is best to use. Improperly used approaches to software development can greatly affect the quality of software. This paper aims to present the situation in the field of Software Systems Development Model and Software Design Model and better understanding of given areas. Modeling is the only way to visualize the design and check the requirements before starting the implementation. The most important thing is that the final product- software best meets the requirements and ideas of the customer. This is exactly what software development models and approaches allow. The second goal of the paper is to understand the importance of using software design models. The paper concludes with a conclusion that combines everything written and provides a better understanding of the importance of approaches and models for software development.

**Keywords:** Agile software development, Traditional software development, Use Case model, UML.

## INTRODUCTION

We are witnessing that currently in most developed countries there is an expansion of the world of information technologies. Day by day, new methodologies, knowledge, experiences, and trends are emerging that are almost impossible to keep up with. As we live in a time of pandemic with the Coronavirus around the world, there is an extraordinary need to move to the online world, ie the world of Information Technology. The mass transition to work at home during the COVID-19 pandemic changed the way many software development teams collaborate and communicate.

Software companies are under constant market pressure to quickly produce new products with new features, cost-effective, and high quality. For this reason, companies are trying to find the best way to produce software that suits their needs. Significant specifics that characterize IT projects, especially software development projects, have conditioned the need to create new approaches, procedures, or methodologies for efficient work on programming and software development. Different project contexts require adequate development approaches in order to properly address the challenges in software projects (Jovanović et al., 2016). Software processes are defined to include all relevant knowledge and concepts that make up the structured set of activities necessary for software system development.

Software development projects mostly start without rigid specifications that are constantly changing and therefore often require frequent changes. In software development, a strong connection with the client is very important. The client is often not sure what exactly to expect as a result, and through requests for change, he goes towards his goal. The team working on software development is ready for a flexible approach to work, constant changes, and close cooperation with the client. When developing software, teamwork is necessary, continuous and fast communication

within the team, frequent meetings with the client, and fast and efficient exchange of opinions and information (Jovanović et al., 2016).

A software development model or software development life cycle model (SDLC) is a process that dictates the direction and results of the achieved project from the very beginning. Once you start software development with one model, it is not possible to change it. There are two approaches to software development: The traditional approach to software development and the Agile approach to software development (Jovanović et al., 2016).

As the traditional approach to software development requires strictly defined steps, where the next activity cannot start if the previous activity is not completed, strict division of roles and strict documentation, a new approach to software development has been created - The agile approach (Adamson et al., 2014).

The main goal of Agile methodologies is to accelerate and improve the software development process, which is easily adapted to changes in the environment and users. An agile methodology is an approach to project management based on 4 key pillars of the Agile Manifesto and 12 principles. The four key pillars of the Agile Manifesto are (Anwer et al., 2017):

- Individuals and interactions are more important in relation to processes and tools,
- Working software is more important than comprehensive documentation,
- Cooperation with clients before negotiating contracts,
- Respond to change rather than stick to a plan.

Agile methodologies represent an iterative approach to development that is flexible and allows the collection of new information during development. There are many agile models such as Extreme Programming (XP), Scrum, Test-Driven Development (TDD), Dynamic System Development Model (DSDM), Feature Driven Development (FDD), Crystal methods, Agile Modeling, etc. (Kumar, & Bhatia, 2012).

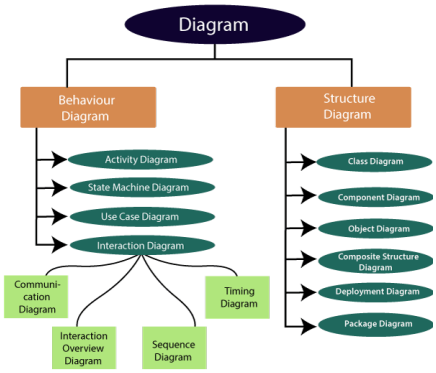
Scrum, the most well-known agile software development methodology, is used in a wide range of environments and for various purposes inside and outside traditional software development. Scrum is an iterative and incremental method of software development. Incremental development is the development of software step by step, while the iterative way is a time planning strategy in which the software is further improved over each defined period of time. Software development work takes place in shorter cycles called sprints. Sprints are time intervals that can last a month, usually lasting two or more weeks. The team from the list of functionalities chooses those functionalities that it can realize during one sprint. During one sprint, a complete whole is created, which is shown to the user, and based on his suggestions, the product in the next cycle is improved in accordance with the suggestions. As the Scrum methodology encourages more efficient collaboration between team members working on complex projects, there are three main roles (Adamson et al., 2014):

- Scrum master,
- Product owner,
- Scrum team.

As the development of information systems is too complex to be planned from the head, system modeling is necessary. Models are products of the analysis and design phase that represent a simplified complex reality of the system. Modeling makes it easy to present complex models for easier understanding. The software design model is a standard used immediately before coding. The use of software design models allows model verification, code generation, and automated test generation. Modeling is the only way to visualize the design and check the requirements before starting the implementation. Throughout history, various modeling tools have been used, such as Structural Analysis and Design Systems (SSAD), Object-Oriented Models, and Unified Modeling Language (UML) has been used since 1995 (Swain, 2010).

The Unified Modeling Language, or UML for short, is a standard graphical language for modeling object-oriented software that helps describe and design software systems. UML combines data modeling techniques, business modeling, object modeling, and components and can

be used throughout the software development lifecycle and through various implementation technologies. UML tries to provide a language so that all stakeholders benefit from one minimum UML diagram. The current UML standard contains 14 different types of diagrams that are divided into two categories: structural diagrams and behavior diagrams with a subset of interaction diagrams (Swain, 2010).




Picture 1. Types of diagrams (Java TPoint, 2022).

Class diagrams are one of the most commonly used diagrams. The main building block of any object-oriented solution. Displays the classes in the system, the attributes and operations of each class, and the relationship between each class. In most modeling tools, the class consists of three parts. The top of the class displays the name, the middle contains the attributes, and the bottom of the class contains operations or methods. Each class must have a unique simple name. A name is a short name or phrase derived from the vocabulary of the system being modeled. Attributes are a property that describes a value that will be contained in each object of the mentioned class. Each attribute can have a name, type, visibility, value, description, etc. A class can have none or more attributes. Operations describe the tasks that an object, as a concrete class phenomenon, will know how to perform (Epstein, & Sandhu, 1999).

In a large system with many related classes, the classes are grouped together and create a class diagram. Different relationships between classes are shown by different types of arrows. There are different relationships that can be defined between classes (Epstein, & Sandhu, 1999):

- Dependency - between two classes means that one class must know about the other class in order to use the objects of that class.
- Association - means a physical or conceptual connection between the appearance of objects or a connection between two classes.
- Aggregation - a special type of association that models the whole-part relationship, where parts are independent classes whose instances can live independently of the class that aggregates them.
- Composition - a special type of aggregation in which parts are weak objects that cannot exist independently without a basic class.
- Generalization and inheritance are used to describe a class that is a type of another class. Generalization is the strongest form of relationship between classes because it creates a close connection between classes. Generalization is used when a class is a specialized type of another class.
- Realization - semantic relation between classifiers, one of which specifies the contract and the other guarantees its implementation.

Use-Case diagrams show the behavior or operation of the system. They are created at an early stage of development to understand the requirements. Using the Use-Case diagram, the functional requirements of the system are collected and the interactions between the user and the system are

described. It is a means of communication between the developer and the customer. The elements of the Use-Case diagram are as follows (Swain, 2010):

- Cases of use - a sequence of actions initiated by the participants, in order to achieve a certain goal.
- Connections
- Participant- Contains one or more roles of one or more non-system entities that communicate with the system. In each case of use, the participant has one role.
- System boundary - Defined by participants and their communication.

The diagram describes the relationships between use cases, participants, use cases, and participants, and contains a detailed description of use cases. The goal of use case modeling is a clear and precise description of system functions as a basis for further system design (Swain, 2010).

The sequence diagram is used to specify the time requirements in the description of complex scenarios. Describes the flow of messages between objects that perform the corresponding operation in the system. It is used to model the dynamic aspects of the system and identifies system events and system operations for the appropriate use case. If use case diagrams are predefined, then the sequence diagram is one of its implementations. Displays the sequence of events generated by the participant and the operations that represent the response to the event in the system. Objects, links, and messages are defined. Time is displayed on the vertical axis, while the collection of objects is displayed on the horizontal axis. The activities of the object are shown in rectangles. Messages are events through which objects communicate and are represented by directed horizontal lines (Swain, 2010).

UML tools are one of the most important reasons why UML is so widely used. UML tools range from free open-source software to those that cost millions of dollars. These tools cover a lot of territory beyond drawing a diagram. They can generate code from design, apply design patterns, reverse engineering code, and perform impact and complexity analysis. Software design models are ideal for abstracting and handling large-scale, high-complexity software systems (Planas, & Cabot, 2020).

## MATERIAL AND METHODS OF WORK

Theoretical research was conducted in this paper. The theoretical part of the research included an insight into the reference literature that deals with the described subject of research. By reading scientific papers and studying already conducted research, the use of different approaches and models in software development was identified and an overview of the situation in the field was given. The research that was studied was conducted by surveying employees in various IT companies. The surveys were in Google Forms or in paper form. Based on the collected information, conclusions were made on the situation in the area and a review of the impact of the Corona Virus pandemic. Differences were observed between different approaches to software development.

## RESULTS AND DISCUSSION

Recent research, as well as practical experience, shows that companies use different development approaches to put together the approach that best suits the appropriate company. Various scientific studies conducted by surveying employees in companies show that developers have faced challenges in software development and that team productivity has changed. A big problem arose in the communication of the programmers. Due to online business, social interaction with colleagues was neglected, which led to reduced ease of communication between employees.

From today's point of view, the most well-known model of traditional software development - Waterfall, is a model for managing software development that has long dominated the IT industry. The Waterfall model is used in large systems whose development is divided into several locations. The traditional software development model is best for clearly defined projects that have definite timelines and well-defined results. A key disadvantage of this model is the inability to effectively

accept changes that arise from user requests during the process. As the phases of the model are sequential, the changes identified cannot be made immediately. The presented shortcomings have led to the emergence of new models: Spiral, V-Model, Rational Unified Process (RUP), and Rapid Application Development. Although many developers are moving to new approaches to software development, the Waterfall model still has wide applications, due to its simplicity, in traditional environments and processes (Jovanović et al., 2016).

According to Google Trend, Agile software development is by far the most searched term in the world in the last 12 months when we talk about approaches to software development. At the heart of any agile approach to software development is teamwork. Agile teams are self-organized teams in which members work in close cooperation with each other. With the Agile approach to software development, a simple design is much more desirable than a complicated one, which enables the delivery of products to be more reliable and timely. Agile management does not offer a universal path to success. Agile methodology is more suitable for the development of smaller projects. They are suitable for project management in which the main constraints are not strictly defined (Anwer et al., 2017).

Recent research has addressed the issue of expanding agile processes, confirming that the coexistence and integration of agile and traditional approaches are possible and even necessary when it comes to large and complex software projects. This knowledge opened a new era of development and application of the so-called. hybrid approaches that aimed to traditionalize to a certain extent, ie. expand agile approaches, respecting their core values and principles. This is the moment when new approaches Safe, DaD, Less, RAGE, Nexus, and Spotify appear. The HELENA study found that agility is strongly represented in development-related activities, while management remains on the more traditional path. The reasons may be that managers, although increasingly open to agile work, are limited by strict environmental processes, external standards, or compliance requirements. Test data show that project management is carried out in a fairly balanced way (with a slight tendency towards greater agility). Nevertheless, implementation and coding, integration and testing, as well as architecture and design are largely implemented in an agile way. The vast majority of respondents agree that it is not difficult to implement agile technology. Research on agile methodologies is growing rapidly while research on the traditional approach to software development is stagnating (Bašić, 2010).

Knowledge of business processes helps in the development of the software itself. In order to design a business process, it is necessary to analyze it. During the analysis of the business process, as much quality information about the business process as possible is collected in order to write a description of the business process based on when diagrams are later generated. Research shows that using the right tools, it is possible to automatically generate UCM, DM, and UIM. Software developers are still necessary in case of disagreements, but also to preserve the quality of the final result. Software design models are ideal for software systems of large scale and complexity. A positive example of the use of business process design is seen in one German company that saved more than $ 50 million in one year by using ARIS software in IT process harmonization (Kuhrmann, 2016).

## CONCLUSIONS

It is not possible to give a complete answer to the question of which model is best to choose when developing software. There are many factors that affect the efficiency of the model itself. When considering, the size of the project, the industrial need, the company's capabilities, and resources, the size of the team, the time it takes to complete the project, etc. should be taken into account. The software development model should be chosen based on the nature of the project itself and adapted exclusively to the project. The goal is not to find the perfect model, but a model that will bring the best functionality to the software being developed, which is in line with the company's culture.

The diversity of business areas makes it impossible to create a development approach that suits all companies. A company that has only a small development team must follow a different process than companies that have large teams working on the same product at the same time.

Therefore, software companies need to tailor an approach to suit their specific needs. Most developmental approaches are created by an evolutionary process where experience is the driver of process change. However, experience is only useful if the process that already exists is improved while creating a new development approach is difficult.

Every business process begins with the client's need and ends with meeting the client's need. In order to increase customer and company satisfaction, business processes are analyzed and designed. Today, it has become necessary to design business processes. The company's task is to harmonize internal and external business, which is impossible without dying the process (Kuhrmann, 2016).

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# INFORMATION SECURITY IN THE FUNCTION OF CORPORATE MANAGEMENT OF INFORMATION TECHNOLOGIES

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## ABSTRACT

It is known that the three basic elements of information security are protection against confidentiality, integrity and availability of information. The ISO/IEC 27001 standard helps companies protect information in any form. The new version of the ISO/IEC 27001:2022 standard follows new trends in IT and introduces new security controls. Information security is not the same in 2022 as it was in 2013, as many companies have embraced remote work and are using virtual applications. The standards of the ISO/IEC 27000 series represent answers to the increasing challenges of implementing information security measures in the company. The paper researched, analyzed and proposed the conceptual framework of information security in the function of corporate management of information resources, services and business values. The goal is to show that there is a strong connection between information security and company operations.

The recommendations and guidelines of the COBIT 2019 management framework were used for information technology management. An important feature of the development and application of the COBIT framework is its flexibility and alignment with many relevant standards.

**Keywords**: international standard 27000 series, COBIT, corporate management of information technologies.

## INTRODUCTION

In the contemporary business environment, all processes must have access to high-quality and secure information and data. Information security is a part of our reality, our work, and our life. System information security includes natural persons and environment, processes, organization and technology (Šikman et al., 2019). Protecting everyday activities that involve critical data, information, and intellectual property from cyber threats is a significant challenge in modern society. To adequately safeguard an information system, it is necessary to align, implement, and monitor all necessary security measures. For these reasons, there is a need for effective information security management, leading to the development of standards and best practice guidelines that provide recommendations for establishing effective protection of information resources.

The international standard ISO 27001 represents a contemporary framework for assessing information security and implementing an Information Security Management System (ISMS) for companies of all sizes, structures, or orientations. An essential characteristic of this standard is risk management and risk assessment. Risk assessment is one of the most critical steps in the implementacion of ISMS, not only because of the result of risk assessment is the basis for planning and conducting the necessary controls but also because of the procedure and methodology of conducting the assessment. (Sikman et al., 2022). Risks that compromise the three fundamental security requirements - confidentiality, integrity, and availability - necessitate the use of security controls. Such risks must be identified, and effective management of these risks is essential.

The process of managing security risks can rightfully be considered the foundation of building a secure and reliable computer infrastructure. Identifying critical information resources

and determining their associated security risks is a process that enables more effective and cost-efficient decision-making related to enhancing security (Službeni glasnik BiH, 2022).

Legal regulations, existing standards, and "best practice" rules prescribe the same recommendations for behavior and information security management system controls across all institutions. Such recommendations are theoretically universal and applicable to a large part of institutions. However, in practice, these requirements are specific to companies within their business operations. There is a lack of connection between financial investments in an information security management system and the quantitative representation of costs, which makes it difficult for information security managers to present economic indicators of information security investments to the institution's management (Šikman, 2021).

During the research on the exposed problem, most authors analyzed information security policy based on knowledge management (Klaić, 2014). Some authors focused on the identification and assessment of operational risk management related to Information and Communication Technologies (ICT) based on the ISO/IEC 27001:2013 standard, applying a fuzzy logic (Pichit, & Chuleekorn, 2018). Simultaneously, a lack of a specific, general model within institutions tailored to their needs and size is observed, aiming to assess the functionality of the Information Security Management System according to the ISO 27001:2022 standard, within the scope of corporate IT governance.

## WHAT CHANGES DOES THE NEW STANDARD ISO/IEC 27001:2022 BRING

The standard ISO 27001 is important for all institutions whose business functions related in any way with information technology and the demand for the protection of confidentiality of information resources. Applying this standard provides better connections with close organizations in the wider environment. The introduction of this standard, businesses show their customers and all interested parties that their business functions implemented on the basis of the principles of security and that the business plans are focused on continuous improvement of the Information security management system (ISMS) (Šikman et al., 2019). After nine years, a new version of the ISO 27001 standard has been published. The new standard, ISO/IEC 27001:2022, has the same broad goals as the previous version. The main changes introduced by the new standard are as follows:

Changed title of the standard: The previous version, ISO 27001:2013, was titled "Information Security Management System," while the new standard, ISO 27001:2022, is titled "Information security, Cyber security, and Privacy Protection Management System." This indicates a fresh approach to information security. The change and expansion of the title to include "cybersecurity and privacy protection" better represent the standard's role, broadening its scope to cover more technical aspects of data protection and cybersecurity.

Reduced number of security controls: The most significant change in Annex A of the standard is the introduction of 11 new security controls. By aligning with ISO 27002, the total number of controls has been reduced from 114 to 93. Some controls were added or merged with existing controls. There are still 35 unchanged controls, 23 controls with modified names, 57 controls merged into 24 controls, and one control split into two. The new controls better reflect changes in technology, the evolution of cyber threats, and take into account risks that were not considered in the previous version. The new security controls are: Threat Intelligence, Information security for use of cloud services, ICT readiness for business continuity, Physical security monitoring, Configuration management, Information deletion, Data masking, Data leakage prevention, Monitoring Activities, Web filtering, and Secure coding. Companies are required to establish internal or use external resources (outsource services) to collect, analyze, and create final information on cyber and indirect threats to the company through the implementation of these new controls. It's worth noting that not all controls are mandatory for implementation. Certification bodies may exclude certain controls if associated risks are not identified, or if there are no legal requirements to establish such controls.

Changed structure of the standard: The new structure of the standard is divided into four thematic categories instead of the previous fourteen. The standard now consists of the following

categories: organizational controls (37 controls), people controls (8 controls), physical controls (14 controls), and technical controls (34 controls). The reduction in the number of categories aims to simplify the implementation of ISMS and provide better clarity in the process of implementation.

The advantages of the new version of the standard can be defined as follows:

Enhanced risk management: The new version of the ISO/IEC 2700:2022 standard provides improved guidelines for identifying, assessing, and managing information security risks. This enables organizations to better understand their risks and address them more effectively to reduce the likelihood of unwanted incidents.

Simpler and improved structural approach to the standard and presentation of controls: The change in the structure of the standard into four thematic categories makes it easier for organizations to comprehend and implement controls. This simplification aids in the efficient implementation of the Information Security Management System.

Expanded focus on cybersecurity and privacy: The addition of "cybersecurity and privacy protection" in the title of the standard reflects a broader coverage of information security, considering new challenges brought by the digital age, including cyber threats and data protection.

Assisting companies in reassessing their risks and threats and implementing security controls: The introduction of new security controls in line with technological advancements and cyber threats enables companies to better assess their specific risks and tailor protective measures to stay ahead of potential threats.

All these advantages contribute to strengthening information security and empower organizations to better manage their information resources in today's complex and dynamic environment.

## GENERAL CHARACTERISTICS OF THE APPLICATION OF THE ISO 27001 STANDARD

The application of the ISO/IEC 27001 standard worldwide is continually growing. Many companies have recognized the benefits that the standard brings to modern business, contributing to a competitive advantage in the market. Figure 1 presents the industrial sectors with the highest number of certifications worldwide according to ISO/IEC 27001 for the year 2021 (ISO Survey, 2021).

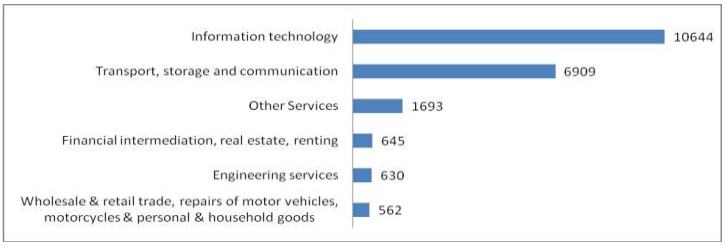


Figure 1. Standard ISO/IEC 27001 - sectors with the largest number of certificates in the world in 2021 (ISO Survey, 2021).

The highest number of certifications is in the Information Technology sector. Nowadays, companies utilize electronic business, which holds the same significance as financial capital. Therefore, data security and protection must be at a high level. For this reason, many companies opt for implementing an ISMS.

The application of modern technologies in business results in market globalization and the need for managing a protection system. In Bosnia and Herzegovina, there is an increasing number of companies choosing to implement ISO 27001, as shown in Figure 2 (ISO Committee, 2021).

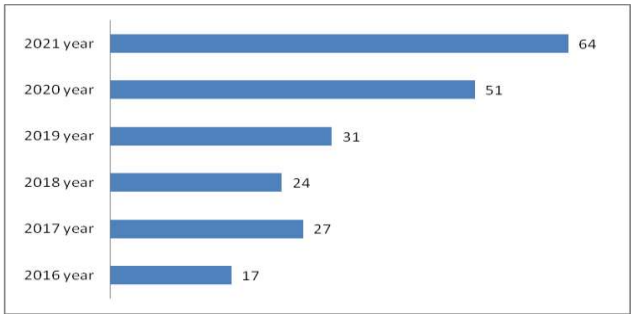


Figure 2. ISO/IEC 27001 standard - certificate number in BiH for the period from 2016 to 2021.

Figure 3 shows the number of companies in Bosnia and Herzegovina and neighboring countries that implemented the ISO/IEC 27001 standard in 2021 (ISO Committee, 2021).

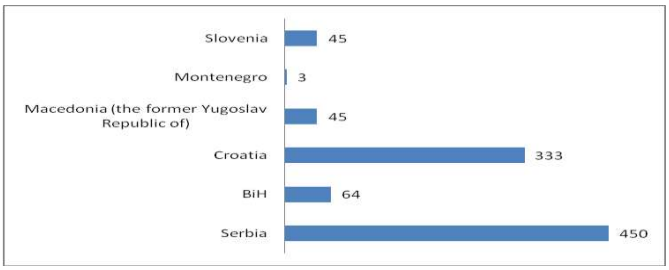


Figure 3. ISO/IEC 27001 standard - number of certificates in BiH and neighboring countries for 2021.

## CORPORATE MANAGEMENT OF INFORMATION TECHNOLOGIES THEORETICAL ASPECT

The use of computers, in the broader context of information technology, aims to increase efficiency and effectiveness in daily activities and processes within a company. The information system of every modern company, in the era of electronic business, should provide necessary internal and external information to deliver quality services. Only a quality information system can lead to a better understanding of the organization and create conditions for successful business (Aleksić Marić, 2008, pp. 21). By analyzing the quality of all components of the information system and their interaction, it is possible to gain insight into the overall quality of the information system and determine potential ways to optimize its quality. Nolan's law of minimum quality of an information system states: "The quality of an information system is equal to the quality of its weakest component." (Aleksić Marić, 2008, pp. 23). In most cases, the human factor poses the greatest threat to the information system, as individuals with insufficient skills and knowledge can hinder its optimal usage. Therefore, it is essential to establish an information system management process.

Corporate governance of information systems and technologies can be categorized into two levels (Spremić, 2017, pp. 205):

Strategic IT governance, which focuses on the external environment and the strategic vision of all stakeholders.

Operational IT management, which focuses on the internal environment, administration, and management of business processes, as well as finding the best administrative and technological solutions for an optimal business model.

Managing the information system is a part of corporate governance that ensures the effective use of information technologies to achieve the company's ultimate goals. It is evident that the company's business objectives determine the strategy of the information system. To determine the strategy of the information system, the company's management, the responsible head of the IT department, and other executives involved in strategic IT management need to be included. In

order to ensure a high-quality information system to achieve business objectives, potential risks and threats that the company may not have immediately identified need to be identified. Therefore, an audit of the information system is conducted, both by internal and independent external auditors. The goal of auditing the information systems is to verify the alignment of business objectives and information system objectives. The audit aims to determine the extent to which the functioning of the information system aligns with the company's business objectives. The object of the audit of information systems is to assess the maturity of IT controls that are part of the information system and are interconnected to achieve the goals of the entire information system. There are several methodologies for auditing information systems, with COBIT and ISO 27001 being two of them, used to methodologically assess the quality of the information system.

## COBIT – THEORETICAL AND TECHNICAL ASPECTS

COBIT (Control Objectives for Information and Related Technologies) is the most commonly used standard for managing information systems and corporate governance of information technology. The standard prescribes the domains, controls, and procedures used for operational and corporate IT management. The author of the COBIT management framework is ISACA (Information System Audit and Control Association), which is a leading global organization providing knowledge, certifications, and education in the areas of security and assurance, as well as corporate governance of information risks and technology.

The latest edition of COBIT 2019 aims to enable more flexible and customized implementation of effective "Enterprise Governance of Information and Technology (EGIT)." The new edition of COBIT introduces changes to the principles, including an adapted cascade of objectives, the establishment of three new processes, the introduction of focus areas, and design factors. Overall, the changes in COBIT respond to many IT-related changes that companies face. The COBIT management framework clearly defines and specifies essential IT processes, precise areas of responsibility, control objectives, and supervision. The framework also provides maturity models, i.e., metrics and goals for IT processes:

- Critical Success Factors (CSF)
- Key Goal Indicators (KGI)
- Key Performance Indicators (KPI) and management recommendations for performance monitoring
- Risk management recommendations
- Control objectives and control tests
- Achievement indicators for planned activities (IT activity goals)
- Maturity models for each business process (quality of each process is evaluated on a scale from 0 to 5)
- A system for measuring the effectiveness of IT on business operations.

The following are explanations of individual stages of COBIT process maturity assessment:

- Level 0 - Non-existent processes:

There is no corporate governance of information technology. The company lacks a responsible person or IT governance center. IT investments are made only when problems arise, and there is no risk assessment.

- Level 1 - Initial stage:

The company management has not yet recognized the significance of IT governance, and there are no formal procedures. The importance of IT risks is not recognized. IT governance is conducted within the IT center, and top management is not familiar with these activities.

- Level 2 - Repeatable processes:

IT governance exists, but procedures are not coordinated between the IT center or other operational organizational units. There is no supervision, coordination, or standardized procedures. Responsibility lies with individuals, and there is no employee training.

- Level 3 - Defined processes:

Employees are familiar with and trained in procedures, and there is IT governance. However, these procedures are not tailored to the company's operations. Responsibility for implementing procedures lies with individuals, and there is no system supervision, making it unlikely to detect deviations from defined processes.

- Level 4 - Managed and measured processes:

Procedures and policies for IT governance exist, and it is possible to supervise these procedures, measure their success, and correct any identified shortcomings. Responsibilities of appropriate corporate bodies are defined. Companies continuously improve processes and activities and set adequate IT governance objectives aligned with business goals. Modern methods are used to measure the achievement of these objectives.

- Level 5 - Optimized processes:

IT corporate governance processes are at a high level. The efficiency and effectiveness of IT are continuously measured, and results are compared with other companies and best practices. The involvement of IT in strategic plans is recognized. All IT activities are predefined according to business priorities.

## EXAMPLE OF FUNCTIONAL FRAMEWORK OF INFORMATION SECURITY AND CORPORATE IT MANAGEMENT

When forming the functional framework for information security and corporate governance, the following starting elements of integration were taken into account:

A) The management of the information security system in the company is based on the application of legal, technical, and organizational frameworks for protection.

B) ISMS (Information Security Management System) complies with legal regulations, professional standards, and certification systems.

C) The company's management analyzes the costs of such a system.

D) Input elements of the information security management system can be variable and non-variable. Non-variable inputs are legal regulations since they do not change frequently, while organizational and technical characteristics of the company are considered variable inputs.

The fundamental elements were created for the formation of the functional framework for information security and IT governance in the company at all levels of COBIT process development and operation. The basic elements of the model for each level correspond to security controls according to the recommendations of ISO 27001:2022 standard. When creating the functional framework, care was taken to ensure that each corresponding element corresponds to the complexity levels of COBIT processes. Tables 1 to 6 represent the functional framework for information security and IT governance according to the levels of COBIT process development.

Table 1. Level 0 – Elements of Non-Existent Processes .

| Elements of information security and IT governance at the zero level of development |
|---|
| There is no IT support center, IT management, and risk assessment in the company. |
| The importance of corporate governance is not recognized |
| The company addresses security issues reactively (after the problem occurs). |

Table 2. Level 1 – Elements of Initial Processes.

| Elements of information security and IT governance at the first level of development |
|---|
| Management has no formal procedures for IT governance. |
| IT management is conducted by the IT center. |
| The company's management is not aware of IT risks and does not consider information security. |
| IT governance exists only when a security incident occurs. |

Table 3. Level 2 – Elements of Repeatable Processes

| **Elements of information security and IT governance at the second level of development** |
|---|
| IT center conducts IT governance, but processes are not coordinated with other organizational units |
| There is no supervision and standardized working procedures. |
| Responsibility for IT management lies with individuals, and employees are not trained. |
| A system of logical controls is introduced for accessing information resources. |
| Procedures for operational implementation of information security exist |

Table 4. Level 3 – Elements of Defined Processes.

| **Elements of information security and IT governance at the third level of development** |
|---|
| Procedures for IT governance exist but are not tailored to the company's operations. |
| Responsibility for implementing security procedures lies with individuals. |
| Employees receive training in information security. |
| There is no supervision and risk assessment of information security processes. |
| An internal information security policy exists but is not aligned with other organizational units. |
| Implementation procedures for personal, organizational, technical, and physical controls are not tailored to the company's operations. |

Table 5. Level 4 – Elements of Managed and Measured Processes.

| **Elements of information security and IT governance at the fourth level of development.** |
|---|
| Implementation procedures for personal, organizational, technical, and physical controls are tailored to the company's operations. |
| Procedures and guidelines for IT governance exist, and process performance can be measured and adjusted. |
| A corporate body is responsible for implementing measurement processes using modern measurement methods |
| The company establishes and improves IT governance procedures aligned with business objectives. |
| Processes for managing business continuity and annual investment plans for ISMS. |
| Monitoring legal provisions related to information security and company compliance. |
| Employee training procedures in information security. |

Table 6. Level 5 – Elements of Optimal Processes.

| Elements of information security and IT governance at the fifth level of development |
|---|
| The efficiency and effectiveness of IT processes are continuously measured, and results are compared with other companies and best practices. |
| IT governance processes are transparent, and corporate bodies continuously monitor processes. |
| All IT activities are predefined based on business priorities. |
| IT management and information security are essential business functions and serve strategic purposes. |
| Financial analysis of investments in the IT sector in a semi-annual or annual period. |
| Establishment of ISMS and preparation for certification. |

## CONCLUSIONS

Many companies employ various forms of information technology in their business operations, which exposes them to numerous threats and new risks. To ensure the quality of their information systems, identify potential risks, and achieve successful operations, periodic audits and evaluations of information systems are increasingly being conducted.

The process of evaluating the success and maturity of information systems is performed periodically. Standards and governance frameworks are used for auditing and assessing information systems, ensuring secure and high-quality business operations. The combination of information security standard ISO 27001:2022 and the COBIT governance framework for corporate IT management greatly assists in the information systems evaluation process. This paper presents levels of information security and IT management maturity, with each level incorporating

fundamental procedures from both standards. It is demonstrated that a strong connection exists between information security and company performance.

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# ARTIFICIAL INTELLIGENCE IN GRAPHIC DESIGN AND ART - SOME ETHICAL AND AESTHETIC QUESTIONS AND THE NEED OF NEW THEORY OF ART

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## ABSTRACT

Artificial intelligence has undoubtedly already entered everyday human lives. It is present in the form of simple household appliances such as robotic vacuum cleaners, in cars in the form of electronic sensors (parking sensors, autopilots, or GPS systems), in computer games in the form of computer-driven roles, in the manufacturing industry, the film industry, education, and science, but also in various other fields of human existence like culture and art. On websites, online stores, and in various software and applications, artificial intelligence has long been used in the form of chat bots. At the end, artificial intelligence and its role in human life, as well as the idea that it will completely replace humans, are increasingly common topics. Be that as it may, the fact is that humans rely more and more on artificial intelligence, which gives rise to certain questions of an ethical and aesthetic nature, especially when it comes to the artistic field. That is why in this article we will discuss the ethical and aesthetic issues that accompany artificial intelligence and its use in various fields of human activity, with an emphasis on design and art.

The application of artificial intelligence in graphic design and art can speed up the design process, improve accuracy and creativity, and reduce the cost of making final products. However, artificial intelligence algorithms are still not sufficiently refined to avoid the traps of uniformity in creativity, and human influence is still indispensable in this process. The article will advocate the position that artificial intelligence still serves only as an auxiliary tool for achieving better and faster results but not as a substitute for the author's creativity, and that there is a need for a new aesthetic and theory in art.

**Keywords***:* artificial intelligence, graphic design, art, authorship, ethics.

## INTRODUCTION

There are many areas and human activities that are managed and even completely replaced by artificial intelligence, especially in the area of industrial production. Today, that influence has been extended to other areas. Opinions regarding the benefits or negative consequences of using artificial intelligence are polarized, and the phenomenon is still unexplored. However, for artists and designers, it can be said that they have gladly accepted the advantages of artificial intelligence in their work and creation. Artificial intelligence can contribute to improving the quality of works (for example, in terms of increasing the resolution and overall image quality), expand creative possibilities, and offer tools and techniques for generating new works. The application of artificial intelligence in graphic design and art can speed up the design process, improve precision, expand creativity, and reduce the cost of making final products. Also, the application of artificial intelligence in science is very welcome (like usage of ChatGPT or different kinds of spell checkers) to overcome language barriers or improve verbal expression in a foreign language. In the film industry, artificial intelligence capabilities are used to generate film characters and

environments, like in *Shrek II (*2004) and *Lord of the Rings (*2003) (Thomas, 2005, p. 47). But the contribution that artificial intelligence can and is making to contemporary art, design, and culture cannot and should not be dismissed. It has led to the emergence of new art genres, techniques, and approaches, as well as a theoretical exploration of art (Aela, 2023; Chatterjee, 2022).

The question of whether artificial intelligence (AI) will be the dominant factor in the future or whether humans will continue to be the bearers of creativity is a complex dilemma. Artificial intelligence is able to perform many tasks that previously required human intervention and expertise, such as processing data, recognizing patterns, and generating new ideas. On the other hand, people are creative beings who possess emotional and intellectual intelligence, the ability to think critically and make decisions, and the unique ability to imagine and create. However, artificial intelligence algorithms are still not sufficiently refined to avoid the traps of uniformity in creativity and cannot be a substitute for the author's creativity. In the article "Who Gets Credit for AI-Generated Art?", Epstein et al. did research on the perception of responsibility, credits, and valence of art generated by artificial intelligence that respondents ascribe to human agents behind the AI system (artists, curators, technologists, and crowds) or the artificial intelligence system itself. The findings showed that when the AI system is presented to the respondents as an agent, respondents ascribe less award or responsibility to the artist (Epstein et al., 2020, p. 6), but „for both the allocation of responsibility and credit, participants thought the artist was the most accountable, followed by the curator, then the technologist, and finally the crowd" (Epstein et al., 2020, p. 7). Artificial intelligence is a tool that can be used in the design process to achieve better and faster results, but only with the active participation of designers, who are ultimately the ones who make creative decisions and visions.

## AI TRENDS IN ART AND DESIGN AND THE ETHICAL QUESTIONS BEHIND THE USE OF AI IN GENERATING ART

It is necessary to take into account that times are changing and that the development of technology, which has greatly influenced the field of design and art, has placed new requirements and obstacles in front of creators. They have to adapt and keep up with the times and use different tools for image processing and the creation of works, and recently also different artificial intelligence software, in order to respond to modern demands for speed, quality, and variety. This is especially evident in the field of graphic design, which is a creative process that requires a high level of human and technological engagement. Artificial intelligence, thanks to its data processing and pattern recognition capabilities, has the potential to improve the design process and the quality of final products. The application of artificial intelligence allows designers to quickly generate different design variations to improve the process of creating and developing design solutions, including the modern design of logos, visual identities, web pages, and applications, as well as other design elements. Also, AI is used to automate the design process, which can reduce costs. For example, the automatic creation of brochures, flyers, or business cards can be done with the help of software that uses artificial intelligence. But, still, artificial intelligence cannot replace the creative effort that people put into their work; human influence is still indispensable in the design process.

But what about art? Do we have the aesthetic and criteria that will give clear guidelines to authors on how to use and relate to new technologies while still allowing them to make their own contribution to the work? In the books for the first grade of elementary school in Bosnia and Herzegovina, there used to be a story about a boy who brought a drawing of a rabbit to school as his homework. When the teacher asked him who drew the drawing, the boy replied that the body was drawn by Dad, the head by Mom, the tail by Grandpa, the ears by Grandma, and the legs by Sister. The teacher then asked the boy what he was doing during that time, and the boy replied that he was watching. The teacher gave the boy a grade for „watching", which caused the boy to blush and feel ashamed afterwards. This is how the educational system in Bosnia and Herzegovina, almost a quarter of a century ago, treated questions of authorship and approach to work, at least when it came to art and the creative aspect. But, before resolving the issues of authorship of AI-generated art, there are questions of aesthetic and theoretical evaluation of such works of art that need to be addressed.

The current state of art and the impact that artificial intelligence has on it seem like a true fulfillment of the French theoretician Roland Barthes' idea of the death of the author. In his text „The Death of the Author", Barthes spoke about the repression of the author and his removal from the text at the expense of the reader in the sense of disengaging the text from the meanings and interpretation of work (Barthes, 1977). But the author was still very much present in the process of creating the work. In the case of AI art, it is very ambiguous who gets the benefits at the cost of the author's expulsion—in this case, from its creation. If the author or authors are excluded from the creation of the work of art, is the initial author's idea sufficient as a basis for the creation of a work to attribute the authorship to the artist, or should the credits and the responsibility be exclusively attributed to another actor behind the AI system (curators, technologists, or crowds, as Epstein et al. (2020) state)? This could lead again to the criticized notion of intentionalism in art and the long-standing debate around the concept of the artist's intention or purpose of the work and its value evaluation, or in this case, even its artistic value. Could Duchamp's *Fountain* (1917) help us understand the issue, or could AI-generated art return us to pure aesthetic appreciation rather than interpretation since the AI is not anti-aesthetic like Duchamp's *Fountain? The postmodernist term "anti-aesthetic" in the sense used by critics of modernism* as *„a critique which destructures the order of representations in order to reinscribe them" (Foster, 1983, p. xv), cannot be applied to AI art.*

In the essay "Marcel Duchamp's *Fountain*, Its History and Aesthetics in the Context of 1917," considering Duchamp's *Fountain* in the context of culture and art in 1917, William A. Camfield stated that Duchamp's *Fountain* was not only "the product of an impulsive decision to challenge" the traditional principles of aesthetics but rather "the expression of its creator" (Camfield, 1987, p.81), related to contemporary culture, technology, and the state of art (Camfield, 1987, p.81), which can also be argued for examples of AI-art because "Who can do it better than AI?" as Duchamp would say for a propeller, according to William Camfield (1987, p.81). In the context of 1917, the *Fountain* was an authentic expression of the artist's observations and reflections on the world around him. The same could hardly be said for any AI-generated art, unless the artist's intent is taken into account.

Let's now consider the issue of authorship over AI-generated art. In his famous text "The Work of Art in the Age of Mechanical Reproduction", Walter Benjamin argued that in the nineteenth and later in the twentieth century, "much futile thought had been devoted to the question of whether photography is an art. The primary question—whether the very invention of photography had not transformed the entire nature of art—was not raised. Soon the film theorists asked the same ill-considered question with regard to the film" (Benjamin, 2007, p.227). Today, in the era of AI, we have to raise the same question about the nature of AI-generated art. Artificial intelligence in art and design works on the principle of generating new images from existing ones using different algorithms, such as so-called style algorithms that recognize and copy the style of one image to another or algorithms that copy the content of one image to another. In these cases, numerous ethical questions arise, such as the question of authorship and the use of original images from which new works were created, i.e., the authenticity of the art work. Likewise, it is necessary to think about the difference between "viewing", i.e., writing prompts (descriptions that the author enters into the AI system so that the system can generate the image) based on which the artificial intelligence generates the image, and the author's contribution, and to ask a question about who the authors are. What is it that makes artificial intelligence work autonomously? Is it the algorithm that AI uses or the social context and the relationship of curators, aestheticians, and art theorists to art itself?

The editors of Aesthetics and Contemporary Art (2019), Carrier and Andina, state in the preface of the book that although "philosophers and cultural historians typically discuss works of art in abstract terms... the true significance of art for philosophy, and philosophy for art, can only be established through close analysis of specific examples" (Carrier, 2019). For the same reason, let's cite a few examples of AI art to illustrate the issues in question. One of the most famous works of AI-generated art (made by "generative adversarial network" or GAN) is the *Portrait of Edmond de Belamy*, whose authorship is signed by The French Collective Obvious (Hugo Caselles-Dupré,

Pierre Fautrel, and Gauthier Vernier). It was sold at the Christie's Gallery auction in 2018 for an astonishing $432,500. The auction sale of this work raised a great media debate about the question of authorship (Kinsella, 2018; Jones, 2018) and the positioning of such work as art, but the Christie's curators decided to declare the sale of this work as "the arrival of AI art on the world auction stage" (Christie's, 2018) and as the beginning of an era of a new approach to art and new art genres.

If AI is going to be valued by curators and estheticians as art (as it already is), without the intention of clarifying the issue of authorship, originality and authenticity, then the solutions really could be seen in a principle that *The Societe des Artistes Independants of Paris* from the 19th century had: "No jury, no prizes" (Camfield, 1987, p.67). But there is still an unanswered question about the nature of AI art, as Benjamin (2007) points out. Unlike photography and film, the AI artist can hardly influence the choice of shot and composition unless it masters the software and the system in sufficient volume to control them. Systematic and profound education and training of artists and designers in the field of AI technology is necessary, not only to remain competitive on the market and in step with the latest trends and technologies, but also to maintain their role as creators in the process of new art shift and design creation.

Let us recall Gadamer's claim in "The End of Art? From Hegel's Doctrine of the Pastness of Art to the Anti-art of Today (1985)", that the term „the end of art" (which was coined by Arthur Danto to mark the moment of rejection of the traditional understanding of value in art – primarily mimetic representation and narration in visual arts (Danto, 1998, p.xv), which happened in the 1960s (Danto, 1998, p.25) with the emergence of contemporary art) „does not simply mean the same as what it so often meant in the life and in the development of Western art, namely, the reaction of a generation to the way things were changing, especially matters of taste, that which a younger generation considers appropriate. It is mostly the older generations who reject new art, shaking their heads as if it were the end of all good taste and real art. Today, we are obviously dealing with a deeper rift [B*ruch*] and disruption [*Einbruch*], with more radical questionability and doubt, which demand that we all appraise the situation in a thoughtful way" (Gadamer, 2022, p.65). Or, if we continue in Gadamere's words, it is a "rift" "which can become the seeds for a new growth" (Gadamer, 2022: 65), a new aesthetic culture. Referring to Hegel, Gadamer claims that "the history of modern painting demands from the painter a long series of working attempts and demands from the viewer a familiarization with the signature style of the artist" (Gadamer, 2022, p.71) in order to be comprehensible to the reader. Since "the work of art is no longer supposed to provide the consumer with unbounded satisfaction" and that "the artist would like to provoke and irritate, and many would like to understand their work as only a kind of suggestion, which invites others to become active in reconfiguring the work and continuing it," as Gadamer says (Gadamer, 2022, p.71), the question of a new aesthetic and conception of art should be raised in the context of artificial intelligence.

In his famous "The Artworld", Arthur C. Danto (1964) talks about the shift from the prevailing mimetic to modern interpretations and evaluations of works of art, which Dante explains in the context of the 19th century and the emergence of post-impressionist painting. Danto claims that, in order for Impressionist works to be accepted as artistic at the moment they appeared, not only a "revolution in taste" was necessary but also a "theoretical revision of rather considerable proportions, involving not only the artistic enfranchisement of these objects but an emphasis upon newly significant features of accepted artworks, so that quite different accounts of their status as artworks would now have to be given" (Danto, 1964, p. 573). It is the new theory that has to give works of AI art this new status and help us understand the contemporary artwork that is missing.

There is another AI-generated art piece, a work titled *Théâtre D'opéra Spatial* done with the Midjourney tool. The work participated in the Colorado State Fair competition and won first prize (ODSC Team, 2022; Roose, 2022). The author of the work, Jason Allen, even admitted that he knew the work could cause controversy, but he still decided to examine what response the audience and the public would have. Finally, let's mention the work called *Pseudomnesia: The Electrician* by the German artist Boris Eldagsen, which won the Sony World Photography Award 2023. Unlike previous authors, Eldagsen refused to accept the award on the grounds that it is a product of

artificial intelligence, but he also testified that "he used the image to test the competition and spark a debate about the future of photography, the BBC reported" (Index Magazin, 2023). Eldagsen and Allen allegedly wanted to provoke and irritate, as Gadamer notices, because it is people who give meaning and value to works of art, regardless of whether we are talking about curators and their theories or audiences. AI gives an entirely new context that creates the conditions for a change in art theory, as Danto postulates, and until that revolutionary upheaval in the approach to art and "tastes" happens, AI art will be a fact of controversy and not an object of a theoretical and aesthetic evaluation.

## CONCLUSIONS

It is quite evident that artificial intelligence will be ubiquitous in the future and will be used in various industries and aspects of life, and the question of whether artificial intelligence will be the dominant factor in the future or whether humans will continue to be the bearers of creativity is a complex dilemma. AI is able to perform many tasks that previously required human intervention and expertise, such as improving or optimizing the quality of the final product or generating new ideas. However, it also supports the fear that exists among creatives (graphic designers and artists) that AI will replace their jobs in the future. AI could be used to generate new ideas, but this further marginalizes humans from the entire creative and artistic process. On the other hand, people are creative beings who possess emotional and intellectual intelligence, the ability to think critically and make decisions, and the unique ability to imagine and create. Although this is possible in some minor areas of design, AI cannot compare to human creativity, which requires abstract thinking and, above all, emotions, which are essential aspects of contemoprary art. Therefore, artists and designers should adapt and further educate themselves about AI technology in order to master it and maintain their role as a context for creating ideas and maintaining aesthetic values. They must educate themselves and be ready to accept new tools and technologies not only in order to stay competitive but also to be able to focus on more creative tasks that require human intervention and not leave aesthetics to technology. No matter how much AI has developed and entered various aspects of our lives, human creativity and artistic work are inherently human, and humans will always be the ones who will be the bearers of creativity and art.

Since art, in order to exist, needs an audience that will "make it possible", and the audience needs a theory to help them "discriminate art from the rest," as Arthur Danto (1964) would say, there is an immense need to develop a new aesthetic and for art theory to integrate a new kind of art, such as AI-generated art. Both fields should work to develop the ethics and aesthetics of art in the context of AI so that art and contemporary culture, shaped by technology, can perform their role as agents of spiritual upliftment.

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# MAPIRANJE RIZIKA OD ŠUMSKIH POŽARA NA TERITORIJI REPUBLIKE SRPSKE PRIKAZANO POMOĆU GIS-a

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## SAŽETAK

Rezultat ovog rada je mapa rizika od pojave šumskih požara na teritoriji Republike Srpske. U ovom radu mapa rizika je kreirana pomoću geografskog informacionog sistema i prikazana je prostorna raspodjela pomenutih rizika na teritoriji Republike Srpske. Svi korišćeni podaci su digitalizovani u rasterskom i vektorskom formatu, te su kao takvi korišteni za dalju analizu pomoću GIS-a. U radu je opisana metodologija pomoću koje je mapa rizika urađena i prema kojim kriterijumima je dodijeljen stepen rizika. Mape rizika od šumskih požara izrađuju se u svrhu planiranja zaštite šuma i šumskog zemljišta od požara. Pored mape, kroz rad su date i smjernice na koji način je moguće uticati na smanjenje rizika od požara, kao i na koji način mapa može bit nadograđena.

**Ključne riječi**: šumski požar, analiza, mapa rizika, Republika Srpska.

## UVOD

U radu je obrađen dosadašnji način procjene ugroženosti od šumskih požara na teritoriji Republike Srpske. Kriterijumi za procjenu definisani su Pravilnikom o sadržaju i postupku izrade plana zaštite šuma od šumskih požara. Takođe, u radu je navedeno da ne postoje svi podaci potrebni za kreiranje mape rizika prema kriterijumima koji su definisani prethodno pomenutog Pravilnika iz razloga što ne postoje svi potrebni ulazni podaci u digitalnom obliku. Nadalje, u radu je prikazana mapa ugroženosti od šumskih požara kreirana pomoću GIS alata i prikazano koliko teritorije Republike Srpske pripada kojoj kategoriji ugroženosti u procentima. Pored mape ugroženosti, izrađena je i mapa sa istorijskom podacima o šumskim požarima, koja prikazuje podudaranja mapirane ugroženosti i stvarne pojave požara na teritoriji Republike Srpske. Nakon svega navedenog ukazano je na neophodnost izmjena pomenutog Pravilnika na način da isti bude prilagođen primjeni novih tehnologija.

## METODOLOGIJA

Za potrebe izrade rada uzeti su i istorijski podaci o pojavi šumskih požara koji su evidentirani od strane Javnog preduzeća šumarstva „Šume Republike Srpske“ a.d. Sokolac i isti su prostorno prikazani na osnovu pojave po šumsko-privrednim područjima. Prikupljeni su i podaci u digitalnom obliku koji se odnose na vegetaciju, nadmorsku visinu, nagib terena, ekspoziciju, temperaturu, padavine, ali i ostali podaci koje je bilo moguće prikupiti u digitalnom obliku. Svi prikupljeni podaci su objedinjeni pomoću GIS-a, odnosno QGIS-a i dodatka za isti RFForestFireRisk. Algoritmom za analizu i kategorizaciju definisane teritorije za koju su prikupljeni podaci, kreirana je mapa ugroženosti od šumskih požara. Mapa je upoređena sa mapom detektovanih požara u periodu od dvanaest godina.

## TRENUTNI SISTEM PROCJENE UGROŽENOSTI OD ŠUMSKIH POŽARA

Kriterijumi za procjenu ugroženosti od šumskih požara utvrđeni su Pravilnikom o sadržaju i postupku izrade plana zaštite šuma od šumskih požara i određeni su sljedećim parametrima:

- Vegetacija;

- Antropogeni faktor;
- Klima;
- Stanište (matični supstrat i vrsta zemljišta);
- Orografija;
- Šumski red i uređenost sastojne.

Šumska vegetacija podijeljena je na sastojne četinara, lišćara, te mješovite sastojne, a za potrebe rada uzeti su u obzir i uzgojni oblici koji su specifični u pogledu osjetljivosti na šumski požar. U okviru dalje podjele vegetacije šumske kulture i plantaže izdvojene su kao posebne kategorije, bez obzira na starost, dok je podjela prirodnih čistih i mješovitih sastojina izvršena prema njihovoj starosti i zahtjevima za svjetlosti.

Iz razloga što je, statistički gledano, veliki procenat uzroka nastanka šumskih požara u posrednoj ili neposrednoj vezi sa čovjekom i njegovim aktivnostima (antropogeni faktor), tako je i ovaj parametar određen podjelom u tri kategorije, s određenim brojem bodova.

Klimatski faktor određen je pomoću tri parametra: srednja godišnja temperatura vazduha, količina padavina i relativna vlažnost vazduha.

Matični supstrat i vrsta zemljišta uzeti su kao posebni parametri koji utiču na stepen ugroženosti od šumskog požara. Stepen ugroženosti od šumskog požara zavisi i od sadržaja vlage u gorivom materijalu na zemljištu (iglice, lišće, granje, panjevi i dr.), a stepen vlažnosti različit je na različitim zemljištima, odnosno matičnom supstratu.

Orografske karakterisitike imaju znatan uticaj na opasnost od pojave šumskih požara. Intenzitet i trajanje insolacije (oblačnosti) utiču na brzinu isušivanja gorivog materijala, a on je različit od eksozicije i inklinacije. Nadmorska visina na kojoj se nalazi sastojna uzeta je kao korektor srednje godišnje temperature vazduha.

Pored toga, održavanje šumskog reda utiče na stepen ugroženosti od šumskih požara. U šumama u kojima se šumski red nije uspostavljen i koji nije održavan povećava se količina gorivog materijala na zemljištu, a time je povećana opasnost od požara. Uticaj svih ugrađenih faktora izražava se zbirom bodova. U zavisnosti od ukupnog broja bodova, sve šume i šumska zemljišta Republike Srpske, prema stepenu ugroženosti od šumskih požara, razvrstavana su u pet grupa:

Tabela 1. Stepen ugroženosti od šumskih požara.
Table 1. Degree of danger from forest fires.

| Stepen ugroženosti | | **Broj bodova** |
|---|---|---|
| I | Vrlo velika | >480 |
| II | Velika | 381-480 |
| III | Umjerena | 281-380 |
| IV | Mala | 150-280 |
| V | Vrlo mala | <150 |

Opisani postupak mapiranja ugroženosti od šumskih požara nije usklađen sa radom pomoću novih informacionih tehnologija, prvenstveno iz razloga nepostojanja podataka o šumskoj vegetaciji u digitalnom obliku. Evidentirani su podaci za državne šume i isti su digitalizovani, ali za privatne šume ne postoje podaci (Ljubojević i Stanković, 2021). Napominjemo da podaci koji su digitalizovani nisu prilagođeni postojećoj metodologiji.

Posmatrajući istorijske podatke o šumskim požarima, vidljivo je da svake godine značajan dio teritorije Republike Srpske bude zahvaćen šumskim požarima i koji prizrokuju velike štete kako na šumskim drvnim sortimentima tako i na potencijalnoj dobiti. Osim ekonomskog aspekta, ogromne štete su prouzrokovane su biodiverzitetu. U Tabeli 2. koja prikazuje istorijske podatke evidentno je da su štete svake godine značajne i da nemaju tendenciju smanjenja.

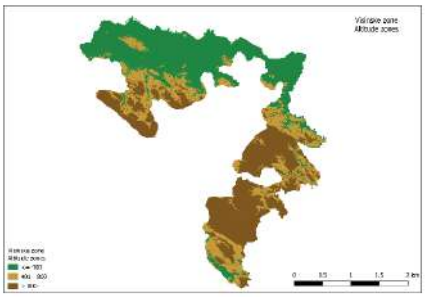
Tabela 2. Istorijski podaci o šumskim požarima
Table 2. Historical data on forest fires

| Godina: | Broj požara: | Opožarena površina (ha): | Totalno uništena drvna masa ($m^3$): | Direktna šteta (BAM): | Troškovi gašenja (BAM): |
|---|---|---|---|---|---|
| 2010 | 79 | 1.523 | 2.802 | 214.441 | 32.713 |
| 2011 | 298 | 14.970 | 79.268 | 2.739.504 | 174.298 |
| 2012 | 546 | 25.508 | 83.491 | 7.084.771 | 743.485 |
| 2013 | 94 | 422 | 741 | 286.973 | 48.199 |
| 2014 | 83 | 428 | 362 | 153.267 | 20.390 |
| 2015 | 179 | 6.067 | 21.654 | 741.890 | 149.757 |
| 2016 | 117 | 3.388 | 17.317 | 812.573 | 47.598 |
| 2017 | 260 | 18.886 | 254.598 | 2.694.786 | 138.833 |
| 2018 | 45 | 599 | 3.361 | 142.844 | 13.227 |
| 2019 | 206 | 3.654 | 13.722 | 609.132 | 77.207 |
| 2020 | 326 | 6.076 | 25.081 | 1.818.269 | 212.079 |
| 2021 | 150 | 12.173 | 57.340 | 1.806.172 | 159.576 |
| 2022 | 192 | 6.832 | 38.263 | 1.497.579 | 83.602 |
| Ukupno: | 2.575 | 100.526 | 598.000 | 20.602.201 | 1.900.964 |

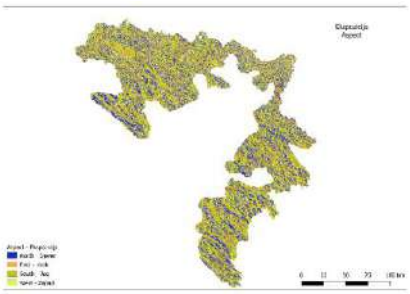
Iz tabele o istorijskim podacima vidi se da godišnje na teritoriji Republike Srpske, u prosjeku bude evidentirano oko 200 požara i da u prosjeku nastane finansijska šteta u iznosu oko 1,5 miliona KM. Iz prikazanog jasno je da je potrebno intenzivnije raditi na suzbijanju pojave šumskih požara, a prvi korak u tim aktivnostima jeste kreiranje mape ugroženosti od istih. Na osnovu podataka dobijenih u procesu mapiranja, moguće je planirati aktivnosti na smanjenju ugroženosti šumskih ekosistema i realizacijom istih bi bio smanjen broj požara, što će za rezultat imati smanjenje gubitaka kako šumskog fonda, tako i će imati uticaj i sa finansijskog aspekta (Ljubojević i Latinović, 2022). U nastavku rada biće prikazana upotreba GIS-a za izradu mapa ugroženosti od šumskih požara i na koji način se iste mogu unaprijeđivati.

## PRIMJENA GEOGRAFSKOG INFORMACIONOG SISTEMA

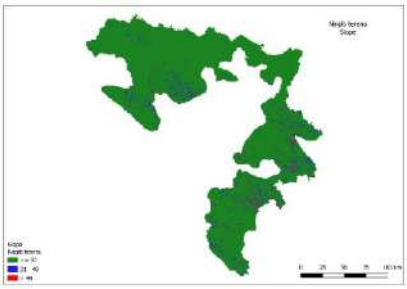
Kao što je prikazano u prvom dijelu rada, trenutna metodologija zahtjeva veliki set podataka koji se tiču vegetacije, a isti ne postoje u digitalnom obliku. Potrebno je metodologiju prilagoditi podacima koji su dostupni, tako da se mapiranje ugroženosti od šumskih požara može uraditi pomoću geografskih informacionih sistema. Mapa izrađena na takav način je jednostavna za izmjene, odnosno unaprijeđenja. Nadalje, takvu mapu je lako distribuirati svima kojima je potrebna (Stojković, 2020). Zbog navedenog potrebno je raditi na izmjeni postojeće metodologije za procjenu ugroženosti od šumskih požara i istu prilagoditi primjeni pomoću novih tehnologija, odnosno rada u GIS-u (Milanović i sar, 2020).



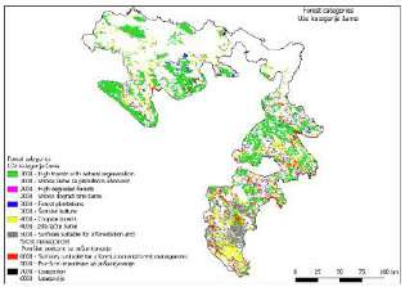
Slika 1. Visinske zone Republike Srpske.
Figure 1. Altitude zones of the Republic of Srpska



Slika 2. Ekspozicija terena Republike Srpske.
Figure 2. Exposition of the terrain of Republika Srpska.

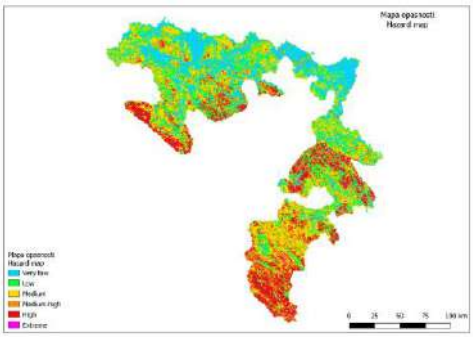


Slika 3. Nagib terena Republike Srpske
Figure 3. Slope of the terrain of Republika Srpska.



Slika 4. Kategorije šuma Republike Srpske.
Figure 4. Forest categories of Republika Srpska.

U radu prikazana mapa je izrađena pomoću QGIS-a i RFForestFireRisk kreiran od strane CIMA Research Fondation. Kao ulazni parametri korišćeni su podaci o vegetaciji iz CORINA programa. Pored navedenih podataka, koristeni su: digitalni model terena odnosno DEM, nagib terena, ekspozicija, udaljenost od puteva, udaljenost od usjeva, istorijski podaci o požarima preuzeti sa EFIS-a i podaci koji se odnose temperature i vlažnosti. Kada se svi podaci integrišu pomoću navedenog dodatka za QGIS, isti kreira mapu koja je klasifikovana u šest kategorija ugroženosti, a to su: vrlo mala, mala, srednja, srednje velika, velika i ekstremna. Kategorije su definisane pomoću ulaznih parametara i različitih metodologija procjene ugroženosti od šumskih požara, te je na osnovu toga definisano da postoji šest kategorija. Prema ulaznim parametarima za cijelu teritoriju Republike Srpske dobijena je mapa ugroženosti iz koje se jasno vidi da najugroženiji dio jeste područje Hercegovine, odnosno teritorija Trebinja i Bileće.



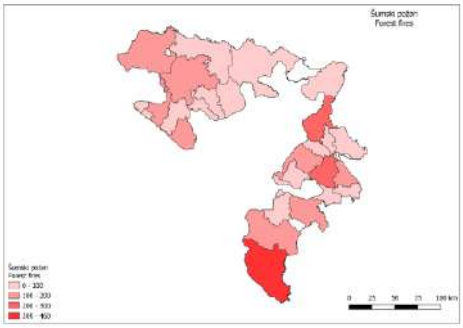
Slika 5. Mapa ugroženosti od šumskih požara Republike Srpske.
Figure 5. Map of risk from forest fires in the Republic of Srpska.

Posmatrajući podatake dobijene iz analize, možemo utvrditi koliko kojoj kategoriji ugroženosti pripada površine izražene procentualno u odnosu na ukupnu teritoriju Republike Srpske. Analizirajući dobijene podatke, vidljivo je da se oko 74% teritorije nalazi u prve tri kategorije što se može okarakterisati kao dosta dobro. Međutim, pored toga zapažamo veliki procenat teritorije u kategoriji pet 16% , što pored kategorije šest predstavlja ciljanu teritoriju za planiranje i aktivnosti za umanjenje rizika od šumskih požara.

Tabela 3. Procenat teritorije Republike Srpske po kategorijama ugroženosti.
Table 3. The percentage of the territory of the Republic of Srpska by categories of vulnerability.

| Kategorija: | Procenat teritorije: |
|---|---|
| 1 | 18,79% |
| 2 | 24,29% |
| 3 | 31,40% |
| 4 | 8,99% |
| 5 | 16,34% |
| 6 | 0,20% |

Kada posmatramo mapu detektovanih požara od strane JPŠ „Šume Republike Srpske“ u posljednjih dvanaest godina, vidimo podudaranje mape ugroženosti i istorijskih podataka (JPŠ „Šume Republike Srpske“, 2023), na osnovu čega se može zaključiti da kreirana mapa ugroženosti prikazuje relevantne podatke.




Slika 6. Prikaz evidentiranih požara po šumsko-privrednim područjima za period 2010. -2022. godine.
Figure 6. Presentation of recorded fires by forest and economic areas for the period 2010 - 2022. years.

Na ovaj način dobijeni podaci jasno ukazuju da je potrebno intenzivnije raditi na smanjenju rizika od šumskih požara na prostorima istočnog dijela teritorije Republike Srpske. Nakon što budu izvršene potrebne aktivnosti kako bi bio smanjen rizik, potrebno je generisati novu mapu ugroženosti od šumskih požara i istu u redovnim intervalima kreirati kako bi se uvijek imali relevantni podaci. Ovdje posebno treba naglasiti klimatske podatke o temperaturi i padavinama, i to iz očitog razloga, a to je da se svake godine očitavaju sve više temperature u ljetnim periodima, a što u velikoj mjeri utiče na procjenu ugroženosti od šumskih požara.

## ZAKLJUČCI

Shodno prikazanom u ovom radu jasno se može vidjeti na koji način je moguće pomoću GIS alata kreirati mapu ugroženosti od požara, te precizno utvrditi u prostoru koji su to lokaliteti najugroženiji. Na osnovu tako dobijenih podataka može se raditi na efikasnijim aktivnostima radi umanjenja ugroženosti teritorija i samim tim svaki put generisati novu mapu. Nove tehnologije odnosno GIS alati mogu za kratko vrijeme izvršiti potrebne kalkulacije i kreirati mapu ugroženosti od šumskih požara. Tako kreirana mapa može se veoma brzo distribuirati svima kojima je ista potrebna. U ovom slučaju, kreirana je mapa ugroženosti za teritoriju Republike Srpske gdje jasno možemo vidjeti da se veliki procenat teritorije, preko 16% nalazi u dvije najugroženije kategorije. Na osnovu mape kreirane za potrebe ovog rada jasno se vidi podudaranje istorijskih podataka o požarima i lokaliteta koji su označeni kao ugroženi na generisanoj mapi. Navedeno govori da je potrebno, na najugroženijim lokalitetima jasno definisati i sprovesti aktivnosti kako bi se smanjila ugroženost. Podaci dobijeni u ovom radu predstavljaju osnovu za izradu planske dokumentacije za navedene aktivnosti. Kako isti nedvosmisleno ukazuju na najugroženija područja, otvara se pitanje daljnje primjene sadašnje metodologije za procijenu ugroženosti šuma od šumskih požara.

Nameće se kao neophodno raditi na kreiranju nove metodologije koju je moguće integrisati sa novim informaciono- komunikacionim tehnologijama, a isto tako potrebno je raditi na prikupljanju podataka u digitalnom obliku, radi adekvatne primjene navedene tehnologije.

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# MAPPING THE RISK OF FOREST FIRES AT THE TERRITORY OF THE REPUBLIC OF SRPSKA PRESENTED THROUGH GIS

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## ABSTRACT

The result of this work is a forest fire risk map on the territory of the Republic of Srpska. In this paper, a risk map was created using a geographic information system and the spatial distribution of risks on the territory of the Republic of Srpska was shown. All data used were digitized in raster and vector format and as such were used for further analysis using GIS. The paper describes the methodology by which the risk map was created and by which criteria the degree of risk was assigned. Forest fire risk maps are created for the purpose of planning the protection of forests and forest land from fire. In addition to the map, guidelines are also given on how to influence fire risk reduction, as well as how the map can be upgraded.

**Keywords**: wildfire, analysis, risk map, Republic of Srpska.

# *ENGINEERING, TECHNOLOGY AND MATERIALS*

# *INŽENJERSTVO, TEHNOLOGIJE I MATERIJALI*

ORIGINALAN NAUČNI RAD – ORIGINAL SCIENTIFIC PAPER DOI: 10.7251/PIMZ2301383M

# EARLY DETECTION OF *PHYTOPHTHORA PLURIVORA* PATHOGEN INFECTION IN SWEET CHESTNUT LEAVES USING NONDESTRUCTIVE OPTICAL METHOD

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## ABSTRACT

This study introduces a novel nondestructive optical method for detecting infections of the invasive *Phytophthora plurivora* pathogen in sweet chestnut (*Castanea sativa*) leaves, as well as monitoring plant health and stress. The proposed method utilizes spectrophotometric measurements to continuously monitor the optical transmission coefficients of plant leaves in real-time. To test the method, one group of plants was infected with the pathogen while another group was kept healthy in prolonged period. The infected group exhibited modified circadian rhythms of the optical transmission, which were indicative of the plants' stress. These findings demonstrate the ability of the proposed optical method to detect early stress in plants and to improve plant health assessment and management by providing an early indicator of plant stress and disease, thereby allowing for prompt intervention and treatment.

**Keywords**: Nondestructive optical method, leaf transmittance, plant health assessment, *Phytophthora plurivora*, sweet chestnut leaves.

## INTRODUCTION

The invasive pathogen *Phytophthora plurivora* poses a significant threat to both natural forests and cultivated sweet chestnut (*Castanea sativa*) trees. This destructive pathogen causes severe infections in leaves, leading to leaf necrosis, reduced photosynthetic activity, and ultimately, the decline and death of infected trees. Early detection and effective management strategies are essential to mitigate the devastating impact of *Phytophthora plurivora*.

Numerous studies have focused on investigating the characteristics and behavior of *Phytophthora plurivora*, shedding light on its pathogenicity and ecological implications. For instance, research by Werres et al. (Werres et al., 2001) identified *Phytophthora plurivora* as a distinct pathogen on *Rhododendron* and *Viburnum*, highlighting its potential as a destructive species. Further investigations by Drenth et al. (Drenth et al., 2006) revealed *Phytophthora plurivora* as a new species with a high diversity among *Phytophthora* species in natural ecosystems of Southwest Australia. These studies emphasize the need for effective detection methods and management strategies for *Phytophthora plurivora*.

In addition to its devastating impact on forests, *Phytophthora plurivora* also poses a significant threat to domestic sweet chestnut trees. Recent studies have highlighted the destructive potential of *Phytophthora plurivora* in these contexts. Notably, Mrázková et al. (Mrázková et al., 2013) detected *Phytophthora plurivora* on forest trees and other ericaceous plants in Czech Republic, underscoring the broad range of susceptible host species. Additionally, Jankowiak et al. (Jankowiak et al., 2014) identified *Phytophthora plurivora* on ornamental plants in nurseries in Poland, further emphasizing the need for effective detection and management strategies in various settings.

Currently, detection methods for *Phytophthora plurivora* primarily rely on traditional approaches, which often involve destructive sampling and laborious laboratory-based techniques. However, these methods have limitations in terms of time consumption, labor intensity, and the inability to provide real-time monitoring capabilities. To overcome these limitations, nondestructive optical methods have emerged as promising alternatives for early detection and continuous monitoring of plant health and stress.

Recent research has demonstrated the potential of nondestructive optical methods in plant pathology, including the detection of stress, nutrient deficiencies, and overall health evaluation. Studies by Miletic et al. (Miletic et al., 2022) and Kasalica et al. (Kasalica et al., 2021) have successfully utilized nondestructive optical methods for sensing nutritional stress in hydroponically cultivated plants and overall health evaluation in various plant species, respectively. These studies highlight the advantages of nondestructive optical methods in providing real-time monitoring capabilities and early detection of plant stress.

By leveraging the benefits of nondestructive optical methods, this study aims to introduce a novel approach for the early detection of *Phytophthora plurivora* pathogen infection in sweet chestnut leaves. Continuous monitoring of optical transmission coefficients will enable real-time assessment of plant health and early identification of stress, allowing for prompt intervention and treatment. The proposed method has the potential to significantly improve the detection and management of *Phytophthora plurivora*, ultimately aiding in the preservation of sweet chestnut trees and the mitigation of the pathogen's impact on forest ecosystems.

## MATERIAL AND METHODS OF WORK

### Experimental Design

The experimental setup utilized a nondestructive measurement system for real-time tracking of optical transmission in plant leaves, as previously described by Kasalica et al. (Kasalica et al., 2021). The system consisted of 20 independent "channels," where each channel corresponded to a single leaf (Figure 1). A red Signal LED with a spectral emission maximum at 665 nm served as the light source for each channel. The Signal LED was coupled to an optical fiber, with the other end attached to a transparent plastic leaf holder made of methyl methacrylate. Two additional optical fibers, one collecting transmitted light and the other collecting reflected light, were also incorporated into the arrangement. The light collection fibers were connected to a leaf holder.

The collected light was transmitted through optical fibers to photodiodes housed in a thermostatically shielded box. The signals from the photodiodes were routed to a precision digital multimeter (DMM) (HP 34970A) connected to a PC via an RS-232 interface. The leaf holder was designed to provide five degrees of freedom for mechanical movement, allowing for tracking of the leaf's position and orientation (Kasalica et al., 2021). Block diagram of the described set-up is given in Figure 1.

### Experimental Setup

The experimental plants were divided into two groups, each consisting of 10 plants, and they were grown in separate independent boxes. Both groups were subjected to identical ambient conditions. The PPFD values were measured using three LED dimmable panels (model: Samsung LED LM301H Quantum Tech V3 Panel Light 240W) mounted in a temperature-controlled box with a specially designed fan system to manage the panel's heating. The mean PPFD value with standard deviation recorded was PPFD = (180 ± 30) μmol/s/m². Additionally, for day-to-day checks, light intensity was measured using a calibrated data logger (illuminometer photometer) located in the center under the LED panel, collecting data every 5 minutes during the experiment. The illuminometer measurements showed a clear correlation with the PPFD values obtained from the plant lighting analyzer.

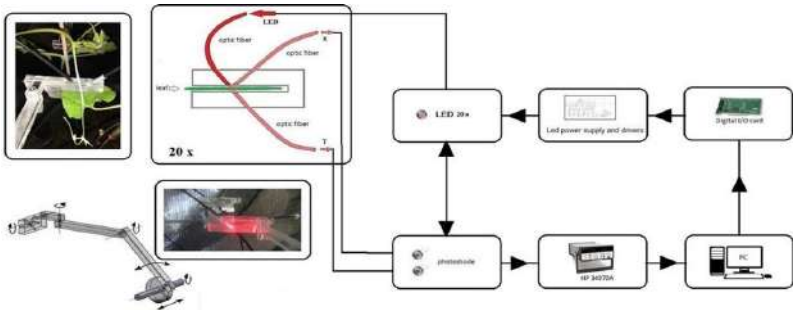


Figure 1. Block diagram (Kasalica et al., 2021).

**Plant Material**

The experiment was conducted in an indoor environment within a temperature-regulated growing chamber set at 23/21°C (day/night) and a photoperiod of 9/15 hours (light/dark). The sweet chestnut (*Castanea sativa*) seedlings were cultivated following standard practices. Seeds were collected and germinated under controlled conditions (Craddock et al., 2005.). The sweet chestnut (*Castanea sativa*) plants used in the experiment had an initial height of approximately (25±4) cm and a stem thickness of (4.8±0.6) cm. The experimental plants were divided into two groups, each consisting of 10 plants. The first group served as the control group and was maintained under regular growth conditions. The second group was subjected to a 48-hour exposure to *Phytophthora plurivora* through flooding and inoculation. After the 48-hour period, measurements were initiated to monitor the optical transmission coefficients of the leaves.

**Flooding and Inoculation of *Phytophthora plurivora***

To initiate the infection process, the plants in the second group were exposed to a flooding treatment followed by inoculation with *Phytophthora plurivora*. The flooding treatment involved immersing the root system of each plant in water for a period of 48 hours. After the flooding treatment, the plants were inoculated with a *Phytophthora plurivora* solution.

The *Phytophthora plurivora* solution was prepared following established protocols described in the literature. For instance, Mrázková et al. (Mrázková et al., 2013) described a similar method for preparing a Phytophthora solution by culturing *Phytophthora plurivora* isolates on a suitable growth medium, such as PARP agar, to obtain actively growing mycelium. The mycelium was then transferred to a liquid medium, such as V8 broth, and incubated under appropriate conditions until a concentrated solution of *Phytophthora plurivora* was obtained.

After the 48-hour flooding and inoculation period, the optical measurements of the leaves in the second group were initiated to monitor the transmission coefficients and assess any changes indicative of stress or infection caused by *Phytophthora plurivora*.

By implementing this experimental design and setup, we aimed to monitor the optical transmission coefficients of the sweet chestnut leaves and detect any potential stress or infections caused by *Phytophthora plurivora*.

**RESULTS AND DISCUSSION**

The obtained transmission coefficient graphs for each measurement location individually reveal changes in optical transmission dependent on leaf thickness and the position of the optical fiber holder. However, the common shape of the circadian rhythm function provides further insights (Figure 2. and Figure 3.):

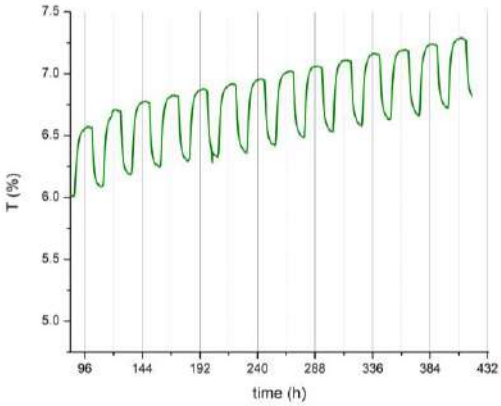


Figure 2. Graph depicting the time-dependent optical transmission dependence of non-inoculated Sweet chestnut, starting from 4th day.

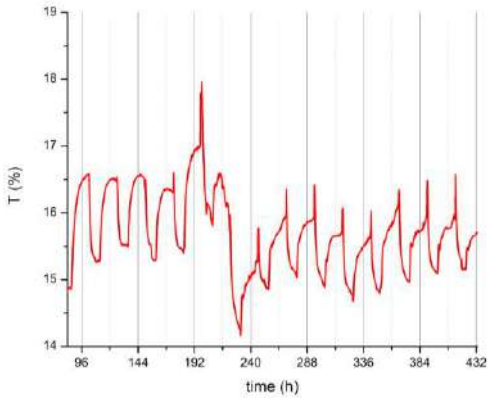


Figure 3. Graph depicting the time-dependent optical transmission dependence of inoculated Sweet chestnut tree, starting from 4th day.

The control group plants exhibit a well-defined circadian rhythm characterized by a slowly increasing trigonometric function with clear and consistent daily and nocturnal amplitudes.

In contrast, the infected group shows an initial peak upon light activation 96 hours after infection, deviating from previous results obtained with this method and indicating the presence of stress.

After 9 days of treatment, this peak becomes significantly pronounced, reaching the value of the entire amplitude at that time.

At 10 days, a decrease in the circadian rhythm amplitude is observed, while the peak becomes increasingly prominent. On the 15th day, the peak value clearly occupies half of the reduced amplitude, which is half of the initial value.

Notably, peaks also appear upon light deactivation, unequivocally indicating high stress levels experienced by the plants.

These results demonstrate changes in the circadian rhythm and a decrease in transmission amplitude in infected plants, serving as clear indicators of stress. Importantly, the occurrence of peaks upon light deactivation is strongly associated with significant stress conditions experienced by the plants.

Figure 4. Non-inoculated tree (left), a young tree (middle), inoculated tree (right).

Furthermore, Figure 4. displays images of the plant before and 4 weeks after infection, as well as the control plant, taken in the laboratory setting. Visual inspection reveals no noticeable changes in appearance, reinforcing the notion that these stress responses are not accompanied by visible alterations.

These findings highlight the ability of our nondestructive optical method to detect and monitor *Phytophthora plurivora* pathogen infection in sweet chestnut leaves. The observed changes in the circadian rhythm and transmission amplitude provide valuable indicators of stress caused by the pathogen, even before visible symptoms manifest. Additionally, the absence of visible alterations in the infected plants underscores the significance of our nondestructive approach in detecting early-stage infections that may otherwise go unnoticed.

## CONCLUSIONS

In conclusion, the nondestructive optical method presented in this study offers an effective and efficient approach for the early detection and monitoring of *Phytophthora plurivora* pathogen infection in sweet chestnut leaves. Its real-time monitoring capability, longitudinal assessment, and noninvasive nature make it a valuable tool for improving plant health assessment, disease management, and minimizing crop losses.

Comparing our nondestructive optical method with traditional methods, such as visual inspection or destructive sampling, highlights its superiority in terms of early detection and continuous monitoring. Unlike traditional methods that rely on visible symptoms or periodic sampling, our method detects subtle changes in plant health before visible symptoms appear and enables real-time monitoring of disease progression. This allows for timely intervention and treatment, minimizing crop losses.

Furthermore, our noninvasive approach ensures the plant's integrity and reduces the risk of secondary infections. Longitudinal assessment provides valuable insights into the dynamics of pathogen infection and the plant's response to stress, enhancing our understanding of disease progression and treatment efficacy.

The significance of our proposed nondestructive optical method is further supported by recent studies exploring nondestructive techniques for plant disease detection. Fang et al. (2015) and Farber et al. (2019) discuss the potential of nondestructive methods in plant health evaluation, emphasizing the importance of early detection and the advantages of real-time monitoring.

Overall, the nondestructive optical method presented in this study offers a valuable and practical solution for early detection and monitoring of *Phytophthora plurivora* pathogen infection in sweet chestnut leaves. Its ability to provide real-time, noninvasive, and longitudinal assessment sets it apart from traditional methods and contributes to advancing plant health assessment and disease management strategies.

## ACKNOWLEDGEMENT

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# FATTY ACID COMPOSITION OF KRANJSKA SAUSAGE WITH CASINGS TREATED WITH PLANT EXTRACTS (*PRINUS SPINOSA* L.)

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## ABSTRACT

This study aimed to evaluate the effectiveness of natural casing treatment with aqueous or ethanol extract of the blackthorn fruits (*Prunus spinosa L.*) on fatty acids content of vacuum-packed Kranjska sausages. Three experimental groups of sausages were produced: CS - a conventional sausage filled in a natural casing; WS - a sausage filled in a natural casing previously submerged in an aqueous blackthorn extract, and; ES - a sausage filled in a natural casing previously submerged in ethanol blackthorn extract. The sausages were produced in industrial conditions, vacuum packaged, and stored at 4°C for 60 days. The GC-FID analytical technique determined the qualitative and quantitative composition of fatty acids in the tested samples.

The predominant saturated fatty acids (SFA) were palmitic (C16:0) and stearic (C18:0), whose amounts ranged from 24.32% to 25.68% and 15.49% to 15.99%, respectively. The most represented monounsaturated fatty acid (MUFA) was oleic acid (C18:1), which ranged from 42.37% to 43.57%. Linoleic acid (C18:2c+t) was the dominating polyunsaturated fatty acid (PUFA), with 7.40% to 7.97%. Based on the obtained results, it can be concluded that treated casings had a statistically significant effect ($p<0.05$) on the content of the identified fatty acids in analyzed samples.

**Keywords:** Kranjska sausage, fatty acids, blackthorn fruits extract, natural casing.

## INTRODUCTION

Consumers, especially in developed countries, are increasingly interested in the elements of nutritional food values and the impact of food ingredients on health. The content of fatty acids in food is very important for a healthy human diet. All around the world, meat traditionally occupies a central position. The fat content and fatty acid composition of meat are significant properties that affect the quality of meat and meat products.

The use of edible coatings and films as a barrier to transit oxygen and water to preserve food quality has intensified recently. Adding plant extracts and some natural bio preservatives gives the coatings antimicrobial and antioxidant properties.

Meat products often contain a non-negligible amount of fat. For Swiss cooked sausages it's about 10 to 30 g fat per 100 g sausage (Schmid et al., 2009) which corresponds to similar products in Germany (Honikel, 2004) and Kranjska sausages (Mandić et al., 2018). In a society with dietary recommendations favoring a low-fat intake, this amount has to be seen as a disadvantage.

There has been a crucial paradigm change in packaging from passive to active as it appears that, nowadays, the passive component no longer considered an active part interacting with the external environment and the food inside (Cattaneo et al., 2014; Rizzolo et al., 2016). The phenomenon could be established by fusing an active agent within a packaging material or at the product contact surface (Bastarrachea et al., 2015). Incorporating the active agent into the packaging matrix is the most dominant method for developing active packaging (Wang et al., 2016). The use of edible coatings and films as a barrier to the passage of oxygen and water to preserve food quality has intensified recently. Adding plant extracts and some natural bio preservatives gives the coatings antimicrobial and antioxidant properties. The blackthorn fruit is a rich source of components with antioxidant and antibacterial characteristics, including flavonoids, anthocyanins, phenolic acids, vitamins, minerals, and organic acids (Ürkek et al., 2019). Among these components, polyphenols are particularly noteworthy for their strong contribution to the

antioxidant capacity of fruits and vegetables compared to other antioxidant compounds, such as vitamins C and E or carotenoids (Gil et al., 2002). Phenolic phytochemicals also hugely impact defense responses, including anti-aging, anti-inflammatory, antioxidant, and antiproliferative effects (Ozkan, 2019). Therefore, the abundance of polyphenols and other antioxidants in blackthorn fruit highlights its potential as a valuable resource for preventing oxidative stress and related health issues.

Blackthorn contains a variety of bioactive polyphenolic compounds, including phenolic acids (neo-chlorogenic and caffeic derivatives), flavonoids (rutin, catechins, procyanidins, quercetin, kaempferol), and anthocyanins (Ganhao et al., 2010), nor-isoprenoid glycosides, and A-type proanthocyanidins (Kumarasamy et al., 2004) as well as ascorbic acid, carbohydrates, macro and microminerals (Dedić et al., 2021). Flavonoids, particularly anthocyanins, are known for potential health benefits due to their antioxidant properties. Blackthorn extracts may be used in various areas, including the food industry, as natural colorants and preservatives because of the polyphenols' antioxidant and antibacterial properties (Pozzo et al., 2019). Another application of blackthorn fruit extracts is in the food industry. Mandić et al. (2018) developed a study on incorporating blackthorn fruit extract of in the natural casing of Kranjska sausages. This study showed that the blackthorn extracts, both aqueous and ethanol, reduced the number of lactic acid bacteria from the surface of vacuum-packed sausages stored at 4°C for 60 days.

For the nutritional quality and possible health effects of low or high consumption of cooked sausages, it is of great interest to know their fatty acid composition. Plant extracts are generally added to prevent the oxidation of fats and proteins and/or inhibit the growth and development of bacteria, yeasts, and molds or prevent product spoilage. This study aimed to evaluate the effectiveness of natural casing treatment with aqueous or ethanol extract of the blackthorn fruits (*Prunus spinosa* L.) on the fatty acids content of vacuum-packed Kranjska sausages.

## MATERIALS AND METHODS

Cooked sausages (Kranjska sausage) were produced in industrial conditions according to the producer's specifications. The following ingredients were used: pork meat, beef meat, firm fatty tissue, water, salt, starch, spices, and preservative E 250. Prepared sausage batter was filled into natural pork casings of 32–34 mm diameter (DERMA DD., Varaždin, Croatia).

To prepare extracts, blackthorn fruits were washed, and the petioles and seeds were removed. For dry extract preparation, 40 g blackthorn fruits were homogenized with 160 mL of solvent (80% ethanol and distillated water), centrifuged for 10 minutes at 1000 rpm, and then treated in an ultrasonic bath for 30 minutes, followed by 30 minutes on a magnetic stirrer. The mixture was filtered and the obtained filtrate was evaporated to a dry residue on a vacuum evaporator and then dried at 50°C. The prepared dry extracts were diluted to 100 g/L concentration using the solvent used for extraction. Natural casings were submerged for 2 hours in prepared extract solutions.

Three experimental groups of sausages were produced: CS - a conventional sausage filled in a natural casing; WS - a sausage filled in a natural casing previously submerged in an aqueous blackthorn extract, and ES - a sausage filled in a natural casing previously submerged in ethanol blackthorn extract. After filling, the sausages were thermally processed until the temperature reached 72°C in the center and, after heat treatment, chilled, vacuum packed and subsequently stored at 4°C for 60 days.

Analyses of sausages were carried out after production and after 60 days of storage. The total fat extraction was performed by the reference BAS ISO 1443:2007 method, and the principle of determination was based on the hydrolysis of the sample with dilute hydrochloric acid. Fatty acid methyl esters of the tested samples were prepared by dissolving samples in hexane and direct esterification with saturated KOH/methanol solution. The equipment used to determine fatty acids was Clarus 680 Perkin Elmer gas chromatograph with FID detector, Elite-wax L 60 m column, ID 0.32, DF 0.5, with the standard: Sigma Aldrich Supelco 37 components FAME MIX. Injector and detector temperature 250ºC, sample volume 1µL, temperature regime: 60ºC for 2 min, 10ºC/min up to 200ºC, 5ºC/min up to 240ºC, and 30 min at 240ºC, flow 1.5 mL/min, nitrogen gas (carrier). The total duration of the analysis was 54 min. The composition of fatty acids is shown as a

percentage of individual fatty acids in the total amount of identified fatty acids (g/100 g of total fatty acids).

The results were statistically processed using the Microsoft Excel 2013 software package and the IBM SPSS Statistics 22.0 (Armonk, NY, United States). Results were presented as mean values of three individual measurements ± standard deviations. The significance of differences between arithmetic means was determined and expressed with 95% probability (Tukey's test).

## RESULTS AND DISCUSSION

The composition of saturated fatty acids (SFA) of analyzed cooked sausages is given in Table 1. The total content of SFA after production was in the range of 43.25-44.45%, and 43.36-44.11% after storage. The lowest SFA content was identified in sample ES in both cases. The most common SFA in cooked sausages was palmitic acid (C16:0) ranged from 24.32-25.68% after production and 24.54-24.88% after storage. It can be noticed that there were statistically significant differences ($p<0.05$) between analyzed samples. Stearic fatty acid (C18:0) was second predominant in all samples and ranged from 15.49-15.71% after production and 15.70-15.99% after storage. Myristic fatty acid (C14:0) ranged from 1.99-2.07%, while other SFA were present in smaller amounts (0.22% and less). These results were similar to the data reported by Momchilova et al. (2023) for reformulated comminuted cooked sausages. Pleadin et al. (2021) also report similar values for palmitic and stearic fatty acids in pork meat products. Regarding monounsaturated fatty acids, the predominant one was oleic acid (C18:1c+t), with content 42.37-43.16% after production and 42.86-43.57% after storage (Table 2). It is the most significant fatty acid of all kinds of meat. In pork, it makes up about 38% of total fatty acids (Barbir et al., 2014). Palmitoleic acid (C16:1) ranged from 2.70-2.95%, and other MUFA were presented in smaller amounts (0.72% and less). Total MUFA content ranged from 46.81-47.72% after production and 47.50-47.70% after storage, and results are in accordance with Pleadin et al. (2021). Schmid et al. (2009) also confirmed these results, reporting the MUFA content from 46 to 50% for Swiss cooked sausages.

Table 1. Composition of saturated fatty acids (means ± standard deviations) of model fermented sausage after ripening (0) and after sixty days (60) of chilling storage (% of total fatty acids).

| | m | CS | WS | ES |
|---|---|---|---|---|
| C8:0 | 0 | n.d | n.d | n.d |
| | 60 | n.d | $0.03^{a} \pm 0.00$ | $0.03^{a} \pm 0.00$ |
| C10:0 | 0 | $0.07^{a} \pm 0.00$ | $0.07^{b} \pm 0.00$ | $0.07^{ab} \pm 0.00$ |
| | 60 | $0.07^{a} \pm 0.00$ | $0.07^{ab} \pm 0.00$ | $0.07^{b} \pm 0.00$ |
| C12:0 | 0 | $0.13^{a} \pm 0.01$ | $0.13^{a} \pm 0.00$ | $0.15^{a} \pm 0.01$ |
| | 60 | $0.12^{a} \pm 0.01$ | $0.12^{a} \pm 0.00$ | $0.12^{a} \pm 0.00$ |
| C14:0 | 0 | $2.05^{a} \pm 0.02$ | $2.07^{a} \pm 0.06$ | $2.01^{a} \pm 0.02$ |
| | 60 | $1.99^{a} \pm 0.03$ | $2.02^{a} \pm 0.01$ | $2.00^{a} \pm 0.02$ |
| C15:0 | 0 | $0.19^{a} \pm 0.00$ | $0.18^{b} \pm 0.00$ | $0.19^{c} \pm 0.00$ |
| | 60 | $0.18^{a} \pm 0.00$ | $0.17^{a} \pm 0.00$ | $0.18^{a} \pm 0.01$ |
| C16:0 | 0 | $24.65^{ab} \pm 0.06$ | $25.68^{a} \pm 0.65$ | $24.32^{b} \pm 0.07$ |
| | 60 | $24.73^{a} \pm 0.07$ | $24.88^{b} \pm 0.02$ | $24.54^{c} \pm 0.03$ |
| C17:0 | 0 | $0.55^{a} \pm 0.01$ | $0.55^{a} \pm 0.00$ | $0.56^{a} \pm 0.02$ |
| | 60 | $0.52^{a} \pm 0.02$ | $0.54^{a} \pm 0.01$ | $0.53^{a} \pm 0.01$ |
| C18:0 | 0 | $15.71^{a} \pm 0.04$ | $15.49^{a} \pm 0.18$ | $15.69^{a} \pm 0.00$ |
| | 60 | $15.96^{a} \pm 0.00$ | $15.99^{a} \pm 0.04$ | $15.70^{b} \pm 0.09$ |
| C20:0 | 0 | $0.19^{a} \pm 0.00$ | $0.22^{a} \pm 0.01$ | $0.11^{b} \pm 0.04$ |
| | 60 | $0.21^{a} \pm 0.01$ | $0.20^{a} \pm 0.00$ | $0.19^{a} \pm 0.01$ |
| C22:0 | 0 | n.d | $0.06 \pm 0.01$ | $0.13 \pm 0.02$ |
| | 60 | $0.14^{a} \pm 0.08$ | $0.08^{b} \pm 0.00$ | n.d |
| ∑SFA | 0 | $43.53^{ab} \pm 0.17$ | $44.45^{a} \pm 0.65$ | $43.25^{b} \pm 0.07$ |
| | 60 | $43.92^{a} \pm 0.10$ | $44.11^{a} \pm 0.06$ | $43.36^{b} \pm 0.13$ |

*mean values with different letters in the same raw differ statically significantly with 95% probability ($p<0.05$).

Table 2. Composition of monounsaturated fatty acids (means ± standard deviations) of model fermented sausage after ripening (0) and after sixty days (60) of chilling storage (% of total fatty acids).

| | d | CS | WS | ES |
|---|---|---|---|---|
| C14:1 | 0 | $0.20^{a} \pm 0.01$ | $0.19^{a} \pm 0.00$ | $0.21^{a} \pm 0.00$ |
| | 60 | $0.19^{a} \pm 0.02$ | $0.19^{a} \pm 0.00$ | $0.20^{a} \pm 0.01$ |
| C15:1 | 0 | $0.05^{a} \pm 0.00$ | $0.04^{a} \pm 0.00$ | $0.07^{a} \pm 0.00$ |
| | 60 | $0.05^{a} \pm 0.00$ | $0.06^{b} \pm 0.00$ | $0.05^{ab} \pm 0.00$ |
| C16:1 | 0 | $2.81^{a} \pm 0.06$ | $2.95^{a} \pm 0.07$ | $2.92^{a} \pm 0.04$ |
| | 60 | $2.82^{a} \pm 0.03$ | $2.82^{a} \pm 0.03$ | $2.7^{a} \pm 0.16$ |
| C17:1 | 0 | $0.43^{a} \pm 0.03$ | $0.40^{ab} \pm 0.00$ | $0.35^{b} \pm 0.00$ |
| | 60 | $0.43^{a} \pm 0.08$ | $0.36^{a} \pm 0.01$ | $0.39^{a} \pm 0.00$ |
| C18:1 c+t | 0 | $42.83^{a} \pm 0.04$ | $42.37^{a} \pm 0.60$ | $43.16^{a} \pm 0.02$ |
| | 60 | $42.86^{a} \pm 0.01$ | $43.35^{b} \pm 0.01$ | $43.57^{c} \pm 0.09$ |
| C20:1 | 0 | $0.70^{a} \pm 0.08$ | $0.67^{a} \pm 0.03$ | $0.72^{a} \pm 0.01$ |
| | 60 | $0.68^{a} \pm 0.04$ | $0.69^{a} \pm 0.01$ | $0.67^{a} \pm 0.02$ |
| C22:1 | 0 | $0.50^{a} \pm 0.21$ | $0.18^{a} \pm 0.02$ | $0.23^{a} \pm 0.04$ |
| | 60 | $0.45^{a} \pm 0.16$ | $0.18^{ab} \pm 0.00$ | $0.12^{b} \pm 0.02$ |
| C24:1 | 0 | $0.19 \pm 0.03$ | n.d | n.d |
| | 60 | n.d | n.d | n.d |
| ∑MUFA | 0 | $47.72^{a} \pm 0.23$ | $46.81^{a} \pm 0.63$ | $47.66^{a} \pm 0.05$ |
| | 60 | $47.50^{a} \pm 0.21$ | $47.64^{a} \pm 0.01$ | $47.70^{a} \pm 0.10$ |

*mean values with different letters in the same raw differ statically significantly with 95% probability ($p < 0.05$)

Table 3. Composition of polyunsaturated fatty acids (means ± standard deviations) of model fermented sausage after ripening (0) and after sixty days (60) of chilling storage (% of total fatty acids).

| | d | CS | WS | ES |
|---|---|---|---|---|
| C18:2 c+t | 0 | $7.68^{a} \pm 0.05$ | $7.73^{a} \pm 0.02$ | $7.97^{b} \pm 0.01$ |
| | 60 | $7.46^{a} \pm 0.06$ | $7.40^{a} \pm 0.04$ | $7.91^{b} \pm 0.02$ |
| C18:3n3 | 0 | $0.47^{a} \pm 0.02$ | $0.49^{a} \pm 0.02$ | $0.55^{b} \pm 0.03$ |
| | 60 | $0.49^{a} \pm 0.01$ | $0.45^{b} \pm 0.01$ | $0.5^{c} \pm 0.01$ |
| C20:2 | 0 | $0.33^{ab} \pm 0.01$ | $0.31^{a} \pm 0.01$ | $0.34^{b} \pm 0.01$ |
| | 60 | $0.34^{a} \pm 0.01$ | $0.31^{a} \pm 0.01$ | $0.32^{a} \pm 0.00$ |
| C20:3n3 | 0 | n.d | $0.16 \pm 0.01$ | n.d |
| | 60 | $0.16^{a} \pm 0.01$ | n.d | $0.11^{b} \pm 0.00$ |
| C20:4 | 0 | $0.08^{a} \pm 0.01$ | n.d | $0.10^{a} \pm 0.02$ |
| | 60 | n.d | n.d | $0.08 \pm 0.01$ |
| C22:2 | 0 | $0.53 \pm 0.05$ | n.d | n.d |
| | 60 | n.d | n.d | n.d |
| C20:5 | 0 | n.d | $0.05^{a} \pm 0.01$ | $0.13^{b} \pm 0.02$ |
| | 60 | $0.13 \pm 0.00$ | $0.09 \pm 0.00$ | n.d |
| C22:6 | 0 | $0.19 \pm 0.03$ | n.d | n.d |
| | 60 | n.d | n.d | n.d |
| ∑PUFA | 0 | $8.75^{a} \pm 0.07$ | $8.74^{a} \pm 0.02$ | $9.10^{b} \pm 0.02$ |
| | 60 | $8.58^{a} \pm 0.011$ | $8.24^{b} \pm 0.05$ | $8.94^{c} \pm 0.03$ |

*mean values with different letters in the same raw differ statically significantly with 95% probability ($p < 0.05$).

SFA- saturated fatty acids; MUFA-monounsaturated fatty acids; PUFA- polyunsaturated fatty acids; USFA- unsaturated fatty acids.

Among PUFAs (Table 3), linoleic acid (C18:2c+t) had the highest share, ranging from 7.68-7.97% after production and 7.40-7.91% after storage. Total PUFA content ranged from 8.74-9.10% after production and 8.24-8.94% after storage. During storage, these values statistically significantly decreased ($p<0.05$). Literature data confirm the results of this study (Schmid et al., 2009; Pleadin et al., 2021).

The ratio of the total content of SFA and USFA and their mutual ratio in the tested samples are given in Table 4. Based on the obtained results, it can be noticed that the ratio SFA/USFA showed significant differences between samples ($p<0.05$). One of the primary parameters currently used to assess the nutritional quality of the lipid fraction of foods is the PUFA/SFA ratio (Romero

et al., 2013). WHO/FAO experts have reported guidelines in which the suggested ratio of PUFA/SFA is above 0.4, and a recommendation by the British Department of Health for PUFA/SFA is more than 0.45 (Teixeira et al., 2020), The PUFA/SFA ratios ranged from 0.19-0.21 for all samples. All analyzed samples were inadequate regarding this indicator. Many authors report similar values for meat products (Schmid et al., 2009; Romero et al., 2013; Pleadin et al., 2021).

Table 4. The ratio of the total content of SFA and USFA of sausages after ripening (0) and after sixty days (60) of chilling storage (% of total fatty acids).

| | d | CS | WS | ES |
|---|---|---|---|---|
| SFA/USFA | 0 | $0.77^{ab}$ | $0.80^{a}$ | $0.76^{b}$ |
| | 60 | $0.78^{a}$ | $0.79^{a}$ | $0.77^{b}$ |
| PUFA/SFA | 0 | $0.20^{a}$ | $0.20^{a}$ | $0.21^{b}$ |
| | 60 | $0.20^{ab}$ | $0.19^{a}$ | $0.21^{b}$ |
| MUFA/SFA | 0 | $1.10^{a}$ | $1.05^{b}$ | $1.10^{a}$ |
| | 60 | $1.08^{a}$ | $1.08^{a}$ | $1.10^{a}$ |
| MUFA/PUFA | 0 | $5.45^{a}$ | $5.35^{ab}$ | $5.24^{b}$ |
| | 60 | $5.53^{a}$ | $5.78^{b}$ | $5.34^{c}$ |
| MUFA n-9 | 0 | $43.33^{a} \pm 0.30$ | $42.55^{a} \pm 0.76$ | $43.39^{a} \pm 0.08$ |
| | 60 | $43.32^{a} \pm 0.18$ | $43.53^{b} \pm 0.01$ | $43.68^{c} \pm 0.09$ |
| PUFA n-3 | 0 | $0.67^{a} \pm 0.02$ | $0.70^{b} \pm 0.01$ | $0.68^{ab} \pm 0.00$ |
| | 60 | $0.79^{a} \pm 0.02$ | $0.53^{b} \pm 0.01$ | $0.63^{c} \pm 0.01$ |
| PUFA n-6 | 0 | $8.08^{a} \pm 0.09$ | $8.04^{a} \pm 0.03$ | $8.41^{b} \pm 0.02$ |
| | 60 | $7.80^{a} \pm 0.09$ | $7.71^{a} \pm 0.03$ | $8.31^{b} \pm 0.04$ |
| n-6/n-3 | 0 | $12.16^{ab}$ | $11.48^{a}$ | $12.31^{b}$ |
| | 60 | $9.93^{a}$ | $14.46^{b}$ | $13.15^{c}$ |

*mean values with different letters in the same raw differ statically significantly with 95% probability ($p < 0.05$)

Another indicator of the nutritional quality of fat is the n-6/n-3 ratio. According to Teixeira et al. (2020), this ratio should be less than 4. All examined samples contained fewer n-3 fatty acids, with the n-6/n-3 ratio of 11.48-12.31 after production and 9.93-14.46 after storage. Pleadin et al. (2021) report similar results for various meat products from Croatia and Montenegro. Schmid et al. (2009) consider that cooked sausages typically contain a large amount of pork fat, which has a negative impact on the n-6/n-3 ratio.

## CONCLUSIONS

Based on the obtained results, it can be concluded that incorporating plant extracts in natural casings had a statistically significant effect ($p<0.05$) on the content of the identified fatty acids in tested samples. The analyzed sausages showed a similar pattern regarding the fatty acid composition. The SFA content was about 44% of total fatty acids, while respective MUFA and PUFA concentrations approximated 47% and 9%.

Of the saturated fatty acids (SFA), palmitic (C16:0) and stearic (C18:0) acids were predominant, and oleic acid (C18:1) was the most represented unsaturated fatty acid (USFA) in all analyzed sample sausages. The nutritional quality parameters of the lipid fraction, the PUFA/SFA, and the n-6/n-3 ratios were not compliant with health recommendations.

## LITERATURE

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# PHYSICOCHEMICAL PROPERTIES OF CREAM CHEESE WITH THE ADDITION OF SELECTED SPICES

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## ABSTRACT

This study aimed to examine the influence of adding selected spices on the physicochemical properties of fresh cream cheese. Six different samples of fresh cream cheese were produced in the milk processing plant (mini cheese factory). The first sample was marked as a control, without the addition of spices, and the other five were produced with the addition of different ones (oregano, basil, parsley, rosemary, and chives) in the amount of 1%. To define the quality of produced cheeses, the following analyzes were performed: determination of moisture, ash, protein, fat, chloride content, determination of acidity, pH measurement, and water activity measurement. Based on the obtained results, it was determined that the addition of spices had a statistically significant ($p<0.05$) effect on the physicochemical properties of fresh cream cheese. Analyzing the results of physicochemical tests of produced samples of cream cheese, it was established that the values of all tested parameters were in accordance with the relevant legal regulations. Produced cheeses with the addition of selected spices meet the quality requirements and might deliver important value and potential effects for different groups of consumers.

**Keywords:** fresh cream cheese, spices, physicochemical properties.

## INTRODUCTION

Cheese is one of the most significant and well-known dairy products obtained by milk coagulation and whey separation. It is one of the quality foods of great nutritional value. Today, cheese is an essential food in the human diet, but it is also increasingly important, representing a country's cultural and traditional mirror (Popović-Vranješ, 2015).

The increase in culinary ideas and gastronomic offers has led to a demand for a variety of spices to elevate certain foods to an even higher level. Spices make food taste unique and different and influence the human organism positively. Herbs are responsible for the recognition of national cuisines; Italian cuisine is recognizable by oregano (*Origanum vulgare*) and basil (*Ocimum basilicum*), Mexican by hot chili (*Capsicum frutescens*), while our region's cuisine is unthinkable without parsley (*Petroselinum crispum*), rosemary (*Rosmarinus officinalis*), laurel (*Laurus nobilis*), basil (*Ocimum basilicum*), lavender (*Lavandula*) and others. Also, some spices are especially related to a season. Cinnamon, ginger and vanilla are most often used during winter, providing a special feeling and comfort. Spices are not used only to change the smell or taste of dishes but also to beautify them, that is, to make them visually attractive (Bauer, 2013; Josipović et al., 2015; Akaraca et al., 2016).

Nowadays, there are a large number of products with spices on the market. Spices are increasingly used in the production of cheese and other milk products to obtain a new taste, improve the aroma and increase the nutritional value of the product (Olmedo et al., 2013; Lobacz et al., 2016; Bhattacharyya et al., 2017; Tarakçı, & Deveci, 2019; El-Sayed, & Youssef, 2019).

Spices or spice extracts can be used in the production of hard cheeses, cottage cheese, cheese spreads, yogurt or a combination of cottage cheese and cream. It is possible to add them to the curd itself, mix it into the cheese towards the end of the process, and then put it in molds or even cover

the cheese with some of the spices, that is, rub the spice well into the cheese (Josipović et al., 2016).

In the production of cheese, the use of medicinal and aromatic herbs is reflected in the improvement of sensory characteristics and the increase of the stability and shelf life of the final product. A product with new physiological properties is also obtained – the so-called functional food. The role of these herbs in extending the shelf life of cheeses is reflected, among other things, in the fact that the essential oils of many medicinal and aromatic plants have antimicrobial activity against a large number of bacteria, viruses, yeasts and molds, thus representing a potentially rich source of new biocides and preservatives (Maćej et al., 2009).

Cheeses with medicinal herbs are traditionally produced in many countries from cow's, sheep's and goat's milk or mixed milk. Many studies indicate the use of different plants and their combinations depending on the area where they thrive and which are characteristic of that climate. France, for instance, which stands out for its large and varied cheese production (over 300 types), also produces a large number of cheeses with herbs. In most of these autochthonous cheeses, the surface of the cheese is wrapped in spice leaves or applied to the surface, while in rare cases, it is placed in the curd itself (Josipovic et al., 2016).

When it comes to cheeses, it is essential to find combinations that will have a maximum protective effect when storing the finished product, especially during the ripening period. A special issue to pay attention to is the health safety of cheeses due to the action of bioactive agents, components of aromatic and medicinal plants with pronounced antimicrobial activity against a large number of bacteria, viruses, yeasts and molds (Maćej et al., 2009).

This study aimed to examine the influence of adding selected spices on the physicochemical properties of fresh cream cheese.

## MATERIAL AND METHODS

Cow's milk purchased from a nearby dairy farm was used to make the cheese. Fresh milk was filtered and then heated in a duplicator at 85°C. When the target temperature was reached (controlled by a thermometer), the milk was left for 15 minutes at the same temperature for pasteurization. The milk was cooled to 25°C, and 0.02% of 33% $CaCl_2$ was added. After mixing for 10 minutes, mesophilic microbiological cultures (Di-prox M195 20UA, manufactured by BIOPROX) were added to the milk. After 30 minutes, microbial rennet in tablets (Fromase 50-endopeptidase) dissolved in water (1 tablet of rennet was added to 50 mL of milk) was added. After stirring, the mass was left for 24 h at room temperature, and curd formed. On the second day, the curd was cut with a curd harp, and the previously prepared cheese molds coated with gauze were filled. At the same time, whey was collected in a previously prepared container. It took 24 hours to drain the curd. The drained curd was weighed and salted by adding 1% salt (NaCl). The mass was mixed well for the salt to be evenly distributed in the cheese. After salting, the cheese samples were weighed and placed in 6 special containers previously marked with numbers. The first unspiced sample was labelled as a control one. The other five samples were seasoned with 1% of selected spices (Table 1). Packaged chopped spices (manufacturer: AD Food Industry "Aleva", Novi Kneževac, Republic of Serbia) purchased at a nearby market were used. After spicing, the cream cheese was lightly mixed for the spices to be evenly distributed in the cheese. Until the analysis, cheese samples were stored in closed containers at 4°C.

Milk input
↓
Pasteurization (85 °C, 10 min)
↓
Cooling (25 °C)
↓
Addition of 33% $CaCl_2$ (0.02%)
↓
Addition of mesophilic microbial culture

↓
Adding rennet (1 tablet in 50 L of milk)
↓
Rest of the curds (24 h)
↓
Curd cutting and processing
↓
Straining and separation of whey (24 h)
↓
Salting and seasoning
↓
Packaging

Figure 1. Production flow diagram.

Table 1. Spices used and their amount in cream cheese.

| Sample | Spices | Amount of spices (%) |
|---|---|---|
| 1 | - | - |
| 2 | Oregano | 1 % |
| 3 | Basil | 1 % |
| 4 | Parsley | 1 % |
| 5 | Rosemary | 1 % |
| 6 | Chives | 1 % |

To define the quality of produced cheeses, the following analyzes were performed: determination of moisture, ash, protein, fat, chloride content, determination of acidity, pH measurement, and water activity measurement.

The moisture and total solids content were determined in the cheese samples by drying at 103±2ºC to constant weight (BAS EN ISO 5534:2006). The total ash content was also determined gravimetrically after heating the samples in a muffle furnace (Micronal) at 550°C (Carić et al., 2000). The protein content was calculated by determining total nitrogen using the Kjeldahl method and converted to total crude proteins using a nitrogen conversion factor of 6.38 for milk proteins (BAS EN ISO 8968-1:2015). Determining the content of fat in cheeses was performed by the acid-butyrometric method (BAS ISO 11870:2012; BAS ISO 19662:2019). The chloride content was determined by potentiometric titration (BAS EN ISO 5943:2015). Water activity (aw) was measured by direct readings in AW Meter (Novasina LabMaster-AW 1119971). The Soxhlet Henkel method (Carić et al., 2000) was used to determine the cheese acidity. The cheese pH value was measured in a cheese solution by mixing equal amounts of cheese and water (Carić et al., 2000) using a pH meter (Hanna instruments, HI 2211).

The results were statistically processed using the Microsoft Excel 2013 software package and the IBM SPSS Statistics 22.0 computer program for Windows (Armonk, NY, United States). The results obtained in this paper are presented as mean values of the individual results of three randomly selected product samples ± standard deviation (SD). The significance of differences between arithmetic means was determined by analyzing the variance with one independent variable (the one-way ANOVA) and multiple interval tests (*Tukey HSD – test*) and expressed with 95% probability ($p<0.05$).

## RESULTS AND DISCUSSION

### Water and dry matter content

Milk and milk products, depending on the type, contain more or less water. In the production of raw materials, water is of great significance because it directly affects the consistency of the product. The stability of many milk products depends on the amount of water. Based on the obtained results, it can be concluded that sample 1, which was produced without the addition of

spices, had the highest water content, in the amount of 71.60%, while the lowest water content was found in sample 5, in the amount of 70.83% (Table 2). Also, sample 1 had the lowest dry matter content (28.40%), while the highest one was found in sample 5 (29.18%). The water content in the fat-free matter of the cheese ranged from 83.24% (sample 6) to 84.93% (sample 4) (Table 2). According to the Rulebook on the quality of milk products (Official Gazette of Bosnia and Herzegovina, 21/11), cheeses with a percentage of water from 69 to 85% in the non-fat content of the cheese (VuBMS) belong to fresh cheeses. Therefore, it was confirmed that the examined cheeses belong to the group of fresh cheeses.

**Fat content**

Milk fat is exceptionally significant for the consistency and sensory properties of cheese. In addition to contributing to energy intake, milk fat also contains many substances necessary for health, such as lecithin, carotene and fat-soluble vitamins A, D, and E. Milk fat in milk affects the pleasant taste of milk, its aroma and consistency and finally, the texture of the finished product (Miletić, 1994). By analyzing the fat content in the tested cream cheeses, it was established that sample 4 had the highest percentage of fat (16.25%), and sample 6 had the lowest fat content (14.33%). The fat content of control sample 1 (produced without spices) was 15.33%. The fat content in the dry matter of the cheese ranged from 49.96% (sample 6) to 56.28% (sample 4) (Table 2). According to the Rulebook on the quality of milk products (Official Gazette of BiH, 21/11), based on the fat content in the dry matter of the cheese, the analyzed products belong to full-fat cheeses.

**Protein content**

The proteins in cheese come from milk proteins. The protein content affects the sensory properties of cheese and its nutritional value. Relatively mature cheeses have a higher protein content than fresh cheeses. The protein content in the tested cheese samples ranged from 9.16% in sample 2 to 9.67% in sample 6 (Table 2).

**Ash content**

Ash is the dry residue obtained after water evaporation and burning organic components from the samples at high temperatures. The ash content depends on the type of food. Based on the obtained results, it can be concluded that sample 1, which was produced without spices, had the lowest ash content (1.50%), while the samples with added spices had a slightly higher ash content of 1.55% (samples 5 and 6) up to 1.65% (sample 4) (Table 2).

**Chloride content (NaCl)**

The chlorides in cheese come from the salt added during cheese production. Salt affects the taste of cheese, the separation of whey from cheese, regulates the ripening of cheese and is used as a preservative enabling prolonged cheese storage. Based on the obtained results, it was established that sample 1, which was produced without spices, had the lowest chloride content (1.09%). The cheese samples with added spices had a chloride content ranging from 1.16% in sample 2 to 1.36% in sample 6 (Table 2).

**Water activity**

Using the water activity value, it is possible to estimate how much free water is available for the metabolism of the present microorganisms. This means that water activity is a suitable parameter that can be used to control the growth and development of microorganisms. An aw value of 0.92 and 0.96 is required for regular bacterial activity (Adam, & Moss, 2008). The activity of water in fresh cream cheese samples was from 0.944 (sample 6) to 0.948 (sample 1) (Table 3), which indicates that the tested cheeses are a suitable and very susceptible environment for the development of microorganisms.

Table 2. Chemical composition of tested samples of fresh cream cheese.

| Parameter (%) | Sample 1 | Sample 2 | Sample 3 | Sample 4 | Sample 5 | Sample 6 |
|---|---|---|---|---|---|---|
| Water | 71.60$^{a}$ ±0.38 | 71.30$^{ab}$ ±0.07 | 71.11$^{ab}$ ±0.05 | 71.13$^{ab}$ ±0.02 | 70.83$^{b}$ ±0.16 | 71.31$^{ab}$ ±0.09 |
| Dry matter | 28.40$^{a}$ ±0.38 | 28.70$^{ab}$ ±0.07 | 28. 09$^{ab}$ ±0.05 | 28.88$^{ab}$ ±0.02 | 29.18$^{b}$ ±0.16 | 28.69$^{ab}$ ±0.09 |
| Water in nonfat substance | 84.57$^{a}$ ±0.28 | 84.89$^{a}$ ±0.72 | 84.31$^{a}$ ±0.29 | 84.93$^{a}$ ±0.65 | 84.48$^{a}$ ±0.30 | 83.24$^{a}$ ±0.65 |
| Fat | 15.33$^{ab}$ ±0.24 | 16.00$^{a}$ ±0.71 | 15.67$^{ab}$ ±0.24 | 16.25$^{a}$ ±0.61 | 16.17$^{a}$ ±0.24 | 14.33$^{b}$ ±0.62 |
| Fat in dry matter | 53.99$^{ab}$ ±0.41 | 55.42$^{a}$ ±2.47 | 54.22$^{ab}$ ±0.90 | 56.28$^{a}$ ±2.16 | 55.42$^{ab}$ ±0.86 | 49.96$^{b}$ ±2.23 |
| Proteins | 9.57$^{a}$ ±0.17 | 9.16$^{a}$ ±0.34 | 9.46$^{a}$ ±0.18 | 9.38$^{a}$ ±0.09 | 9.57$^{a}$ ±0.14 | 9.67$^{a}$ ±0.01 |
| Chlorides | 1.09$^{a}$ ±0.00 | 1.16$^{ab}$ ±0.07 | 1.23$^{b}$ ±0.04 | 1.26$^{bc}$ ±0.04 | 1.24$^{bc}$ ±0.02 | 1.36$^{c}$ ±0.03 |
| Ashes | 1.50$^{a}$ ±0.03 | 1.61$^{ab}$ ±0.00 | 1.58$^{ab}$ ±0.09 | 1.65$^{b}$ ±0.02 | 1.55$^{ab}$ ±0.02 | 1.55$^{ab}$ ±0.00 |

$^{a-c}$ mean values with different letters in the same row differ statically significantly with 95% probability ($p < 0.05$)

**pH value**

The pH value represents the active acidity of the cheese. It is of great importance in cheese production because it affects the elasticity of the mass as well as the sensory and other physical properties of the cheese. Based on the measured values, it is noticeable that the addition of spices to the cream cheese significantly affected ($p<0.05$) the pH value. The pH values in the examined cheeses ranged from 4.19 (sample 2) to 4.31 (sample 3 and sample 4) (Table 3).

**Acidity**

The titration acidity of cheese is determined by titrating the sample with bases, most often NaOH, with the addition of the phenolphthalein indicator. This acidity is used to measure the latent acidity, which originates from undissociated acidic components with a large buffer capacity. The lowest value of titration acidity (64.00 °SH) was found in samples 1, 4 and 5, while sample 6 had the highest titration acidity (67.60 °SH) (Table 3).

Table 3. Physical properties of tested samples of fresh cream cheese.

| Parameter | Sample 1 | Sample 2 | Sample 3 | Sample 4 | Sample 5 | Sample 6 |
|---|---|---|---|---|---|---|
| $a_w$ value | 0.948$^{a}$ ±0.000 | 0.947$^{ab}$ ±0.001 | 0.946$^{bc}$ ±0.000 | 0.946$^{bc}$ ±0.001 | 0.945$^{c}$ ±0.000 | 0.944$^{d}$ ±0.000 |
| pH value | 4.22$^{a}$ ±0.00 | 4.19$^{a}$ ±0.00 | 4.31$^{b}$ ±0.00 | 4.31$^{b}$ ±0.01 | 4.27$^{c}$ ±0.01 | 4.25$^{c}$ ±0.01 |
| Acidity (°SH) | 64.00$^{a}$ ±0.00 | 66.00$^{b}$ ±0.33 | 64.80$^{a}$ ±0.65 | 64.00$^{a}$ ±0.00 | 64.00$^{a}$ ±0.00 | 67.60$^{c}$ ±0.33 |

$^{a-d}$ mean values with different letters in the same row differ statically significantly with 95% probability ($p < 0.05$)

A wide range of these cheeses are produced across Europe, from soft to semi-soft and semi-hard to hard ones. Cheeses with herbs are traditionally made in Turkey, mainly soft white and white cheeses in brine.

Cheese with herbs “Otlu” (in Turkish, “Otlu peynir” translates as “cheese with herbs”) is an integral part of every meal in a Turkish household. The chemical composition of this traditional Turkish cheese with spices can vary. The parameters range in the following intervals: dry matter 44.95-68.72%, milk fat 14-34%, proteins 16.6-27.4%, salt 3.3-6.4%, pH 4.84- 5.96, and titration

acidity 0.27-0.78% of lactic acid (Hayaloglu, & Fox, 2008; Tarakçi et al., 2004). Scientists found that adding herbs decreased the cheese's pH because increasing the concentration of herbs significantly reduced the pH value of the cheese (Tarakçi, 2004; Tarakçi et al., 2006). Herbs also raise the cheese acidity, which stimulates the initial growth of lactic acid bacteria in raw milk (Coşkun, & Tunçtürk, 2000). The increased concentration of iron in "Otl" cheese is a consequence of the added herbs (Mendil, 2006), and also the high level of vitamin C, which was detected in these cheeses (~3mg per 100 g of cheese) (Coşkun, & Öztürk, 2000).

Unlike Turkey, where soft to semi-hard white cheeses are traditionally produced with herbs inside the cheese mass, semi-hard and hard cheeses are made in Switzerland, mainly in varieties with herbs on the surface. These cheeses contain 55% fat in dry matter and are packaged as whole wheels, quarter wheels and in portions of 150 g or 125 g (Maćej et al., 2009).

The chemical composition of spices is complex, with each one having a specific and dominant ingredient that contributes to the aroma of the product and/or the antimicrobial and antioxidant effects of the spices, as well as the influence on the physical and chemical properties of the cheeses to which they are added.

## CONCLUSIONS

Based on the obtained results, it was determined that the addition of spices had a statistically significant ($p<0.05$) effect on the physicochemical properties of fresh cream cheese. Analyzing the results of physicochemical testing of produced cream cheese samples, it was established that the values of all tested parameters were in accordance with the relevant legal regulations. Produced cheeses with the addition of selected spices meet the quality requirements and might deliver important value and potential effects for different groups of consumers.

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# CHEMICAL PROPERTIES OF SHELLED AND UNSHELLED APRICOT SEEDS, PHYSICO-CHEMICAL AND ANTIOXIDATIVE CHARACTERIZATION OF OILS OBTAINED FROM THESE SEEDS

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## ABSTRACT

Apricot (*Prunus armeniaca*) is a continental stone fruit that belongs to the Rosaceae family. The aim of this work was to determine the chemical properties of shelled and unshelled apricot seeds, as well as the physico-chemical and antioxidant characteristics of the oils obtained from these seeds. The content of moisture, crude ash, crude protein and crude fat in unshelled apricot seeds amounted 4.79%; 2.60%; 21.31% and 47.72%, respectively, and the values for these parameters were not significantly different in relation to shelled apricot seeds where the following values were obtained: 5.02%; 2.53%; 22.06%; 51.79%, respectively. The content of potassium, magnesium, phosphorus and calcium, expressed in mg/100g, in unshelled and shelled apricot seeds were 618.86 and 567.04; 259.83 and 248.06; 144.28 and 136.26; 118.04 and 117.10, respectively. Unshelled apricot seeds contained more different fatty acids compared to shelled apricot seeds. The content of the two plentiful fatty acids, oleic and linoleic, was approximately equal. The density, refractive index at 20˚C, iodine number and saponification number of the unshelled apricot seed oil amounted 0.91 g/mL, 1.4701, 98.92 g $I_2$/100g and 199.14 mg KOH/g, and were almost identical to the values obtained for the shelled seed oil. The acid level of unshelled apricot seed oil was 0.96 $cm^3$/100g, and it differed from that of unshelled apricot seed oil (1.47 $cm^3$/100g). Similar to the seed samples, the two most abundant fatty acids in oils were oleic (66.05% in unshelled seed oil and 68.37% in shelled seed oil) and linoleic (23.41% in unshelled seed oil and 23.65% in shelled seed oil). Both types of oils showed weak antioxidant activity with regard to DPPH and ABTS radicals, with the fact that the oil of shelled apricot seeds ($IC_{50}$= 5757.58 mg/mL) showed slightly better antioxidant activity with regard to ABTS radical compared to unshelled apricot seed oil ($IC_{50}$=6793.61 μg/mL), while with regard to the DPPH radical, unshelled apricot seed oil ($IC_{50}$=43504.44 μg/mL) showed better antioxidant activity compared to shelled apricot seed oil ($IC_{50}$=45637.5 μg/mL).

**Keywords**: apricot, seed oil, physico-chemical characteristics, antioxidative activity.

## INTRODUCTION

Apricot (lat. *Prunus armeniaca*), also known by the name "apricot", is a continental stone fruit that, together with plums, almonds, peaches, sour cherries and cherries, belongs to the Rosaceae family. Apricot grows as a bush or a low tree, 8 to 12 m high, with a trunk up to 40 cm in diameter. Apricot fruits are yellow or orange in color and medium in size (about 1.5-2.5 cm in diameter), with red or darker orange shades on the side of the fruit that was facing the sunlight. Apricot fruit consists of skin (exocarp), flesh (mesocarp) and pit (endocarp). On average, the flesh makes up 85% of the total weight of the fruit, the pit 7.7%, and the skin 7.3%. The most important characteristics of the pits are size and shape. The weight of apricot pits varies from 1-5 grams. According to the UPOV descriptor, the shape of pits can be: ovoid, elongated, elliptical, round and inverted ovoid. One of the most important characteristics for determining apricot varieties is the taste of the seed (kernel) inside the pit. Among the varieties grown in our country, those with a sweet core prevail. These are, among others, varieties: Mađarska najbolja, Čačansko zlato, Novosadska rodna, Harkot, NS-4 and others. The number of varieties with a bitter core is smaller.

These are, for example, the varieties: Goldrič, Čačanska pljosnata, Kečkemetska ruža, Bergaruž (Milatović, 2013). Apricot seeds, which are usually rejected as by-products in fruit processing, contain significant amounts of oil, which is a source of oleic acid (over 70%) and ɣ-tocopherol (315-512 mg/kg) (Stryjecka et al., 2019; Shariatifar et al., 2017). The percentage of seed in an apricot pit varies from 18.8% to 38.0% (Alpaslan, & Hayta, 2006). Apricot seeds contain the cyanogenic glycoside amygdalin. Although amygdalin is poisonous, in small amounts it can have a therapeutic effect, stimulating breathing, improving digestion, and can be used to treat cancer (Li, 2009). Apricot seeds are also rich in essential amino acids and contain high concentrations of minerals potassium and magnesium, as well as vitamins of the B complex. Apricot seed oil is considered as good edible oil and can be used for other industrial purposes. Apart from their use in the food industry, the extraction of such oils can also pave the way for their use in various preparations such as pharmaceuticals, cosmetics, face creams and lip balms (Gupta et al., 2012). During fruit ripening, a series of complex biochemical reactions take place that lead to the formation of phenolic compounds, carotenoids and volatile components. Among these compounds, carotenoids predominate, a group of pigments present in all photosynthetic organisms, which are largely responsible for the yellow to red color of fruits. In recent years, there has been increasing interest in polyphenols and carotenoids due to their antioxidant properties and ability to fight against chronic diseases. It has been proven that dietary antioxidants can provide effective protection against oxidative damage in living organisms (Ali et al., 2011).

The aim of this work was to determine the chemical properties of shelled and unshelled apricot seeds, as well as the physico-chemical and antioxidant characteristics of the oils obtained from these seeds.

## MATERIAL AND METHODS OF WORK

For the purposes of this work, seeds from apricot pits (lat. *Prunus armeniaca* L.) obtained as a by-product on the brandy production line were used. Apricot pits were delivered and stored in a dried state, in mesh (rachel) bags, in a dark and dry place until the moment of analysis. Apricot seeds, used to obtain the oil that will be analyzed in this paper, were obtained by mechanical peeling of apricot pits. During the process of mechanical peeling, the pits break and the seeds are released. The obtained seeds are divided into two parts. One part of the seeds was used in the obtained form as a sample of unshelled apricot seeds. The second part of the seeds was soaked in distilled water for 24 hours, after which the seeds were drained, shelled and dried at room temperature. The seeds prepared in this way were used as a sample of shelled apricot seeds.

Prepared samples of unshelled and shelled apricot seeds were pressed on a screw press during cold pressing process. In order to achieve greater pressing efficiency, the press head was heated and the temperature was periodically maintained between 80 ºC and 100 ºC. As a product of pressing, oil with sediment and cake, which is discarded, are obtained. The obtained oil samples were filtered through filter-paper in order to remove the impurities. Filtered oils were stored in dark glass bottles, at refrigerator temperature, and used for analysis.

The density, refractive index, acid number, peroxide number, saponification number and iodine number of oil were determined according to standard AOAC methods. The content of dry matter, ash, protein, fat and minerals in apricot seeds was determined also according to standard AOAC methods.

The antioxidant activity of the oil with regard to the stable DPPH radical (2,2-diphenyl-1-picrylhydrazyl) was determined according to the method of Liyana-Pathiranan and Shaidi (2005). Trolox solution was used to create the calibration curve, and it is represented by the equation $y=7.0993x-0.4433$; $R^2=0.9722$. The antioxidant activity of the oil with regard to the stable $ABTS^+$ radical (2,2-azinobis-(3-ethylbenzothiazoline-6-sulfonyl)-diammonium salt) was determined according to the method described by Re et al. (1999). Trolox solutions were used to make the calibration curve, which is represented by the equation $y=15.94x+10.527$; $R^2=0.9984$.

Clarus 680 Perkin Elmer instrument with FID detector, Elite-wax L 60 m column, ID 0.32, DF 0.5, standard: Sigma Aldrich Supelco 37 components FAME MIX was used to determine fatty acids in the samples. Injector and detector temperature 250 ºC, sample volume 1 µL, temperature

regime 60 ºC for 2 minutes, 10 ºC/min to 200 ºC, 5 ºC/min to 240 ºC and 30 minutes at 240 ºC. Total duration 54 minutes, flow rate 1.5 mL/min, gases nitrogen (carrier), hydrogen and air (for FID). The composition of fatty acids is shown as a percentage share of individual fatty acids in the total amount of identified fatty acids (g/100 g of total fatty acids).

Statistical data processing was performed in MS Excel 2010, and the results were presented as mean±standard deviation of three parallel measurements.

## RESULTS AND DISCUSSION

Based on the obtained results (Table 1), we see that the moisture content in unshelled apricot seeds is slightly lower compared to the sample of shelled apricot seeds. The determined percentage of moisture in the sample of unshelled apricot seeds was slightly lower in relation to the values obtained by Özcan (2000) for the moisture content of unshelled apricot seeds. Analyzing the seeds of several different apricot varieties, Özcan (2000) found that the moisture content varies depending on the apricot variety and ranges from 4.91 to 5.12%. Comparing the values obtained for unshelled and shelled apricot seeds, we see that the ash content was slightly higher in the seeds containing the shell. The values obtained for the ash content in the samples of unshelled and shelled apricot seeds were in agreement with the values determined by Özcan (2000). By analyzing the seeds of different varieties, he obtained that the ash content in apricot seeds ranged from 2.10-2.67%. Also, the obtained values were in the range stated for the ash content in seeds by Manzoor et al. (2012), which amounts to 2.11-3.89%. By comparing the values obtained for the protein content, we see that their content in shelled apricot seeds was higher than the protein content in unshelled seeds. The values obtained for the protein content of unshelled and shelled apricot seeds, were lower compared to the values obtained by Özcan (2000) (23.58-27.70%). The protein content in the analyzed samples was higher compared to the value range of 13.21-20.90% for protein content, which Manzoor et al. (2012) stated in their work. From the obtained results, it can be seen that shelled seeds had a higher fat content than unshelled apricot seeds. The determined fat content in the samples was higher than the values reported by Manzoor et al. (2012) obtained by analyzing the seeds of 4 different varieties of apricots, 32.23-42.51%. On the other hand, these values obtained for unshelled and shelled apricot seeds were approximately the same as the values reported by Özcan (2000), which range from 46.3-51.4%.

Table 1. Physico-chemical characteristics of apricot seeds.

| Parameter | Unshelled apricot seeds | Shelled apricot seeds |
|---|---|---|
| Moisture (%) | 4.79±0.0356 | 5.02±0.0264 |
| Ash (%) | 2.60±0.2525 | 2.53±0.0387 |
| Crude protein (%) | 21.31±0.4082 | 22.06±0.1180 |
| Crude fat (%) | 47.72±0.1314 | 51.79±0.2811 |

For the following mineral substances: iron (Fe), lead (Pb), cadmium (Cd), selenium (Se) and molybdenum (Mo), the analysis showed that they were not presented in the analyzed samples.

By comparing the results obtained for unshelled and shelled apricot seeds, we see that the content of individual mineral substances in the sample of unshelled apricot seeds for all determined mineral substances was higher with the exception of sodium (Table 2).

By comparing the obtained values for the content of mineral substances with the values obtained by Lazos (1991), we see that the aluminum content in the analyzed samples was higher compared to the value he obtained, which is 1 mg/100g of sample. Lazos (1991) stated the following values for individual mineral substances: for copper 1.3 mg/100g of sample, magnesium 156.0 mg/100g of sample and calcium 19.2 mg/100g of sample, and they were significantly lower compared to the obtained values during the analysis of unshelled and shelled apricot seeds.

Potassium content was higher in unshelled apricot seeds (618.86 mg/100g) than in shelled seeds (567.04 mg/100g), the content in unshelled seeds is lower compared to the value that was obtained by Lazos (1991) for unshelled seeds, which was 685.0 mg/100g of sample.

Unlike Lazos (1991), who stated that the iron content in apricot seeds was 1.3 mg/100g of sample, no iron was detected in the analyzed samples of unpeeled and peeled apricot seeds.

According to Lazos (1991), the amount of sodium was 7.0 mg/100g of sample, which was slightly lower than the values for sodium presented in the table below.

Table 2. Content of mineral substances in apricot seeds.

| Minerals (mg/100g of sample) | Unshelled apricot seeds | Shelled apricot seeds |
|---|---|---|
| Aluminium (Al) | 1.82±0.8185 | 1.55±0.0400 |
| Copper (Cu) | 4.01±2.8600 | 3.50±3.1097 |
| Potassium (K) | 618.86±9.3149 | 567.04±6.2650 |
| Calcium (Ca) | 118.04±5.2650 | 117.10±4.5986 |
| Magnesium (Mg) | 259.83±5.8129 | 248.06±8.3094 |
| Manganese (Mn) | 1.12±0.0216 | 0.84±0.0004 |
| Sodium (Na) | 7.58±0.2449 | 7.85±0.0900 |
| Phosphorous (P) | 144.28±6.5448 | 136.26±2.9257 |
| Chrom (Cr) | 0.24±0.0158 | 0.14±0.0070 |

The content of fatty acids in unshelled and shelled apricot seeds, as can be seen from Table 3, was different. Unshelled apricot seeds contained more different fatty acids compared to shelled seeds, with the content of the two most important fatty acids, oleic and linoleic, being approximately the same in both analyzed samples.

The result obtained for the content of oleic acid in unshelled apricot seeds, is consistent with the results reported by Alpaslan and Hayta (2006). They stated that the content of oleic acid ranges from 58.3–73.4%.

The determined content of linoleic acid in unshelled seeds was also consistent with the values stated in their work by Alpaslan and Hayta (2006), according to them the content of linoleic acid ranges from 18.8–31.7%.

Table 3. Content of fatty acids in the analyzed samples of apricot seeds.

| Fatty acid (%) | Unshelled apricot seeds | Shelled apricot seeds |
|---|---|---|
| Undecanoic acid (C11:0) | 0.30±03000 | - |
| Tridecanoic acid (C13:0) | 0.10±0.1000 | - |
| Myristic acid (C14:0) | 0.35±0.0500 | - |
| Myristoleic acid (C14:1) | 0.06±0.0552 | 0.02±0.0200 |
| Pentadecanoic acid (C15:0) | 0.04±0.0453 | 0.24±0.2450 |
| cis-10-pentadecenoic (C15:1) | 0.02±0.0158 | - |
| Palmitic acid (C16:0) | 5.22±0.0951 | 5.44±0.0100 |
| Palmitoleic acid (C16:1) | 0.84±0.0300 | 0.90±0.0071 |
| Heptadecanoic acid (C17:0) | 0.04±0.0071 | 0.01±0.0100 |
| cis-10-heptadecanoic acid (C17:1) | 0.10±0.00 | 0.05±0.0500 |
| Stearic acid (C18:0) | 1.40±0.0255 | 1.48±0.0255 |
| Oleic acid (18:1) | 67.03±1.3700 | 67.99±0.0200 |
| Linoleic acid (C18:2) | 23.32±0.5000 | 23.87±0.1700 |
| Arachidonic acid (C20:0) | 0.10±0.0951 | - |
| Erucic acid (C22:1) | 0.58±0.5800 | - |
| Nervonic acid (C24:1) | 1.42±1.2120 | - |

The yield of oil obtained from unshelled apricot seeds after pressing was 36.56%. Considering that this oil contained a lot of sediment, it was filtered for 24-48 hours. After the completed filtration and removal of the sediment, the yield of the oil obtained from unshelled apricot seeds was 28.87%. The yield of oil obtained from shelled apricot seeds, after pressing, was slightly higher than the oil obtained from unshelled seeds and amounted to 44.34%. After removing the sediment by filtration, the yield of the oil obtained from the shelled apricot seeds was 33.08%.

Physico-chemical characteristics of cold pressed oils are presented in Table 4. The values obtained for the oil density of unshelled and shelled apricot seeds were very close. The oil density of unshelled seeds was 0.9076 g/cm$^3$, while the oil density of shelled apricot seeds was 0.9104 g/cm$^3$. These values correspond to data found in the literature, where values for the density of apricot seed oil ranged from 0.876-0.932 g/cm$^3$ (Alpaslan, & Hayta, 2006).

The refractive index, determined at a temperature of 20 ºC, was 1.4701 for unshelled apricot seed oil, and 1.4700 for shelled apricot seed oil. The obtained values were almost identical and in accordance with the values found in the literature where the refractive index was 1.464-1.480 (Alpaslan, & Hayta, 2006).

The acid level of the oil of unshelled apricot seeds was 0.96 cm$^3$/100g, while the value obtained for the oil of shelled seeds was slightly higher and was 1.47 cm$^3$/100g.

The iodine number provides information on the degree of unsaturation of the oil, and for the oil of unshelled apricot seeds, a value of 98.92 g$I_2$/100g was obtained. A very similar value of 98.90 g$I_2$/100g was obtained for the oil of shelled apricot seeds. Different values for the iodine number were found in the literature, so these values correspond to the range of 96.4-106.3 g$I_2$/100g (Manzoor et al., 2012).

The saponification value of 199.14 mgKOH/g was determined for the oil of unshelled apricot seeds, and a close value of 198.115 mgKOH/g was obtained for the oil of shelled apricot seeds. Values found in the literature reported by Manzoor et al. (2012) for apricot seed oil were 189.1-199.4 mgKOH/g. The obtained values of the saponification number indicate the presence of fatty acids of relatively low molecular weight.

Table 4. Physico-chemical characteristics of cold pressed oils obtained from unshelled and shelled apricotseeds.

| Parameter | Unshelled apricot seed oil | Shelled apricot seed oil |
|---|---|---|
| Density (g/cm$^3$) | 0.9076±0.0004 | 0.9104±0.0006 |
| Refractive index at 20ºC | 1.4701±0.0002 | 1.4700±0.0001 |
| Acid level (cm$^3$/100g) | 0.96±0.0255 | 1.47±0.0300 |
| Iodine value (g $I_2$/100g) | 98.92±0.7900 | 98.90±0.0354 |
| Saponification value (mg KOH/g) | 199.14±1.2300 | 198.115±0.5550 |

The content of fatty acids in the oil of unshelled and shelled apricot seeds, determined by the gas chromatography method, indicated a fairly similar content of fatty acids in these oils (Table 5). The most dominant fatty acid in these oils was oleic acid (C18:1), whose content in the oil of unshelled apricot seeds is 66.045%, and a very close value of 68.37% was found in the oil of shelled apricot seeds. The obtained values of the content of oleic acid (C18:1), in the oils of unshelled and shelled apricot seeds, are in accordance with the data found in the literature, where values of 62.34-80.97% (Manzoor et al., 2012) and 68 % (Lazos, 1991) of oleic acid (C18:1) in apricot seed oil.

The second fatty acid in abundance in these oils is linoleic acid (C18:2) present in the oil of unshelled apricot seeds in the amount of 23.41%, and in the oil of shelled apricot seeds 23.65%. According to data found in the literature, the content of linoleic acid (C18:2) in apricot seed oil ranges from 13.33-30.33% (Manzoor et al., 2012) and 24.20% (Lazos, 1991), which is in accordance with the values obtained for the oils analyzed in this work.

The content of palmitic acid (C16:0) in the oil of unshelled apricot seeds was 5.35%, and in the oil of shelled apricot seeds 5.345%. The obtained values were in accordance with the data found in the literature, where values of 3.35-5.93% (Manzoor et al., 2012) and 4.93% (Lazos, 1991) of palmitic acid (C16:0) in the oil were reported.

Stearic acid (C18:0) in the oil of unshelled apricot seeds is found in the amount of 1.51%, and in the oil of shelled apricot seeds 1.46%, which is in accordance with the values of 1.10-1.68% reported by Manzoor et al. (2012).

The content of myristoleic acid (C14:1) is slightly higher in the oil of unpeeled apricot seeds and amounts to 0.18%, while in the oil of peeled apricot seeds this value is 0.025%. Palmitoleic

acid (C16:1) was detected in the oil of unshelled apricot seeds at a value of 0.865%, and a slightly higher amount was found in the oil of shelled apricot seeds (0.915%).

Cis-10-heptadecanoic acid (C17:1) in the oil of unshelled apricot seeds was found in a higher amount compared to the oil of shelled apricot seeds. Namely, in the oil of unshelled apricot seeds, 0.275% of cis-10-heptadecanoic acid (C17:1) was found, while in the oil of peeled apricot seeds, 0.055% of the same acid was found.

Of the other fatty acids, the following were found in the oil of unshelled apricot seeds: cis-10-pentadecanoic acid (C15:1) in the amount of 0.185%, erucic acid (C22:1) in the amount of 0.79% and nervonic acid (C24:1) in the amount of 1.38%. The same were not detected in the oil of shelled apricot seeds.

On the other hand, some fatty acids were found in the oil of shelled apricot seeds, the presence of which was not detected in the oil of unshelled apricot seeds, such as: myristic acid (C14:1) and pentadecanoic acid (C15:0) in the amount of 0.02 each %, margaric acid (C17:0) in the amount of 0.05%, α-linoleic acid (C18:3n3) in the amount of 0.04% and arachidonic acid (C20:0) in the amount of 0.045%.

Table 5. Content of fatty acids in analyzed apricot seed oil samples.

| Fatty acid (%) | Unshelled apricot seed oil | Shelled apricot seed oil |
|---|---|---|
| Myristic acid (C14:0) | - | 0.02±0.0200 |
| Myristoleic (C14:1) | 0.18±0.1800 | 0.025±0.0250 |
| Pentadecanoic acid (C15:0) | - | 0.02±0.0200 |
| Cis-10-pentadecenoic acid (C15:1) | 0.185±0.0650 | - |
| Palmitic acid (C16:0) | 5.35±0.2200 | 5.345±0.2150 |
| Palmitoleic acid (C16:1) | 0.865±0.0150 | 0.915±0.0050 |
| Heptadecanoic acid (C17:0) | - | 0.05±0.0200 |
| cis-10-heptadecanoic acid (C17:1) | 0.275±0.2750 | 0.055±0.0550 |
| Stearic acid (C18:0) | 1.51±0.0000 | 1.46±0.0600 |
| Oleic acid (18:1) | 66.045±1.7850 | 68.37±0.5000 |
| Linoleic acid (C18:2) | 23.41±0.5400 | 23.65±0.4200 |
| α-linoleic acid (C18:3n3) | - | 0.04±0.0400 |
| Arachidonic acid (C20:0) | - | 0.045±0.0450 |
| Erucic acid (C22:1) | 0.79±0.7900 | - |
| Nervonic acid (C24:1) | 1.38±1.3800 | - |

In Table 6, the antioxidant activity of the oil obtained from apricot seeds was shown in relation to the stable $ABTS^+$ radical (2,2-azinobis-(3-ethylbenzothiazoline-6-sulfonyl) diammonium salt) and DPPH radical (2,2-diphenyl-1-picrylhydrazyl). The results are expressed as an $IC_{50}$ value expressed in μg/mL and as a TEAC value (Trolox equivalent antioxidant capacity) in μgTrolox/mL. The DPPH test is based on the hydrogen atom exchange reaction between the antioxidant and the stable DPPH radical. In the reaction, the intensely colored DPPH radical is reduced to the corresponding hydrazine, which is monitored spectrophotometrically by the drop in absorbance at 517 nm. The $IC_{50}$ value represents the concentration of the sample or reference substance that is required to inhibit 50% of DPPH radicals. Lower $IC_{50}$ values indicate a better antiradical activity of the tested sample on DPPH.

The obtained value for the $IC_{50}$ of the oil obtained from unshelled apricot seeds was 43,504.4444 μg/mL, while the $IC_{50}$ value of the oil obtained from shelled apricot seeds was 45,637.5000 μg/mL. The obtained values indicated that oil from unshelled apricot seeds had a slightly better antiradical activity on stable DPPH. Testing of antioxidant activity using the $ABTS^+$ method is based on colorimetric measurement of the degree of discoloration of $ABTS^+$ radicals in the presence of antioxidants. For the oil obtained from unshelled apricot seeds, the $IC_{50}$ value with regard to the stable $ABTS^+$ radical was 6,793.6129 μg/mL and was higher than the value obtained for the oil from shelled apricot seeds, which amounted 5,757.5806 μg/mL.

Table 6. Antioxidant activity of oil samples with regard to stable ABTS and DPPH radicals.

| Samples | ABTS test | | DPPH test | |
|---|---|---|---|---|
| | TEAC (µgTrolox/mg) | $IC_{50}$ (µg/mL) | TEAC (µgTrolox/mg) | $IC_{50}$ (µg/mL) |
| Unshelled apricot seed oil | 0.00038896 | 6,793.6129 | 0.00012677 | 43,504.4444 |
| Shelled apricot seed oil | 0.00038896 | 5,757.5806 | 0.00011269 | 45,637.5000 |

## CONCLUSIONS

Apricot seeds are a by-product of fruit processing and are generally discarded as waste. On the basis of the conducted chemical analyses, as well as the collected data related to apricot seeds, it is concluded that these are high-quality seeds that can positively affect the health of their consumers. The analyzed chemical composition of unshelled and shelled apricot seeds is approximately the same.

Oils from shelled and unshelled apricot seeds are good quality oils. By processing apricot seeds, the amount of waste is reduced, and the resulting product has a number of positive effects on human health and is a nutritionally high-quality food that is used in industries such as: food, cosmetics, pharmaceuticals and many others.

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# INVESTIGATION OF MECHANICAL AND MICROSTRUCTURES OF EUTECTIC WELDED AND BRAZE WELDING APPLICATION IN AL-CU PIPE JOINTS

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## ABSTRACT

One of the most important factors in cooling systems is ensuring tightness. For this, it is necessary to form strong aluminum copper pipe connections. These connections working under vibration should not leak during long-term use. In this study, aluminum and copper pipes joined by eutectic welding and brazing method were investigated. Tensile test, impermeability and bursting tests were applied to all samples. Microstructures at the junction interfaces were investigated under scanning electron microscopy (SEM). As a result of the experimental studies, eutectic welding and brazing connections were compared. Although the eutectic weld joint length is 50% shorter than the brazed joint, the tensile test gave approximately the same value of 22 N/mm2. In the blast tests, on the other hand, the eutectic source showed 16.67% higher pressure resistance.

**Keywords:** aluminum tube, copper tube, cooling system, brazing, eutectic bond, sealing.

## INTRODUCTION

Soldering of aluminium with copper becomes more significant, because of relatively low process temperature of about 400–450°C. It is applied not only in electrotechnical industry, in joining Al–Cu conductors, but also in cooling and air-conditioning equipment and in solar construction of collectors (Winiowski, 2003; Mirski et al., 2013).

Today, aluminum and copper pipes, which are widely used in the heating and cooling sector, have gained more importance due to increasing costs. Due to high costs, companies have increased their efforts to reduce the amount of copper use in the cooling cycles and to increase the amount of aluminum, which is relatively cheaper. Since aluminum is difficult to connect or source directly to the cooling system, it is necessary to switch with copper. For this reason, aluminum copper pipe connections that provide gas transmission in the system have gained importance (Gündüz, 2022).

In the study, an experimental comparison of eutectic and brazing welding was made in order to prevent gas leaks in aluminum copper pipe connections used in the refrigeration industry. In the experimental study, the design and manufacture of pipe connections were carried out. Two different welded joints are welded to ensure tightness.

Applied Tests:

- Tensile test,
- Leak test,
- Blast test,
- Microstructure testing (SEM).

It is thought that this study will be beneficial especially for the companies that produce for the white goods sector or have gas leakage problems by joining aluminum copper pipe welding in their products.

In the study of A. Ambroziak et al., the applications of eutectic welding and brazing welding of aluminum and copper pipes were examined separately. In the researches, copper and aluminum pipes with a diameter of 6.9 mm were joined separately by eutectic welding and brazing welding, and the connection was examined mechanically. It has been stated that eutectic welding is more suitable for mass production conditions due to its easy and fast application.

The quality of solder joints made by flame soldering was strongly associated with the skills of the solder. It has been found that it is not possible to achieve perfect repeatability of the process in brazed joints. It has been predicted that the application in eutectic welded joints is more suitable for mass-produced lines since the same reproducible results are obtained (Ambroziak et al., 2020).

In another study by T. Watanabe et al. on the eutectic welding of aluminum and copper pipes with a diameter of 8 mm and a wall thickness of 0.6 mm, the coalescence rate was emphasized. From the study, experiments were carried out at seven different joining speeds, from 0.2 mm/sec to 20 mm/sec. The relationship between the splicing speed and the tensile strength of the joint was investigated. The best results were obtained in the tensile test when the joining speed was 20 mm/s (Watanabe et al., 1998).

As the joining temperature, in the experiments carried out at intervals from 560°C to 620°C, the best result was given by the jointing at 560°C and 20 mm/sec. As a result, the faster the splicing speed and the lower the joint temperature, the greater the contact, and the greater the joint strength.

The eutectic welding method is a recently developed welding method different from the known welding methods. It is used to join two different metals. In our study, eutectic welding was applied in the welded connection of aluminum and copper pipes.

**Joining Aluminum and Copper Pipes by Eutectic Welding**

Eutectic Reaction ; It is the process of joining two metals under heat and pressure by heating them up to the eutectic temperature of two metals with a difference in melting temperatures, that is, to the lowest melting temperature. It takes place below the melting temperature of the main materials.

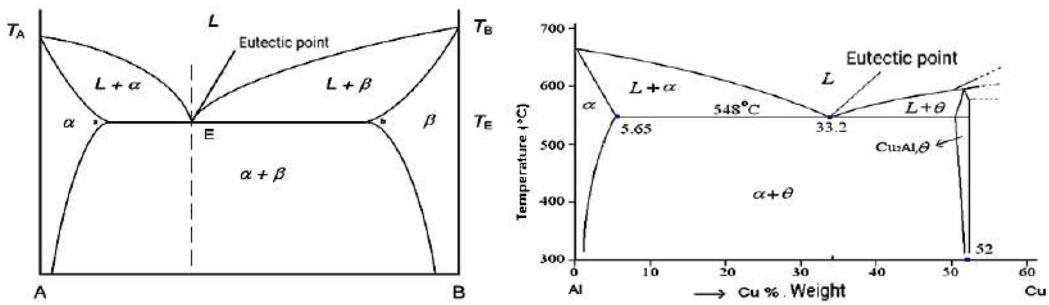



Figure 1. Eutectic Reaction (William et al., 2020; Hiroyasu, 2019).

**Brazing Joining Aluminum and Copper Pipes**

Brazing is one of the methods in which a filler metal is melted between two metals, filling the gap and providing the connection. These ductile connections are resistant to vibrations in cooling systems.

## MATERIAL AND METHODS OF WORK

### Material

Aluminum pipe material, whose trade name is '1070 A (ASTM B 209)', was used in the studies. The chemical components and mechanical properties of the aluminum pipe are given in the table below.

In the studies, copper pipe with the trade name 'Cu-DHP' (Desoxidized high phosphorus residue copper) was used. Chemical components and mechanical properties of copper pipes are given in the tables below.

Table 1. Chemical Composition (1070 A).

| **International Standard Number** | **Chemical Composition (%)** | | | | |
|---|---|---|---|---|---|
| 1070 A (ASTM B 209) | Al (min) 99.7 | Si (max) 0.20 | Fe (max) 0.25 | Zn (max) 0.07 | Cu, Mn, Mg, Ti (max) 0.03 |

Table 2. Technical specifications.

| International Standard Number | Tensile Strength (MPa) min | Yield Strength (MPa) min | % Strain (min) | Hardness HBW |
|---|---|---|---|---|
| 1070 A (ASTM B 209) | 60 | 23 | 25 | 18 |
| Cu-DHP | 220-260 | 140 | 33 | - |

Table 3. Chemical Composition (Cu-DHP)

| **Trade Name** | **Chemical Composition (%)** | |
|---|---|---|
| Cu-DHP | Cu 99 | P 0.015-0.040 |

### Brazing Filler material

In the studies, a self-flux ring form filler metal with the code 'A5.8-BAlSi-4' according to AWS standards was used. Filling material with the code AL 4047 was preferred because it is compatible with the area to be bonded due to the aluminum and silicon elements it contains, and because silicon increases the fluidity.

Table 4. Technical specifications (Brazing Filler).

| **AWS Code** | **Colour** | **Melting Temp.** | **Flow Temp.** | **Density** | **Brazing Temperature (°C)** | **Chemical Composition (%)** |
|---|---|---|---|---|---|---|
| A5.8-BAlSi-4 | Grayish White | 577 °C | 582 °C | 0.096 Lbs/in$^3$ | 582-604 | 0.01 Cu, 0.20 Fe, 0.01 Mn, 0.01 Mg, 12.08 Si, 0.05 Ti, 0.01 Zn, 88 Al |

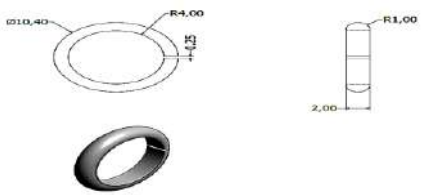



Figure 2. Brazing Filler Material.

**Method**

Eutectic Welding Process

The welding machine and hydraulic circuit diagram used for the Eutectic Welding Process are given in Figure 3.

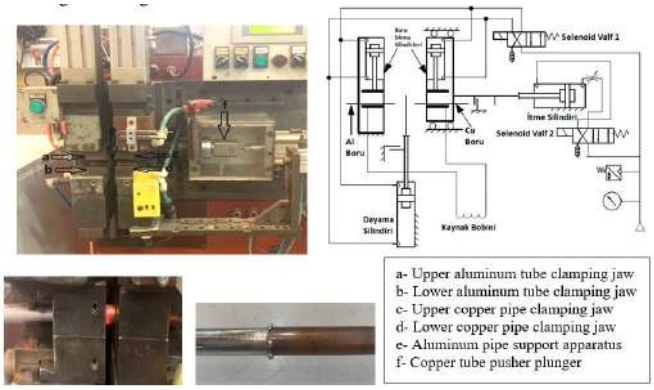



Figure 3. Eutectic welding machine and hydraulic circuit diagram.

Figure 4. Aluminum and Copper Pipe Eutectic Connection Method Pipe Cutting.

Aluminum and copper pipe samples are supplied in coils.

Samples are cut in pipe cutting machine according to their dimensions.

Aluminum and copper pipe samples were obtained by cutting with a pipe cutting knife using the orbital method.

**Copper Pipe End Shrinking Machine**

A shrinking (narrowing) machine is used to give an angled form to the copper pipe ends. Angled form is given with the help of molds rotating around the pipe axis in the machine. Pipes are pushed into the machine by applying pressure by hand.

Figure 5. Copper Pipe End Shrinking/Narrowing Machine.

**Copper Tube End Shrinking Mold**

The copper pipe ends used for the eutectic weld joint are shaped with the help of the molds in the shrinking machine in the Figüre 6.

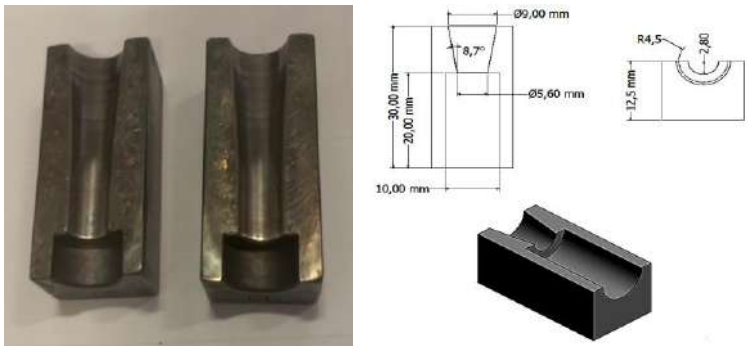



Figure 6. End Shrinking mold of Cu Pipes.

**Eutectic Welding of Al-Cu Pipes**

It is a type of welding method that has been developed recently, unlike the known welding methods. It is used to join two different metals. In our study, eutectic welding was applied in the welded connection of aluminum and copper pipes. The aluminum pipe is brought to the eutectic temperature and then the copper pipe is pushed into the aluminum pipe with a pressure of 2 bar (10 mm) connection is formed. In the measurement made, the temperature of the connection point at the junction was measured as 563.7 °C on average. After the welding process, the heating process was terminated and the samples were removed from the mold.

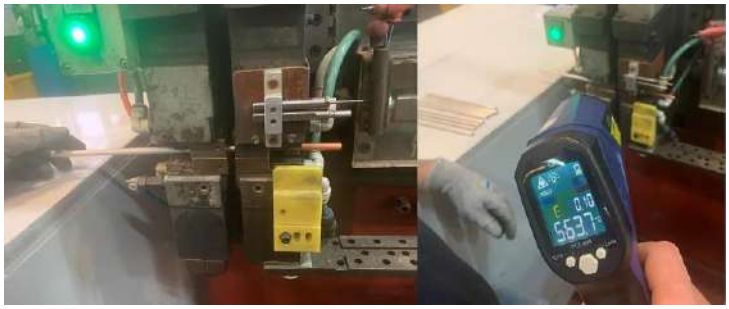


Figure 7. Eutectic welding of Al-Cu pipes.

Part dimensions for the eutectic welded joint are shown in Figure 8; for hard solder is given in Figure 9.

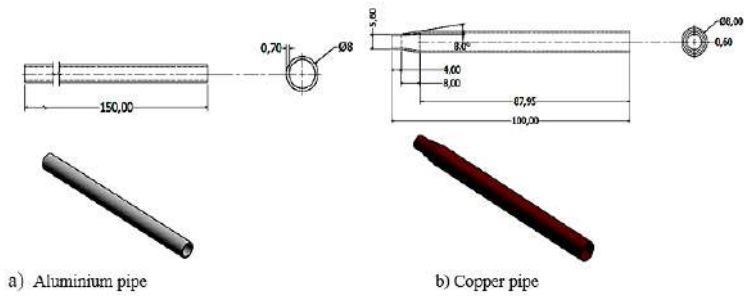



Figure 8. Eutectic Sample Material Dimensions.

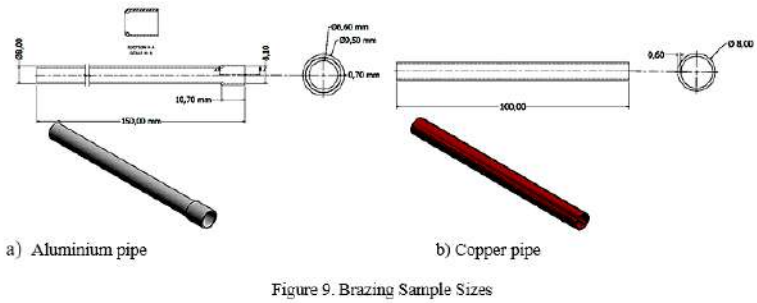



Figure 9. Brazing Sample Sizes.

**Brazing process of Al-Cu Pipes**

1- Al Pipe End Forming Operation : A certain length of blowing was applied to the aluminum pipe end before brazing. The punch in the figure was used for the inflation operation. During the operation, acetone was sprayed onto the punch tip to prevent the heating caused by friction. At the same time, cleaning is provided at the punch and pipe end. The pipe end is expanded by the punch entering and exiting at a distance of 15 mm from the aluminum pipe end.

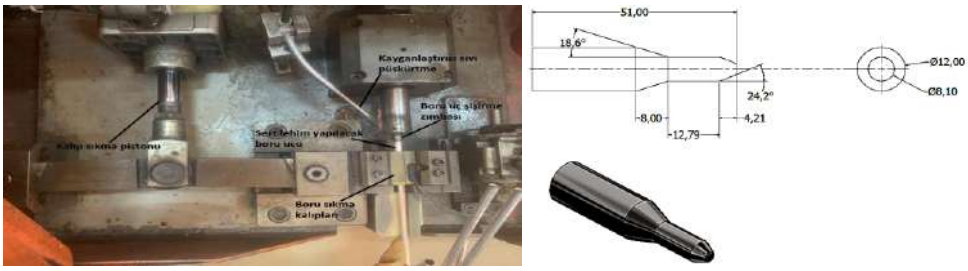



Figure 10. End forming machine and end forming pin.

2-Brazing of Al-Cu Pipes: The brazing application with the help of a blower is shown Figure11. In the experimental study, a mixture of natural gas and oxygen was used for brazing application. The pressures of the gases used were adjusted as 1 bar for natural gas and 10 bar for oxygen. The weld joint area was heated up to the brazing temperature (593.9°C), allowing the solder filler to melt and penetrate. Temperature measurements were made with a laser measuring device.

Figure 11. Brazing of Al-Cu Pipes.

Images and Technical Dimensions of the connections are given in Figure 12.

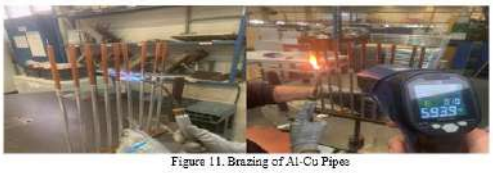


Figure 11. Brazing of Al-Cu Pipes

Images and Technical Dimensions of the connections are given in Figure 12.

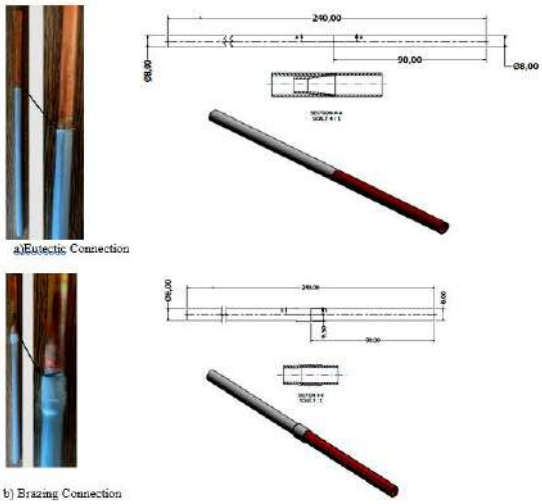



Figure 12. Eutectic Connection and Brazing Connection.

## EXPERIMENTAL TESTS

### Tensile Test

Ten samples were prepared and the tensile test was applied. At the end of the tensile test, the maximum shear force in the eutectic joint was 1108.59N, and the maximum stress amount was 22.33 N/mm².

The average maximum shear force in the brazing joint was 1097.11 N, and the average maximum stress amount was measured as 22.72 N/mm². In all tensile tests, all sample types were broken by the aluminum tube, not the connection point (Figure 13).

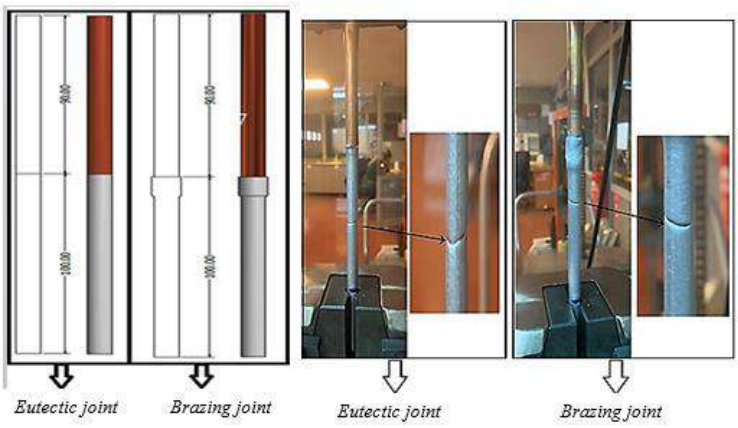



Figure 13. Tensile Testing of eutectic welded and brazed parts.

**Leakage Test**

All samples were connected to the leak tester shown in Figure 14a. A total of 600 samples were tested, 200 of each type of sample. One end of the samples was connected to the device and the other end was closed with clamps for blinding in order to complete the test.

In the test device, 10 bar helium gas was injected into the sample. Tested for 60 seconds in pressurized Helium gas. During the test period, the device checks whether there is helium gas emission to the environment with helium gas detectors in the closed cabinet. The device gives an audible warning when there is leakage in the samples and lights up a red warning lamp. If there is no leakage, it can be seen that there is no leakage in the samples by turning on the green warning lamp. At the end of the tightness test, 2 (1%) leaks occurred in both welded connections.

**Pressure Burst Test**

In the blast test, the samples were placed in the test cabinet and the cabinet of the device was closed. Pressurized hydraulic oil is sent into the sample by the test operator. The pressure at which the samples exploded was checked over the pressure gauge. Three samples were tested and the averages of the results were taken (Figure 14 b).

The samples with eutectic connection were damaged at 210 bar, the aluminum tube body part.In the brazed joint specimens, damage occurred just below the expanded pipe joint for brazing application at 180 bar.

Figure 14. a) Leakage Test; b) Pressure Burst Test

**Eutectic and brazing Microstructure Investigation (SEM) Al soluble in Cu**

The microstructure images of the cross-sectional surface of the eutectic junction are given in Figure 15.The connection area and line are clearly visible. As you get closer to the images, aluminum and copper structures that dissolve in each other appear in the connection area. These structures are formed during the coupling when the eutectic temperature is reached.

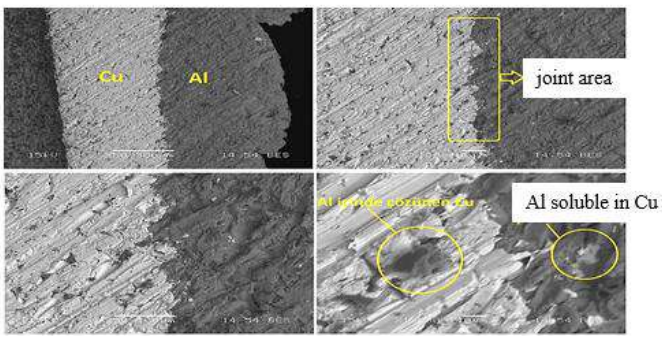



Figure 15. Eutectic Junction Microstructures.

The microstructures of the brazing joint are given in Figure 16. In the images, the presence of aluminum region, copper region and intermediate transition regions filling between copper and aluminum were observed. The border lines between these regions are clearly observed. The region shown as the filler area is the image of the molten filler metal filling the area given as the joint gap between the aluminum and copper pipe. It is seen that the intermediate space is filled by the filler metal in such a way that there is no gap.

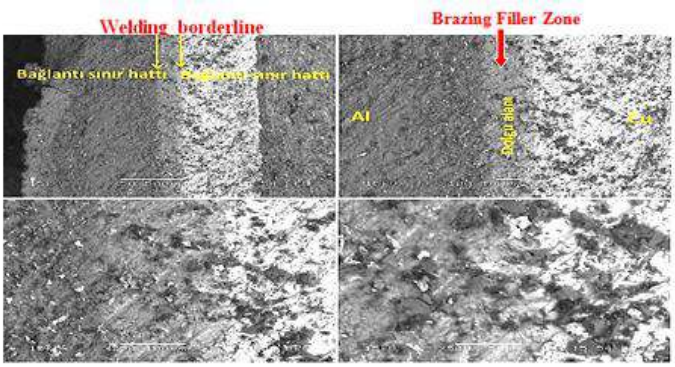



Figure 16. Brazing Microstructures.

**Welding Connection Lengths**

In the measurements made on the sample connection surfaces with a microscope with a camera, the connection length of the eutectic-bonded aluminum and copper pipe is 3.37 mm, and the connection length of the aluminum and copper pipe connected by brazing is 7.01 mm (Figure 17). The difference between them is 52%.

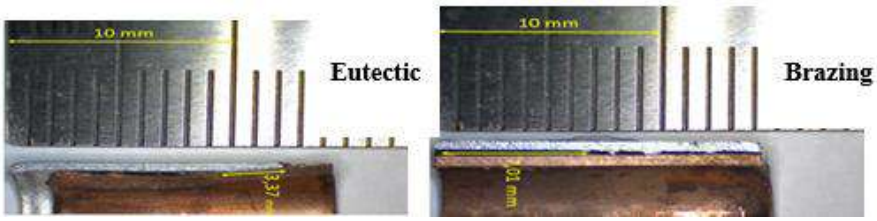



Figure 17. Eutectic and Brazing Weld Joint Lengths.

**RESULTS AND DISCUSSION**

In the blast test results, the eutectic weld joint was measured an average of 16.67% higher than the brazed joint. It is thought that the reason for the low brazing connection is due to the thinning of the wall thickness due to the expansion of the pipe during the blowing process (Figure 18).

In the data obtained from the tensile test device, the maximum shear force in the average eutectic connection was measured as 1108.59 N, and the average maximum shear stress amount was measured as 22.33 N/mm² (Figure 19 a).

The average maximum shear force in the brazing joint was 1097.11 N, and the average maximum shear stress amount was measured as 22.72 N/mm² (Figure 19 b).

In the tensile test results, none of the specimens broke from the connection area, all of them broke from the aluminum tube. While the rupture in the eutectic connection occurred at the midpoints of the aluminum tube body, the specimens connected by brazing method ruptured at the

points close to the connection region. It is thought that this situation causes the punch to break from this region in the tensile test by weakening the material during pipe end inflation.

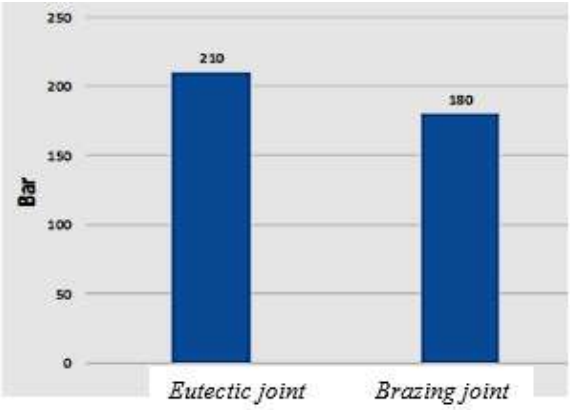
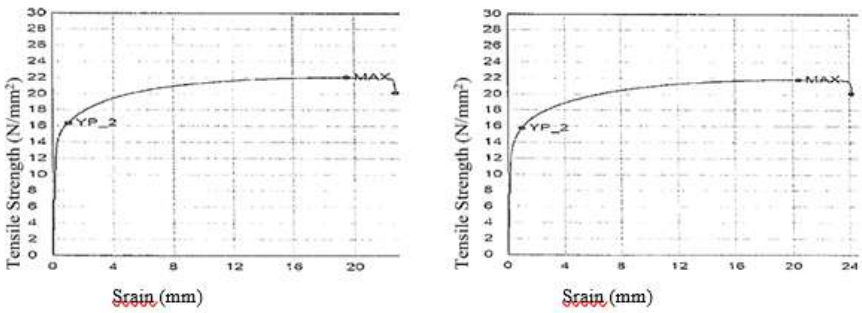



Figure 18. Blast test results.




a)Average Tensile test results for eutectic junction b) Average Tensile test results for brazing joint

Figure 19. Average Tensile test results for eutectic and brazing joint.

When the Leakage Test Results were evaluated, the tests were completed with 1% leakage. As can be seen in the Table 5, out of 200 samples tested, 2 (1%) samples with eutectic connections and 2 (1%) samples with brazing connections were detected, ie leaky samples.

Table 5. The Leakage Test Results.

| Property | Eutectic | Brazing |
|---|---|---|
| **Number of tests** | **200** | **200** |
| Number of Leaks | 2 | 2 |
| Leakage Percentage | %1 | %1 |

When the connection points of the eutectic connected sample were examined under the microscope, it was seen that aluminum and copper dissolved in each other and formed a bond at the junction boundary line. The bond surface is realized between the angled surface of the copper pipe and the surface where the aluminum contacts this point.

When the connection points of the brazed specimen were examined under the microscope, it was observed that the gap between the aluminum and copper tube was filled with molten filler metal and the connection was achieved.

## CONCLUSIONS

In the blast test results, it was determined that the eutectic weld joint was damaged at 16.67% higher pressure than the brazed weld joint

According to the tensile test results, the rupture points were realized from the aluminum pipe body for the eutectic weld joint, while for the brazed weld joint they were realized just below the connection area. As in the burst test, it is thought that this is due to the reduction in wall thickness due to pipe end expansion.

When we examined the results of the leak test, it was determined that the leak rate was 1% in brazed weld joint and brazed weld joint in the test study performed with 200 samples each.

In the SEM analysis, it was observed that both welded joints had good penetration without gap formation. Aluminum and copper structures dissolving in each other in the eutectic junction region showed good penetration. In hard solder, copper and solder filler and aluminum solder filler provide good penetration.

Although the eutectic connection creates a 52% shorter connection than the brazing connection, it provides a 16.67% advantage in blasting pressure. It also showed similar strength in the tensile test with a shorter connection.

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# INVESTIGATION OF STATIC AND DYNAMIC STRENGTH OF AIR SUSPENSION BELLOWS IN HEAVY VEHICLES

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## ABSTRACT

Air suspension bellows is a rubber-based polymer material that needs to be used in heavy-duty vehicles. The service life of the rubber and court cloth used as the bellows material changes due to the process. While premature damage to the bellows increases the risk of accidents, frequent replacements cause an increase in costs. In this study, improvement studies based on the court cloth and the process were carried out. At the end of the study, two types of air bellows materials passed static tests. These tests are; DMA, RPA tests for pre-cooking rubber mixture; for court cloth, elongation, z and s twist, adhesion strength, court thickness. Tensile test, hardness and impermeability tests were applied to the samples after the vulcanization process. With the improvements made, the mechanical tests have been confirmed. Blasting and fatigue tests were carried out for the life of the bellows. The mold firing temperature was reduced from 185°C to 180°C, the time was reduced from 415 seconds to 385 seconds, and it was determined that the product life of the bellows increased by 15% at 12 bar constant pressure.

**Keywords**: Air suspension bellows, Rubber, Court cloth, Bellows bursting test, Fatigue test.

## INTRODUCTION

Heavy vehicles are special vehicles that are exposed to high stresses and vibrations due to the weight of the loads they carry. Therefore, they need an effective suspension system to ensure safety, increase driving comfort and maintain the durability of vehicles. At this point, air suspension systems come to the fore as a preferred solution for heavy vehicles. Air suspension systems use air pressure to control the vehicle's height and adapt to varying height loads. These systems can change the ground clearance by adjusting the height of the vehicles, thus improving aerodynamic performance when traveling at high speed. In addition, height-adjustable suspensions provide vehicles with better handling on uneven surfaces and increase comfort for the driver and passengers (Pahl, 2016).

The purpose of this research is to examine the static and dynamic strength of air suspension bellows used in heavy vehicles. Air suspension bellows are subject to vibrations and stresses that vehicles encounter when carrying high loads and in various road conditions. Therefore, understanding how these bellows behave under static and dynamic load is of great importance for both safety and performance. Improvement studies were carried out based on the research, the court cloth in the air suspension bellows and the production process. These studies were also evaluated with static and dynamic strength tests. In addition, the factors affecting the strength will be analyzed and the existing systems will be improved. This research aims to contribute to making the suspension systems of heavy vehicles safer, durable and efficient.

### Air Suspension Bellows

Air suspension bellows are defined as elastomeric structures that are an important component in the suspension systems of heavy vehicles. These bellows fulfill the task of the springs in the suspension system of the vehicles. It is designed to adjust the vehicle height using high pressure air and to optimize the suspension in laden or unladen conditions.

Air suspension bellows are generally produced from high-strength rubber or elastomeric materials and attract attention with their compressibility and tensile strength properties. Its task is to regulate the height of the vehicle, adapt to varying loads and help the suspension system to provide high performance, safety and driving comfort (Zhu, & Ye, 2017).

Air suspension bellows increase the load carrying capacity of heavy vehicles and increase driving comfort by absorbing vibrations and shocks. It also improves aerodynamic performance with height adjustment and optimizes vehicle handling. Air suspension bellows is considered a critical component to increase the durability and performance of heavy vehicles (Prokopov, 2005).

The general structure of air suspension bellows is formed by the use of two or more interlocking layers of rubber or elastomeric. These sheets are made of materials with compressible and high tensile strength properties. There may also be reinforcement elements inside the bellows to hold the air pressure.

In terms of components, air suspension bellows usually consists of four layers. These are the inner rubber, the first and second court cloth, and the outer rubber (Figure 1).

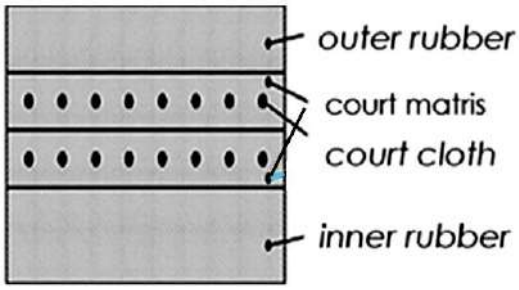


Figure 1. Layers (Oman et al., 2010).

The first layer, the inner rubber, is used to prevent the leakage of the compressed air supplied to the system.

The court cloth in the second and third layers is wrapped at certain angles and brought together in the form of knitting. Court cloths are used in pairs, thereby suspending incoming counterforces.

The last layer of outer rubber is used to protect the bellows against harmful external effects.

Air suspension bellows, created by the combination of these components, play an important role in controlling the height of vehicles, adapting to varying loads and increasing the performance of the suspension system.

## MATERIAL AND METHODS OF WORK

### Material

In this study, a single type of dough mixture and 2 types of court cloths were used in the air suspension bellows. It is a product that contains more than one component in rubber materials and emerges as a result of the interaction of these components with each other. Major components are as follows:

- Polymer (rubber)
- Fillers
- Antiozonant
- Antioxsidant
- Oils
- Resin
- Cookers
- Accelerators

The rubber mixture is the recipe (mixture) in Table 1 below; The recipe (mixture) in Table 2 was used for the lining of the court cloth. The inner and outer rubber mixture (Table 1) and the

court matris rubber mixture (Table 2), which make up the rubber layers in Figure 1, were obtained as a result of our previous preliminary studies.The difference of this mixture from other mixtures is that the filler and polymer combinations used affect the product life.

Table 1. Outer and inner Rubber mix .

| Covering | phr |
|---|---|
| SVR CV 60 | 60 |
| SBR 1723 | 27.5 |
| CBR 1203 | 20 |
| N326 | 47 |
| Silica | 7.5 |
| Naphtanic Oil | 10 |
| ZnO | 5 |
| Zinc Stearat | 1.5 |
| TMQ | 2 |
| Resin | 2 |
| Total | 182.5 |
| Sulfur | 4.5 |
| Sulfenamide group accelerator | 2.8 |

Table 2. Court matris mix.

| Lining | phr |
|---|---|
| SVR CV 60 | 40 |
| CB 22 | 60 |
| ZnO | 4 |
| STA | 1.5 |
| Aktiplast | 2 |
| Antilux | 1 |
| TMQ | 2 |
| N326 | 50 |
| Parafinic Oil | 5 |
| Resin | 2 |
| Total | 167.5 |
| Sulfur | 2.5 |
| Sulfenamide group accelerator | 1.5 |

(phr: parts per hundred of rubber)

Two types of court cloth were used in experimental studies. The polymer material of the court cloth is PA66 (Polyamide 6.6). Technical specifications are given in Table 3 and Table 4. The numbers and letters on the court cloth are explained below.

NY1400_2_120
NY: NY 6.6 (Polyamide 6.6)
1400: Weight of 1 km is 140 g,
2: Twist in 2 directions
120: Indicates the number of courts in decimeters.

NY940_2_130
NY: NY 6.6 (Polyamide 6.6)
940: Weight of 1 km is 140 g,
2: Twist in 2 directions
130: Indicates the number of courts in decimeters.

Table 3. Court cloth technical specifications type 1.

| (Type1) NY1400_2_120 | | | | | |
|---|---|---|---|---|---|
| Physical Properties | **Unit** | **Min** | **Target** | **Max** | **Average** |
| Breaking Strength | kgf | 22 | - | - | 22.73 |
| Elongation at Break | % | 21.5 | 24.5 | 32 | 27.5 |
| Z Twisting | TPM | 280 | 300 | 320 | 305 |
| S Twisting | TPM | 280 | 300 | 320 | 299 |
| Cord Thickness | mm | 0.63 | 0.68 | 0.73 | 0.66 |

TPM: twist per meter

Table 4. Court cloth technical specifications type 2.

| (Type2) NY940_2_130 | | | | | |
|---|---|---|---|---|---|
| Physical Properties | **Unit** | **Min** | **Target** | **Max** | **Average** |
| Breaking Strength | kgf | 14 | - | - | 14.8 |
| Elongation at Break | % | 23 | 24.3 | 25 | 24 |
| Z Twisting | TPM | 330 | 350 | 350 | 350 |
| S Twisting | TPM | 330 | 350 | 350 | 350 |
| Cord Thickness | mm | 0.57 | 0.58 | 0.59 | 0.58 |

In the trial studies, rubber and the rubber materials on which the court cloth is covered were kept constant. A single type of rubber mixture and two different court cloths are used. Polyamide 6.6 was used as the court cloth material. As a result of the tests performed on both types of court

cloths, the 'NY1400' court cloth type with a high thread thickness was preferred. In the experimental study, it was aimed to increase the material life by working on the vulcanization conditions (parameters) by using existing rubber mixtures and court cloth. Experimental tests on materials are shown in Table 5.

## METHOD

### Banbury

The rubber mixture is processed in the mixers called Banbury, in the following steps:

Preparation of Materials: The rubber, fillers, chemical additives and other components to be mixed are pre-weighed. These materials are generally used in granule or powder form.

Preparation Procedures: Necessary precautions should be taken for the preparation of the Banbury mixer. The inside of the mixer should be cleaned and the necessary heating/cooling systems should be checked.

Heating of the Mixer: It is heated inside the Banbury mixer at a suitable temperature (usually close to the processing temperature of the rubber material) by a heating system. This ensures a better dispersion of the ingredients and helps the mixture to be homogeneous.

Addition of Materials: Prepared rubber material, fillers, chemical additives and other components are added sequentially to Banbury. Usually, the rubber material is pre-added, and then fillers and other additives are added.

Mixing Process: When mixing is started, the Banbury mixer usually has rotating discs or a semi-cylindrical bowl. While the mixer rotates at high speed, it holds the ingredients together, kneads and distributes them. This process is necessary for the materials to form a homogeneous mixture. Mixing time often varies depending on the properties and components of the rubber mixture.

Cooling: After mixing is complete, it is usually cooled by the Banbury mixer cooling system. This ensures that the mixture remains within a certain temperature range and maintains the desired properties of the mixture.

Removal of Mixture: When mixing is complete, the door of the Banbury mixer is opened and the mixture is removed. The mixture is usually immediately transported to another processing step or storage container to protect against plasticization.

### Molding The Air Bellows

General steps for molding air suspension bellows:

Mold Design: The first step is to design a suitable mold for the air suspension bellows. The mold should contain the desired bellows shape and dimensions. Mold design can be done using engineering calculations, CAD (Computer Aided Design) or other design tools.

Mold Preparation: The mold is cleaned and the necessary mold accessories (e.g. locating rings or cores) are added. The mold surface is usually coated with a release agent or a non-stick material.

Final Operations: The bellows is cleaned of its residues after being removed from the mold. In addition, the controls of the bellows are made in accordance with the quality standards.

### Vulcanization

The vulcanization process of air suspension bellows is a method used to harden rubber material. Vulcanization increases the durability of the rubber by enabling it to gain elastic properties. Before the vulcanization is placed in the press mold, the figure is given with air in the pre-Shaping section and then the product is placed in the press. The bellows, which takes the shape of the mold with the help of the hot air coming from the lower mold, is cooked in accordance with the determined temperature, pressure and time parameters.

Figure 2. Vulcanization (Cooking) press.

## EXPERIMENTAL TESTS

It is important that the design, material selection, assembly methods and tests are carried out correctly in order for the bellows systems to work correctly and to have a long life (Yılmaz, 2017).

Certain tests were carried out for the rubber and court cloths used in the experiments. These tests are tests for quality control purposes to evaluate the performance of the material and its usability in certain applications.

### RPA and DMA Test

RPA (Rheological Process Analysis) test helps to determine the characteristics of the material such as elasticity, viscosity, heat resistance. RPA results provide information on the material's machinability, hardness, tensile properties, and durability.

DMA (Dynamic mechanical analysis) test is used to examine some mechanical behavior of rubber material. This test measures the properties of the material such as modulus of elasticity, damping factor, tan δ (shear angle). DMA results provide information on factors such as the material's vibration resistance, fatigue life, and operating temperature range.

DMA is based on measuring the response of a material after a variable load is applied to it. In other words, energy is applied to the material and how much of the applied energy is transmitted back by the material is measured. The difference represents energy loss. Another advantage of dynamic mechanical analysis is that the frequency of applied force and temperature can be tested at desired time intervals. In this way, it can be decided which of the characteristics of the material is better.

The 1400_2 (Type 1) court cloth was tested at 180°C for 385 seconds.

Table 5. DMA (Dynamic mechanical analysis) results.

| | Unit | Requested | Measured | Test Standard |
|---|---|---|---|---|
| DMA<br>Glass Transition Temperature (Tg) | °C | -40 | -70 | ASTM D7028 |

ASTM D7028 provides a standardized procedure for determining the Tg (The glass transition temperature) of polymer matrix composites using the dynamic mechanical analysis (DMA) technique. DMA involves subjecting the material to oscillating deformations to characterize its elastic and viscous behavior. By analyzing how the material responds to temperature variations, this test method enables the determination of Tg.

### Tensile and Hardness Test

Tensile test and Shore A hardness tests were applied to the bellows samples after vulcanization. Tests were carried out by cutting at least 3 pieces of tensile test samples in ASTM D412 Standards over the bellows samples.

The technical specifications of the bellows rubber after vulcanization are given in Table 6.

**Blast Test**

The blast test is a test performed by filling the bellows with water. The test was carried out in accordance with the TS EN 13597 Standard. As a result of the test, the test is completed when the bellows ruptures from the inside to the outside or when a popping sound is heard. The test bellows specimens resisted undamaged up to a pressure of approximately 23 bar.

At 180°C and 385 s, the samples were determined to withstand up to 26.5 bar pressure (15.2%). The following image shows an example of a test (Figure 3).

Table 6. Technical characteristics of Rubber after vulcanization (1400_2 Court cloth).

| **Technical Data** | | | | |
|---|---|---|---|---|
| Specification | **Unit** | **Requested** | **Measured** | **Test Standart** |
| Hardness | Shore A | - | 60 | ASTM D 1415 |
| Density | g/cm³ | - | 1.13 | ASTM D 1817 |
| Tensile Strength | MPa | ≥ 15 | 17.5 | ASTM D 412 |
| Elongation at Break | % | ≥ 400 | 410 | ASTM D 412 |
| | **RPA** | | | |
| Frequency: 3 Hz<br>Temperature: 180°C | - | - | 0.18 | ASTM D 6601 |

| | |
|---|---|
| Displacement | ± 75mm |
| Pressure | 7 bar |
| Frequency | 2 Hz |
| Mounting Height | |

| | |
|---|---|
| Mounting Height | 20 mm |
| Water Flow Rate | 10 Bar\min |
| Blast Pressure | 28 Bar |
| Test Duration | 2,8 min |

Figure 3. MTS test parameters and damaged specimen after bellows blast test.

**MTS Life Test**

MTS (Machine Test System) life test is a test performed by moving the bellows in a vertical position multiple times under the influence of real forces, with reference to the way the bellows works in the vehicle. As a result of the test, it is considered sufficient to complete its life in a minimum of 1 000 000 cycles. The test is completed if the valid criterion in products that have reached the end of their life is the separation of the court or air leakage.

As a result of the testing of the samples at 180°C and 385 s, the bellows completed its life in 1 150 000 cycles. (15%)

In the bellows after the Mts test:

- The rubber separates from the court cloth (Figure 4.a)
- Bubbles form on the outer surface (Figure 4.b)
- There are cracks on the inner surface (Figure 4.c).

a) Separation b) Bubble c) Cracks

Figure 4. Errors after bellows test.

## RESULTS AND DISCUSSION

Firstly, bellows firing processes were carried out at mold firing temperature from 185°C to 175°C, firing time from 415 seconds to 360 seconds and at 12 bar constant pressure. Details are given in Table 7 below. After firing, DMA, blasting and life tests were carried out.

In a similar study, it has been shown that the changes made in the vulcanization parameters affect the product life. It has been observed that plastic deformation occurs in the structures of court cloths depending on time, and therefore, there are improvements in product life with changes in vulcanization (Turna, 2017).

Another study investigated the fatigue strength of rubber cord composites commonly used in air suspensions. He investigated the effects of five process and material parameters to determine the static and dynamic mechanical properties of rubber/cord composite structures. These parameters are the type of yarn, temperature, pressure, cooking time and cord angle. It has been shown that these parameters determine the mechanical life of the bellows (Kapucu, 2017). In this study, vulcanization process parameters were optimized considering that the vulcanization process in air suspension bellows used in heavy vehicle vehicles has a significant effect on product life. The vulcanization process parameters are shown in Table 7. When the tensile strengths of the samples using Type 1 and Type 2 court cloth were compared, it was determined that the strength of Type 1 court cloth was 21% higher on average.

Table 7. Vulcanization process parameters.

| **Vulcanization Parameters** | **1. Test** | **2. Test** | **3. Test** | **4. Test** |
|---|---|---|---|---|
| Temperature | 185°C | 180°C | 180°C | 175°C |
| Pressure (bar) | 12 | 12 | 12 | 12 |
| Time (sec) | 415 | 385 | 360 | 385 |

Table 8. General test results.

| Properties | 1. Test (185°C) | 2. Test (180°C) | 3. Test (180°C) | 4. Test (175°C) |
|---|---|---|---|---|
| Test Number | 3 | 3 | 3 | 3 |
| MTS | 1 000 000 | 1 150 000 | 990 000 | 985 000 |
| Blast Test (bar) | 23.0 | 26.5 | 22.9 | 22.8 |
| Vulcanization Time (sec) | 415 | 385 | 360 | 385 |

## CONCLUSIONS

This study shows that the vulcanization process in air suspension bellows used in heavy duty vehicles has a significant effect on product life. It has been determined that optimizing the vulcanization process in the bellows increases the product life.

It has been determined that the product life increased by 15% with the optimum vulcanization parameters (temperature, pressure and time) obtained with a single type of dough mixture and two

types of court cloth, and also the blasting pressure in the bellows withstands a higher pressure by 15.2%.

In tensile tests, it has been determined that the tensile strength of Type 1 court cloth is 21% higher than Type 2 court cloth.

When the ideal cooking is provided in the bellows, the wearing or loosening of the court cloths is delayed depending on time. In this way, it is thought that the carrying capacity also increases with time.

As a result, the life of air suspension bellows used in heavy-duty vehicles can be significantly increased if the correct vulcanization process and optimum parameters are used. This will reduce the maintenance costs of vehicles and provide a safer driving experience.

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# QUALITY TESTING OF SODIUM BICARBONATE

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## ABSTRACT

Sodium bicarbonate ($NaHCO_3$), also known as baking soda, is widely used in different branches of industry (chemical, food, pharmaceutical, cosmetic, etc.), but also in the household. When talking about the use of baking soda in the household, one of the frequent questions is whether it contains aluminium. Therefore, the aim of this work is to examine the quality of commercially available baking soda products.

Samples used for analysing the quality of products are different commercial products found in marketplaces and pharmacies in Banja Luka, and one sample obtained directly from the soda ash factory. In this paper the products were tested for the concentration of $NaHCO_3$, chlorides, ammonium ion and aluminium, in accordance with standard methods.

The results show that the mass fraction of $NaHCO_3$ for all tested samples is very high (99.30%–99.99%). The tested concentrations of chloride and ammonium ions also show slight deviations in the tested samples, and the obtained values range from 0.00%–0.05%. The presence of aluminium was found in all tested samples in traces, and the obtained values range from 0.0025%-0.0050%.

Based on the obtained results, it can be concluded that all tested samples of baking soda from the domestic market are of extremely high purity, while impurities are present in very low concentrations.

**Keywords**: sodium bicarbonate, commercial product, quality, impurities.

## INTRODUCTION

Sodium bicarbonate, also known as baking soda, is a white inorganic salt, characterized by good solubility in water. Sodium bicarbonate ($NaHCO_3$) is considered an important “green” chemical, which is widely used in the food and chemical industry, in pharmaceutical products, additives, detergents, etc (Jiang et al., 2019). This salt starts to decompose at temperatures higher than 82°C (Hartman et al., 2013) into sodium carbonate, water, and gaseous carbon dioxide, which causes faster fermentation (Fakhri et al., 2016). Evidence of the harmful effects of sodium bicarbonate use on general health has not been found in the literature. On the other hand, many benefits of using this compound in therapeutic doses have been reported (Fakhri et al., 2016).

Sodium bicarbonate can be produced by crystallization reactions, from different raw materials, such as sodium carbonate, sodium chloride, sodium sulphate, etc.

All reactions can be divided to:

- direct synthesis – sodium bicarbonate is produced directly, without intermediaries,
- indirect synthesis – first, complete or incomplete production of sodium carbonate, and then the production of desired product, $NaHCO_3$.

Production of sodium bicarbonate from natural resources implies production from mineral deposits – mineral trona. The production process requires relatively small material and energy costs, it is included in the so-called "green technologies", which gives it an advantage, compared to the processes of synthetic soda production. Mineral trona is a mixture of carbonates with the general formula $Na_2CO_3 \cdot NaHCO_3 \cdot 2H_2O$. However, the mineral is usually contaminated with other minerals (clay, halite, quartz, dolomite, oil shale, mica), which most often contain the elements Ca,

Mg, Al, Fe, S, P, organic carbon (Lazić et al., 2021). The accompanying minerals must be removed, which complicates the production process. However, the main disadvantage of this process is that the raw material (trona) is only found in certain locations in Namibia, Turkey, Tanzania, China, and Wyoming in the USA, which significantly increases the cost of transportation (Bonfim-Rocha et al., 2019).

The most common indirect production process of sodium bicarbonate is a synthetic and very complex production process known as the Solvay process. The main raw materials for sodium bicarbonate production according to the Solvay process are NaCl, $CO_2$, and $NH_3$ as additional compound that is not included in the composition of the final product, and which is constantly regenerated. This process is based on the formation of hardly soluble sodium hydrogen carbonate by introducing carbon dioxide into a solution of sodium chloride saturated with ammonia. The technological procedure to produce soda ash can be broken down into several stages, and is represented by a summary reaction (Lazić et al., 2021):

$$NaCl + CO_2 + NH_3 + H_2O \rightarrow NaHCO_3 + NH_4Cl$$

Because of the content of the impurities, produced $NaHCO_3$ does not meet the necessary quality to be used in the food and pharmaceutical industry (Lazić et al., 2021). Therefore, the obtained $NaHCO_3$ is converted into soda ash ($Na_2CO_3$) by calcination, and then $CO_2$ is introduced into the prepared solution of soda ash to produce baking soda, according to the reaction:

$$Na_2CO_3 + CO_2 + H_2O \rightarrow 2NaHCO_3$$

Due to the high demand for baking soda, the production of $NaHCO_3$ becomes one of the possible solutions for using waste $CO_2$, which would enable not only the reduction of its emission into the air but also for $CO_2$ to become a valuable raw material (Bonfim-Rocha et al., 2019).

## MATERIAL AND METHODS OF WORK

Samples of baking soda used for this research are different commercial products found in marketplaces (4 samples) and pharmacies (2 samples) in Banja Luka, and one sample obtained directly from the soda ash factory.

Commercial names of sodium bicarbonate samples are:

- Soda from factory (Industrial),
- Soda Orgona,
- Soda Topingo,
- Soda Brič,
- Soda Bonito,
- Soda Unijapak,
- Soda without aluminium.

The initial solutions used for analysis were prepared by dissolving the samples in a concentration of 1 g/dm$^3$.

All solutions used in this research were prepared with deionized water with an electrical conductivity of 0.055µS/cm.

An overview of the analysed parameters and standard test methods is presented in Table 1.

Table 1. List of analysed parameters and used standard methods.

| Parameter | Unit | Method |
|---|---|---|
| $NaHCO_3$ | mg/dm$^3$ | Volumetric (acidimetry) |
| $Cl^-$ | mg/dm$^3$ | Volumetric (argentometry) |
| $NH_4^+$ | mg/dm$^3$ | Volumetric (Kjeldahl method) |
| Al | mg/dm$^3$ | Spectrophotometric with eriochrome cyanine R |

Because of the impossibility of measuring absorbance for aluminium, which was in a very low area due to the low concentration of Al in tested samples of baking soda, sample spiking was performed. Sample spiking refers to the addition of a solution of exactly known concentration to the tested sample. The concentration of a standard solution (spike) was 0.1197 mg/dm$^3$ Al, and in each sample was added 2 cm$^3$ of prepared standard. After measuring the concentration of Al in spiked samples, the concentration of the spike was subtracted, to obtain the concentration of Al in the examined samples.

**Calculations**

After the experimental work and concentration measurements, final concentrations and percentages of some analysed components that can be found in baking soda and can determine its purity, are calculated using the following equations:

$$NaHCO_3\left(\frac{mg}{dm^3}\right) = V_{(HCl)} \cdot C_{(HCl)} \cdot M_{(NaHCO_3)} \cdot \frac{1000}{100} \quad (1)$$

$$Cl^-\left(\frac{mg}{dm^3}\right) = V_{(AgNO_3)} \cdot C_{(AgNO_3)} \cdot M_{(Cl^-)} \cdot \frac{1000}{100} \quad (2)$$

$$NH_4^+(\%) = \frac{(V_1 - V_2) \cdot 0.0018}{m_{sample}} \cdot 100 \quad (3)$$

In equation (3) $V_1$ and $V_2$ are volumes of NaOH standard solution spent in the titration of blank and sample, respectively, during the determination of ammonia by standard Kjeldahl method.

**RESULTS AND DISCUSSION**

The results of testing the purity of baking soda in all tested samples were over 1000 mg/dm$^3$. For this reason, an analysis of the deionized water was performed for the tested parameters. The analysed parameters of deionized water are:

$$NaHCO_3(mg/dm^3) = 15.57$$
$$Cl^-(mg/dm^3) = 1.80$$
$$NH_4^+(mg/dm^3) = 1.02$$

For all analysed samples of baking soda, obtained values of concentrations for hydrogen carbonates, chlorides, and ammonium ions collected for deionized water were subtracted from total concentrations obtained after analysis of samples prepared with that deionized water. The final, corrected results for baking soda samples are presented in Table 2.

Titration with HCl standard solution showed that analysed samples do not contain $OH^-$ and $CO_3^{2-}$ ions (Table 2), and alkalinity is due to the presence of $HCO_3^-$ ions. A fresh solution of sodium bicarbonate 0.1 mol/dm$^3$ (10.6 g/dm$^3$) has a pH value of about 8.3, regardless of concentration.

Table 2. The results for analysed samples of baking soda.

| Parameter | Values obtained for analysed samples of baking soda | | | | | | |
|---|---|---|---|---|---|---|---|
| | Industrial | Orgona | Topingo | Briž | Bonito | Unijapak | Without Al |
| $OH^-$ (mg/dm$^3$) | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| $CO_3^{2-}$ (mg/dm$^3$) | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| $NaHCO_3$ (mg/dm$^3$) | 999.5 | 993.1 | 999.5 | 994.3 | 994.8 | 999.9 | 995.7 |
| $Cl^-$ (mg/dm$^3$) | 0.360 | 0.360 | 0.360 | 0.721 | 0.000 | 0.541 | 0.000 |
| $NH_4^+$ (mg/dm$^3$) | 0.000 | 0.500 | 0.000 | 0.000 | 0.000 | 0.320 | 0.000 |
| Al (mg/dm$^3$) | 0.025 | 0.029 | 0.052 | 0.035 | 0.049 | 0.049 | 0.015 |
| Ɛ | 999.89 | 993.99 | 999.90 | 995.06 | 994.85 | 1000.81 | 995.72 |

Consumption of the standard HCl solution (0.1 mol/dm$^3$) in the titration with the methyl orange indicator enables the calculation of $NaHCO_3$ concentration according to equation 1, but also the mass fraction, which indicates the degree of purity obtained.

The mass fraction of $NaHCO_3$, for all tested samples of baking soda, is shown in Figure 1.

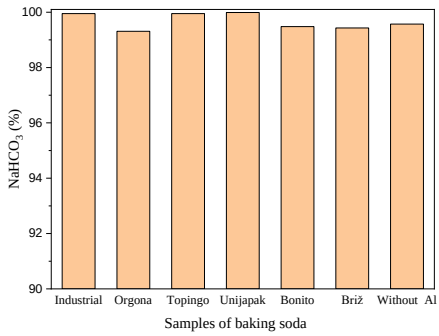


Figure 1. Mass fraction of $NaHCO_3$ in analysed samples of baking soda.

Figure 1 shows that the mass fraction of $NaHCO_3$ for analysed samples of baking soda is in the range of 99.30% to 99.95%, which means that all samples are of a very high degree of purity. The highest degree of purity is the Unijapak sample, with 99.99%, and the lowest degree of purity (99.30%) was found in the Orgona sample. The sample "Baking soda without aluminium" is the only sample that has an indicated $NaHCO_3$ content on the declaration, which is 99.9 g/100g, while in this research the $NaHCO_3$ content was found to be 99.6 g/100g.

The Solvay process is the most significant and widely used in the production of baking soda. The main raw material in this production process is a saturated solution of NaCl. $CO_2$ and $NH_3$ are introduced into the solution of sodium chloride, and sodium bicarbonate is produced. Therefore, chlorides are one of the possible impurities in the final product.

The mass fraction of chlorides, for all analysed samples of baking soda, is shown in Figure 2.

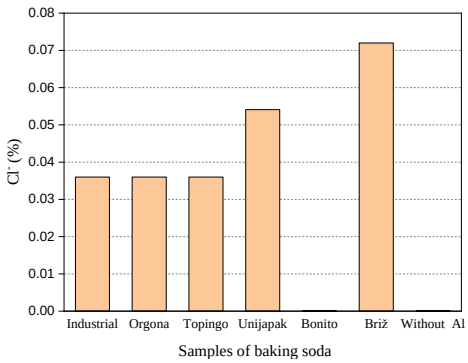


Figure 2. Mass fraction of chlorides in analysed samples of baking soda.

Figure 2. shows that chlorides are not present in two samples: Bonito and Baking soda without aluminium. The Brič sample has the largest mass fraction of chloride, which is 0.072%. Other samples (Industrial, Orgona and Topingo) have an identical mass ratio of present chlorides, which is 0.036%.

Ammonium is an additional compound in the production of sodium bicarbonate, without which $NaHCO_3$ crystals would not form. The ammonia regeneration process is responsible for maintaining this way of producing baking soda. Regeneration enables the circulation of expensive chemicals (ammonia) in the production process, but also environmental protection. Of course, the ammonium ion should not be present in the final product. For this reason, the samples were tested for the presence of ammonium ions.

The mass fraction of ammonium ions, for all analysed samples of baking soda, is shown in Figure 3.

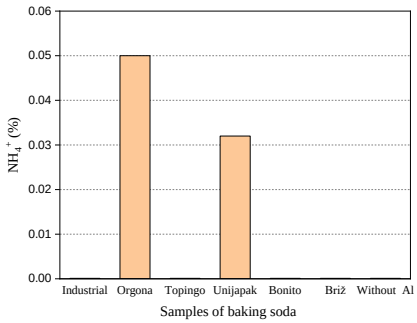


Figure 3. Mass fraction of ammonium ion in analysed samples of baking soda.

During experimental work for the determination of ammonium ion concentration, the obtained values for NaOH (0.1 mol/dm$^3$) consumption during titration of samples, for five tested samples (Industrial, Topingo, Brič, Bonito, Without Al) were identical to the NaOH consumption in titration of the blank (deionized water). Based on that, it was concluded that ammonium ion is not present in the mentioned samples. On the other hand, the presence of a very small amount of ammonium ion (in traces) was found in the two other samples, Orgona (0.05%) and Unijapak (0,03%).

Given that in our region the Solvay process is used to produce baking soda, it was interesting to examine whether any of the commercial samples of $NaHCO_3$ were produced from trona minerals. Usually, soda produced from trona minerals has more impurities. One of the frequent doubts about the use of baking soda in households is whether it contains aluminium. This doubt arose due to the identifying baking soda as a baking powder because baking powder contains one or more acids and starch in addition to baking soda. Very often, salts of phosphoric or tartaric acid, potassium-sodium tartrate, or sodium-aluminium sulphate are added as an acid component.

The analysis for the presence of aluminium in soda samples was carried out spectrophotometrically, so it was necessary to first construct a calibration curve for aluminium. The calibration curve for aluminium is shown in Figure 4.

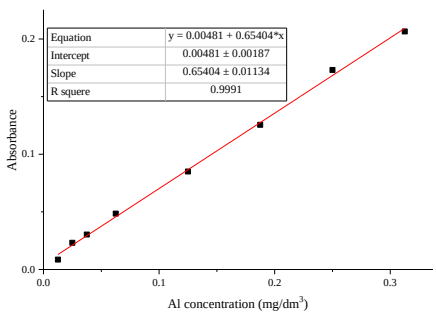


Figure 4. Calibration curve for Al.

The obtained values of the aluminium concentration for all tested samples, minus the concentration of the added spike, are presented in Figure 5.

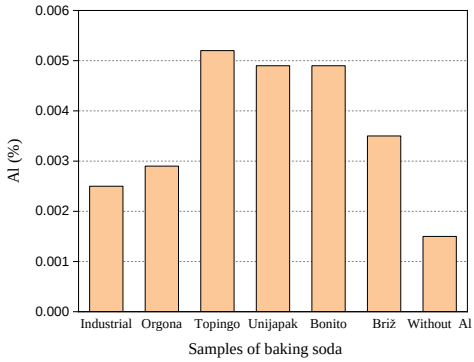


Figure 5. Mass fraction of aluminium in analysed samples of baking soda.

In all samples, aluminium is present in very low concentrations, and the lowest concentration of aluminium was found in the sample labelled as Soda without aluminium, with a percentage content of 0.0015%. Based on the analysis performed and the aluminium content, it can be stated that the samples of baking soda that can be found on the domestic market are produced entirely by the Solvay process.

All tested samples of baking soda have a certain concentration of aluminium in traces, although aluminium is not introduced into the production process as raw material. The assumption is that the presence of aluminium in the tested samples comes from the rinsing water (drinking water). During the production of drinking water, $Al_2(SO_4)_3$ is added as a coagulant to the water. Its residual concentration is prescribed by the Regulations (Pravilnik o zdravstvenoj ispravnosti vode namjenjene za ljudsku potrošnju, 2017), which is 0.2 mg/dm$^3$. However, even the highest concentration of Al, found in the sample Topingo (0.052 mg/dm$^3$), is significantly lower than the maximum allowed concentration of aluminium in drinking water.

## CONCLUSIONS

Baking soda is a commercial product that receives a lot of attention due to its use in various branches of industry, as well as in the household, so testing its quality is of great importance. This research aimed to examine the quality of some samples of baking soda, which can be found on the domestic market. Based on the conducted analyses, it was established that the tested samples have a high degree of purity and are of uniform quality regardless of the manufacturer. All tested impurities are present in small concentrations, so it can be said that these are high-quality samples. The high quality of the tested samples indicates that during the production process of baking soda, there is strict quality control of both incoming raw materials and the final product.

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# MULTILAYER PERCEPTRON CLASSIFICATION MODEL FOR DETECTING EMOTIONAL DISTRESS IN BREAST CANCER PATIENTS

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## ABSTRACT

Breast cancer is one of the most common malignancies, and one of the leading causes of cancer-related death among women. This research aimed to explain emotional distress based on self-empowerment skills and interpersonal interactions in breast cancer patients using the explainable multilayer perceptron classification model. The participants in this research were a sample of 735 patients age ranged from 19-80 with breast cancer from Tajrish Hospital in Tehran in 2022 who were selected by convenience sampling through online platforms. The survey assessments included demographic characteristics (age and job, marital status and educational level), emotional distress, self-empowerment skills, interpersonal interactions, and family care.

The data were analyzed using the Multilayer Perceptron Classification Model. The input layer includes age and job, marital status and educational level, self-empowerment skills, interpersonal interactions, family care and gender) and the output layer (target feature) includes emotional distress divided into low and high groups using a mean split. The results indicated that the accuracy of the classification in the training and test samples was 75.6% and 73.5% respectively. The AUC of 0.812 in the models was near to 1 indicating an excellent fit. Interpersonal interactions, self-empowerment, family care, age, having job, educational level and marital status were the most important effects in explaining the classification of emotional distress.

**Keywords:** breast cancer, emotional distress, multilayer perceptron, self-empowerment skills, interpersonal interactions.

## INTRODUCTION

Breast cancer is a prevalent and serious health concern affecting millions of women worldwide. It is among the most common malignancies and is one of the leading causes of cancer-related death among women. Breast cancer develops when abnormal cells in the breast grow uncontrollably, and if left untreated, can spread to other parts of the body. It is essential to diagnose and treat breast cancer as early as possible to increase the chances of successful treatment and improve patient outcomes. Breast cancer can cause significant emotional distress in patients. The diagnosis alone can be a traumatic and life-changing event, leading to fear, anxiety, and depression. Patients may experience feelings of shock, disbelief, anger, guilt, and helplessness. The uncertainty of the future and the potential impact on family and relationships can add to the emotional burden. Treatment, including surgery, radiation, and chemotherapy, can also be physically and emotionally taxing, leading to further distress. The fear of recurrence and the potential for long-term side effects can also contribute to ongoing emotional challenges. It is essential that healthcare providers address the emotional needs of breast cancer patients to support their overall well-being and quality of life.

Several studies have investigated the emotional distress experienced by breast cancer patients. For instance, a study by Grégoire et al. (2017) present results showed that mind–body interventions seem to be an interesting psychological approach to improve the well-being of breast cancer patients. Ouakinin (2015) described a predictive model which suggests the impact of pattern of anger management and an anxious attachment style in the emotional disturbance reported by these

patients. Findings suggest that insecure attachment schemes, dysfunctional anger regulation strategies and a lack of psychophysiological activation may be discussed as relevant factors that modulate emotional distress associated with the diagnosis of breast cancer. Cohen (2002) highlighted the importance and relevance of positive attitude for reducing emotional distress in general and level of anxiety in particular. Saeedi-Saedi (2015) concluded that oncology specialists should utilize mental health services to improve their patients' mental health as well as to control the consequences of the disease because emotional distress can affect the quality of life of breast cancer patients. Quattropani, Lenzo, Mucciardi & Toffle (2016) Stated that gender, negative beliefs and cognitive self-consciousness explained the 58% variance for overall distress of patients during chemotherapy.

Overall, these studies suggest that emotional distress is a significant issue among breast cancer patients, and interventions that address their emotional needs can be beneficial.

This goal of research is explaining emotional distress based on self-empowerment skills and interpersonal interactions in breast cancer patients using the explainable multilayer perceptron classification model.

## METHODOLOGY

The participants in this research were a sample of 735 patients age ranged from 19-80 with breast cancer from Tajrish Hospital in Tehran in 2022 who were selected by convenience sampling through online platforms. The survey assessments included demographic characteristics (age and job, gender, marital status and educational level), Emotional Distress, Self-Empowerment Skills, Interpersonal Interactions, and family care. The data were analyzed using the Multilayer Perceptron Classification Model. The input layer includes age and job, marital status and educational level, Self-Empowerment Skills, Interpersonal Interactions, and family care) and the output layer (target feature) includes Emotional Distress divided into Low and High groups using a mean split. For increasing the accuracy of the model and avoiding overfitting, two hidden layers were determined consisting of 12 and 10 units respectively. Activation functions used were the Hyperbolic tangent and Sigmoid in the hidden layer and output layer respectively. 70% of the total sample was used as the training sample and the rest was used as the test sample. Table 1 presents Network information.

Table 1. Network Information.

| **Network Information** | | | |
|---|---|---|---|
| **Input Layer** | Factors | 1 | gender |
| | | 2 | marital status |
| | | 3 | education level |
| | | 4 | job |
| | Covariates | 1 | age |
| | | 2 | familycare |
| | | 3 | self-empowerment |
| | | 4 | Interpersonalnteraction |
| **Hidden Layer(s)** | Number of Units[a] | | 8 |
| | Rescaling Method for Covariates | | Standardized |
| | Number of Hidden Layers | | 2 |
| | Number of Units in Hidden Layer 1[a] | | 12 |
| | Number of Units in Hidden Layer 2[a] | | 10 |
| | Activation Function | | Hyperbolic tangent |
| **Output Layer** | Dependent Variables | 1 | EmotionalditressG |
| | Number of Units | | 1 |
| | Activation Function | | Sigmoid |
| | Error Function | | Sum of Squares |

## RESULTS AND DISCUSSION

The data were analyzed using the Multilayer Perceptron Classification Model. The input layer includes 7 features age and job, marital status and educational level, emotional distress, self-empowerment skills, interpersonal interactions, and family care) and the output layer (target feature) includes emotional distress divided into low and high groups using a mean split.

Figure 1 presents neural network architecture.

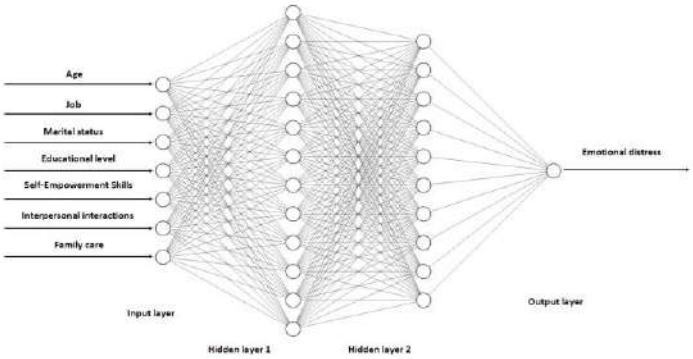


Figure 1. Neural network architecture.

Table 2 presents a summary of processing. There are 735 valid instances for classification.

Table 3 presents main results of research. There are presented correct percent for low and high emotional distress for training and testing. The overall percent for testing phase is 75%, which is satisfactory for the observed theme.

Table 2. Case Processing Summary.

| | | N | Percent |
|---|---|---|---|
| Sample | Training | 515 | 70.1% |
| | Testing | 220 | 29.9% |
| Valid | | 735 | 100.0% |

Table 3. Classification results.

| Sample | Observed | Predicted | | |
|---|---|---|---|---|
| | | low | high | Percent Correct |
| Training | low | 208 | 59 | 77.9% |
| | high | 75 | 173 | 69.8% |
| | Overall Percent | 55.0% | 45.0% | 74.0% |
| Testing | low | 80 | 28 | 74.1% |
| | high | 27 | 85 | 75.9% |
| | Overall Percent | 48.6% | 51.4% | 75.0% |

Figure 2 presents sensitivity and specify and also lift chart. Both parts present low and high emotional distress and their specific characteristics during classification process. Sensitivity measures how well the model can correctly identify instances of the positive class, while specificity measures how well the model can correctly identify instances of the negative class. Table 4 presents the importance of independent variables. The highest importance is noticed at Interpersonal interaction and self-empowerment, respectively. Visualization of proposed results is shown at Figure 3.

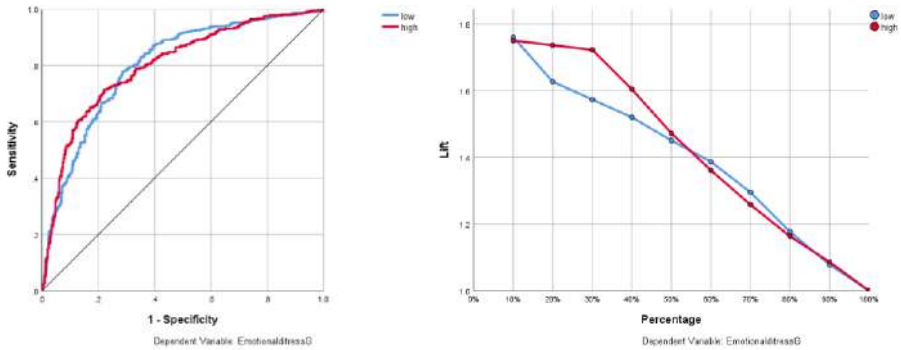


Figure 2. a) Sensitivity and specify b) Lift chart.

Table 4. Independent Variable Importance.

| | Importance | Normalized Importance |
|---|---|---|
| gender | .026 | 8.7% |
| marital status | .043 | 14.1% |
| education level | .070 | 23.2% |
| job | .044 | 14.7% |
| age | .093 | 30.9% |
| family care | .166 | 55.0% |
| self-empowerment | .256 | 84.7% |
| interpersonal interaction | .302 | 100.0% |

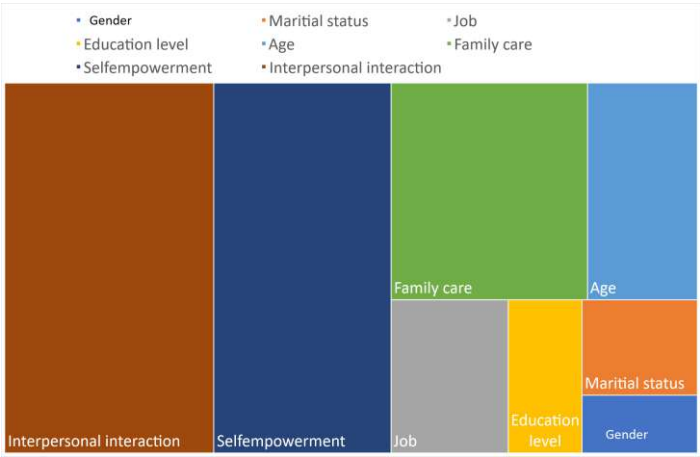


Figure 3. Visualization of results.

## CONCLUSIONS

The findings of this study revealed that the classification model achieved an accuracy of 75.6% in the training sample and 73.5% in the test sample, indicating a reasonably good performance. The area under the curve (AUC) value of 0.812 suggested an excellent fit of the model. The results further indicated that interpersonal interactions, self-empowerment skills and family care were identified as the most significant factors influencing the classification of emotional distress in breast cancer patients. These findings highlight the importance of considering psychosocial factors such as self-empowerment skills and interpersonal interactions in understanding and addressing emotional distress in breast cancer patients. By recognizing the

influence of these factors, healthcare professionals can develop targeted interventions and support strategies to enhance the emotional well-being of individuals affected by breast cancer. Future research could benefit from larger and more diverse samples to ensure broader generalizability of the findings.

## ACKNOWLEDGEMENT

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# ODNOSI IZMEĐU SASTAVA MJEŠAVINE I MEHANIČKIH SVOJSTAVA POLIETILENSKIH DUVANIH FILMOVA

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## SAŽETAK

Proizvodnja polietilsnkih duvanih filmova, koji se upotrebljavaju za izradu ambaleže, odnosno različitih vrsta vreća i kesica, je veoma složen proces. Ovim postupkom se rastopljena plastična masa ekstrudira kroz prstenasti alat i formira cilindar debelih zidova. Još uvijek zagrijan i razmekšali cilindar se duvanjem vazduha širi u šuplji cilindar određenog prečnika i određene debljine zida.

Na kvalitet filma utiče se podešavanjem i usaglašavanjem visine linije hlađenja, odnosom duvanja, radnom brzinom i kapacitetom ekstrudera. Na kvalitet filma se može uticati i dodavanjem aditiva u procesu ekstrudiranja. Na taj način materijal dobija željenu boju, čvrstinu, elastičnost, eliminiše se statički elektricitet, a moguće je uticati i na druge osobine.

Za proizvodnju filmova korišćeni su komercijalno dostupni PELD, PEHD, reciklirani PE materijal koji nije korišćen u orginalne svrhe (Post Industrial Recyled Materials) i aditivi. Miješanjem svježeg polietilena, aditiva i recikliranog polietilena u različitim odnosima dobijaju se proizvodi različitih mehaničkih karakteristika.

**Ključne riječi**: ekstrudirani duvani filmovi, mehanička svojstva, polietilen.

## UVOD

Polietilen je termoplastični materijal koji je zahvaljujući svojim dobrim mehaničkim svojstvima, dobrim optičkim svojstvima i hemijskoj postojanosti veoma tražen tehnički materijal u građevinarstvu, poljoprivredi i industriji, kao i u proizvodnji ambalaže i proizvoda široke potrošnje. Nakon stagnacije u 2020. godini zbog pandemije Covid-19, svjetska proizvodnja polimernih materijala je nastavila rast, i u 2021. godini je iznosila oko 390,7 miliona tona. O toga, oko 27% se odnosi na proizvodnju različitih tipova polietilena (Plastics Europe, 2022).

Danas se proizvodi mnogo vrsta komercijalnih polietilena koji se međusobno razlikuju po strukturi, molekulskoj masi, stepenu grananja i kristalnosti, ali i po vrsti i količini dodatih aditiva. To sveukupno uzrokuje značajne razlike u njihovim svojstvima. Istraživanja su pokazala da granica razvlačenja polietilenskih filmova ili širenja crijevnog filma, pored parametara prerade, zavisi od gustine, stepena grananja i orjentacije kristalnih regija u polimeru (Rennert i sar., 2013). Ekstrudiranjem se najčešće prerađuju polietilen velike gustine (PEHD) i polietilen male gustine (PELD), kao i njihove mješavine. Njihova hemijska struktura se zasniva samo na dugom lancu metilenskih jedinica, ali PEHD ima veći stepen kristalnosti od PELD zbog manjeg broja bočnih polimernih grana i kraćih bočnih grana. Veći stepen kristalnosti poboljšava većinu mehaničkih svojstava polietilena, posebno prekidnu čvrstoću, ali ima i veliki uticaj na njegova reološka i termička ponašanja (da Silva, & Wiebeck, 2017). Osim funkcionalnih svojstava na kojima se zasniva primjena polietilena, od udjela kristalne faze zavisi boja i prozirnost polietilena. Prozirnost polietilenskog filma je važan vizuelni element koji utiče na odluku kupca prilikom izbora proizvoda. Veći stepen kristalnosti znači veću gustinu i manju prozirnost polietilena. Stepen prozirnosti raste sa gustinom polietilena, ali na njega utiče i način prerade (Reyne, 2013).

Jedno od najčešćih područja primjene polietilena su ekstrudirane folije i filmovi. S obzirom da se polietilenski ekstrudirani filmovi odlikuju visokom čvrstoćom i fleksibilnošću, mogućnošću zavarivanja, kao i malom propustljivošću gasova i tečnosti, predstavljaju jedan od najčešćih materijala koji se koriste za izradu vreća za smeće, vreća za namirnice, termoskupljajućih folija

namijenjenih za pojedinačno ili zbirno pakovanje različitih proizvoda, rastezljivih folija i drugih proizvoda slične namjene. Proizvode se postupkom ekstruzionog duvanja, a debljina im se kreće od 0,015 mm do 0,025 mm.

Prvi korak u proizvodnji polietilenskih vrećica jeste ekstrudiranje duvanih filmova pri čemu se sirovina u obliku granulata transformiše u film. Ekstrudiranjem se može proizvesti crijevni ili ravni film, koji mogu biti nabrani, jednoslojni ili višeslojni i drugih konfiguracija. Pri ovom postupku oblikovanja rastopljena plastična masa se protiskuje kroz prstenasti alat i formira crijevo određenog prečnika i određene debljine zida. Za duvanje crijeva koristi se vazduh pod pritiskom. Strujom vazduha se podešavaju dimenzije filma, tj. prečnik mekog crijeva i debljina filma, i vrši orijentisanje polimera. Pored toga, strujom vazduha se vrši i hlađenje, čime se stabilizuje oblik, kontroliše kristalizacija i sprečava sljepljivanje zidova crijeva. Duvano crijevo je sa gornje strane zatvoreno parom valjaka za namotavanje koji prihvataju i odvode film, čime se postiže dodatno istezanje i orijentisanje materijala (Rodriguez i sar., 2015).

Proces ekstrudiranja rastopljene polimerne mase u kontinuirani crijevni film, na prvi pogled, djeluje veoma jednostavan. Međutim, postupak ekstruzije duvanih filmova predstavlja jedan od najsloženijih i najosjetljivijih tehnologija obrade polimernih materijala. Pored brojnih parametara prerade polimernog materijala u zoni topljenja granula polimera, zoni kompresije i zoni istiskivanja, kao što su: radna brzina puža, kapacitet ekstrudera, odnosom duvanja, odnos povlačenja, intenzitet i brzina hlađenja folije, jačina zatezanja kotura za namotavanje i dr. na karakteristike dobijenog filma može se uticati dodavanjem relativno malih količina različitih aditiva. Postoji više od 300 jedinjenja koja se upotrebljavaju u ove svrhe (Čačko i sar., 2022).

Cilj ovog rada je bio povezati mehanička svojstva polietilenskog duvanog filma namijenjenog za izradu kesica i vrećica sa udjelom različitih vrsta polietilena i najčešćih aditiva za ovakav tip proizvoda, a to su: punila, klizno sredstvo i *Masterbach*, odnosno boja. Interakcije polimernih molekula sa neorganskim punilima utiče na njihova svojstva na mikroskopskom nivou (konformacija, kristalnost) i na makroskopskom nivou (čvrstoća, tvrdoća, žilavost). Polietilenska folija koja ne sadrži nikakve aditive ima visok koeficijent trenja. Da bi se postigao manji koeficijent trenja u formulaciju filma se ugrađuje male količine aditiva koji pospješuju klizanje, tj. klizna sredstva. Ako se žili postići veći stepen klizanja onda se mora dodatno, za vrijeme ekstrudiranja filma, dodati masterbatch aditiv za klizanje. Međutim, potrebno je znati da visok procenat aditiva može izazvati druge štetne efekte. Nakon ekstrudiranja, po svojoj funkciji, veliki dio kliznih sredstava migrira na površinu filma gdje ometaju koronsku obradu. Koronska obrada je neizostavan korak u procesu pripreme filma za štampu putem kojeg se mijenja površina filma, povećava sposobnost vlaženja i prihvatanja boje u procesu štampe (Nowaczy i sar., 2004).

## MATERIJAL I METODE

Mehanička svojstva polimernih materijala mogu se ispitati brojnim statičkim i dinamičkim metodama djelovanjem relativno većih ili manjih sila deformacije. Međutim, najkorisnija i najčešće primjenjivana metoda jeste ispitivanje ponašanja polimernog materijala u uslovima naprezanje-deformacija, odnosno ispitivanje uticaja sile deformacije i sklonosti materijala ka kidanju, odnosno istezanju.

Uticaja sastava polimerne smjese za ekstrudiranje na mehanička svojstva duvanog filma ocijenjen je na osnovu rezultata mjerenja prekidne čvrstoće i prekidnog izduženja, jer su to važna svojstva za mnoge primjene. Mjerenje prekidne čvrstoće i izduženja, na svim uzorcima, provedena su prema zahtjevima standarda ISO 527-1. Pravougaona epruveta, dimenzija 20x180 mm, postavljena je između hvataljki dinamometra na polaznom rastojanju 40 mm i istezana uzduž glavne ose konstantnom brzinom 50 mm/min. Zabilježena je sila potrebna za kidanje epruvete, te određena prekidna čvrstoća i izduženje. Mjerenje je izvršeno na univerzalnom dinamometru sa pneumatskim hvataljkama, model AGS–X SHIMADZU. Da bi se osigurala pouzdanost u rezultate mjerenja, za svaki tip uzorka ispitivanja su ponavljana najmanje pet puta.

Uzorci polietilenskih filmova, koji su bili predmet ispitivanje, dobijeni su ekstruzionim duvanje mješavine različitih tipova komercijalnih polietilena i odgovarajućih aditiva. Korišćena su dva tipa polietilena velike gustine (PEHD), dva tipa polietilena male gustine (PELD) i reciklirani

polietilen (RecPE). Reciklirani polietilen je zapravo polietilen odbačen u toku prerade na ekstruderu, tzv. *Post Industrial Recyled Materials* (PIRM) koji nije korišćen u namijenjene svrhe i time onečišćen. Ova vrsta otpadnog polietilena se selektuje po sastavu i boji i ponovo vraća u oblik granula. S obzirom da je pretrpio jedan dodatni oblik prerade u odnosu na svježi polietilen naziva se regranulat i može se miješati sa svježim polietilenom u određenom procentu.

Da bi se podesili optimalni tehnički parametri oblikovanja duvanih filmova potrebno je poznavati svojstva polimernih materijala koji se prerađuje, a koja su data u tehničkoj dokumentaciji proizvođača komercijalnih polietilena (Tabela 1).

Tabela 1. Svojstva polimernih materijala korišćenih za proizvodnju polietilenskih duvanih filmova.
Table 1. Properties of polymer materials used for the production of polyethylene blown films.

| **Karakteristika** | **Jedinica** | **PEHD** | | **PELD** | |
|---|---|---|---|---|---|
| | | **1** | **2** | **1** | **2*** |
| Gustina | kg/m$^3$ | 946 | 938 | 921 | 923 |
| Maseni protok rastopa 2,16/190°C | g/10 min | 0,18 | 0,20 | 0,30 | 2,4 |
| Temperatura mekšanja po Vikatu | °C | <75 | <75 | 98 | 94 |
| **Karakteristike duvanog filma na 0,040 mm** | | | | | |
| Otpornost na probijanje ($F_{50}$ metoda A)* | g | 90 | 165 | 180 | 110 |
| Prekidna čvrstoća MD/TD | MPa | - | - | 26 / 23 | 22 /21 |
| Granica razvlačenja MD/TD | MPa | 24 /26 | 21/23 | -/11 | 14 /11 |
| Ukupno jedinično izduženje MD/TD | % | 480/640 | 500/660 | 500/700 | 470/570 |
| Otpornost na cijepanje MD/TD (Elmendorf) | g/mil | 19/270 | 30/350 | 200/200 | - |

*granulat polietilena sadrži anti-blok agense ili sredstva protiv sljepljivanja*

U polietilenski granulat se mogu dodaju koncentrati boje ili *Masterbach* i drugi aditivi, zavisno od namjene. U ovom proizvodnom procesu pripremljena smjesa polietilena i aditiva transformiše se u jednoslojni, meki crijevni film od kojeg se oblikuje vrećice širokog raspona veličina, oblika i stilova koje se koriste za pakovanje prehrambenih proizvoda i nošenje proizvoda široke potrošnje.

Tabela 2. Karakteristike punila i Masterbach-a.
Table 2. Characteristics of fillers and Masterbach.

| **Karakteristika** | **Punilo** | **Masterbach crvena boja** | **Masterbach plava boja** |
|---|---|---|---|
| Gustina | 1,6–1,64 g/cm$^3$ | 500–550 kg/m$^3$ | 750 kg/m$^3$ |
| Maseni protok rastopa 2,16/190°C | 0,20–0,40 g/10 min | 14–19 g/10 min | 25 – 35 g/10 min |
| Sadržaj $CaCO_3$ / pigmenta | 69–71 %m/m | 20 %m/m | 12 %m/m |
| Vlažnost / temperatura obrade | ≤ 30% | 260 °C | 240 °C |

Na slikama 1 i 2 prikazan je proces oblikovanja duvanog filma i završne obrade duvanog filma prilikom proizvodnje crvenih vrećica tzv. tregerica.

Slika 1. Vertikalna ekstruzija duvanog filma prema gore.
Figure 1. Vertical extrusion of blown film upwards.

Nosač filma Vučni valci Usjecanje ručki

Slika 2. Konfekcioniranje kesa.
Figure 2. Confection of bags.

Tabela 2. Uslovi obrade duvanih filmova od PE.
Table 2. Processing conditions of PE blown films.

| **Parametri ekstrudera** | **Brzina puža** | **100 o/min** |
|---|---|---|
| Parametri glave kalupa | Temperaturni profil od lijevka za doziranje do glave ekstrudera | PEHD 180 – 182 – 221 – 215 – 205 °C<br>PELD 148 – 148 – 162 – 156 – 146 °C |
| Formiranje crijeva | Odnos duvanja (odnos između prečnika naduvanog crijeva i prečnika alata) | 1:4 |
| | Odnos povlačenja | 1:7,85 |

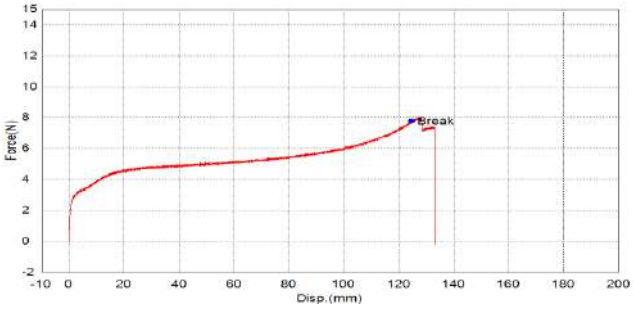
## REZULTATI I DISKUSIJA

Sastav smjese za ekstrudiranje i srednje vrijednosti višestrukih mjerenja debljine, gramature, prekidne čvrstoće i prekidnog istezanja proizvedenih ekstrudiranih duvanih filmova prikazani su u tabeli 3.

Tabela 3. Sastav smjese za duvanje i karakteristike duvanog filma.
Table 3. Composition of the blowing mixture and characteristics of the blown film.

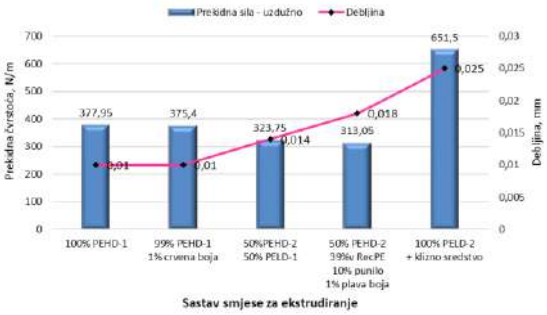
| **Karakteristika proizvedene polietilenske folije** | **Jedinica** | **Sastav smjese za ekstrudianje** | | | | |
|---|---|---|---|---|---|---|
| | | **100% PEHD-1** | **99% PEHD-1 1% crvena boja** | **50% PEHD-2 50%PELD-1** | **50% PEHD-2 39% RecPE 10% punilo 1% plava boja** | **100% PELD-2 + klizno sredstvo** |
| Debljina | mm | 0,010 | 0,010 | 0,14 | 0,018 | 0,025 |
| Gramatura | g/m$^2$ | 6,780 | 9,903 | 13,788 | 10,196 | 22,328 |
| Prekidna čvrstoća | N/m | 377,95 | 375,40 | 323,75 | 313,05 | 651,50 |
| Prekidno istezanje | % | 181,86 | 308,23 | 207,76 | 108,44 | 63,70 |

Na slici 3 prikazan je dijagram odnosa prekidne sile i izduženja na primjeru uzorka filma pripremljenog od 99% PEGD i 1 % crvene boje. Rezultati mjerenja ostalih uzoraka prikazani su u tabeli 3.



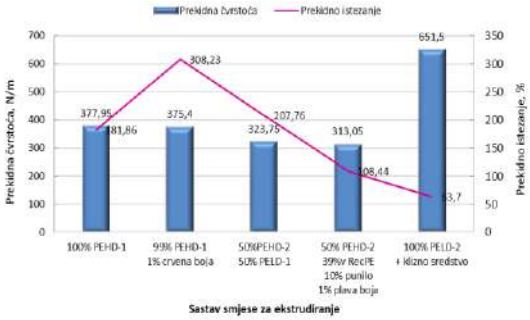

Slika 3. Primjer tipične krive opterećenje-istezanje (folija proizvedene od 99% PEHD i 1% crvene boje).
Figure 3. Example of a typical load-elongation curve (film produced from 99% PEHD and 1% red color).

Na osnovu izmjerenih i izračunatih podataka nacrtani su histogrami na kojima je prikazana zavisnost karakteristika duvanog filma od sastava smjese za duvanje, odnosno masenog udjela različitih vrsta polietilena i aditiva.




Slika 4. Uticaj sastava smjese za duvanje na debljinu i prekidnu čvrstoću filma.
Figure 4. Influence of the composition of the blowing mixture on the thickness and breaking strength of the film.

Ispitivanje na zatezanje je pokazalo da filmovi čija se debljina kreće 0,014 – 0,018 mm imaju manju prekidnu čvrstoću od filmova debljine 0,01 mm, što znači da prekidna čvrstoća ne zavisi isključivo od debljine filma. Tanji filmovi su bili izloženi većem naprezanju tokom istezanja i postignuta je veća orjentacija kristalnih faza što se odrazilo i na veću čvrstoću. Ranija istraživanja su pokazala da mehanička svojstva polietilena, pored gustine i stepena grananja lanaca, zavise od orjentacije kristalnih faza. Veća orjentacija kristalnih faza u polimernom materijalu povećava zateznu čvrstoću i druga fizičko-mehanička svojstva kao što su barijerna svojstva prema gasovima i vodenoj pari (Rennert, 2013).




Slika 5. Odnos sastava smjese za duvanje i čvrstoće.
Figure 5. Relationship between the composition of the blowing mixture and strength.

Najlošiju prekidnu čvrstoću ima uzorak koji u svom sastavu sadrži $CaCO_3$ i RecPE. Brojna istraživanja su pokazala da interakcija neorganskih punila sa polimernim molekulama smanjuje pokretljivost molekula u kristalnim područjima i poboljšava mehanička svojstva ekstrudiranih polimernih materijala (Gay i sar., 2005; Ruiz, 2000). Uzrok lošijih mehaničkih svojstava ovog uzorka filma može biti prisustvo RecPE koji je izgubio dio mehaničko-fizičkih svojstava tokom regranulacije uslijed termičke degradacije materijala. Pored toga, ukoliko regranulat nije dobro osušen povećava se procenat vlage u smjesi koja može da dovede do nastajanja šupljina u ekstrudiranom materijalu i hrapavu površinu filma.

Uzorak PE filma koji sadrži klizno sredstvo pokazuje najveću prekidnu čvrstoću i najmanje prekidno izduženje. Uzorak je pripremljen od PELD čiji je MFR 8–13 puta veći od ostalih sirovina. MFR je veličina koja se koristi za procjenu fluidnosti i Mw polmernog materijala.

Visok MFR ukazuje na nižu viskoznost i manju Mw rastaljene polimerne mase. Kraći lanci su pokretljiviji, manje isprepletenosti makromolekula, što olakšava polimernim materijalima da odgovore na naprezanja.

## ZAKLJUČCI

Svojstva polietilenskih duvanih filmova određena su svojstvima polimera, svojstvima aditiva, njihovim masenim udjelima u smjesi, kao i njihovim međusobnim interakcijama.

Filmovi čija se debljina kreće 0,014 – 0,018 mm imaju manju prekidnu čvrstoću od filmova debljine 0,01 mm. Tanji filmovi su bili izloženi većem naprezanju tokom istezanja i postignuta je veća orjentacija kristalnih faza što se odrazilo i na njihovu veću prekidnu čvrstoću.

Najlošiju prekidnu čvrstoću ima uzorak koji u svom sastavu sadrži $CaCO_3$ i regranulat polietilena. S obzirom da su tokom recikliranja oslabljena mehanička svojstva polietilena, da bi se popravila svojstva ovog uzorka filma potrebno je smanjiti maseni udio regranulata u smjesi za duvanje.

Uzorak PE filma koji sadrži klizno sredstvo pokazuje najveću prekidnu čvrstoću i najmanje prekidno izduženje.

Najveću prekidnu čvrstoću ima uzorak PELD-2 kojem je dodato klizno sredstvo. Ovaj uzorak sirovog polietilena ima daleko najveći maseni protok rastopa (MFR) koji iznosi 2,4 g/10 min.

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# RELATIONSHIPS BETWEEN THE STRUCTURE AND MECHANICAL PROPERTIES OF POLYETHYLENE BLOWN FILMS

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## ABSTRACT

The production of polyethylene blown films, which are used for the production of packaging, such as different types of bags and pouches, is a very complex process. With this procedure, the molten plastic mass is extruded through a ring tool and forms a thick-walled cylinder. The still heated and softened cylinder expands by blowing air into a hollow cylinder of a certain diameter and wall thickness. The quality of the film is affected by adjusting and matching the height of the cooling line, the blowing ratio, the working speed and the capacity of the extruder. The quality of the film can also be affected by add of additives in the extrusion process. In this way, the material gets the desired color, firmness, elasticity, static electricity is eliminated, and it is possible to influence other properties as well. Commercially available PELD, PEHD, recycled PE material that was not used for original purposes (Post Industrial Recycled Materials) and additives were used for the production of films. By mixing fresh polyethylene, additives and recycled polyethylene in different ratios, products with different mechanical characteristics are obtained.

**Keywords:** blown film extrusion, mechanical properties, polyethylene.

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# PCM APPLICATION IN LIGHT CONSTRUCTION BUILDINGS IN VARIOUS CLIMATES

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## ABSTRACT

Incorporating phase change materials (PCM) into building structures as passive latent heat thermal energy storage technologies offers a potential solution for reducing energy demand and regulating thermal comfort in occupied buildings. Integrating PCM into lightweight walls can improve their thermal performance by increasing building heat capacity and decreasing energy consumption. The effects of phase change materials (PCMs) added to the thermal envelope of lightweight residential containers on building thermal comfort are investigated in this study. The simulations were run for the summer period because it is difficult to achieve thermal comfort without using a lot of energy at that time. Thermal comfort is highly dependent on both, climatic conditions and the materials used to construct the building's thermal envelope, and the simulation was performed for weather conditions in five different geographic locations using TRNSYS simulation software. The paper examines the effects of PCM on indoor air temperature, specifically on reduction of maximum air temperature and temperature fluctuations.

**Keywords**: Building, PCM, Phase-change material, Thermal comfort, TRNSYS.

## INTRODUCTION

Trends in the construction of residential spaces all over the world change every day. The construction of massive buildings is increasingly being pushed out by the construction of cheap, lightweight structures designed to withstand extreme weather conditions such as heavy rains, strong winds and powerful earthquakes. Also, these are objects that can be quickly and easily assembled and, if necessary, dismantled and moved to another location, and their modularity allows that, by combining the stacking of containers, light objects can be adapted to all needs. Thus, apart from housing workers on construction sites, for offices, tobacconists, markets or smaller catering facilities, containers also began to be used as facilities for occasional stays during the weekend or annual vacation. The two largest student cities in the Netherlands and England are built from containers and a large number of students live in them every day. An increasingly popular trend is, of course, choosing a residential container for everyday life. More and more families in the world are deciding to choose a residential container for their permanent living space (Varmus, 2023).

Aside from the installation of insulating materials in the container's outer shell, one of the main disadvantages is that lightweight buildings do not have a large thermal capacity, which has a significant impact on the thermal comfort for people who live in them. Incorporating phase-changing materials (PCM) into the thermal envelope is one method for improving the thermal capacity of lightweight construction buildings (Roth et al., 2017).

PCMs are primarily used to increase the building envelope's capacity for heat storage and to reduce both internal temperature changes and energy demand. Thermal energy absorption, storage, and release are the three steps of the PCM principle. PCMs can store a significant amount of thermal energy by switching from one phase to another over a very narrow temperature range. The

transformation from solid to liquid state is frequently used in building construction where the phase transition occurs at constant temperature.

A significant number of works about PCM use in buildings have recently been published. It is important to remember that research must be conducted for each climate to determine which phase-changeable material or combination of materials will have the greatest impact on reducing energy consumption and payback time (Panayiotou et al., 2016; Jayalath et al., 2016).

The researchers (Al-Absi et al., 2022) investigated the thermal performance of PCM-based panels created for exterior wall finishes by fusing microencapsulated PCM with cement render and foamed concrete using experimental methods. The panels were subjected to repeated heating and cooling cycles in order to determine how well they performed thermally when compared to panels without PCM. During the PCM melting process, the internal surface temperature of the PCM-based panels decreased by up to 7.35°C.

A dynamic energy simulation program was used in the study (Wi et al., 2020) to apply an analysis of the enthalpy-temperature function based on the thermal properties of 22 different types of shape-stabilized phase change materials (SSPCM). The SSPCM was used to improve the energy efficiency of buildings while also improving the low heat storage performance of wooden structures. The indoor temperature behavior during heating and cooling periods was investigated to confirm the improvement in building heat storage performance. By maintaining the thermal inertia of SSPCM, the peak summer temperature was reduced by 4.1 °C.

In paper (Li et al., 2015), researchers investigated lightweight buildings integrated with phase change material (PCM) in order to improve the thermal performance of lightweight buildings. EnergyPlus software with a building model validated by experiment data is used to investigate the improvement of the indoor thermal environment with PCM under typical weather conditions in China's five climate zones. The findings show that PCM can effectively control indoor temperature rises and fluctuations. In temperate regions, the PCM can improve the indoor thermal environment of lightweight buildings for the majority of the year.

Because thermal comfort is highly dependent on both climatic conditions and the materials used to construct the building's thermal envelope, this study investigates the effects of phase change materials (PCMs) added to the thermal envelope of lightweight residential containers on indoor air temperature. The simulations were run for seven days during the hottest summer period using a typical meteorological weather file. Geometry of lightweight object, built-in materials and weather conditions in five different geographic locations were simulated using TRNSYS simulation software. The study looks into how PCM affects indoor air temperature, specifically how it reduces maximum air temperature and temperature fluctuations.

## MODEL AND SIMULATION

The basic type of housing container shown in the Figure 1 was chosen for the analysis of the impact of incorporating phase-changing materials into the thermal envelope. The floor of this container consists of plasticized sandwich panels. On both sides of panels are metal sheets 3mm thick, inside is PU filling 50mm (conductivity 0.13 kJ/hmK, heat capacity 2.09 kJ/kgK, density 40kg/m$^3$), finish cement chipboard 20mm thick with thermal conductivity 0.26 W/mK, heat capacity 1.15 kJ/kgK and density 1250-1400 kg/m$^3$. Ceiling/Roof panel is made of galvanized metal sheet RAL9002 on sides with 100mm thick mineral wool filling (conductivity 0.18 kJ/hmK, heat capacity 0.9 kJ/kgK, density 80 kg/m3). Walls consists of galvanized sandwich panel with 60mm mineral wool filling (conductivity 0.18 kJ/hmK, heat capacity 0.9 kJ/kgK, density 80kg/m3) and windows are with glass type 4/16/4 with Ar (u-value 1.27 W/m$^2$K).

Figure 1. Lightweight structure for people to stay in.

Google SketchUp software was used to create the geometry of the observed house required for thermal behavior modelling (Figure 2). TRNSYS3d for Google SketchUpTM was used as a plug-in to enter the geometric data into the building model. The thermal performance of an lightweight object with one thermal zone is modeled by the TRNSYS module Type56.

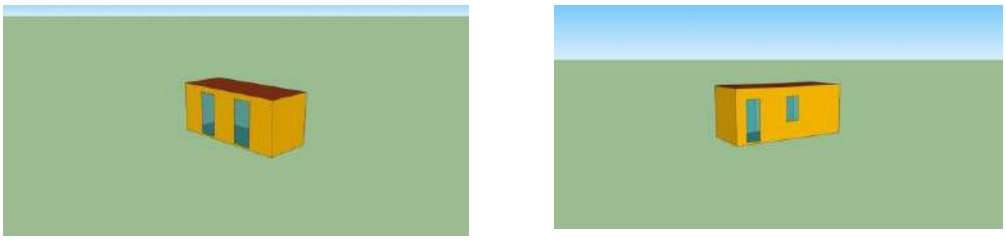

Figure 2. SketchUp model of a lightweight construction object.

With the aim of comparing the internal temperature in the container without PCM and in the container with embedded PCM material, simulations of the thermal behavior of the object without and with PCM (Figure 3) were performed in the Simulation Studio of the TRNSYS software package. To simulate the behavior of a PCM completely placed inside the envelope, a specially developed TRNSYS module Type1270 was used, which means the PCM is not directly adjacent to the zone air. This module is intended to interact with Type56 and can model a PCM located anywhere along a Type56 wall's thickness.

The phase change material is placed in the ceiling and in the south wall panels of the container. The commercial phase change material ENRG BlanketTM-Q25 from Phase Change Energy Solutions producer was chosen for this purpose. Its latent heat of fusion is 255 J/g and its phase change temperature is 25 °C.

The simulation was run for the summer period of July the 1$^{th}$-8$^{th}$ (for a period from 4344$^{th}$ to 5088$^{th}$ hour observed since the year's beginning), with a simulation step of 5 minutes based on typical meteorological year's weather file.

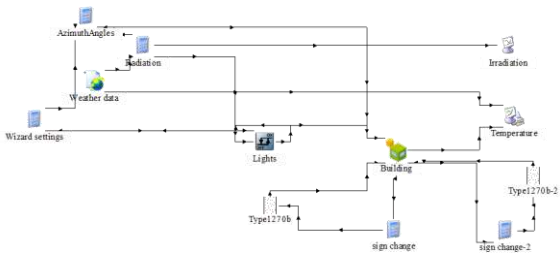


Figure 3. Simulation studio component scheme.

## RESULTS AND DISCUSSION

The simulation was done for five different locations: Banjaluka, Beograd, Kopaonik, Podgorica and Split. The simulation results of the model of lightweight object without and with added PCM are shown at graphs in Figures 4-8. Each graph represents three air temperatures, namely: ambiental temperature (red), zone indoor temperature of the basic model without PCM (blue) and the zone indoor temperature of the model containing PCM (black). The basic model and the model with PCM clearly have different air temperatures in the observed zone. As the temperature outside changes, so does the temperature difference. The difference between the air temperatures in zones of the observed models increases as the outside temperature rises and decereses as the outside temperature is declining.

The temperature differences range from 8.8 °C to 11 °C, as shown in Table 1. Since Kopaonik mountain has the lowest external air temperature in relation to the chosen PCM material, the difference was as expected, the smallest. The biggest difference was found in Banjaluka, which doesn't have the highest outside temperatures, like Podgorica for instance, but has cooler nighttime temperatures that favorably influence the cooling of PCM material and thus enhance the conditions for PCM application.

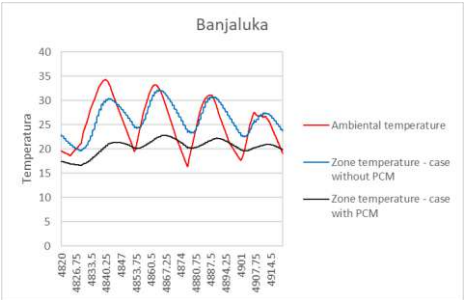


Figure 4. Indoor temperature difference in lightweight object without and with PCM placed in Banjluka.

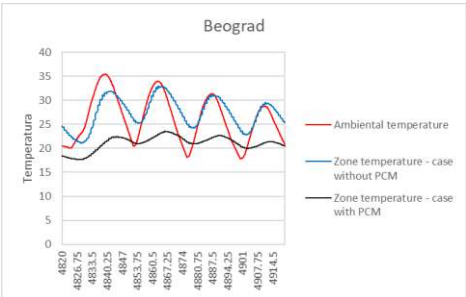


Figure 5. Indoor temperature difference in lightweight object without and with PCM placed in Beograd.

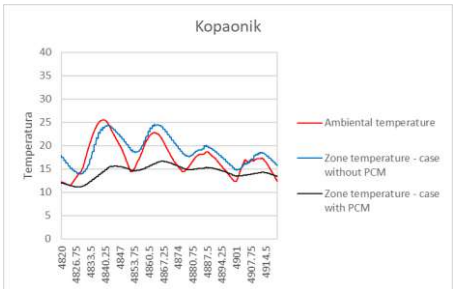


Figure 6. Indoor temperature difference in lightweight object without and with PCM placed at mountain Kopaonik.

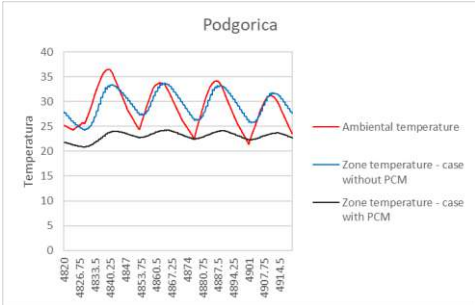


Figure 7. Indoor temperature difference in lightweight object without and with PCM placed in Podgorica.

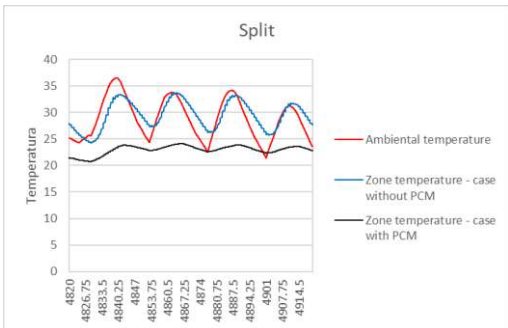


Figure 8. Indoor temperature difference in lightweight object without and with PCM placed in Split.

Table 1. Indoor temperature difference.

| Locations | Temperatures | | | |
|---|---|---|---|---|
| | *Ambiental temperature, °C* | *Zone temp. (without PCM), °C* | *Zone temp. (with PCM), °C* | *Temperature difference, °C* |
| Banjaluka | 33.5 | 30 | 21 | 11 |
| Beograd | 35 | 31.4 | 21.5 | 9.9 |
| Kopaonik | 24.3 | 23.9 | 15.1 | 8.8 |
| Podgorica | 36.1 | 33 | 23.8 | 9.2 |
| Split | 36.2 | 33 | 23.7 | 9.3 |

## CONCLUSIONS

This study examines how the thermal envelope of lightweight residential containers with added phase change materials (PCMs) affects the temperature of the interior air. The simulations for five different locations were run by using of TRNSYS simulation software and typical meteorological weather file for seven days during the hottest part of the summer between July the 1$^{th}$ and 8$^{th}$. It specifically looks at how chosen commercial PCM material ENRG BlanketTM-Q25 reduces the maximum air temperature and temperature variations in relation to indoor air temperature.

It‘s found that the air temperature in the building of light construction decreased from 8.8°C at Kopaonik to 11°C in Banjaluka as a result of the installation of PCM in the ceiling and in the south-facing exterior wall in all 5 locations.

There is a weaker nighttime cooling of the PCM in the envelope in cities with high daytime temperatures and relatively high nighttime temperatures, and the temperature differences between the cases with and without PCM are a little less pronounced.

Therefore, the best results of PCM application are found in places with high daytime, but also relatively low nighttime outdoor air temperatures with the selection of the appropriate PCM material for that geographical area.

## ACKNOWLEDGEMENT

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# DISTRIBUTION OF MINIMUM MAIN NORMAL STRESS IN UNIAXIAL TENSION PLATE WITH CIRCULAR OPENING

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## ABSTRACT

The growth of production is largely related to the increase in the volume of scientific and technical information used in the process of constructing. The collection, processing, transmission and analysis of technical information can greatly affect the process of constructing. By having such information, constructors come up with ideas more easily and carry out processes of constructing more easily. In the process of constructing, constructors perform various calculations and analyses. Analysis of the state of stress is one of the main analyzes in the process of constructing of machine parts. Therefore, the aim of this paper was to analyze the distribution of the minimum main normal stress during axial tension of isotropic rectangular plates with a central circular opening. For this analysis, the finite element method (FEM) and the ANSYS software package were used, and steel as one of the most well-known isotropic materials was used for the plate material.

**Keywords:** circular opening, minimum main normal stress, rectangular plate, ANSYS software package.

## INTRODUCTION

During the intensive scientific development, many theoretical and practical models were created for the analysis, synthesis and testing of constructions. Structural analysis methods are research methods that seek answers about construction properties. Based on the created physical form of the mechanical construction, simplified models are formed, and then a mathematical model is selected for calculation and analysis. The analysis is performed using the chosen theoretical-analytical, numerical or experimental method and the construction is improved step by step until the desired goals are achieved. Practically, the analysis collects data that enables the correction of constructive solutions, i.e. the evolution of existing or the improvement of newly developed constructions. In addition, analysis methods are used to collect data and knowledge on which the development of future mechanical constructions will be based. Depending on the speed of the analysis, the features of the construction can be identified very early, that is, more constructive variants can be developed and the most favorable solution can be chosen (Nikolić, 1999).

It is known that the mechanical construction is composed of many parts that make up a functional whole. Machine parts in most cases have a complex geometric shape. To assess the reliability and safety of parts and construction, it is necessary to know the values and distribution of stress (Radojković, 2005).

Openings in machine parts are sources of stress concentration. Analytical methods can be used to determine the distribution and concentration of stress around openings in machine parts, whereby the basic division of these methods can be made into exact and approximate. An important place among approximate methods is occupied by the method of the function of complex

variables and it can be used to determine the distribution and concentration of stress both in isotropic and anisotropic homogeneous fields with openings (Savin, 1968).

Differential equations that describe the state of stress of more complex structures and geometric shapes, as well as complicated contour conditions, usually cannot be solved by analytical methods, so the search for approximate particular solutions is resorted to using numerical methods. By applying numerical methods and the FEM as one of the most used numerical methods, results were obtained on the stress distribution in plates with circular (Mekalke at al., 2012), rectangular (Rahman, 2018), elliptical (Patel, & Desai, 2020) and a square hole (Radojković at al., 2023), whereby the obtained results confirmed the justification of the application of the mentioned method.

## REVIEW OF THE ANALYTICAL RESULTS OF THE DISTRIBUTION OF THE MAIN NORMAL STRESSES IN A PLATE WITH A CIRCULAR OPENING

In this chapter, the procedure and results obtained using analytical methods will only be briefly presented (Savin, 1968; Radojković, 2005). They refer to an isotropic field with a central circular opening, and the complex variable function method was used as an analytical method.

Stress functions during uniaxial tension of an isotropic field with a central circular opening of radius R (Savin, 1968; Radojković, 2005) have the form:

$$\varphi(\zeta) = \frac{pR}{4}\left[\frac{1}{\zeta} + 2\zeta\right],$$
$$\psi(\zeta) = -\frac{pR}{4}\left(\frac{1}{\zeta} + \zeta - \zeta^3\right), \qquad (1)$$

where: $\zeta$ – independent variable, $p$ – intensity of tensioning surface forces.

Expressions for calculating stress components in the polar coordinate system (Savin, 1968; Radojković, 2005) are:

$$\sigma_\rho = \frac{p}{2}\left[\left(1-\rho^2\right) + \left(1 - 4\rho^2 + 3\rho^4\right)\cos 2\theta\right],$$
$$\sigma_\theta = \frac{p}{2}\left[\left(1+\rho^2\right) - \left(1 + 3\rho^4\right)\cos 2\theta\right],$$
$$\tau_{\rho\theta} = \frac{p}{2}\left(1 + 2\rho^2 - 3\rho^4\right)\sin 2\theta\,, \qquad (2)$$

where: $\rho$ – radius vector, $\theta$ – angle between the normal at a point on the contour of the opening and the $x$ axis and is measured while going around the contour in the positive mathematical direction.

When $\rho = 1$ is put in the expression for $\sigma_\theta$ (2) (Savin, 1968; Radojković, 2005), the expression for calculating the stress on the opening contour is arrived at in the form:

$$\sigma_\theta = p\left(1 - 2\cos 2\theta\right). \qquad (3)$$

From the expression (3), it can be seen that the maximum stress values $\sigma_\theta$ are obtained at $\theta = \pm\pi/2$, i.e. is obtained by:

$$\left(\sigma_\theta\right)_{\max} = 3p. \qquad (4)$$

Based on the expressions for $\sigma_\rho$, $\sigma_\theta$ and $\tau_{\rho\theta}$ (2) (Savin, 1968; Radojković, 2005), the values of the main stresses $\sigma_{max}$, $\sigma_{min}$ and $\tau_{max}$ can be calculated. Figure 1 shows the distribution of the main normal stresses during uniaxial tension of an isotropic field with a circular opening, surface forces of intensity $p$. These results were used for comparison with the numerical results obtained in this paper.

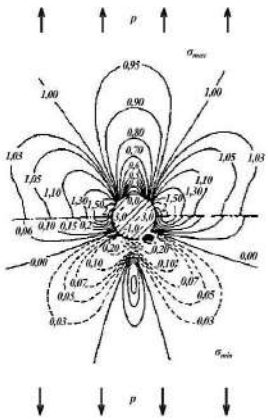

Figure 1. Lines of maximum $\sigma_{max}$ (upper half of the figure) and minimum main normal stress $\sigma_{min}$ (lower half of the figure) in uniaxial tension isotropic field with a circular opening.

## REVIEW OF THE NUMERICAL RESULTS OF THE DISTRIBUTION OF THE MINIMUM MAIN NORMAL STRESS IN A PLATE WITH A CIRCULAR OPENING

In order to obtain numerical results on the distribution of the minimum main normal stress $\sigma_{min}$, the FEM and the ANSYS software package were used in this work. The tests were performed on uniaxially tensioned rectangular plate-type elements, dimensions 2 m × 5 m × 0.1 m. The position of the plate is such that its shorter side is parallel to the direction of the $x$ axis, and the longer side is parallel to the direction of the $y$ axis. The rectangular plate is weakened by a central circular opening, diameter $d$ = 100 mm, and tensioning is performed by surface forces of intensity $p$ = 1 N/m$^2$ in the direction of the $y$ axis. The plate on which the tests are performed is made of isotropic material, and steel was chosen for it, for which the modulus of elasticity of the material is $E = 2.1 \times 10^5$ N/m$^2$, and Poisson's coefficient $\mu$ = 0.33. Discretization of the model (plate) was performed with 2D triangular solid finite elements with six nodes.

Figure 2 shows only the detail of the finite element mesh around the circular opening, created in the ANSYS software package, and Figure 3 shows the distribution of the minimum main normal stress $\sigma_{min}$ in a uniaxially tensioned steel plate with a central circular opening of diameter $d$ = 100 mm, where the tensioning is done by surface by forces of intensity $p$ = 1 N/m2, whose attack lines are perpendicular to the shorter side of the rectangular plate. From Figure 3, it can be seen that the highest value of this stress is obtained at the points of intersection of the contour of the opening and the $y$ axis and is $\sigma_{min}$ = -0.994 N/m$^2$.

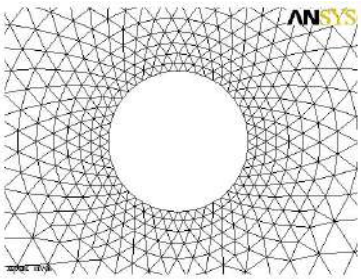


Figure 2. Finite element mesh detail of a uniaxially tensioned plate weakened by a circular opening with a diameter of d = 100 mm.

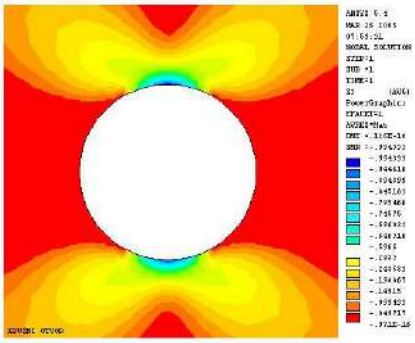

Figure 3. Distribution of the minimum main normal stress $\sigma_{min}$ in a uniaxially tensioned plate weakened by a circular opening with a diameter of d = 100 mm.

## ANALYSIS OF ANALYTICAL AND NUMERICAL RESULTS OF MINIMUM MAIN NORMAL STRESS DISTRIBUTION

In this paper, the results on the distribution of the minimum main normal stress $\sigma_{min}$ were obtained numerically, using FEM and the ANSYS software package. They were compared with the results from theory (Savin, 1968; Radojković, 2005), in order to determine the accuracy of the applied numerical method and the obtained results. Table 1 shows the values of the minimum main normal stress $\sigma_{min}$, which were arrived at by the analytical method (ANAL) and the finite element method (FEM). The obtained results refer to uniaxially tensioned steel plates with a circular opening of diameter $d$ = 100 mm.

Table1. Stress values $\sigma_{min.}$

| Method | $\sigma_{min}$, N/m$^2$ |
|---|---|
| ANAL | -1.000 |
| FEM | -0.994 |

Analyzing the results from Table 1, which were obtained by uniaxial tensioning of a steel plate with a circular opening, it can be concluded that the highest values for the minimum main normal stress $\sigma_{min}$ are obtained at the intersection of the contour of the opening and the $y$ axis (blue color of the stress field in Figure 3). Also, from the same table, it can be seen that by applying FEM and the ANSYS program package, approximately the same values as the theoretical values are obtained (Savin, 1968; Radojković, 2005).

## CONCLUSIONS

The aim of these researches was to reach results on the distribution of the minimum main normal stress σmin, to examine the influence of the circular opening on the distribution of this stress and to verify the numerical results obtained in this paper.

Numerical results on the distribution of the minimum main normal stress σmin were obtained in the paper. The FEM and the ANSYS software package were used to obtain the results, and the results of the distribution of this stress are illustrated in Figure 3. When it comes to the influence of the circular opening on the distribution of the minimum main normal stress σmin, based on the results obtained in this work, the results from the theory and the results obtained for other shapes of the opening, conclude that this shape of the opening has no significant influence, because small values are obtained for this stress. Regarding the application of numerical methods, and the FEM as the chosen method for obtaining results in this paper, it can be said that it confirmed the justification of the application, because the obtained results are close to the analytical results from the theory. Also, the applied software package proved to be reliable for solving such and similar problems.

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# STRESS ANALYSIS OF GEAR SHIFT FORK WITH MASS OPTIMIZATION

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## ABSTRACT

This study focuses on stress analysis and optimization of a gear shift fork. The main function of the gear shift fork is to enable proper engagement and disengagement of the required gear to achieve a specific transmission ratio. The aim of this study is to create a new optimized design of the fork and perform an analysis. Using Autodesk Inventor 2023 software, a 3D model of the fork is created, a finite element mesh is generated, and a static analysis of the old and new model is performed under identical constraints and loads. Using the Shape Generator option within Autodesk Inventor software, optimization which lead to a reduction in the mass of the part by 23% is performed. However, the analysis results show that the maximum Von Mises stress increases in the optimized model.

**Keywords**: analysis, stress, gear shift fork, optimization, Autodesk Inventor

## INTRODUCTION

Today, in industry, saving materials, energy and production time are key factors for increasing the efficiency and profitability of production. That's why optimization has become an indispensable stage in the process of constructing a product. The industry demands that the negative characteristics be minimized and the positive ones maximized in order to optimize the products as much as possible. Due to the rapid development of technology, where nuances are important for market success, optimization is essential. In order to optimize, methods for minimizing mass, cost and the like are often applied. Therefore, there are numerous studies and publications that deal with the optimization and analysis of different structures.

The main function of the fork is to enable the gears to be engaged and disengaged, depending on the desired gear ratio. The main function of the gearbox is to adjust the position of the fork to achieve the engagement between the desired gears and the synchronizer ring. During gear shifting, the fork is exposed to loads, which makes it necessary to check the loads acting on it in order to ensure its long service life.

In order to increase the reliability of the system, the paper (Bo et al., 2015) analyzed the strength and stiffness of the gear shift fork. For this purpose, a 3D model of the fork and a mesh of finite elements were used, which analyzed the effects of force of different values on strength and stiffness. Research results show that the highest stress concentration appears on the lower part of the fork under the action of a force of 1500 N. These results can be applied in practice to improve the performance of automatic mechanical transmission. The publication (Qiangwei, 2017) shows the static analysis of the fork of the truck gearbox, which also shows the presence of the highest stresses under the action of a force of 1500 N. Based on the analysis, the stress distribution and vibrations occurring during operation were obtained. A vibration control scheme was proposed in accordance with the obtained results.

The paper (Joshi, & Sharma, 2018) shows the stress distribution on the old fork model with v block and on the new one without it. The analysis showed that the deformation displacements are

the same on both models, but that the stress on the new model without the v block are lower compared to the old one.

The publication (Patel et al., 2015), refers to the accuracy of the manufacturing of the gear shift fork. A new 3D model was designed that reduces production time, increases efficiency, and achieves material saving. Also, in the paper (Jianjun et al., 2016), the method of manufacturing the gear shift fork was discussed in order to achieve the best possible quality of the transmission system. A mathematical model was developed to determine the most favorable parameters of the actuator, which would ensure fast and precise shifting of the gearbox. An actuator based on a pneumatic cylinder was designed. This actuator has been shown to have good performance in terms of gear shifting speed and precision. These results are important for the development of electric vehicles and the development of appropriate technology that would enable efficient gear shifting and thereby improve vehicle performance. Also, these results can be useful in further research concerning the development of gearboxes for electric vehicles.

The relationship between fork stiffness and performance of a five-speed manual transmission is described in (Jaideep et al., 2013). Greater stiffness of the gear shift fork can lead to an improvement in the quality of the transmission. It has been shown that the stiffness of the gear shift fork can be increased in several ways, including increasing the thickness of the fork and using materials with a higher modulus of elasticity. The results of the research show that the influence of the stiffness of the gear shift fork on the quality of the transmission is most pronounced at low speeds and lower loads, while the influence is smaller at higher speeds and higher loads.

This paper presents the results of the static analysis of the transmission fork, the optimization and the static analysis after the optimization, that is, the mass reduction. After the analysis, the area with the highest stress concentration was obtained, then the mass of the part was reduced by 23%, after which the analysis was carried out again.

## MATERIAL AND METHOD

The gear shift fork model was created in Autodesk Inventor 2023 software package, as shown in Figure 1 (Autodesk, 2023).

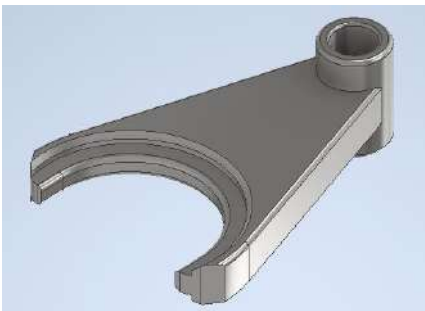

Figure 1. 3D model of the gear shift fork.

The material from which the fork is made is carbon steel. After the fork model was made, a static analysis was performed to determine the place with the highest stress concentration. The Shape Generator option, available in the Autodesk Inventor 2023 software package, was then applied to optimize the model.

## RESULTS

After the formation of the 3D model, a simulation was performed that shows the places with the highest stress concentration under the action of a force of 100, 200 and 500 N. The obtained results are shown in Figures 2, 3 and 4.

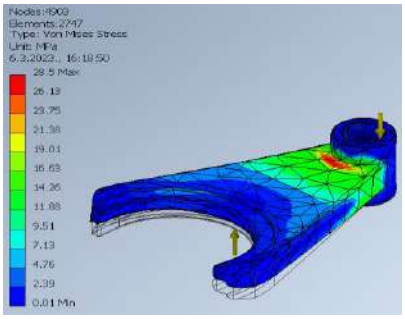


Figure 2. Stress distribution under the force of 100 N.

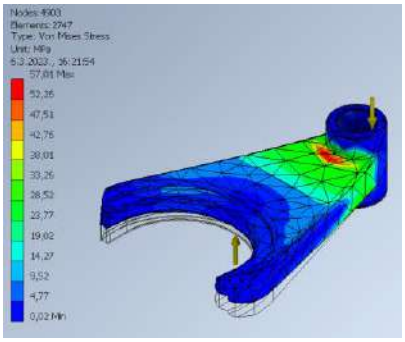


Figure 3. Stress distribution under the force of 200 N.

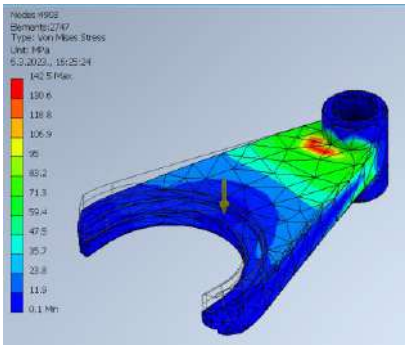


Figure 4. Stress distribution under the force of 500 N.

The results show that the maximum Von Mises stress of 142.5 MPa occurs at a load of 500 N.

The next step is mass optimization, through the Shape Generator option, in which mass is reduced by 23%. By specifying loads and constraints, the program generated an area where the mass of the part will be reduced, as shown in Figure 5.

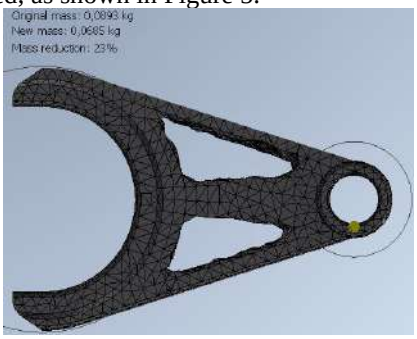


Figure 5. Part optimization.

In order to check the places with maximum stress concentration, a static analysis was performed again on the optimized model. Figure 6 shows the results obtained when the fork was loaded with a force of 500 N.

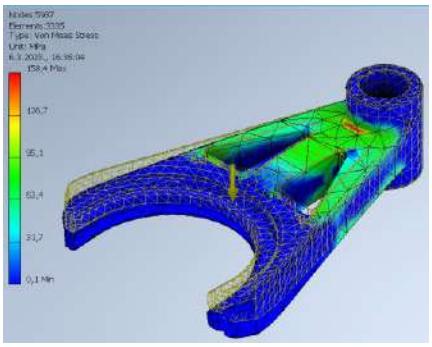


Figure 6. Stress distribution under the force of 500 N on the optimized model without rib.

Then, another modification was made to the model by adding a rib at the location of the highest stress concentration. The results of the static analysis of the optimized fork with the rib are shown in figures 7, 8, and 9.

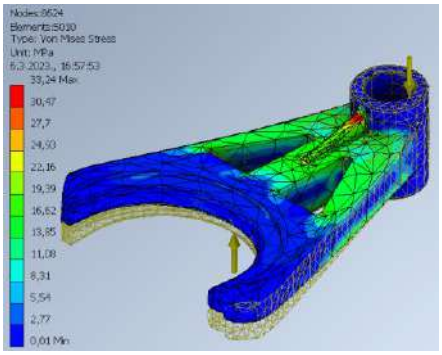


Figure 7. Stress distribution under the force of 100 N on the optimized model.

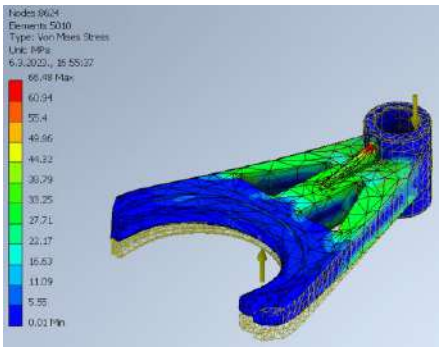


Figure 8. Stress distribution under the force of 200 N on the optimized model.

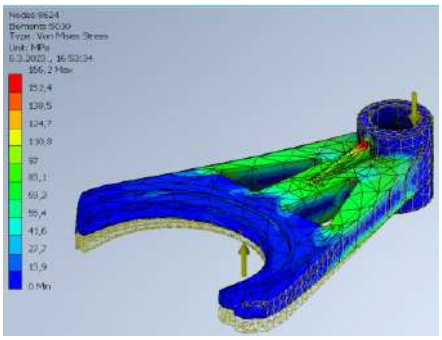

Figure 9. Stress distribution under the force of 500 N on the optimized model.

According to the analysis results, the maximum Von Mises stress occurs at the point of the rib to the cylindrical surface. The maximum stress value of 166.2 MPa occurs under the action of a load of 500 N. Figure 10 shows the results of the analysis before and after optimization with the given tabular values.

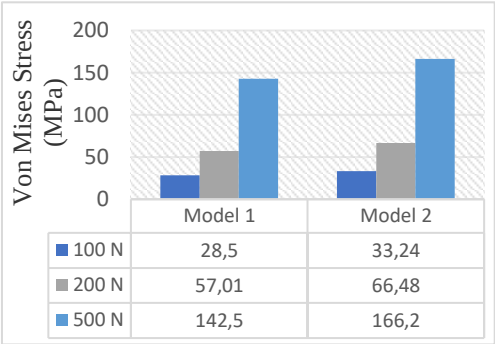


Figure 10. Results before and after optimization.

## DISCUSSION

Based on the results, it can be concluded that the Von Mises stress increases in proportion to the increase in load. On the first model, which is not optimized, stress have lower values compared to the new model. After optimization, reinforcement in the form of ribs was added to reduce the maximum stress on the edges of the openings located on the lightened part of the fork. By adding a rib, the maximum stress is transferred to the part between the cylindrical part, which is mounted on the shaft and the rib. In the optimized model, there was an increase in the maximum stress due to the added reliefs in order to reduce the mass.

Compared to the results obtained in (Bo, Wenqing, Yiqiang, & Shanshi, 2015), the same data were obtained that when the force value increases, voltages increase proportionally. Works differ in stress distribution due to different fork construction.

## CONCLUSIONS

In order to present the optimization procedure, this paper presents the structural optimization of the gear shift fork, whereby the weight of the part is reduced by 23%. After the conducted research, the conclusion is reached that the optimization supported by 3D modeling software is a simple and quick procedure of analysis and optimization of the part. In this way, it is possible to save materials, extend the working life of the system, shorten the time of production and modification of existing parts. As part of this work, optimization was performed, part reinforcement was added, however, the stresses increased compared to the model before the optimization was performed, so future research directions could be based on how to reduce stresses under the same constraints and loads.

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# THE POSSIBILITY OF USING POLYMER-BASED PHASE CHANGE MATERIALS FOR THERMAL ENERGY STORAGE

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## ABSTRACT

Phase change materials (PCM) are attractive energy storage technologies due to their high energy storage density and the ability to reversible absorb and release thermal energy at a nearly constant temperature. Polymers and polymer-based eutectic mixtures are promising PCMs. This study aims to investigate heat properties (melting temperature ($T_m$), latent heat ($\Delta H$) and thermal conductivity($\lambda$)) of potential PCMs based on polyethylene glycol polymer (PEG2000). We prepared following two and three components materials: PEG2000: ethylene glycol (5:6): PEG2000: PPG 400 (1:5); PEG2000: PPG400: Choline chloride (2:2:15); PEG2000: ethylene glycol (5:6); PEG2000: Glyoxal (5:2). The prepared three components material belong to deep eutectic solvents. Tm of the prepared materials are lower compared to pure PEG2000 ($T_m$ = 57 ºC) e.g. $T_m$ of PEG2000: PPG400: Choline chloride is 43 ºC. The determined melting enthalpies are also lower for prepared materials compared to PEG2000. This decrease is lower for eutectic mixture such as PEG2000: Choline chloride: ethylene glycol. We can conclude based on the obtained result that eutectic mixtures based on polymers are promising PCMs.

**Keywords:** deep eutectic solvents, phase change materials, polymers, melting temperature, enthalpy.

## INTRODUCTION

The growing demand for clean and sustainable energy solutions, combined with the need to reduce greenhouse gas emissions and mitigate climate change, has compelled researchers and engineers to investigate innovative energy storage technologies. Phase change materials (PCMs) offer unique advantages for thermal energy storage. At nearly constant temperatures, PCMs can store or release significant amounts of energy during the phase transition from solid to liquid or vice versa (Lamrani et al., 2021). This property makes PCMs ideal for a variety of thermal energy storage systems, including solar collectors (Karthikeyan et al., 2023), air conditioning units, heating and cooling systems, etc. (Qiao et al., 2022).

According to their chemical composition, PCMs can be classified as organic, inorganic, or eutectic. Organic materials, such as paraffin and non-paraffin substances like glycol, polyol, and fatty acid, are commonly used for thermal energy storage due to their suitable transition temperature, high storage density, and stable chemical and physical properties. These organic PCMs offer several advantages, including a wide temperature range, a high latent heat of fusion, long-term stability, compatibility with most materials, a phase transition with minimal volume change, and recyclability (Singh et al., 2021). However, there are certain drawbacks, such as low thermal conductivity, incompatibility with certain container materials (e.g., plastic containers), and flammability. Inorganic PCMs predominantly consist of salt hydrates, which are combinations of water and salts, as well as metallic compounds (Zhang et al., 2022). The inorganic PCMs have following benefits: higher storage density (almost double that of organic PCMs), greater thermal conductivity (approximately double that of organic PCMs), low cost, compatibility with plastic containers, and non-flammability. However, there are certain drawbacks: inorganic PCMs can be

corrosive, undergo a significant volume change during phase transition, and may experience issues such as separation and supercooling. Eutectic PCMs are formed by combining two or more components to create a distinct PCM with desired properties (Sun et al., 2023). This combination can involve organic-organic, organic-inorganic, or inorganic-inorganic compositions.

Polymers have been discovered to be a flexible PCM with typical organic PCM properties, including high latent enthalpy, a wide transition temperature range, high thermal stability, ease of chemical modification, strong biocompatibility, and non-toxic and non-corrosive natures (Sundararajan et al., 2016). Physically mixing polymers with some supporting materials, mixing two or more polymers in the proper ratio, chemical modification of polymers, and vacuum impregnation in porous materials are the most common ways to fabricate polymer-based PCMs. However, the physical thermal properties of polymers with different molar masses, such as thermal conductivity, phase transition property, heat capacity, and the corresponding thermodynamic functions, have rarely been investigated. The majority of studies on poly-based PCMs mainly focus on the design and synthesis of new PCMs and improving their performance for thermal energy storage. Different types of polymers (Polyethylene glycol or Polypropylene glycol), due to low hazardous and flammable properties, have been investigated as the PCM. The use of polymers to create effective PCM systems has been suggested because of their advantageous properties: suitable phase change temperatures and large phase change enthalpy, elevated long-term thermal/chemical stability, low toxicity and resistance to corrosion, limited volume change during solid-liquid phase change, readiness to be incorporated into porous inert substrates, and the possibility to choose the more suitable grade for the particular application (Karaman et al., 2011., Kou et al., 2019). Due to the availability of polymers with different molecular weights and, consequently, various melting temperature (Hocker et al., 2012), a polymer with the right melting point in relation to the expected operating conditions could be chosen.

The present study aims to evaluate the thermal properties of proposed PCMs based on polyethylene glycol polymer (PEG 2000), such as onset melting temperature, the melting temperature, the latent heat, and thermal conductivity. The choice of PEG is further supported by the material's high melting/crystallization enthalpy and acceptable phase change temperatures. PEG exhibits strong long-term thermal/chemical stability, corrosion resistance, and little volume change during the transition from the solid to the liquid phase. PEG2000 has high melting temperature (57 °C). In order to decrease melting temperature of PEG200 we created two- and three-component materials based on this polymer and studied their thermal characteristics.

## MATERIAL AND METHODS OF WORK

The following chemicals were used for preparation of two and three component PCMs: PEG2000, PPG400, Ethylene glycol, Choline chloride (ChCl), and Glyoxal. All chemicals were purchased from Sigma Aldrich (St. Louis, MO, USA). The list of prepared and studied potential PCMs is given in Table 1.

The studied two components polymer PCMs were prepared using following procedure: accurately weighted mass of PEG2000 was stirring at magnetic stirrer and hitting at 60 °C till a monophasic solution has been formed. After melting PEG2000, the second component (PPG400, ethylene glycol, or glyoxal) was slowly added drop by drop, and the homogenization of the solution is visually monitored. Schematic view of the preparation procedure of the polymer based PCMs is given in Figure 1. The PCM 4 was synthesized by adding an organic salt (ChCl) to a homogenized mixture of two polymers (PEG 2000 and PPG400). Homogenized mixture of two polymers was the same way as two components PCMs. After obtaining monophasic homogenous mixture, stirring and heating at 60 °C was continues for 2 h.

The thermal characteristics of the samples, including the onset melting temperature ($T_{om}$), the melting temperature ($T_m$), and the latent heat ($\Delta H$), were determined using a Differential Scanning Calorimeter (DSC 151R, SETRAM instruments). The measurement procedure involved heating the sample from 25°C to 65°C at a rate of 5°C per minute.

To accurately determine the enthalpy-temperature curve of the targeted phase change materials, a DSC baseline test was performed. This involved conducting a DSC measurement across the entire

temperature range using empty sample and reference pans, employing the same heating rate that would be used for subsequent tests. This baseline measurement provided the reference signal, against which the heat flow signals of the PCM measurements were compared and adjusted.

Table 1. Initial components, weight ration and chemical structures of the prepared two and three components materials.

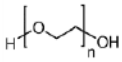
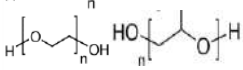
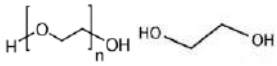
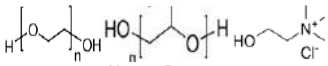
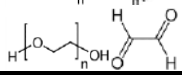
| PCM samples | Initial components | Weight ration | Chemical structure |
|---|---|---|---|
| PCM 1 | PEG 2000 | / |  |
| PCM 2 | PEG 2000: PPG 400 | (1:5) |  |
| PCM 3 | PEG 2000: Ethylene glycol | (5:6) |  |
| PCM 4 | PEG 2000: PPG400: Choline chloride | (2:2:15) |  |
| PCM 5 | PEG 2000: Glyoxal | (5:2) |  |

Figure 1. Schematic view of polymer PCM synthesis.

The thermal conductivity of the PCM samples was measured using a thermal conductivity measurement platform (MP-2, Thermtest instruments) equipped with a THW-L3 sensor. The procedure involved preparing the sample by shaking it and heating it to its melting temperature. The molten PCM was then poured into a warm measuring cell placed inside a dry bath. The temperature of the dry bath was gradually reduced to 25 °C, and measurements were taken. The THW-L3 sensor used a detect current setting to determine the appropriate amount of current based on a test measurement. By analyzing the test result, an optimal current value was selected to achieve the desired temperature rise during testing. This allowed for an accurate determination of the thermal conductivity of the PCM samples using the MP-2 platform and THW-L3 sensor.

## RESULTS AND DISCUSSION

DSC measurements were used to acquire data on the melting temperature, melting onset temperature, and latent heat of fusion. The measured thermal properties of the PCM samples are shown in Table 2. As shown in Figure 2, each DSC curve has one peak for the heating process. The highest peak was obtained for pure PEG2000. The obtained $T_m$ of PEG2000 (57.4 °C) is higher than the corresponding published data (50.92 and 52.65 °C) and the calculated latent heat of PEG2000 ($\Delta H$ = 126.72 $Jg^{-1}$) is lower comparing with literature data (154.1 and 165.43 $Jg^{-1}$) (Kou et al. 2019).

Thermal storage properties of the PEG2000 were affected by the addition of the second and third components. The melting temperature, and onset melting temperature of the samples display a tendency to decrease with the addition of PPG400, Ethylene glycol, Choline chloride, and Glyoxal. The lowest melting temperature of 43.99 ºC was recorded for the sample PCM 4, while the onset melting temperature is 33.54 ºC. The measured value of the latent heat of this sample is 41.84 $Jg^{-1}$ and this is the highest value after the latent heat of PEG2000. For PCM2, PCM3, and PCM5 samples, besides reducing the melting temperature, there was also a notable decrease in the

value of latent heat. The lowest value of latent heat was recorded for sample PCM 2 where with the addition of PPG400 latent heat value of PEG2000 drops from 126 $Jg^{-1}$ to 15.56 $Jg^{-1}$.

Table 2. Thermal characteristics of the samples determined using a DSC.

| PCM sample | Thermal properties | | |
|---|---|---|---|
| | $T_{om}$, °C | $T_m$, °C | $\Delta H$, J $g^{-1}$ |
| PCM 1 | 48.83 | 57.40 | 126.72 |
| PCM 2 | 41.88 | 47.03 | 15.56 |
| PCM 3 | 34.32 | 44.15 | 29.68 |
| PCM 4 | 33.54 | 43.99 | 41.84 |
| PCM 5 | 40.53 | 45.35 | 19.40 |

The measured thermal conductivity of the investigated PCMs is shown in Figure 3. The highest thermal conductivity value of 0.23 $Wm^{-1}K^{-1}$ was recorded for sample PCM 1, which consists of PEG2000. On the other hand, PCM 3 and PCM 5 materials have a slightly lower thermal conductivity of approximately 0.21 $Wm^{-1}K^{-1}$ compared to PCM 1. PCM 2 displays the lowest thermal conductivity of 0.066 $Wm^{-1}K^{-1}$ among the samples.

## CONCLUSIONS

The possible two and three component phase change materials based on polymer PEG2000 were synthesized and their thermal properties were investigated in this study. Preparation of the proposed material are easy and no time consuming. The thermal properties of the synthetized materials, such as the melting temperature, melting onset temperature, and latent heat of fusion were measured using DSC. The melting temperatures of the prepared materials are lower compared to pure PEG2000. The determined values of latent heat are also lower for prepared materials compared to PEG2000. The lowest decrease in latent heat value was obtained for PCM 4 (PEG2000: Choline chloride: ethylene glycol), while the biggest decrease was obtained for PCM 2 (PEG 2000: PPG 400 (1:5)). PCM 2 also displays the lowest thermal conductivity of 0.066 $Wm^{-1}K^{-1}$ among the samples. It should be emphasized that the PCMs with addition of either ethylene glycol or glyoxal only slightly decrease thermal conductivity of PEG2000. These findings pave the way for further exploration and investigation.

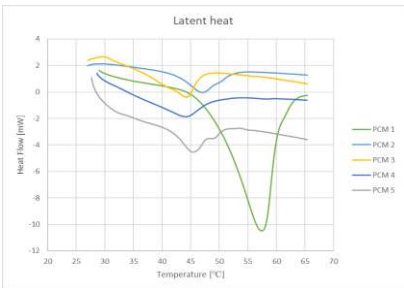



Figure 2a. DSC curves of PCM samples.

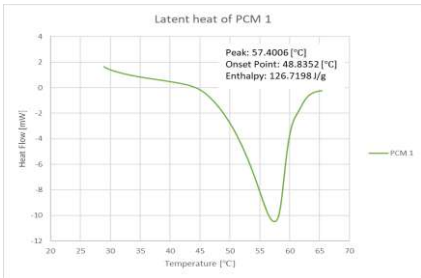



Figure 2b. DSC curve of PCM 1.

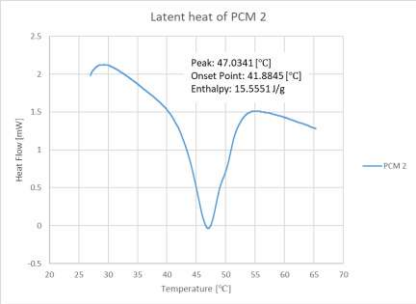



Figure 2c. DSC curve of PCM 2.

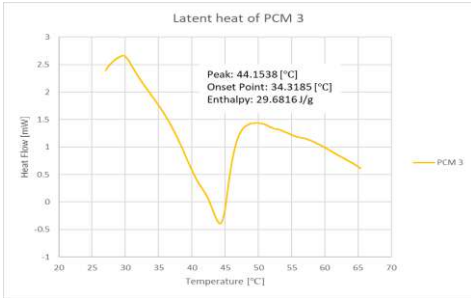



Figure 2d. DSC curve of PCM 3.

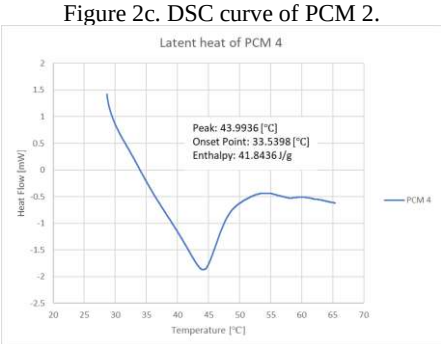



Figure 2e. DSC curve of PCM 4.

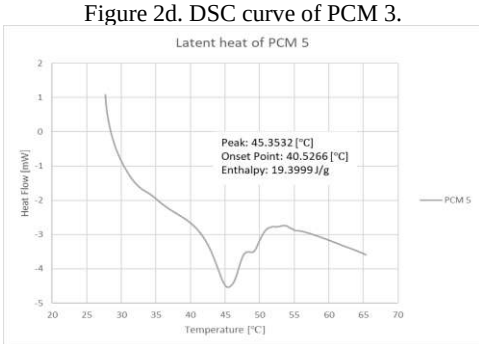



Figure 2f. DSC curve of PCM 5.

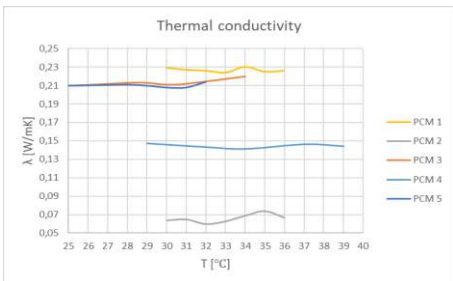



Figure 3. Thermal conductivity of PCMs.

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# PHYSICAL AND CHEMICAL OF WASTE VEHICLE TIRES, HOT ASPHALT EFFECT ON PROPERTIES

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## ABSTRACT

In today's world, with the increasing population density, consumption habits are also changing and increasing rapidly in proportion to the population. The development of the industry, the transportation of products produced together, the increase in the rate of individual vehicle ownership have also increased the rate of vehicle tire usage significantly.

This situation has led to the development of new environmental problems. Developing environmental problems have pushed countries to seek disposal of waste tires. In this study, it was used as an additive to hot asphalt as a disposal method of waste tires. The effect of waste tire on the physical and chemical properties of hot asphalt was investigated. Waste vehicle tires were granulated based on powder metallurgy principles with the help of water jet and a homogeneous mixture was provided with hot asphalt at 160 °C. Asphalt samples mixed with 2%, 4%, 6% and 8% rubber powder were prepared and subjected to Marshall test. The Marshall test results of the control sample obtained from hot asphalt without additives were compared. The waste tire ratio of the sample that provides the optimum value improvement was determined as 8%. Then, Indirect Tensile Strength Test, Bitumen Filled-Void Ratio Test, Breaking Energy Test, Loading Test, Tire Track Tests were applied to this sample. As a result, it was concluded that 8% waste tire additive had a positive effect on the physical and chemical properties of hot asphalt.

**Keywords**: hot asphalt, waste tire, disposal, waste management.

## INTRODUCTION

In Nowadays, the increase in the world population density and the change in the consumption trends of the societies lead to the rapid consumption of the resources in the world we live in, but also bring environmental pollution. This situation has led countries to create emergency action plans in terms of waste management and has led them to seek to develop a policy on their own for the disposal of waste. Vehicle tires are one of the most difficult materials to recycle in terms of waste management. Land transportation is still the most important pillar of today's logistics. The rate of individual vehicle owners is also increasing rapidly. For this reason, hundreds of thousands of tons of waste vehicle tires are formed every year. According to the 2018 data of the Turkish Statistical Institute, the amount of waste tires in our country is approximately 400,000 tons. With the regulation that entered into force on January 1, 2007 in our country, the procedures and principles regarding the recovery, disposal, collection and transportation system of end-of-life tires and the management of expired tires were determined. Main methods for recycling waste tires:

- Direct evaluation without any chemical treatment. For these purposes, it is used in docks and ports, children's playgrounds, sports halls and landscaping works.
- Re-use of worn tires by coating. The most important point here is that the steel part of the vehicle tire is not damaged.
- Use as fuel in cement and thermal power plants.

- Evaluation of waste tires as raw materials. The end-of-life tire is separated into its components by various chemical methods, and as a result, materials such as gas, carbon black, oil, steel are brought back into the economy.

In this study, rubber particles obtained by powder metallurgy principles were homogeneously mixed with 160 °C hot asphalt. The physical and mechanical properties of the modified asphalt obtained as a result of the mixture were investigated. Marshall Stabilization test was carried out to determine the rubber powder ratio to be added to the hot asphalt during the study and it was tried to determine which ratio of the mixture contributes to the mechanical and physical properties at the optimum level.

As a result of the study, when the samples were examined in terms of Marshall stability criterion, it was determined that the sample with 8% rubber powder added showed the highest performance. For this reason, Indirect Tensile Strength Test, Bitumen Filled-Void Ratio Test, Breaking Energy Test, Loading Test, Tire Trace Tests were applied to the prepared control sample and 8% rubber powder added sample. As a result of the experiments, it was observed that the 8% rubber powder added sample performed better than the control sample taken from the asphalt produced by conventional methods. As a result of the research, it has been determined that the rubber dust obtained from the tires that have completed their life increases the rubbing and tire track resistance of the asphalt, prevents bitumen bleed at high temperatures, and increases the surface wear resistance. In this study, asphalt with 8% rubber powder was also paved and noise measurements were made. The results show that rubber powder added asphalt yielded more successful results in terms of sound damping than asphalt produced by other classical methods. It is thought that this situation will contribute positively to the reduction of sound pollution by preventing urban traffic noise. Considering similar academic studies; Arabani et al. investigated the contribution of granulated waste tires to asphalt applications. They used tire waste additive ratios at 1%, 3% and 5% in their studies and subjected these samples to the creep test at 40 ◦C. As a result of the test, the deformation values of the waste rubber added samples were lower than the control sample (Arabani et al., 2009). Satoda obtained black carbon from scrap rubber by distillation method and added it to asphalt to obtain modified asphalt. He laid the modified asphalt and made 10 observations. As a result of the observation made; The paved asphalt showed good resistance to environmental effects and even its stability was not deteriorated. It also found a significant reduction in traffic noise. Cao added waste tire particles directly to the hot asphalt mix and subjected it to Marshall and rutting tests. As a result, it was determined that the waste tire significantly increased the strength of the asphalt at high and low temperatures (Cao, 2007).

## MATERIAL AND METHODS OF WORK

### Type of Aggregate Used in the Laboratory Study

Type-2 wear gradation specified in the Highways Technical Specification will be used in the experimental study. Abrasion Type-2 gradation limits and the properties of the aggregate to be used in the test are given in Table 1.

Table 1. Properties of the aggregate to be used in the experiment.

| Material Feature | Experiment Result | | Relevant Standard | Desired Limits |
|---|---|---|---|---|
| | Fine | Coarse | | |
| Density (gr/cm$^3$) | 2,70 | 2,70 | ASTM C 127<br>TS EN 1097/6 | - |
| Water Absorption (%) | 0,997 | 0,864 | ASTM C 127<br>TS EN 1097/6 | <2,5 |
| Compact Unit Volume Weight (kg/m$^3$) | 1911,6 | | TS 3529 | - |
| Loose Unit Volume Weight (kg/m$^3$) | 1756,4 | | TS 3529 | - |
| Wear Loss (%) | 24,4 | | ASTM C 131<br>TS En 1097/2 | <30 |

Determination of Bitumen Used in Laboratory Study

In the experimental study, it is planned to use a binder with 50/70 penetration. The test results and properties of the binder used in the study are given in Table 2. Waste rubber was added at the rate of 8% by weight of bitumen. Modified bitumen was obtained by mixing this mixture in a bitumen mixer.

Table 2. Properties of the binder used in the study.

| Experiment | Experiment Result | Standart | Limit Values |
|---|---|---|---|
| Penetration (25 ºC, 1/10 mm) | 62 | ASTM D5<br>TS 118 En 1426 | 50-70 |
| Density (gr/cm$^3$) | 1,05 | ASTM D70 | 1,0-1,1 |
| Ductility (25ºC, 5 cm/dk) | >100 | ASTM D 113<br>TS 119 | +100 |
| Flash Point (ºC) | 275 | ASTM D 92<br>TS 123 EN 22592 | Min. 230 |
| Heating Loss (%) | 0,49 | ASTM D 6<br>TSEN 12607-2 | Maks. 0.50 |
| Softening Point (ºC) | 51 | ASTM D 36<br>TS 120 EN 1427 | 46-54 |

In order to determine the bitumen content, the void ratio, free weight, homogeneous dispersion rate of the bitumen, aggregate void ratio, Marshall flow value of the sample are calculated and plotted. To calculate the most efficient bitumen percentage to be used; The bitumen ratio that provides Marshall stability, the bitumen ratio that makes the void ratio 4%, the bitumen ratio that brings the practical specific gravity to the desired level, and the bitumen ratio that makes the void ratio filled with bitumen to 70% are determined by reading the graphics. By taking the average of the determined values, the optimum bitumen percentage to be used in the experimental study is calculated. We can calculate the optimum bitumen percentage by two methods. In the first, the average of the 4 values determined by reading from the graphs is taken. In the second, the calculation is made without taking into account the bitumen-filled void ratio. As a result, the optimum bitumen percentage is compared with the values in the flow-bitumen graph and it is determined whether it remains within the values specified in the Highway Specifications. In order to determine the bitumen percentage in our study, 7 different bitumen ratios (in the range of 3.5-6.5%) were used.

Table 3. Average values obtained from the Marshall experiment.

| Bitumen rate (%) | VMA (%) | With bitumen Full Space rate (%) | Space rate (%) | Practical Specific Weight (gr/cm$^3$) | Marshall Stabilite (kg) | Flowing (mm) | MQ (kg/mm) |
|---|---|---|---|---|---|---|---|
| 3,5 | 15,56 | 48,85 | 8,02 | 2359,71 | 1636,26 | 2,42 | 682,55 |
| 4,0 | 15,30 | 56,97 | 6,65 | 2378,51 | 1779,51 | 2,46 | 742,96 |
| 4,5 | 15,07 | 65,23 | 5,31 | 2396,37 | 2040,22 | 2,72 | 754,54 |
| 5,0 | 14,78 | 74,13 | 3,89 | 2415,96 | 1970,40 | 2,25 | 895,62 |
| 5,5 | 14,55 | 83,05 | 2,53 | 2433,97 | 1781,63 | 2,67 | 687,19 |
| 6,0 | 14,66 | 89,82 | 1,56 | 2442,42 | 1597,06 | 3,00 | 534,13 |
| 6,5 | 15,17 | 93,48 | 1,05 | 2439,35 | 1296,49 | 4,05 | 320,60 |

As a result of the Marshall experiment, the bitumen rate was 4.74%, the practical specific gravity-bitumen rate was 6%, the void rate-bitumen rate was 4.94%, and the vacancy rate filled with bitumen was 4.72%. In order to determine the optimum bitumen ratio, these results were summed and the arithmetic average was taken and the final bitumen ratio was calculated as 5.1%.

**End of Life Car Tires**

The first pioneering countries in the use of waste tires as additives to hot asphalt are developed countries such as the United States, Spain, Portugal, Germany and Russia. As a result of this situation, the economic and cultural development of our country, the re-evaluation of recyclable materials has formed a sector in itself. Indeed, our country has surpassed many developed countries in bringing recyclable products into the economy and has become one of the leading countries in the world in importing recyclable waste.

In this study, waste tires that have completed their life were turned into rubber powder without any chemical treatment with the help of powder metallurgy method and water jet and homogeneously mixed with hot asphalt at 160 ºC. The transactions were carried out in Yıldırım Municipality Asphalt Plant. The properties of the waste tire used in the experiment are given in Table 4.

Table 4. Characteristics of Waste Tires Used in the Experiment.

| Materials | Features | Values |
|---|---|---|
| | Aseton (%) | 15,5 |
| | Ash(%) | 6 |
| Tire Rubber | Carbon Black (%) | 29,5 |
| | Rubber Hydrocarbons (%) | 49 |
| | Density (gr/cm$^3$) | 1,15 |

## RESULTS AND DISCUSSION

**Reading Marshall Experiment and Results of End-of-Life Rubber Additive Sample and Control Sample**

Today, waste tires that have expired are grinded by various methods and modified asphalt is obtained by two different methods, wet and dry. In dry method; Before the hot binder is added to the asphalt mix, the pulverized waste tire powder is directly added to the mix together with the aggregates. In the wet method; The waste tire powder is mixed with the binder bitumen and the bitumen is modified.

The dry mix method is the most preferred method by the manufacturers as it does not cause an extra operating time and cost during asphalt production. In this study, modified asphalt production was carried out by dry method in Yıldırım Municipality Asphalt Production Facility.

After the bitumen ratio to be used in the test samples was determined, samples with and without waste tire powder were prepared to be used in the tests. Waste tire ratios in the modified asphalt samples were added as 2%, 4%, 6% and 8% of the aggregate weight. These ratios were determined according to the Marshall ratio, which is an important parameter for the performance of the asphalt mixture.

Table 5. Average Values Obtained from Marshall Test for Pure Mixture.

| VMA (%) | With bitumen Full Space rate (%) | Space rate (%) | Practical Specific Weight (gr/cm$^3$) | Marshall Stability (kg) | Flowing (mm) | MQ (kg/mm) |
|---|---|---|---|---|---|---|
| 15,26 | 72,81 | 4,22 | 2404,54 | 2027,54 | 1,76 | 1166,85 |

The average values of the powder rubber-added samples obtained from waste tire containing 5.1% binder obtained from the Marshall experiment are given in Table 6.

When Table 5 and Table 6 of the control sample are examined, it is seen that the design criteria are generally met. When Table 6 is examined, the Marshall stability of the asphalt samples modified with waste tire powder was found to be minimum 900 kg, the inter-aggregate void ratio was found to be minimum 14%, the void ratio was found to be between 3-5% and these criteria were met for all waste tire ratios. In the asphalt filled-void ratio, 2% and 4% waste rubber powder added samples were 77.35% and 77.45%, respectively. According to the Highways regulation, the results obtained must be in the range of 65-75% in order to ensure the standard. In this case,

asphalt samples containing 2% and 4% waste rubber powder were out of the standard. Considering the Marshall ratio, the highest value was obtained from the sample with 8% waste rubber powder.

Table 6. Average Values Obtained from Marshall Test for Powder Rubber Additive Mixture.

| Waste rate (%) | VMA (%) | Bitumen Full Space Rate (%) | Space rate (%) | Practical density (gr/cm$^3$) | Marshall Stability (kg) | Flowing (mm) | MQ (kg/mm) |
|---|---|---|---|---|---|---|---|
| 2 | 14,51 | 77,35 | 3,36 | 2425,99 | 1878,72 | 2,26 | 891,56 |
| 4 | 14,81 | 75,45 | 3,70 | 2417,51 | 2009,49 | 1,79 | 1130,69 |
| 6 | 15,21 | 73,11 | 4,16 | 2406,09 | 2109,33 | 2,22 | 934,22 |
| 8 | 15,64 | 70,78 | 4,64 | 2393,98 | 2120,83 | 1,79 | 1182,92 |

The results obtained from the Marshall experiment were evaluated and together with the sample control sample with 8% waste rubber dust ratio; It was subjected to Indirect Tensile Strength Test, Void Ratio Content, Breaking Energy Test, Loading Test and finally Tire Track Tests and the following graphics were obtained.

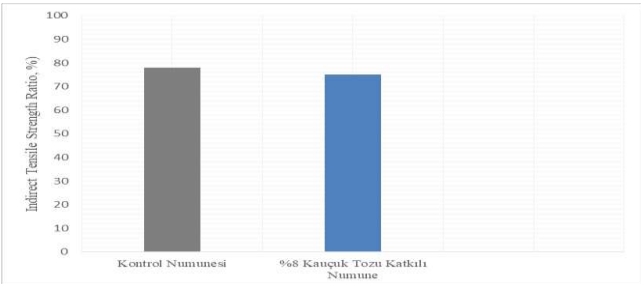


Figure 1. Indirect Tensile Strength Chart of Rubber Powder Added Sample and Control Sampler.

In terms of tensile strength, the control sample and the modified waste tire additive sample showed almost similar performance. It has been determined that the modified sample is within the standard range specified in the Highways Technical Specification in terms of tensile strength.

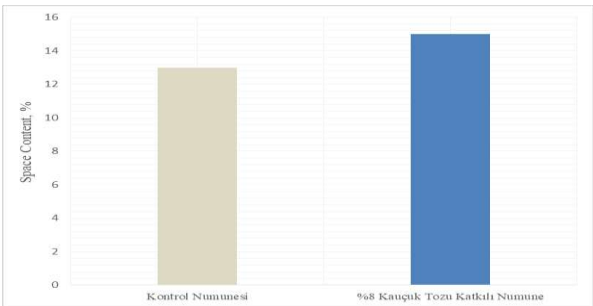


Figure 2. Void Content Graph of 8% Rubber Powder Additive Sample and Control Sample.

In terms of void content, it was determined that the modified asphalt contained more void ratio than the control sample. It has been observed that the obtained ratio complies with the standards determined in the Highway Specifications, and it has been understood that the high void ratio causes the asphalt to be more resistant to bitumen bleed, rutting and cracking at high temperatures.

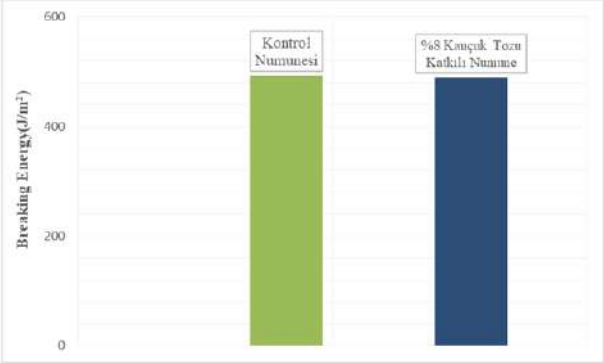


Figure 3. Breaking Energy Graph of Rubber Powder Added Sample and Control Sample.

When examined from the breaking energy parameter, the modified sample showed almost the same performance as the control sample. When evaluated in terms of this parameter, it was concluded that modified asphalt will also perform well at low temperatures.

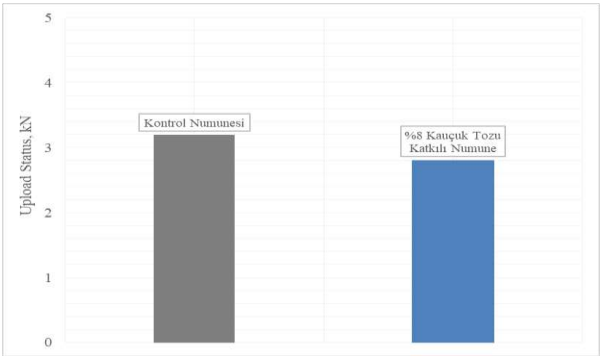


Figure 4. Loading Chart of Rubber Powder Added Sample and Control Sample.

It has been determined that as the amount of waste rubber increases, the bond between aggregate and binder bitumen will become stronger. However, the change in other parameters should be taken into account when determining the modifier additive ratio.

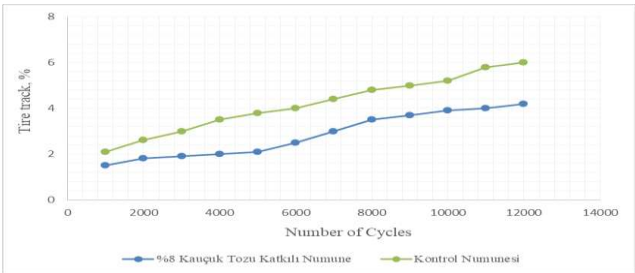


Figure 5. Tire Track Graph of 8% Rubber Powder Additive Sample.

When examined in terms of tire tread formation parameter, the sample modified with waste tire powder performed better than the control sample. Waste tire dust added to the asphalt increased the deformation resistance of the asphalt. Modified asphalt performs better at higher temperatures under repetitive load and with increased wheel cycle number. The sample with the addition of waste rubber powder showed 7.55% higher performance than the control sample.

## CONCLUSIONS

The use of asphalt has become quite common and without alternatives today. Many asphalt producer institutions and companies are in search of reducing asphalt production costs. On the other hand, disposal and disposal of waste tires is an important issue for countries in terms of preventing environmental pollution. In this study, waste tires were pulverized and added to asphalt as a modifier at 2%, 4%, 6%, and 8% ratios. Marshall test was applied to the prepared samples. According to the Marshall test, the 8% waste rubber powder added sample and the control sample, which gave the best performance, were compared in terms of tensile strength, void ratio, breaking energy, loading and tire trace criteria.

In order to determine the bitumen content, flow and stability tests were applied to the sample containing bitumen in 7 different ratios (between 3.5 and 9.5), and the resulting bitumen rate was calculated as 5.1%.

Asphalt sample produced by conventional methods and asphalt sample with 8% waste rubber powder were compared according to Marshall stability criterion. The Marshall ratio of the control sample was 1166.85 kg/mm, and the Marshall stability was 2027.33 kg. Marshall ratio of 8% waste rubber powder added asphalt sample was 1182.92 kg/mm and Marshall stability value was 2120.83 kg. When the values obtained are compared, the sample with waste tire powder added better performance than the control sample, since it strengthens the adhesion bond between the aggregate and bitumen of the waste tire powder.

## LITERATURE

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# THE USE OF EGG SHELL, CHICKEN FEATHERS, MARBLE POWDER AS CONCRETE ADMIXTURE AND INVESTIGATION EFFECTS

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## ABSTRACT

Food industry waste has a great potential for use in terms of prevalence, accessibility and quantity. In this research, the effects of eggshells on concrete by substitution of cement were investigated. In addition, the results of using chicken feathers together with egg shells as fiber reinforcement material were also examined. For the comprehensive evaluation of the effects of eggshell, marble dust, which is a waste of limestone and marble industry widely used in the cement industry, was also used as an additive. In this context, an additive-free cement was prepared under laboratory conditions and 12 cement samples with additives were prepared by substituting all additives to this cement in different proportions. Physical, chemical and mechanical tests of these samples were carried out. According to the test results, conformity assessment of all samples according to the cement standard was carried out separately. It has also been determined that CEM I 42.5 R Portland cement can be produced and used at higher rates by substituting up to 10% of ground eggshell. Cement produced with eggshell has been found to increase the early strength of concrete. In addition, it was determined that the setting time of the concrete was shortened if chicken feathers were added to the cement together with the egg shell.

**Keywords:** cement, concrete, eggshell, chicken feather, marble powder, limestone additive.

## INTRODUCTION

Today, in parallel with the increase in the world population, the consumption of all natural resources is also increasing. Accordingly, together with the need for resources, the wastes generated as a result of consumption are also increasing rapidly. The reuse of wastes, on the other hand, provides both lower costs and savings of depleted resources. In addition, it also provides very positive contributions to reducing the carbon footprint by reducing the emission of carbon emissions and other harmful gases together with the prevention of environmental pollution.

In this study, it is aimed to use marble dust, which is the waste output of the marble industry, and egg shells, which is the waste output of the food industry, as additive materials, instead of the traditional additives used in concrete, which is a composite material, and cement, which is the most important component of concrete. In addition, the use of chicken feathers, which is a waste output of the livestock and food industry, as a reinforcing material for binding fiber (fiber) will be examined.

In order to keep the scope wide, limestone (limestone) will be used as a reference additive throughout the entire study. Limestone additive in cement is defined as cement additive in TS EN 197-1:2012 Standard and has been used by all factories during cement production without any problems for years. In this study, Dinçer Çimento ve Beton San. Trade Inc. Pure limestone (limestone) was used as a cement additive obtained from the raw material quarry of the factory.

“When marble blocks extracted from marble (natural stone) quarries are cut with diamond saw cutters in marble cutting factories, marble dust, which can reach fine dimensions in the micron range, is exposed. The amount of waste marble dust generated annually in Turkey and collected in landfills is approximately 650 thousand tons” (Cömert, 2012). In recent years, many academic

studies and industrial trials have been carried out for the purpose of using the marble dust stock, which has increased with the increasing production capacity, as a cement additive in accordance with the standards. Many of these studies and trials have yielded positive results, and its use on an industrial scale is often hampered by high moisture content and transportation costs. The purpose of using marble dust in this study is to consider it as a second reference next to limestone in terms of its source, rather than examining its usability as an additive. So much so that marble powder has a very high CaCO3 (Calcium Carbonate) content like limestone (limestone) in terms of chemical composition. The marble dust to be used in the study was taken from the stock area of a marble factory operating in the Afyon region, where diamond cutting powders are stocked.

In our country, 1.35 billion chickens were slaughtered in 2022 and the amount of feathers removed from each chicken is 55 grams on average in cleaned and dried condition. Accordingly, a great majority of chicken feathers around 74 thousand tons per year cannot be evaluated. In this study, chicken feathers will be used as a reinforcing material to act as a binding fiber (fiber) in cement mortar, and the relative effects of eggshell powder on concrete compressive strength will be examined. After the chicken feathers to be used in the study were collected in mixed form from the coops of local chicken producers, the necessary cleaning processes were carried out. Some technical information about chicken feathers is provided by Bahar Hindi Entegre A.Ş., operating in Antalya and producing chicken products in the past. taken from the factory.

## MATERIAL AND METHODS

The materials used in the studies and their properties and the methods applied are explained in this section. All experimental studies were carried out by Dinçer Çimento ve Beton San. Trade Inc. made in the Quality Control Laboratory of the factory.

### Materials

In order to carry out independent tests of the additives planned to be used and to compare the results in a healthy way, first of all, the clinker sample was grinded together with gypsum (gypsum or dihydrate) in the laboratory, and a blind sample, that is, a cement sample without additives, was prepared. Additive cement samples were prepared by substituting all additive samples to be used in experimental studies separately into this blank sample. During the study, ground limestone (limestone), marble dust, eggshell powder and chicken feathers were used as reinforcement material to replace this cement. Physical and chemical analyzes of each material and each cement sample prepared with these materials were performed. After the mortars were prepared separately from the cement samples, the prism concretes were poured and cured for 2 days, 7 days and 28 days, compressive strength and other mechanical tests were carried out. Conformity assessment was carried out considering the results found, cement type and replacement additive amounts defined in TS EN 197-1:2012 Standard (TS EN 197-1, 2012).

### Preparation of the Blind Sample

Portland clinker and gypsum (gypsum, CaSO4.2H2O) samples required for the blank sample to be prepared in order to make comparisons by substituting the additives planned in the study independently from each other, were taken from the weighed rubber bands feeding the cement mills of the factory. Gypsum is an indispensable component used as a setting (freezing) time regulator in cement. The chemical analysis and phase values of the clinker used in the prepared blank sample are given in Table,1 and the chemical analysis of the gypsum stone is given in Table 2.

In order to regulate the setting (freezing) time of Portland clinker, 5% by mass of gypsum was added into it and it was taken from the mill after grinding in a laboratory type ball mill for 30 minutes. The prepared blank sample is given in Figure 1.

Table 1. Chemical analysis and phases of the clinker sample used for the blank sample.

| Experimental Data | Result Values | Phase and Modules | Result Values |
|---|---|---|---|
| $SiO_2$ (%) | 21,17 | Serbest CaO | 1,52 |
| $Al_2O_3$ (%) | 5,53 | Lime Saturation Factor | 96,32 |
| $Fe_2O_3$ (%) | 4,01 | Silikat Modülü (S.M.) * | 2,22 |
| CaO (%) | 66,35 | Aluminum Module * | 1,38 |
| MgO (%) | 1,37 | C3S (Alit) * | 60,10 |
| $SO_3$ (%) | 0,50 | C2S (Belit) * | 15,35 |
| $Na_2O$ (%) | 0,19 | C3A (Selit) * | 7,87 |
| $K_2O$ (%) | 0,89 | C4AF (Ferrit) * | 12,20 |
| Loss of Glow (%) | 0,22 | | |

Table 2. Chemical analysis of the gypsum sample used for the blank sample.

| Experimental Data | Result Values |
|---|---|
| $SiO_2$ (%) | 3,16 |
| $Al_2O_3$ (%) | 0,75 |
| $Fe_2O_3$ (%) | 0,44 |
| CaO (%) | 33,25 |
| MgO (%) | 0,58 |
| $SO_3$ (%) | 40,26 |
| $Na_2O$ (%) | 0,18 |
| $K_2O$ (%) | 0,21 |
| Loss of Glow (%) | 20,99 |
| Kristal Su (Hidrate Su) (%) | 17,49 |

## RESULTS AND DISCUSSION

### Determination of Mortar Consistency (Water Requirement)

First of all, consistency test is performed on the cement sample to be tested for compressive strength and other mechanical tests, and the water requirement of the mortar prepared with the cement sample is determined. For this, 500 grams of cement sample was weighed on a scale with 1 gram precision. 125 mL of distilled water, which was rested at room conditions for at least 24 hours, was poured into the mixing chamber of the mortar mixing device, and the cement sample was carefully added within 10 seconds. The mortar mixing device was immediately started and stopped at low speed for 90 seconds. Within 30 seconds, the walls of the mixing chamber were cleaned and added to the mixture, and the mortar mixing device was operated at low speed for 90 seconds and mixed. A clean lubricated vicat ring was placed on the glass plate, the cement paste in the mixing chamber was placed without delay and the mortar surface was leveled. Zero adjustment was made by attaching the probe to the Vicat instrument. The tip of the probe was lowered in the middle of the vicat ring until it slightly touched the upper surface of the mortar, left for 1-2 seconds and released. The probe entered the mortar with its own weight. For cement paste with normal consistency, if the water used is sufficient, the probe descends to the glass plate until it remains 6±2 mm in half a minute. This process was repeated with water at least once for each sample, and the required amount of water for the cement samples was determined.

### Compressive Strengths

When comparing the concrete performances of additives by adding them to the cement, another condition for their conformity with the CEM I Portland Cement class and CEM II / A-L Portland Calcareous Cement class according to the TS EN 197-1:2012 Standard is the concrete compressive strength (compressive strength) (TS EN 197-1, 2012).

While naming the cements, it depends on the type of admixture (like CEM I or CEM II / A-L), the variety of additives (like CEM II / A-M (P-L), the amount of admixture type (like CEM II / B-L), 28 days min. compressive strength (such as CEM II / A-L 42.5) and 2 days min. It is classified according to the amount of compressive strength (such as CEM II / B-L 42.5 R) and gets coding.

**Evaluation of Compressive Strength Results According to CEM I Class**

2 days, 7 days and 28 days compressive strengths of cements with additives prepared in CEM I class with 5% replacement additives and blind samples are given below graphically. When all compressive strengths were examined, calcareous cement gave the best performance with 5% additive substitution compared to the blank sample prepared as a reference. Even though the cement with marble powder additive lagged behind in compressive strength for 2 days, it was the cement that showed the second highest performance in 7 days and 28 days. Both eggshell powder added and eggshell powder chicken feather reinforced cement samples generally showed relatively low performance in compressive strengths. Addition of 0.1% chicken feather to eggshell powder in 5% additive substitution did not provide a significant performance increase. The fact that the eggshell powdered cement sample is higher than the marble powder added cement in only 2 days of compressive strength shows that the eggshell powder alone has some early strength increasing feature. This shows that in factories producing low early strength cement and in regions with harsh winter climates, an advantage can be obtained by using eggshell powder for early strength reductions in ready-mixed concrete.

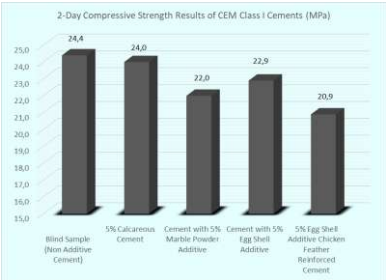


Figure 1. 2-day compressive strength (MPa) of CEM Class I cement samples.

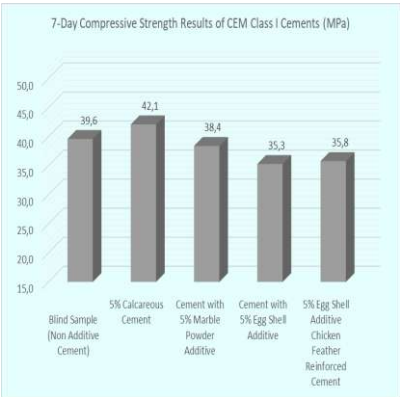


Figure 2. 7-day compressive strength (MPa) of CEM Class I cement samples.

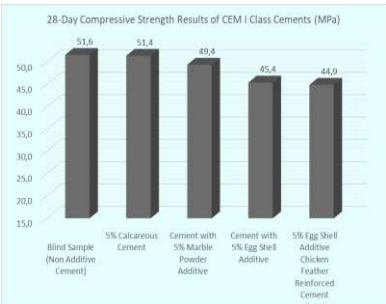


Figure 3. 28-day compressive strength (MPa) of CEM Class I cement samples.

Evaluation of Compressive Strength Results According to CEM II / A-L Class

When the compressive strengths given in Figures 1, 2, and 3 graphs of the blind sample and the 10% additive substituted cement samples are examined, the calcareous cement is the cement with the highest compressive strength after the reference blind sample, and it again surpassed the blind sample in 7-day strengths. Although marble powder added cement showed the best performance according to 7 days and 28 days strengths after calcareous cement, it lagged behind eggshell powder added cement in 2 days strength. Cement with eggshell powder additive, which had early strength increasing feature, did not perform well at 7 days and 28 days strength, and gave very close strength results with chicken feather reinforced cement. Even though the eggshell powder added chicken feather reinforced cement gave the lowest 2 days strength to the 10%+0.2% replacement additive, this time it gave almost identical results to the eggshell powder added cement at 7 days and 28 days strengths.

The compressive strength results obtained from the experiments with 10% substitution additive and graphed below (Figure 1,2,3) are compared in the chart in Figure 4, starting from the high strength class from right to left. While 10% calcareous cement cannot meet the 52.5 N strength class requirements, it is seen that it is CEM II / A-L 42.5 R type cement by meeting the 42.5 R strength requirements. However, while 5% replacement additive can also meet the requirements for the 52.5 N strength class, the strength class has decreased with the increase in the additive. Cement with 10% marble powder additives, 10% eggshell powder added cement and 10% eggshell powder 0.2% chicken feather reinforced cements are also CEM II / A-L 42.5 R type cements as they meet the 42.5 R strength class requirements. . However, cement with 10% eggshell powder additive and 10% eggshell powder and 0.2% chicken feather reinforced cements meet the requirements of 42.5 R strength class with a small margin. Therefore, it may decrease to 42.5 N resistance class in the 2-day strength performance decrease due to the adverse conditions to be experienced in the process, and to 32.5 R resistance class in the 28-day strength decrease.

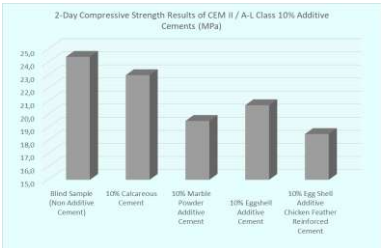


Figure 4. 2-day compressive strength (MPa) of CEM II / A-L Class cement samples with 10% replacement additives.

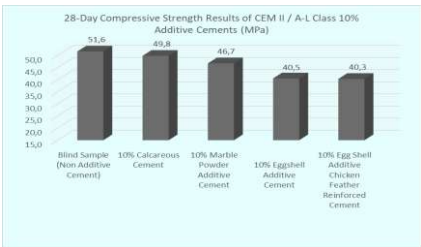


Figure 5. 28-day compressive strength (MPa) of CEM II / A-L Class cement samples with 10% replacement additives.

When the compressive strengths of the produced samples with 15% admixture were compared from the Figures 4 and 5 graphs, the 2 day and 28 day strength performances were calcareous cement, marble powder added cement, eggshell powder added cement and eggshell powder added chicken feather reinforced cement in order from high to low. In the 2-day strength,

the eggshell powder added cement again broke the ranking with its early strength increase feature and surpassed the marble powder added cement. 0.3% chicken feather reinforcement material added to the eggshell powder added cement at a 15% replacement additive ratio created a negative impact on the compressive strengths and further reduced the strengths.

**Setting (Freezing) Time Determination**

To determine the setting (freezing) times of the cement samples, a cement paste of normal consistency was prepared with 500 grams of cement and 125 grams of water, and the hour was recorded. After placing the cement paste in the ring of the vicat tool and smoothing the surface with a gauge, the ring containing the dough was carefully placed in the vicat tool. The Vicat needle was adjusted to point to zero when it touched the subfloor where the ring was placed. The Vicat needle was lowered until it touched the upper surface of the dough in the ring, held for 1-2 seconds and released. The needle was suddenly inserted vertically into the dough. The value on the display was read after the needle was fully inserted into the dough (or 30 seconds after the needle was released, whichever comes first). A needle was inserted into the dough every 10 minutes to determine the setting start time. The puncture site of the needle should be 8 mm from the ring edge and 10 mm from the previous puncture site. The needle was thoroughly wiped with a cloth after each insertion. Setting is considered to have started when the needle inserted into the cement paste is 6±3 mm away from the lower plate. The clock was read and recorded. The time elapsed from the moment the cement and water are mixed to the start of the set gives the set start time. After the start of the setting, the needle continued to be dipped into the dough every 10 minutes. The moment when the needle can penetrate the dough by a maximum of 0.5 mm gives the setting time. The clock was read and recorded again. The end of the socket is the time from the moment of zero to the sinking time of 0.5 mm. These processes were repeated for each sample separately to determine the setting times and are given in Figure 6.

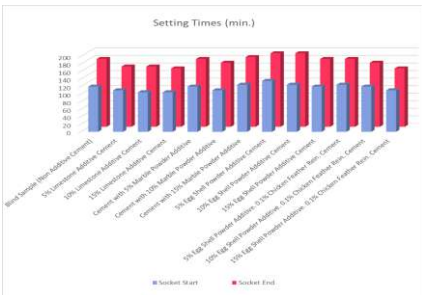


Figure 5. Set (socket) start and set end times of all cement samples.

**Volume Expansion Determination**

Volume expansion determinations were continued from the cement pastes left over from the setting time determination. If the paste is insufficient, the volume expansion can be determined by preparing the cement paste of normal consistency with 500 grams of cement and 125 grams of water. The lightly oiled Le Chatelier mold was placed on a lightly oiled glass plate and filled with cement paste. The upper surface of the Le Chatelier mold was smoothed with a spatula. The upper surface was covered with a glass plate and a weight of about 75 grams was placed on it. The molds were kept in a curing cabinet at a temperature of 20±1°C and at least 90% humidity for 24 hours. After 24 hours, the glass plates on the molds were removed. The openings of the rod ends in the molds were measured and recorded (a). The molds were placed in the boiling pot with the sticks up. The boiling pot was heated to boiling in 30 minutes and kept at boiling temperature for 3 hours. At the end of the boiling time, the bar ends clearance was re-measured (b). After the molds were taken from the hot environment and allowed to cool down to the laboratory ambient temperature, the distances (c) between the rod ends were measured and rounded to the nearest 0.5 mm.

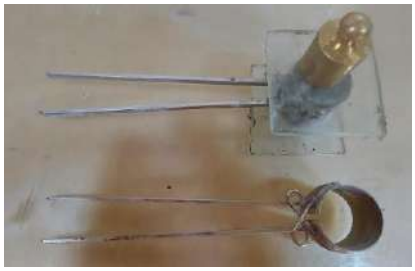

Figure 6. Volume expansion test on Le Chatelier ring (top) and empty ring (bottom).

According to the test results, (b-a), (c-b) and (c-a) values were calculated separately in mm. The value (c-a) gives the total volume expansion in mm. When the volume expansion of the prepared samples was calculated, the volume expansion value of the blank sample was 0.5 mm, and the volume expansion of all the other samples was found to be 1 mm. Since the upper limit of volume expansion in the TS EN 197-1:2012 Standard is 10 mm, it has been observed that all of our samples comply with the standard.

The main purpose of this study is to examine the effects of eggshell and chicken feathers on cement and concrete and to investigate their usability. Many tests were carried out by planning to replace it with cement and the results were compared with limestone and marble dust, which can be used as a substitute additive. In this direction, an admixture-free cement sample (blind sample) was prepared and the additives to be examined were substituted into this cement at different rates. The physical, chemical and mechanical tests of cement samples produced starting from granular clinker under laboratory conditions were carried out and the cement classes that they were qualified according to the criteria given in the TS EN 197-1:2012 cement standard were also determined. Thus, a partial cement production process was manually simulated under laboratory conditions.

It was observed that all cement samples examined in two groups as CEM I and CEM II / A-L according to the additive amount class, met the minimum standard requirements of the chemically related cement class. When the workability properties of the mortar were examined, calcareous cement showed the best performance and showed the same properties as the reference blank sample. Despite the increase in the amount of additive, it has preserved its consistency.

Cement mortar with marble powder additives, on the other hand, showed a slight loss of consistency with the increase in the amount of additive, but generally showed properties close to calcareous cement mortar. It also succeeded in reducing the water requirement of the mortar.

In the eggshell powder added cement mortar, the water requirement increased and the consistency decreased compared to the reference blank sample. With the increase in the amount of additives, the workability also decreased. The sulphur-like burnt odor that emerged while grinding the eggshell powder was mildly evident in the mortars of the cements with 10% and 15% additives. In cement mortars reinforced with chicken feathers to egg shell powder, although the amount of water was increased depending on the consistency, it quickly lost its consistency and the workability became very difficult. In particular, when cement mortar reinforced with 0.3% chicken feathers to 15% eggshell powder was placed in the mold, some feather fibers separated from the mortar surface and formed craters. While it became difficult to level the mortar surface, slight odor formation was observed in the mortar. Here it is understood that the size of the trimmed chicken feathers, about 10 mm, should be smaller. In addition, dry chicken feathers have increased the need for water due to their large surface area.

Chicken feather reinforced cements with eggshell powder showed the worst performance in concrete compared to other samples, as can be seen from the consistency of the mortar and the water requirement. It gave the lowest compressive strength results in the comparison in each additive group. Although the compressive strengths of cements with eggshell powder additives were better than cements with chicken feathers, they lagged behind the cements with limestone and marble powder in 7 days and 28 days of compressive strength. However, it has shown that it has

the ability to increase early strength by giving higher compressive strength than marble powder added cements at 2 days compressive strength (Kocatepe, 2019).

In the compressive strength tests performed separately with three additive groups, 5%, 10% and 15%, the blind sample gave the highest compressive strength, and the ranking was calcareous cement, cement with marble powder additives, cement with eggshell powder additive and chicken feather with eggshell powder additive. continued as reinforced cement. Based on the 42.5 R strength class cement, which is the most preferred and most produced in the market in Turkey, the limestone additive can be easily used in all three substitution ratios. Marble powder additive could not meet the 42.5 R strength class requirements by reducing the early strength by 15%. While production can be made in the 42.5 R strength class with 5% and 10% additives, it will be possible to produce in the 42.5 N strength class, which is a subclass with 15% additives. The probable reason for this may be the pollution mixed with the marble dust in the storage conditions. With the additive of egg shell powder, it is possible to produce in 42.5 R strength class at 5% and 10% additive rates. However, since the compressive strength remains low for 28 days at a 15% additive rate, it falls into the 32.5 R strength class. Similarly, it will be possible to produce in 42.5 R strength class with 5% + 0.1% and 10% + 0.2% additives made with chicken feather reinforcement to egg shell powder, and in 32.5 R strength class with 15% additives. Therefore, it has been proven that CEM I 42.5 R Portland cement can be produced easily with eggshell and chicken feathers. None of the additives created a significant volume expansion in the concrete and did not create any non-compliance.

## CONCLUSIONS

It has been observed that egg shells and chicken feathers can easily be used as replacement additives for cement. In industrial conditions, it is obvious that better results can be obtained by optimizing the process parameters.

Eggshell powder additive and eggshell powder additive with 0.1% chicken feather additive and 5% additive CEM I 42.5 R class cement, 10%+0.2% additive CEM II / A-L 42.5 R class It has been proven under laboratory conditions that cement can be produced and concrete can be poured easily. The most preferred and most produced cements in our country's market are in the 42.5 R strength class.

CEM II / A-L 32.5 R class cement can be produced even at a high additive rate of 15% with 0.3% chicken feather additive to eggshell powder additive and eggshell powder additive.

Even if the performance of cements produced under laboratory conditions with eggshell powder additive and chicken feather additive to eggshell powder additive is lower than the cements with limestone cement and marble powder additive produced under the same conditions, it is possible to produce higher performance cement by changing the process parameters under operating conditions.

The egg shells have been removed as much as possible from oil, protein residues and membranes by hand under hot water during the preparation stage. However, the smell coming from the mortar of the cement prepared with high additive ratio during grinding showed that the cleaning process was not sufficient. This process may create extra workload and cost, even a bottleneck, compared to other additive types in operating conditions in continuous and high usage amounts. If better cleaning is done by overcoming this problem, higher performances can be obtained from egg shells.

Eggshell powder showed a good performance at 2-day strengths in the compressive strength test at all additive ratios, revealing its early strength increase feature. This will help to eliminate the problem of low early strength by using it in cement factories and concrete production facilities that have low early strength problems, or in regions where strength drops more than normal due to harsh winter conditions.

The use of chicken feather as a reinforcing material to eggshell powder in cement for binding fiber (fiber) did not show the expected effect. The reason for this is that although it is used in very low proportions by mass, it has become too large both in terms of size and volume in the 40x40x160 prism. Particularly, it remained in very large pieces among the fine-sized standard

censor sand particles and the mortar did not perform adequately because it disrupted the integrity of the concrete. Instead, it is thought that chicken feathers will perform much better when used in smaller sizes in 40x40x160 prism concretes or in 150x150x150 mm in size ready mixed concrete prepared with aggregates, thus revealing the binding fiber properties.

In all additives used in cement in general, the setting time was prolonged with the increase in the additive ratio, while the setting time was shortened as the amount of chicken feather reinforcement applied to the eggshell powder increased. This has revealed the feature of shortening the setting time of the chicken feather supplement. The use of chicken feathers in cement factories and concrete production facilities that have long setting problems due to process conditions or the amount of additives, or in regions with long setting times due to harsh winter conditions, and even in projects where fast setting is required, will help to eliminate these problems.

Considering all the tests carried out during the work, the production of cement and concrete in accordance with the standards will be possible by using egg shells and chicken feathers as additives.

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# 1D TEMPERATURE TOMOGRAPHY OF A FLAME, BASED ON VIS-NIR SPECTROMETRY

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## ABSTRACT

This study presents a novel method for the reconstruction of the temperature distribution inside firebox of a coal power plant. A set of experimental measurements was performed on the premises of a large commercial coal power plant. The distribution of the temperature has been reconstructed using spectrometry measurements. Radiative heat transfer model was used to solve inverse problem by damped least-squares (Levenberg-Marquardt) method. This research offers experimental, and measurement set up in power plant based on two spectrometers. Two probes were coupled to two identical spectrometers via optical fiber cables. The temperature field distribution was measured in one dimension, along the line of sight between two horizontally opposed optical probes. The advantage of this method is in its simplicity and in addition, it enables the faster determination of temperature profile. The new method avoids the need for an insertion of cooled probes deep into the firebox. It also enables calculating of the average attenuation coefficient which is related to the concentration of particles in the flame. This method gives the opportunity to be modified for determination of 2D and 3D temperature distributions.

**Keywords:** Temperature measurement, temperature profile, spectrometry.

## INTRODUCTION

Accurate monitoring and mapping of temperature distributions within the firebox of a coal power plant are critical for achieving high combustion efficiency and optimizing heat transfer to the boiler. The shape of the flame and the distribution of temperature fields play a significant role in determining the efficiency of heat transfer (Askarova et al., 2012; Kuang et al., 2012). However, non-optimal temperature field distributions can lead to operational challenges, such as slagging and high NOx emissions, which affect the overall performance and sustainability of coal power plants (Ballester, & García-Armingol, 2010).

To address these challenges, this study aims to present a pioneering method for the reconstruction of temperature distribution inside the firebox of a coal power plant. In order to accomplish this, a series of experimental measurements were conducted on the premises of a large commercial coal power plant. The temperature distribution was reconstructed using state-of-the-art vis-NIR spectrometry measurements, offering a novel and powerful approach to temperature tomography of a flame.

In recent years, there have been significant advancements in research related to temperature tomography techniques in combustion systems. For instance, Askarova et al. (2012) employed mathematical simulations to understand the behavior of pulverized coal combustion in a chamber, providing valuable insights into temperature distributions. Kuang et al. (2012) investigated asymmetric combustion characteristics and NOx emissions in a down-fired utility boiler under varying boiler loads, shedding light on the intricacies of temperature fields in practical combustion systems. Furthermore, Ballester and García-Armingol (2010) explored diagnostic techniques for monitoring and controlling practical flames, emphasizing the importance of temperature field mapping for efficient combustion processes.

Recent advancements in imaging technology have also contributed to the field of temperature distribution reconstruction. Niu et al. (2022) utilized Tikhonov regularization for

tomographic laser absorption reconstruction. Shui et al. (2021) used dictionary learning for tomographic absorption spectroscopy to solve ill-posed inversion problem. Zhang et al. (2021) proposed method based on direct solution algorithm for a fast tomographic reconstruction.

By building upon the existing research and leveraging the potential of vis-NIR spectrometry, this study aims to contribute to the field of temperature tomography of a flame in coal power plants. The proposed method holds immense promise for enhancing combustion efficiency, reducing emissions, and optimizing the overall performance of coal-fired systems.

## MATERIAL AND METHODS OF WORK

To measure the temperature field distributions in a coal power plant's firebox, a one-dimensional approach was adopted, focusing on the line of sight between two horizontally opposed optical probes. Each optical probe was securely housed within a robust stainless-steel tube, strategically positioned protruding through the firebox wall, as depicted in Figure 1.

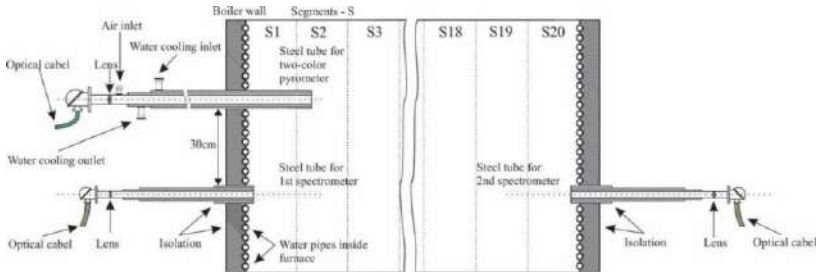


Figure 1. Space inside firebox with two mounted stainless-steel tubes for spectrometers and one for two-color pyrometer. Space is segmented for measurement of temperature profile.

The optical probes were meticulously connected to two identical spectrometers using high-quality optical fiber cables. Spectral radiances were measured at 40 wavelengths ranging from 800 nm to 900 nm using the advanced Aurora 4000 spectrometers. This spectral range was chosen to capture crucial temperature-related information within the flame.

In order to ensure independent measurements of the temperature distribution, an additional two-color pyrometer was employed. The pyrometer, coupled to an 8-meter-long stainless-steel tube, offered an alternative means of temperature assessment. This supplementary method provided complementary data and enhanced the reliability of the overall temperature reconstruction process.

Prior to the utilization of our novel method, several popular techniques have been employed to investigate temperature distributions in combustion systems. For instance, Lukovic et al. (2018) used two-color pyrometer for reconstruction of temperature profile of the flame and calculating attenuation coefficient in a coal power plant.

In contrast, our approach capitalizes on the capabilities of spectrometry and two-color pyrometry, enabling non-intrusive, high-resolution temperature measurements along the line of sight. This unique combination of techniques provides comprehensive insights into the temperature field distributions within the firebox of a coal power plant.

By employing the described materials and methods, we aimed to accurately capture and reconstruct the temperature distribution in the firebox, ultimately contributing to the optimization of combustion efficiency and the reduction of emissions in coal power plants.

## RESULTS AND DISCUSSION

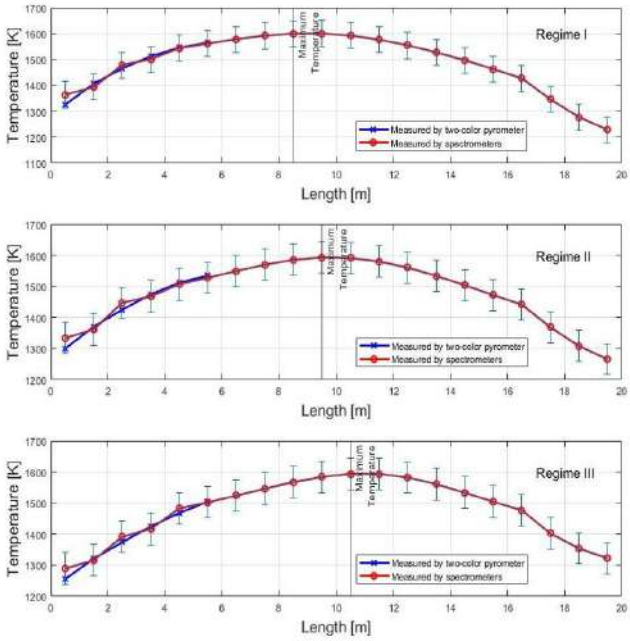


Figure 2. Distribution of measured temperatures along distance between two walls inside firebox for three loading regimes.

Figure 2 displays the comparison between the distribution of absolute temperatures obtained from the two-color pyrometer coupled with a stainless-steel tube (blue line) and the reconstructed temperature distribution using the Levenberg-Marquardt optimization algorithm (red line). The close agreement between the first six measurement positions validates the accuracy and reliability of our method for temperature reconstruction based on spectrometric measurements.

The average coefficient of absorption was calculated to be 0.061 $m^{-1}$ with an initial value of 0.07 $m^{-1}$ for the optimization algorithm.

While the remaining positions measured with the spectrometers could not be directly verified with the pyrometer due to limitations in tube length, the results obtained from the spectrometric measurements contribute to a comprehensive understanding of the overall temperature field within the firebox. Our approach utilizing vis-NIR spectrometry overcomes limitations of traditional methods and provides enhanced spatial coverage, improved accuracy, and non-invasiveness. This makes it a valuable tool for optimizing combustion efficiency, reducing emissions, and ensuring the sustainable operation of coal power plants.

Compared to popular methods like thermocouples, thermographic phosphors, and laser-induced fluorescence (Wondraczek et al., 2004.; Wang et al., 2010; Monkhouse, 2002; Lawitzki et al., 1990), our approach offers advantages such as non-intrusive, high-resolution temperature measurements along the line of sight. It enables continuous monitoring of temperature variations in real-time, providing insights into the dynamic behavior of the combustion process. The combination of vis-NIR spectrometry and the Levenberg-Marquardt optimization algorithm provides a robust and effective solution for temperature tomography of a flame.

## CONCLUSIONS

In conclusion, our proposed method based on vis-NIR spectrometry offers significant advantages in terms of simplicity, speed, and practicality for temperature tomography of a flame. By eliminating the need for intrusive cooled probes, our approach streamlines the measurement process and reduces potential complications. Additionally, the ability to calculate the average attenuation coefficient enhances the characterization of the combustion process.

Compared to traditional methods, our approach overcomes limitations in spatial coverage, invasiveness, and real-time monitoring. The adaptability of our method for determining 2D and 3D temperature distributions opens up new avenues for comprehensive characterization and optimization of combustion processes in coal power plants.

Future research can focus on further refinements of our method, including the development of advanced algorithms and techniques for the reconstruction of temperature distributions. Comparative studies with other existing methods will provide valuable insights into the strengths and limitations of different approaches, facilitating ongoing discussions in the field of temperature measurement and monitoring in combustion systems.

Ultimately, the application of our method has the potential to significantly contribute to the optimization of combustion efficiency, reduction of emissions, and overall performance improvement in coal power plants, leading to more sustainable energy production.

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# KREIRANJE MODULA INFORMACIONOG SISTEMA ZA ODRŽAVANJE MOTORNIH VOZILA

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## SAŽETAK

Informacioni sistem za održavanje motornih vozila je veoma složen i sadrži veliki broj procesa, tokova podataka, skladišta podataka i spoljnih objekata. Istovremeno jasna i detaljna specifikacija sistema zahteva da se i na predstavljanje sistema pomoću DTP-a primeni metoda apstrakcije. To se postiže sa jedne strane hijerarhijskom dekompozicijom procesa, a sa druge strane specifičnim načinom prikazivanja strukture i sadržaja tokova i skladišta podataka u rečniku podataka strukturne sistem analize, uz eventualno hijerarhijsko prikazivanje strukture spoljnih objekata, kreiranjem modula.

**Ključne reči**: Analiza procesa, održavanje motornih vozila, složeni tehnički sistemi, moduli.

## UVOD

Analiza predstavlja proučavanje problema pre preduzimanja neke aktivnosti. U specifičnom domenu razvoja računarskog sistema, analiza se odnosi na proučavanje nekog područja delatnosti ili aplikacije, što obično vodi ka specifikaciji novog sistema. Najznačajniji proizvod analize sistema je specifikacioni dokumet. Jedan od osnovnih zadataka praćenja aktivnosti održavanja podržan je računarom jeste oblikovanje tih aktivnosti u odgovarajuće module, odnosno definisanje modula održavanja u okviru informacionog sistema održavanja i stvaranje veza između njih i ostalih podsistema u celini. Strukturna sistem analiza (SSA) nastala je kao odgovor na problem neadekvatne specifikacije zahteva korisnika pomoću klasičnih sredstava funkcionalne analize.

## STRUKTURNA SISTEM ANALIZA

Osnovne karakteristike strukturne sistem analize su (Adamović, 2016):

- jasna grafička specifikacija, pogodna za komunikaciju sa korisnikom,
- istovremeno jasan i detaljan opis sistema, primenom metode apstrakcije tako da se sistem na višim nivoima apstrakcije opisuje jasno a na nižim detaljno,
- logička specifikacija procesa, koja opisuje šta će budući sistem raditi i šta će pružati korisniku,
- kombinacijom sa ranije definisanim proširenim modelom objekti – veze, pored ostalih prednosti koje SSA pruža, dobija se i formalna specifikacija, koja je, iako ne potpuno izvršena, pogodna za definisanje preciznih pravila za njenu transformaciju u prototip ili direktno u radni sistem.

Osnovni koncepti za specifikaciju informacionog sistema u SSA su (Adamović, 2016):

- Funkcije (procesi obrade) – SSA posmatra informacioni sistem kao funkciju (proces obrade) koja na bazi ulaznih generiše izlazne podatke. Ulazni podaci se dovode u proces obrade, a izlazni iz njega odvode preko tokova podataka. Drugim rečima, procesi obrade podataka predstavljaju aktivnu komponentu sistema koja vrši transformaciju strukture i sadržaja ulaznog (ili ulaznih) tokova u izlazni (ili izlazne) tok podataka;
- Tokovi podataka – tretiraju se kao vod ili kao pokretna traka kroz koji stalno teku ili koja stalno nosi podatke ili grupe podataka poznate strukture na najrazličitijim nosiocima – papirni dokumenti, niz poruka koje čovek unosi preko tastature terminala, skup informacija dobijen preko neke telekomunikacione linije i slično;

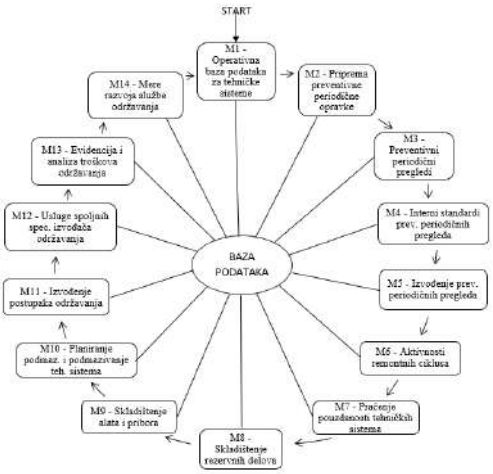
- Interfejsi – tj. izvori ulaznih, odnosno ponori izlaznih tokova podataka mogu biti objekti van sistema koji sa sistemom komuniciraju nazivaju se interfejsi. Oni predstavljaju neki objekat van konteksta posmatranog sistema koji se javlja kao izvor i/ili ponor tokova podatala;
- Skladišta podataka – posmatraju se kao tokovi u mirovanju, odnosno odloženi, akumulirani tokovi, različite vrste evidencija, arhiva, kartoteka i datoteka. Za skladišta kao i za tokove od interesa su isključivo njihov sadržaj i struktura. Naime, skladište podataka je tok podataka u mirovanju. Pod skladištem podataka se može podrazumevati kartoteka, evidencija, registar, datoteka i slično.

Njihov međusobni odnos se prikazuje preko Dijagrama toka podataka (DTP) koji prikazuje vezu interfejsa, odnosno skladišta kao izvora tj. ponora podataka sa odgovarajućim procesima i međusobnu vezu procesa. DTP predstavlja mrežni model sistema koji sadrži četiri osnovne komponente sistema: procese obrade podataka (aktivne komponente sistema), interfejse sa kojima sistem komunicira, skladišta podataka koje procesi koriste i/ili ažuriraju i tokove podataka koji povezuju ostale komponente sistema i njihove grafičke oznake.

Postupak hijerarhijske dekompozicije DTP-a vrši se tako što će jedan proces sa DTP-a višeg nivoa apstrakcije dekomponuje i prikazuje pomoću celokupnog DTP-a nižeg nivoa apstrakcije, pri čemu se moraju poštovati određena pravila i konvencije. Osnovno pravilo koje se mora poštovati pri dekompoziciji je pravilo bilansa nivoa: ulazni i izlazni tokovi DTP-a dobijenog dekompozicijom moraju biti ekvivalentni sa ulaznim i izlaznim tokovima procesa koji se dekomponuje.

## MODULI ZA POTREBE INFORMACIONOG SISTEMA ODRŽAVANJA

Osnovne karakteristike modula za potrebe informacionog sistema održavanja (Slika 1) biće prezentovani i obezbeđena njihova skorija primenljivost.




Slika 1. Moduli informacionog sistema održavanja.

Prvi modul predstavlja ulazni modul ovog sistema i i sadrži informacije o raspoloživim mašinama, opremi, njihovoj lokaciji, tehničkom sastavu, izvođenju radova održavanja na njima, specifikaciju izvršilaca aktivnosti održavanja, potrebnom broju radnika na radovima održavanja pojedinačnih projekata i dr. Drugi modul obuhvata način i strukturu postupaka preventivnog održavanja, planiranje i terminiranje elemenata logističke podrške, planiranje i terminiranje troškova, planiranje i terminiranje raspoloživih resursa (Adamović, & Ilić, 2013). Preventivni periodični pregledi nemaju povratnih informacija za nađeno stanje na licu mesta i zbog toga se za svaku aktivnost kreira novi dokument. Četvrti modul predstavlja osnovne nosioce informacija za

vršioca aktivnosti procesa sprovođenja preventivnog pregleda. Izvođenje preventivnih periodičnih pregleda se aktivira, ako ima potrebe za to, posle izvršenih aktivnosti periodičnog pregleda. Ovaj modul daje listu kvarova koje trebamo otkloniti i gde; operativni redosled izvođenja i sprovođenja ovih aktivnosti za svaki tehnički sistem i definiše mesto izvođenja radova. Aktivnosti remontnog ciklusa obezbeđuje informacije o:

- tehničkim karakteristikama sistema,
- neophodne za definisanje strategije i politike razvoja tehničkih sistema,
- za analizu načina korišćenja, odnosno eksploatacija tehničkog sistema i
- starosti tehničkih sistema.

Praćenje pouzdanosti tehničkih sistema sadrži pregled sastavnih delova tehničkih sistema čije se ponašanje prati, istorijat tehničkog stanja sistema, merenje i kontrolu parametara stanja tehničkog sistema u procesu eksploatacije, podatke o radnom mestu i vremensku sliku stanja u radu i stanja u otkazu tehničkog sistema. Modul za upravljanje zalihama rezervnih delova i materijala i omogućava držanje tih zaliha u granicama projektovanih i dozvoljenih odstupanja uspostavljenih prema potrebama održavanja kontinuiteta procesa proizvodnje sa jedne strane i minimiziranja obrtnih novčanih sredstava sa druge strane. Skladište alata i pribora je sličan kao modul M8, ali s tom razlikom što umesto rezervnih delova posmatra alate i pribor. Planiranje podmazivanja i podmazivanje tehničkih sistema je modul kojim se teži dati neophodne informacije koje će obezbediti smanjeno trenje i trošenje materijala i to sistemskim praćenjem uvođenja maziva između tarnih površina u tehničkim sistemima koje su u relativnom kretanju. Izvođenje postupaka održavanja predstavlja modul kojim se utvrđuje operativni redosled izvođenja i sprovođenja aktivnosti održavanja za svaki tehnički sistem. Sledeći modul je predviđen za situacije kada radove na održavanju izvode druge angažovane firme, a evidencija i analiza troškova postupaka održavanja obuhvata: statističke analize, izveštaje, kontrolu troškova i dr. Mere razvoja službe održavanja obuhvata: strukturu i tehničke podatke tehničkih sistema, praćenje troškova osnovnih sredstava, mesto korišćenja tehničkog sistema, amortizaciju i opis tehničkih sistema.

## ZAKLJUČCI

Model strukturne sistemske analize predstavlja jednu potpunu metodologiju za specifikaciju informacionog sistema, odnosno softvera koja se na različite načine može povezati sa metodama drugih faza u neku specifičnu metodologiju celokupnog razvoja informacionog sistema. SSA može biti polazna osnova za: metodu strukturnog projektovanja programa, projektovanje logičke strukture baze podataka, može se tretirati kao metodološki postupak dekompozicije nekog sistema na podsisteme sa ciljem da se nalaženjem modela podataka podsistema i njihovom integracijom dođe do potpunog modela podataka posmatranog sistema.Kreiranje modula nam omogućava:

- poboljšanje praćenja i ocenivanja stanja motornih vozila, opreme, instalacija i dr.;
- optimalno planiranje potrebnih resursa;
- povećanje vremena eksploatacije i pouzdanosti motornih vozila;
- upravljanje parametrima procesa i upravljanje troškovima održavanja;
- optimizaciju potrošnje energije, ljudskog rada, rezervnih delova, maziva i dr.;
- brz pregled neophodnih informacija;
- laku i jednostavnu statičku obradu podataka sa minimalnom papirologijom;
- povezivanje podsistema održavnja sa ostalim podsistemima preduzeća itd.

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Adamović, Ž., & Ilić, B. (2013). Nauka o održavanju tehničkih sistema. *Srpski akademski centar, Novi Sad*.

# CREATION OF INFORMATION SYSTEM MODULE FOR MOTOR VEHICLE MAINTENANCE

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**ABSTRACT**

The information system for motor vehicle maintenance is very complex and contains a large number of processes, data flows, data stores and external objects. At the same time, a clear and detailed specification of the system requires that the method of abstraction be applied to the presentation of the system using DTP. This is achieved on the one hand by the hierarchical decomposition of the process, and on the other hand by a specific way of displaying the structure and content of data flows and storage in the data dictionary of the structural analysis system, with possible hierarchical display of the structure of external objects, by creating modules.

**Keywords:** Process analysis, maintenance of motor vehicles, complex technical systems, modules.

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# UTICAJ DIJAGNOSTIKE STANJA PUTNIČKIH VOZILA NA POUZDANOST I ZAŠTITU ŽIVOTNE SREDINE

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## SAŽETAK

U moderna vozila ugrađuju se sistemi koji omogućavaju veću sigurnost i komfor. Dijagnostika u vozilu omogućuje nadzor sistema nad samim sobom i nad svim perifernim komponentama. Takođe, detektuje i čuva poremećaje i smetnje koje se detektuju u celom sistemu. Zahtevi koje treba da ispuni je kontinualno nadziranje svih karakteristika sistema, kao što su: fizički ulazi/izlazi, funkcionalno ponašanje sistema i konfiguraciju mreže. Dijagnostika, kao sastavni deo održavanja prema stanju, treba da utvrdi tehničko stanje sastavnih komponenti sa određenom tačnošću u određenom trenutku vremena. Utvrđivanje radnog stanja sastavnih komponenti se ostvaruje primenom odgovarajućih savremenih instrumenata sa ciljem povećanja sigurnosti i pouzdanosti korisnika vozila, kao i zaštite životne sredine.

**Ključne reči:** dijagnostika, pouzdanost, sigurnost, dugotrajnost.

## UVOD

Dijagnostika je tehnologija koja ima za cilj, sa jedne strane vezana za tehničko stanje vozila, tj. da samo vozilo dijagnosticira i sa druge strane ispravne komponente bez održavanja da upotrebi u vozilu radi obezbeđenja njegovorg funkcionisanja. Alokacija dijagnostike u sistemu održavanja vozila proizilazi iz njene dvojne uloge. Dijagnostika se bavi pre svega stanjem vozila u trenutku posmatranja, ali i predikcijom (predviđanjem stanja u budućnosti), kao i retrospekcijom (prošlošću vozila). Tačnost predviđanja ponašanja vozila u budućnosti veća je ukoliko se zasniva na većem broju podataka o njegovom ponašanju u prošlosti, naročito ukoliko su poznati uslovi njegovog korišćenja i održavanja u prošlosti, sadašnjosti i budućnosti (Todorović, 1993).

Dijagnostika, kao sastavni deo održavanja prema stanju, treba da utvrdi tehničko stanje sastavnih komponenti sa određenom tačnošću u određenom trenutku vremena. Utvrđivanje radnog stanja sastavnih komponenti se ostvaruje primenom odgovarajućih savremenih instrumenata i na osnovu čulnih opažanja specijalista za dijagnostiku.

Dugovečnost, pouzdanost i dijagnostika su uzajamno povezani parametri koji određuju tehničko stanje vozila u celosti. Dijagnostika se bazira na dovoljno razrađenoj naučnoj osnovi, na matematičkim i fizičkim metodama koje omogućuju postizanje optimalnih rezultata i kao takva predstavlja nov ogranak tehničke kibernetike. Osim toga, dijagnostika čini važan sastavni deo održavanja jer ona omogućuje da se bez prethodne demontaže odredi tehničko stanje vozila i predvidi resurs njihovog pouzdanog rada (Milošević et al., 2016).

## SISTEM DIJAGNOSTIKE I POLJE PRIMENE

Sistem dijagnostike vozila obuhvata sledeće aktivnosti (Milošević et al., 2016):

- uspostavlja zakonitosti promene parametara stanja vozila i njegove pogodnosti za kontrolu;
- izbor dijagnostičkih parametara i određivanje karakteristika njihovih promena i veza sa parametrima stanja vozila;
- utvrđivanje normativa dijagnostičkih parametara;
- određivanje mogućnosti postavljanja dijagnoze;
- izbor, uz tehno-ekonomsko obrazloženje, odgovarajuće metode i mernih sredstava;
- određivanje optimalne procedure dijagnostike;

- utvrđivanje režima, tehnologije, kao i mesta i položaja dijagnostike u ukupnom sistemu održavanja vozila.

Dijagnostička platforma daje okvire za dijagnostiku radi odabira pravih alata za širinu i dubinu dijagnostike. Dijagnostički softver se koristi kao alat za definisanje sekvenci i servisnih informacija za generisanje ekspertnih sistema za servisere. Spoljna dijagnostika se koristi za komunikaciju sa spoljnim testnim sistemom za efikasniju analizu grešaka i njihovo otklanjanje. Veza sa eksternim sistemom omogućuje programiranje varijanti u sistemu. Zahteve koje treba da zadovolji su: zapisivanje i čitanje statičkih podatka, zapisivanje i čitanje dinamičkih podataka, programiranje varijanti u nepromenljivu memoriju, programiranje i kontrola ulaza/izlaza i istovremeno normalno i dijagnostičko komuniciranje sa punom funkcionalnošću vozila (Maksimović i Kamberović, 1998).

Kompleksna i moderna oprema za dijagnosticiranje motornih vozila mora da pruži kompleksne zahteve:

- paralelno testiranje i programiranje modula, smanjenje vremena i troškova, veća funkcionalnost,
- provera električne instalacije, delimično ili potpuno testiranje električne instalacije,
- podešavanje vozila i testiranje po zakonskim normativima, zakonskom regulativom definisan način merenja emisije smeše izduvnih gasova iz motora,
- testiranje podsklopova podsistema – testiranje vrata, kabine, funkcionalnost senzora motora, prikupljanje podataka merenja, fleksibilan način povezivanja na različite sisteme,
- rešenje opravki – ispravljanje i pregled grešaka kao i selektivno obavljanje procesa, mogućnost pripreme i upravljanja testovima, kao i konfiguracije podataka za testiranje,
- upravljanje sistemom kvaliteta – prikaz za upravljanje informacijama o kvalitetu,
- pristup informacijama – mogućnost pristupa podataka između različitih platformi, paralelni prikaz informacija za sistem praćenja i za sistem dijagnostifikovanja,
- interfejs prema spoljnim snabdevačima.

Kad je u pitanju autoindustrija, dijagnostika se može podeliti na četiri glavna područja primene (Maksimović i Kamberović, 1998):

- dijagnostika u vozilu;
- proizvođačka dijagnostika;
- servisna dijagnostika;
- telemetrijska dijagnostika.

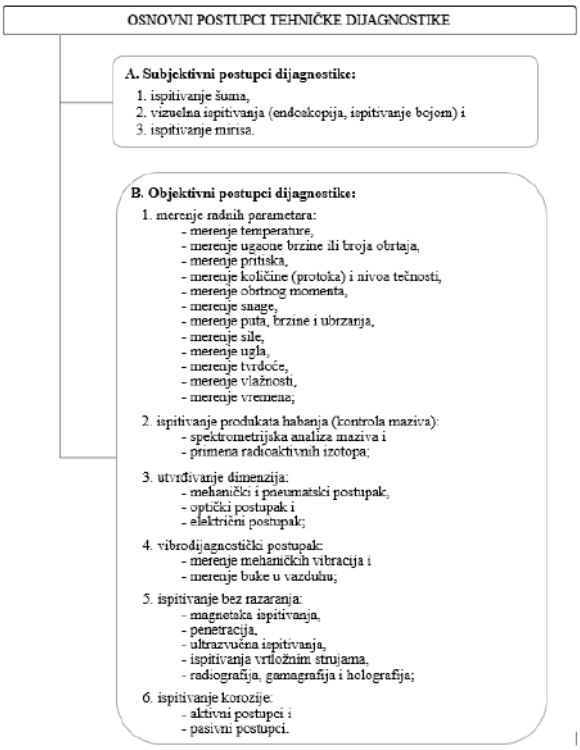
U moderna vozila ugrađuju se sistemi koji omogućavaju veću sigurnost i komfor. Dijagnostika u vozilu omogućuje nadzor sistema nad samim sobom i nad svim perifernim komponentama. Takođe, detektuje i čuva poremećaje i smetnje koje se detektuju u celom sistemu. Zahtevi koje treba da ispuni je kontinualno nadziranje svih karakteristika sistema, kao što su:

- fizički ulazi/izlazi,
- funkcionalno ponašanje sistema i
- konfiguraciju mreže.

Danas su gotovo svi složeni tehnički sistemi opremljeni komunikacionim procesorima, tj. interfejsima i adapterima koji omogućavaju održavanje na daljinu u slučaju zastoja i otkaza. Priključak omogućava da specijalista za proizvodni proces prikupi podatke i parametre sa vozila i stvori sliku o nastaloj situaciji i trenutno pristupi otklanjanju uzroka zastoja. Postoje tri tehnička rešenja o ostvarivanju ove komunikacije:

- daljinski pristup na procesni računar mašine korisnika preko modema pomoću standardnih alata za daljinski pristup,
- korišćenje multimedija za prenošenje pokretnih slika sa lica mesta preko interneta,
- individualna rešenja su pristupačna i bazirana na direktnom priključenju upravljačke procesne jedinice na servisnu centralu.

Telemetrijske tehnologije modernih vozila omogućuju nove dimenzije u održavanju vozila kao i veze između vozila i vozača. Ova tehnologija omogućuje duboke promene, što je vidljivo kroz smanjenje troškova kod održavanja vozila. Telemetrija kao tehnologija je interesantna za mnoge ciljne grupe koje su zainteresovane za izvođenje daljinske dijagnostike, profil vozača, nadziranje i kontrolu stanja vozila. Na slici 1. dati su osnovni postupci tehničke dijagnostike.



Slika 1. Osnovni postupci tehničke dijagnostike.

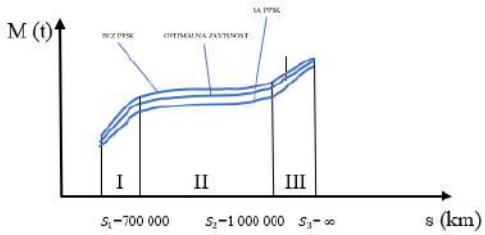
## UTICAJ DIJAGNOSTIKE STANJA NA POUZDANOST PUTNIČKIH VOZILA

Metodologija istraživanja i rešavanja uticaja dijagnostike stanja na pouzdanost motornih vozila predstavlja analizu rešenja čiji kvalitet i stepen egzaktnosti zavisi od kvaliteta odabranih i stepena korišćenih parametara. Ujedno, sama primena neadekvatnih parametara ne daje najbolja rešenja. Dobijene vrednosti datih odstupanja od optimalnog rešenja su moguće i realne zbog nepravilne procene i neadekvatnog izbora glavnih uticajnih parametara. Kada se analiziranjem komponenata sklopova motornih vozila ili samog procesa izbora parametara dobijaju zahtevani rezultati, tada se dati parametri dijagnostike stanja pouzadnosti smatraju povoljnim. Zabeležena najveća postignuta vrednost smatra se najboljom. Izabrani parametar iskazuje optimalnu vrednost, kada u sprezi sa drugim komponentama nudi rešenje koje daje maksimalnu vrednost u okviru analize pouzdanosti (Maksimović i Kamberović, 1998).

Zavisnost optimalnih kriterijuma daje rezultate koji mogu biti linearni ili približno linearni, stalno rastući ili opadajući, bez izraženog maksimuma ili minimuma funkcije. Neki optimum izražene vrednosti raste ili opada sa rastom ili padom uticajne veličine. Istraživanje tog rasta ili pada se odvija do granica mogućeg za određene parametre komponenata motornih vozila. Usavršavanje dijagnostike stanja i njenog uticaja na pouzdanost motornih vozila je u funkciji izbora najboljeg parametra između više mogućih alternativa. To znači da se odnosi na svaku komponentu sklopa motornih vozila posebno, što govori da organizovanje optimalnog procesa primene parametara stanja komponenti uključuje više komponenata sklopova. Reč je o iskazivanju

stanja motornih vozila preko stanja sastavnih komponenti sklopova, a za to je potrebno imati više informacija, kako o motornom vozilu u celini, tako i za sastavne komponente sklopova (Todorović, 1993).

Na slici 2. prikazane su tri oblasti optimalne zavisnosti u kojima nastaju otkazi bez PPSK i sa PPSK kontrole parametara dijagnostike stanja komponenti motornih vozila na osnovu određenog pređenog puta i to: I – oblast rada sastavnih komponenti sklopova $0 \div S_1$, II – oblast optimalnog rada komponenti sklopa $S_1 \div S_2$, III – oblast nestabilnog rada komponenti sklopa $S_3 \div \infty$.




Slika 2. Vrednosti promena u funkciji vremena eksploatacionog rada i otkaza bez i sa primenom kontrole parametara dijagnostike stanja motornih vozila.

Iz sprovedenog istraživanja konstatujemo da su sastavne komponente motornih vozila: kolenasto vratilo (stabilni ležajevi) $M_1$, kolenasto vratilo (leteći ležajevi) $M_1$, bregasto vratilo $M_3$ i svi imaju minimalni broj otkaza.

Analizirani otkazi sastavnih komponenti posmatranih sklopova motornih vozila, biće svrstani u oblast njihovog nestabilnog rada, iz razloga što tada dolazi do njihovog intenziviranja. Ako sa $L_1$ obeležimo vreme do kada se analizirani sklop uhodava, a sa $L_2$ vreme do koga je analizirani sklop imao rad bez otkaza (eksploataciono-sigurni rad), onda je svaki interval vremena posle $L_2$ interval njegovog nestabilnog rada $L''_2 > L_2$, tj. interval rada sa rizikom.

## ZAKLJUČCI

Za rešenje problema određivanja optimalnih periodičnosti sprovođenja postupaka održavanja korišćena je metoda simulacije pod kojom se ovde podrazumeva eksperimentisanje s modelom, gde se procesi odvijaju u određenom vremenskom intervalu u cilju određivanja.

U savremena vozila ugrađuju se sistemi koji stižu od različitih snabdevača (OEM – Original Equipment Manufacturers). Dijagnostička platforma, softver, procesi i dijagnostička ekspertiza, kao i saradnja sa OEM-ovima su osnova za kreiranje rešenja u osoblju. Rešenja se ogledaju u četiri kompletna zahteva:

- univerzalnost i pogodnost za dijagnostiku svih vozila;
- mehanizaciju i automotizaciju operacija za dijagnostiku;
- stabilnost pokazivanja, jednostavnost, preciznost i osetljivost uređaja;
- prikladnost i bezopasnost izvođenja dijagnostičkih radova.

Sistem za telemetrijsko upravljanje u vozilu je takav sistem koji je u osnovi softver koji služi da se napravi kompleksna aplikacija koja je u interakciji sa elektronskim modulima smeštenim u vozilo. Takođe su komponente usmerene ka OEM-ovim, telemetrijskim aplikativnim servis provajderima. Ovim se postiže, da se podaci iz vozila pretvore u informaciju za proces prikupljanja, analizu, sintezu i izveštavanje, što u konačnici značajno utiče na pouzdanosti putničkih automobila i zaštitu životne sredine.

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# INFLUENCE OF PERSONAL VEHICLE DIAGNOSTICS ON RELIABILITY AND ENVIRONMENTAL PROTECTION

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## ABSTRACT

Modern vehicles are equipped with systems that enable greater safety and comfort. Diagnostics in the vehicle enables the system to monitor itself and all peripheral components. It also detects and stores disturbances and interferences that are detected throughout the system. The requirements it should fulfill is continuous monitoring of all system characteristics, such as: physical inputs/outputs, functional behavior of the system and network configuration. Diagnostics, as an integral part of condition maintenance, should determine the technical condition of the constituent components with a certain accuracy at a certain moment in time. Determining the working condition of the constituent components is achieved by applying appropriate modern instruments with the aim of increasing the safety and reliability of vehicle users, as well as environmental protection.

**Keywords**: Diagnostics, reliability, security, longevity.

# ***PSYHOLOGY***
# *PSIHOLOGIJA*

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# ODNOS AUTORITARNOSTI I VIRTUELNOG PONAŠANJA NA DRUŠTVENIM MREŽAMA

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## SAŽETAK

Osnovni cilj ovog istraživanja bio je da se provjeri da li postoji statistički značajna povezanost autoritarnosti i virtuelnog ponašanja na društvenim mrežama, kao i da li postoje razlike u virtuelnom ponašanju na društvenim mrežama s obzirom na sociodemografske karakteristike. U istraživanju je učestvovalo ukupno 242 ispitanika, 65 muških i 177 ženskih ispitanika. Starost ispitanika se kretala između 16 i 66 godina, dok je prosječan uzrast iznosio 33 godine. Instrumenti koji su korišteni u istraživanju su: upitnik za prikupljanje podataka o sociodemografskim karakteristikama ispitanika (konstruisan za potrebe ovog istraživanja), upitnik Autoritarnost (za ispitivanje stepena autoritarnosti) i VPDM-upitnik (upitnik za ispitivanje virtuelnog ponašanja na društvenim mrežama). Rezultati istraživanja su pokazali da postoji statistički značajna povezanost autoritarnosti i dva oblika virtuelnog ponašanja na društvenim mrežama, a to su virtuelno otuđivanje i negativan stav prema društvenim mrežama. Takođe, nađene su značajne razlike u virtuelnom ponašanju na društvenim mrežama s obzirom na pol, starost i obrazovanje.

**Ključne riječi**: autoritarnost, virtuelno ponašanje, društvene mreže, povezanost, razlike.

## UVOD

Industrijski i tehnološki razvoj u 21. vijeku je doveo do ubrzanog razvoja Interneta a samim tim i društvenih mreža. Svaki dan se pojavljuje sve veći broj kako društvenih mreža tako i njihovih korisnika, koji im mogu uglavnom pristupiti bilo gdje i bilo kada. Društvene mreže sve više ljudima služe kao jedan od glavnih izvora informacija bilo da se radi o politici, nauci, popularnoj kulturi i ostalim životnim područjima. S obzirom da ponašanje osobe u velikoj meri zavisi od njenih personalnih osobina, zainteresovao nas je odnos pojedinih osobina ličnosti sa ponašanjem na društvenim mrežama. Odrastanje u patrijarhalnoj državi kao što je Bosna i Hercegovina sa sobom nosi ozbiljne izazove, a pojedine teorije ističu upravo patrijarhalno uređenje kao faktor formiranja određenih osobina, od kojih je izabrana osobina autoritarnost kao varijabla ovog istraživanja.

Autoritarnost je postala popularna tema, kojom su se objašnjavali događaji u Evropi tridesetih i četrdesetih godina prošlog vijeka (Smither, 1993) i predstavlja varijablu političke psihologije koja prati istoriju do Drugog svjetskog rata i istraživanja učestvovanja građana u zločinima počinjenim tokom Holokausta (Stenner, 2005). U ovom radu se autoritarnost posmatra kao konstrukt koji obuhvata specifično ponašanje osobe koje se manifestuje kroz prihvatanje vrijednosti i standarda okoline (ali i njihovom rigidnom pridržavanju), te nekritičnom prihvatanju autoriteta, tendenciji da se oštro reaguje prema ljudima koji krše konvencionalne vrijednosti, antiintraceptivnosti, poštivanju vlasti i pozitivnom odnosu prema njoj (Rot, 2006). Pored navedenog, autoritarnost podrazumijeva i poslušnost i poštivanje autoriteta, prilagođavanje drugima ili jednom riječju konformizam. Šiber (1989) smatra da autoritarnost označava sindrom psiholoških osobina koje karakterišu neslobodnog pojedinca u neslobodnom društvu i podrazumijeva otuđenje od ljudskih mogućnosti, odnosno gubljenje individualnosti.

Društvene mreže se definišu kao grupe koje se formiraju na Internetu i koje povezuju zajednički interesi i interesovanja, prijateljstvo, potreba da objavljuju i prate objave drugih i

razmjenjuju uzajamno korisne informacije, kao i da se međusobno pomažu savjetima i na drugi način, odgovorima na pitanja drugih članova mreže, i td. Karatsoli i Nathanail (2020) kažu da su društvene mreže glavni komunikacijski kanal za razmjenu mišljenja, informacija, uticaja na odluke i promociju poslovanja.

Samo virtuelno ponašanje može da bude veoma različito kod različitih korisnika. Tako, Bodroža, Jovanović i Popov (2009) navode 6 oblika ponašanja: zavisnost od društvenih mreža, virtuelno otuđivanje, socijalizacija putem društvenih mreža, negativan stav prema društvenim mrežama, samoprezentacija u cilju postizanja seksualne stimulacije i profil kao virtuelni self. Autori pod zavisnošću od društvenih mreža podrazumijevaju nemogućnost kontrole impulsa i vremena provedenog na društvenim mrežama kao i zapostavljanje drugih obaveza i aktivnosti zbog društvenih mreža. Virtuelno otuđivanje se odnosi na zanemarivanje realnog spoljašnjeg svijeta radi onlajn druženja. Pojedinci naajčešće izbjegavaju integraciju prijateljstva sa društvenih mreža sa stvarnim životom i povlače se iz svakodnevnih aktivnosti koje nisu onlajn iskustvo. Pod socijalizacijom putem društvenih mreža se podrazumijeva ostvarivanje kontakata i stvaranje bliskih veza putem društvenih mreža, koje se kasnije mogu preseliti u stvarni spoljašnji svijet. Negativan stav se odnosi upravo na postojanje negativnih shvatanja i stavova prema društvenim mrežama i njihovim korisnicima. Samoprezentacija u cilju postizanja seksualne stimulacije podrazumijeva uređivanje slika, videa i generalno personalnih informacija s ciljem dobijanja tuđih simpatija u čijoj osnovi često stoji težnja za postizanjem seksualne stimulacije. Posljednji opisani oblik virtuelnog ponašanja je profil kao virtuelni self koji se odnosi na medijum za predstavljanje važnih informacija o ličnosti pojedinca i profil se posmatra kao identitet pojedinca.

## METOD

### Problem i cilj istraživanja

Problem istraživanja se odnosi na ispitivanje povezanosti između autoritarnosti i virtuelnog ponašanja na društvenim mrežama. S tim u vezi, teorijski cilj istraživanja jeste da se utvrdi eventualna veza između autoritarnosti i virtuelnog ponašanja na društvenim mrežama, kao i da se ispitaju razlike u virtuelnom ponašanju s obzirom na sociodemografske karakteristike (pol, godine starosti, stepen obrazovanja, materijalni status).

### Hipoteze

S obzirom na nedostatak istraživanja u dostupnoj literaturi na temu povezanosti autoritarnosti i virtuelnog ponašanja na društvenim mrežama, prva postavljena hipoteza je nulta i glasi:

H1: Ne postoji statistički značajna povezanost između autoritarnosti i virtuelnog ponašanja na društvenim mrežama.

Druga hipoteza je alternativna hipoteza, a postavljena je na osnovu prethodno sprovedenih istraživanja (Herring, & Stoerger, 2013; Duggan et al., 2015; Barker, 2009; Lenhart, & Madden, 2007) i glasi:

H2: Postoje statistički značajne razlike u virtuelnom ponašanju na društvenim mrežama s obzirom na sociodemografske karakteristike ispitanika (pol, godine starosti, stepen obrazovanja, materijalni status).

### Uzorak i procedura

U ovom istraživanju je učestvovalo ukupno 242 ispitanika. Uzorak istraživanja nije ujednačen po polu s obzirom da je skoro 3 puta više ispitanika ženskog pola (73%) u odnosu na ispitanike muškog pola (27%). Ispitanici su, u odnosu na starost, podeljeni u nekoliko grupa: starosna grupa od 16 do 25 godina, starosna grupa od 26 do 35 godina, starosna grupa od 36 do 45, starosna grupa od 46 do 55 i starosna grupa od 56 i više godina, pri čemu su grupe mlađih ispitanika (starosti od 16 do 35 godina) najbrojnije, a prosečna starosna dob je 33 godine. Najveći procenat ispitanika živi u gradu (62%), srednjeg je materijalnog statusa (87,5%), sa srednjoškolskim obrazovanjem (43%) i nije u braku (46%). Kada je u pitanju korištenje društvenih mreža, čak 80% ispitanika koristi Fejsbuk, Viber koristi 73% ispitanika, Instagram koristi 70% ispitanika a JuTjub 56% ispitanika: ostale društvene mreže se koriste u nižem stepenu.

**Instrumenti**

Od instrumenata smo koristili Upitnik za prikupljanje podataka o sociodemografskim karakteristikama ispitanika (pol, godine starosti, stepen obrazovanja, materijalni status, bračni status, najčešće korištene društvene mreže), koji je konstruisan za potrebe ovog istraživanja.

Za ispitivanje autoritarnosti korišćen je upitnik koji je konstruisao Eysenck a adaptirao Marković (Lebedina-Manzoni, 1991). Upitnik se sastoji od 19 tvrdnji na koje ispitanici odgovaraju u skladu sa Likertovom skalom gdje 1 označava „uopšte se ne slažem“ a 5 označava „u potpunosti se slažem“. Niži stepen označava više prisustvo autoritornosti, a viši stepen označava manje prisustvo. U ovom istraživanju je provjerena pouzdanost upitnika i utvrđeno je da je koeficijent unutrašnje konzistentnosti iznad zadovoljavajućeg nivoa uz Cronbach's Alpha vrijednost α = .77.

Za ispitivanje virtuelnog ponašanja na društvenim mrežama korišćen je VPDM-upitnik (autori Bodroža, Jovanović i Popov, 2009). Upitnik se sastoji od 42 tvrdnje koje su podijeljene na 6 subskala: zavisnost od društvenih mreža, virtuelno otuđivanje, socijalizacija putem društvenih mreža, negativan stav prema društvenim mrežama, samoprezentacija u cilju postizanja seksualne stimulacije i profil kao virtuelni self. Ispitanici odgovaraju u skladu sa Likertovom skalom gdje 1 označava „uopšte se ne slažem“ a 5 označava „u potpunosti se slažem“. Koeficijenti unutrašnje konzistentnosti svih subskala takođe su provjereni: zavisnost od društvenih mreža α = .78, virtuelno otuđivanje α = .81, socijalizacija putem društvenih mreža α = .87, negativan stav prema društvenim mrežama α = .88, samoprezentacija u cilju postizanja seksualne stimulacije α = .74 i profil kao virtuelni self α = .74. Koeficijenti pouzdanosti svih skala su iznad zadovoljavajućeg nivoa. Takođe je provjeren i koeficijent pouzdanosti za skalu u cjelini i Cronbach's Alpha pokazuje veoma visok koeficijent pouzdanosti uz vrijednost α = .92.

**Metode obrade podataka**

Pri obradi rezultata korišteni su standardni statistički postupci. Za proveru metrijskih karakteristika upotrebljenih skala korištene su mere koje pokazuju nivo pouzdanosti testa (Cronbach's Alpha). Za analizu distribucije odgovora ispitanika na tvrdnjama korištenih skala korištene su mere centralne tendencije (aritmetička sredina) i mere varijabilnosti (standardna devijacija, skjunis, kurtozis). Za ispitivanje povezanosti između autoritarnosti i virtuelnog ponašanja na društvenim mrežama korišten je Spirmanov koeficijent korelacije dok su za ispitivanje razlika u virtuelnom ponašanju na društvenim mrežama s obzirom na sociodemografske karakteristike korišteni Mann-Whitney test i Kruskal-Wallis test. Obrada podataka je vršena SPSS 20 paketom.

## REZULTATI

Pre obrade rezultata utvrđene su deskriptivne karakteristike i normalnost distribucija odgovora ispitanika na korištenim skalama. Analiza skale autoritarnosti prikazana je u tabeli br.1. Značajnost odstupanja distribucije od normalne raspodjele je provjerena Kolmogorov-Smirnov testom normalnosti distribucije, koji ukazuje da distribucija ne odstupa statistički značajno od normalne raspodjele ($K\text{-}S_t$=.04; $p_{k\text{-}s}$=.20).

Tabela 1. Deskriptivne karakteristike odgovora ispitanika na skali Autoritarnosti.
Table 1. Descriptive characteristics of respondents' answers on the Authoritativeness scale.

| | N | Min | Max | AS | SD | Sk | Ku | Kolmogorov-Smirnov test | $p_{k\text{-}s}$ |
|---|---|---|---|---|---|---|---|---|---|
| Autoritarnost | 242 | 25 | 93 | 58.99 | 10.97 | .09 | .09 | .04 | .20 |

Utvrđene su deskriptivne karakteristike i normalnost distribucija odgovora ispitanika na skali i subskalama virtuelnog ponašanja na društvenim mrežama (VPDM) i podaci su predstavljeni u tabeli br.2.

Tabela 2. Deskriptivne karakteristike odgovora ispitanika na skali VPDM, kao i na njenim subskalama.
Table 2. Descriptive characteristics of respondents' answers on the VPDM scale, as well as on its subscales.

| | N | Min | Max | AS | SD | Sk | Ku | Kolmogorov-Smirnov test | $p_{k-s}$ |
|---|---|---|---|---|---|---|---|---|---|
| VPDM (ukupno) | 42 | 49 | 205 | 99.08 | 26.59 | .93 | 1.27 | .09 | .00 |
| ZDM | 42 | 11 | 50 | 25.76 | 8.63 | .43 | -.57 | .09 | .00 |
| Vo | 42 | 9 | 45 | 15.11 | 7.13 | .78 | 3.50 | .19 | .00 |
| SpDM | 42 | 7 | 35 | 16.38 | 8.05 | .54 | -.86 | .14 | .00 |
| NspDM | 42 | 6 | 30 | 18.87 | 5.21 | .01 | -.15 | .06 | .02 |
| Spss | 42 | 5 | 25 | 10.25 | 4.65 | .13 | .99 | .18 | .00 |
| Pvs | 42 | 5 | 25 | 12.71 | 4.18 | .32 | .05 | .08 | .00 |

Napomena:
ZDM = Zavisnost od DM
Vo = Virtuelno otuđivanje
SpDM = Socijalizacija putem DM
NspDM = Negativan stav prema DM
Spss = Samoprezentacija u cilju postizanja seksualne stimulacije
Pvs = Profil kao virtuelni self

Kolmogorov-Smirnovim testom normalnosti distribucije utvrđeno je statistički značajno odstupanje od normalne raspodjele na svim primenjenim subskalama ($K\text{-}S_t$=.09; $p_{k-s}$=.00).

U daljoj analizi, za provjeru povezanosti autoritarnosti i virtuelnog ponašanja na društvenim mrežama, korišten je neparametrijski statistički postupak za provjeru povezanosti tj. Spirmanov koeficijent korelacije (tabela br.3).

Tabela 3. Povezanosti autoritarnosti i virtuelnog ponašanja na društvenim mrežama.
Table 3. Correlations between authoritarianism and virtual behavior on social networks.

| | **r** | **p** |
|---|---|---|
| Autoritarnost * VPDM | .14 | .03 |

VPDM = Virtuelno ponašanje na društvenim mrežama

Rezultati pokazuju da postoji statistički značajna korelacija između autoritarnosti i virtuelnog ponašanja na društvenim mrežama. Korelacija je pozitivnog smjera i niskog intenziteta (r= .14) i statistički je značajna na nivou p= .05. Radi boljeg uvida u odnos između ispitivanih varijabli, provjerena je i povezanost autoritarnosti sa svakom subskalom virtuelnog ponašanja na društvenim mrežama (tabela br.4).

Tabela 4. Povezanosti autoritarnosti i subskala virtuelnog ponašanja na društvenim mrežama.
Table 4. Correlations between authoritarianism and virtual behavior subscales on social networks.

| | Autoritarnost | |
|---|---|---|
| | **r** | **p** |
| Zavisnost od DM | .09 | .13 |
| Virtuelno otuđivanje | .22 | .00 |
| Socijalizacija putem DM | .03 | .61 |
| Negativan stav prema DM | .27 | .00 |
| Samoprezentacija u cilju postizanja seksualne stimulacije | .01 | .88 |
| Profil kao virtuelni self | .04 | .47 |

Dobijeni rezultati pokazuju da postoji statistički značajna korelacija između autoritarnosti i dvije subskale virtuelnog ponašanja na društvenim mrežama i to: virtuelno otuđivanje (r= .22; p= .00) i negativan stav prema društvenim mrežama (r= .27; p= .00). Korelacije su pozitivnog smjera i srednjeg intenziteta i statistički su značajne na nivou p= .01. Ostale subskale nisu pokazale statistički značajnu korelaciju sa autoritarnošću.

S obzirom da distribucija odgovora ispitanika na zavisnoj varijabli odstupa od normalne raspodjele, za provjeru razlika u virtuelnom ponašanju na društvenim mrežama s obzirom na sociodemografske karakteristike korišteni su Mann-Whitney test i Kruskal-Wallis test.

Tabela 5. Razlike u virtuelnom ponašanju na društvenim mrežama s obzirom na pol.
Table 5. Differences in virtual behavior on social networks with regard to gender.

| Pol | N | VPDM |
|---|---|---|
| Muški | 65 | 145.53 |
| Ženski | 177 | 112.68 |
| Mann-Whitney test | | 4190.50 |
| Z | | -3.237 |
| p | | .00 |

VPDM = Virtuelno ponašanje na društvenim mrežama.

Nađene su statistički značajne razlike između muškaraca i žena kada je u pitanju virtuelno ponašanje na društvenim mrežama (tabela br.5). Da bi se utvrdilo koja su tačno virtuelna ponašanja na društvenim mrežama po kojima se razlikuju muškarci i žene, provjerene su i razlike između polova s obzirom na različite oblike ponašanja na društvenim mrežama (tabela br.6).

Tabela 6. Razlike u virtuelnom ponašanju na društvenim mrežama s obzirom na pol.
Table 6. Differences in virtual behavior on social networks with regard to gender.

| Pol | N | ZDM | Vo | SpDM | NspDM | Spss | Pvs |
|---|---|---|---|---|---|---|---|
| *Muški* | 65 | 131.60 | 138.65 | 147.48 | 124.30 | 159.49 | 129.71 |
| *Ženski* | 177 | 117.79 | 115.20 | 111.96 | 120.47 | 107.55 | 118.49 |
| U | | 5096.00 | 4638.00 | 4063.50 | 5570.50 | 3283.00 | 5219.00 |
| Z | | -1.361 | -2.327 | -3.510 | -.378 | -5.152 | -1.109 |
| p | | .17 | .02 | .00 | .70 | .00 | .26 |

ZDM = Zavisnost od DM
Vo = Virtuelno otuđivanje
SpDM = Socijalizacija putem DM
NspDM = Negativan stav prema DM
Spss = Samoprezentacija u cilju postizanja seksualne stimulacije
Pvs = Profil kao virtuelni self

Rezultati istraživanja ukazuju na statistički značajne razlike kada su u pitanju virtuelno otuđivanje, socijalizacija putem društvenim mreža i samoprezentacija u cilju postizanja seksualne stimulacije, na kojima ispitanici muškog pola postižu više skorove.

Nađene su statistički značajne razlike i u virtuelnom ponašanju na društvenim mrežama s obzirom na godine starosti ispitanika (tabela br.7).

Tabela 7. Razlike u virtuelnom ponašanju na društvenim mrežama s obzirom na godine starosti.
Table 7. Differences in virtual behavior on social networks with regard to age.

| Godine starosti | N | VPDM |
|---|---|---|
| 16 – 25 | 75 | 164.57 |
| 26 – 35 | 83 | 101.89 |
| 36 – 45 | 46 | 104.52 |
| 46 – 55 | 29 | 103.57 |
| 56 + | 9 | 88.00 |

$\chi^2$*=41.594; df=4; p=.00*

Dalja provera odnosila se na utvrđivanje razlika između ispitanika različitih uzrasta s obzirom na oblike ponašanja na društvenim mrežama (tabela br.8). Uvidom u rezultate može se zaključiti da postoje statistički značajne razlike u virtuelnom ponašanju na društvenim mrežama s obzirom na godine starosti ispitanika (p= .00), osim za subskalu negativan stav prema društvenim mrežama (p= .02).

Tabela 8. Razlike u virtuelnom ponašanju na društvenim mrežama s obzirom na godine starosti.
Table 8. Differences in virtual behavior on social networks with regard to age.

| Godine starosti | N | ZDM | Vo | SpDM | NspDM | Spss | Pvs |
|---|---|---|---|---|---|---|---|

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 16 – 25 | 5 | 157.77 | 156.43 | 159.80 | 109.83 | 169.67 | 148.00 |
| 26 – 35 | 3 | 102.45 | 106.39 | 108.77 | 119.16 | 110.69 | 104.01 |
| 35 – 45 | 6 | 103.97 | 105.41 | 93.87 | 151.38 | 90.49 | 118.08 |
| 46 – 55 | 9 | 121.40 | 105.50 | 109.71 | 116.43 | 92.05 | 108.60 |
| 56 + | 9 | 84.94 | 103.50 | 99.44 | 103.94 | 73.17 | 121.06 |
| Kruskal-Wallis test | | $\chi^2$=31.670 df=4 p=.00 | $\chi^2$=27.512 df=4 p=.00 | $\chi^2$=34.334 df=4 p=.00 | $\chi^2$=11.324 df=4 p=.02 | $\chi^2$=56.740 df=4 p=.00 | $\chi^2$=17.135 df=4 p=.00 |

Napomena: ZDM = Zavisnost od DM
Vo = Virtuelno otuđivanje
SpDM = Socijalizacija putem DM
NspDM = Negativan stav prema DM
Spss = Samoprezentacija u cilju postizanja seksualne stimulacije
Pvs = Profil kao virtuelni self

U predstavljenim rezultatima se može uvidjeti obrazac ponašanja s obzirom na godine. Kod većine subskala se beleži da se, sa porastom broja godina starosti, visina skora sve više smanjuje, što nije slučaj sa subskalom negativan stav prema društvenim mrežama, kod koje najveći skor postižu ispitanici koji imaju između 35 i 45 godina starosti.

Potvrđeno je i prisustvo razlika u virtuelnom ponašanju na društvenim mrežama s obzirom na stepen obrazovanja (tabela br.9).

Tabela 9. Razlike u virtuelnom ponašanju na društvenim mrežama s obzirom na stepen obrazovanja.
Table 9. Differences in virtual behavior on social networks with regard to the level of education.

| Stepen obrazovanja | N | VPDM |
|---|---|---|
| Završena samo osnovna škola | 6 | 90.92 |
| Nezavršena srednja škola | 4 | 132.13 |
| Završena srednja škola | 104 | 120.40 |
| Student | 34 | 160.76 |
| Završen osnovni studij | 80 | 111.58 |
| Završen master studij | 14 | 101.11 |

$\chi^2$=14.761; df=5; p=.01

Pri tom su razlike između ispitanika različitih obrazovnih profila s obzirom na oblike ponašanja na društvenim mrežama prikazane u tabeli br.10. Iz navedenih rezultata se može zaključiti da postoje statistički značajne razlike u virtuelnom ponašanju na društvenim mrežama kod ispitanika različitog stepena obrazovanja, i to u odnosu na četiri vrste virtuelnog ponašanja: zavisnost od društvenih mreža, virtuelno otuđivanje, socijalizacija putem društvenih mreža i samoprezentacija u cilju postizanja seksualne stimulacije (p= .01), dok za subskalu negativan stav prema društvenim mrežama (p= .07) i profil kao virtuelni self (p= .91) nađene razlike nisu statistički značajne. Rezultati pokazuju da studenti postižu najviše skorove na subskalama koje su statistički značajne, dok ispitanici sa završenom samo osnovnom školom na svim skalama postižu najniže skorove.

Tabela 10. Razlike u virtuelnom ponašanju na društvenim mrežama s obzirom na stepen obrazovanja.
Table 10. Differences in virtual behavior on social networks with regard to the level of education.

| Stepen obrazovanja | N | ZDM | Vo | SpDM | NspDM | Spss | Pvs |
|---|---|---|---|---|---|---|---|

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| ZsOŠ | 6 | 96.50 | 85.50 | 55.58 | 174.17 | 98.50 | 102.08 |
| NSŠ | 4 | 121.75 | 157.00 | 137.13 | 59.63 | 159.13 | 142.63 |
| ZSŠ | 104 | 119.67 | 125.92 | 118.43 | 125.47 | 114.71 | 123.59 |
| S | 34 | 166.78 | 152.03 | 155.51 | 103.69 | 159.60 | 127.29 |
| ZOS | 80 | 109.08 | 106.56 | 115.74 | 125.88 | 117.32 | 117.84 |
| ZMS | 14 | 105.29 | 105.14 | 118.36 | 105.36 | 102.39 | 115.07 |
| Kruskal-Wallis test | | $\chi^2=18.348$ *df=5* *p=.01* | $\chi^2=14.125$ *df=5* *p=.01* | $\chi^2=14.403$ *df=5* *p=.01* | $\chi^2=10.157$ *df=5* *p=.07* | $\chi^2=14.348$ *df=5* *p=.01* | $\chi^2=1.497$ *df=5* *p=.91* |

ZsOŠ = Završena samo osnovna škola
NSŠ = Nezavršena srednja škola
ZSŠ = Završena srednja škola
S = Student
ZOS = Završen osnovni studij
ZMS = Završen master studij

ZDM = Zavisnost od DM
Vo = Virtuelno otuđivanje
SpDM = Socijalizacija putem DM
NspDM = Negativan stav prema DM
Spss = Samoprezentacija u cilju postizanja seksualne stimulacije
Pvs = Profil kao virtuelni self

Provera razlika između grupa s obzirom na materijalni status data je u tabeli br.11. Rezultati pokazuju da ne postoje statistički značajne razlike u virtuelnom ponašanju na društvenim mrežama s obzirom na materijalni status ispitanika (p=.08).

Tabela 11. Razlike u virtuelnom ponašanju na društvenim mrežama s obzirom na materijalni status.
Table 11. Differences in virtual behavior on social networks with regard to material status.

| Materijalni status | N | VPDM |
|---|---|---|
| Lošiji nego kod većine | 13 | 158.81 |
| Kao kod većine | 207 | 121.09 |
| Bolji nego kod većine | 22 | 103.30 |

$\chi^2=5.189$; *df=2; p= .08*

## DISKUSIJA

Osnovni nalaz ovog istraživanja jeste da postoji statitički značajna povezanost osobine autoritarnosti i virtuelnog ponašanja na društvenim mrežama. Radi boljeg uvida o kojim tačno virtuelnim oblicima ponašanja na društvenim mrežama se radi, provjerena je povezanost autoritarnosti i različitih oblika virtuelnog ponašanja na društvenim mrežama (zavisnost od društvenih mreža, virtuelno otuđivanje, socijalizacija putem društvenih mreža, negativan stav prema društvenim mrežama, samoprezentacija u cilju postizanja seksualne stimulacije, profil kao virtuelni self).

Podaci su pokazali da se su dva oblika virtuelnog ponašanja značajno povezana sa autoritarnošću, i to virtuelno otuđivanje i negativan stav prema društvenim mrežama. To znači da osobe koje imaju visoke skorove na autoritarnosti preferiraju društvene mreže u odnosu na stvarni život i iskustva i najčešće se povlače iz oflajn svijeta i izbjegavaju integraciju poznanstava sa društvenih mreža. Prema nekim autorima (Maslow, 1943; Adorno i sar., 1950, prema Rot, 2006) nagon za moći i ispoljavanje tendencije da se ima više moći su neke od osobina koje karakterišu autoritarne osobe. Potencijalno objašnjenje dobijenih rezultata u ovom istraživanju jeste da autoritarni ispitanici svoju moć i dominaciju ispoljavaju putem društvenih mreža, jer nemaju mogućnost da to praktikuju u stvarnom svijetu bez posljedica, dok se na društvenim mrežama mogu "sakriti" iza drugog identiteta i sigurno ispoljavati potrebu za moći. Takođe, putem društvenih mreža autoritarni ispitanici mogu zadovoljiti brojne seksualne nastranosti, koje se navode kao jedna od osobina autoritarne osobe. Te nastranosti mogu zadovoljiti katarzičnim putem kroz razgovore sa drugima na društvenim mrežama koji imaju slična interesovanja, čime se udaljavaju od stvarnog svijeta. Negativan stav prema društvenim mrežama mogu razviti autoritarni pojedinci koji oštro reaguju prema korisnicima društvenih mreža koji krše konvencionalne vrijednosti. Takođe, Druzin i Gordon (2018) ističu da je kontrola protoka informacija jedno od najvažnijih pravila autoritarne osobe, međutim to nije uvijek moguće na društvenim mrežama. Iako

pojedinac uglavnom može kontrolisati protok svojih informacija, ipak ne može uticati na to šta drugi objavljuju, pa iz tog razloga mogu formirati negativan stav.

Druga hipoteza se odnosila na razlike u virtuelnom ponašanju na društvenim mrežama s obzirom na sociodemografske karakteristike ispitanika (pol, godine starosti, stepen obrazovanja, materijalni status). Kada je u pitanju pol ispitanika, rezultati istraživanja su pokazali da muškarci postižu više skorove kada su u pitanju virtuelno otuđivanje, socijalizacija putem društvenih mreža i samoprezentacija u cilju postizanja seksualne stimulacije. Fallows (2005) ove razlike između muškaraca i žena objašnjava načinom korištenja društvenih mreža i Interneta. U poređenju sa ženama, muškarci na mreži češće koriste Internet da bi provjerili vremensku prognozu, provjerili vijesti i sportske kao i političke informacije, preuzeli softver, i najčešće igrali onlajn igre. S druge strane, žene su na mreži češće zbog slanja i primanja poruka, dobijanja uputstava i mape, traženja zdravstvenih i vjerskih informacija. Najveća razlika između muških i ženskih ispitanika je način komunikacije, gdje ženski ispitanici više vremena provode u učvršćavanju već postojećih odnosa sa društvom i bliskim osobama, dok kod ispitanika muškog pola dolazi do virtuelnog otuđenja od pojedinaca iz stvarnog svijeta i do socijalizacije sa pojedincima iz onlajn svijeta. Isti autor navodi i da ispitanici muškog pola češće od ženskih ispitanika vrijeme provode na stranicama za odrasle kao i na stranicama za upoznavanje partnera, čime se može objasniti viši skor na subskali samoprezentacija u cilju postizanja seksualne stimulacije.

Kada su u pitanju godine starosti utvrđene su statistički značajne razlike u virtuelnom ponašanju na društvenim mrežama i obrazac ponašanja s obzirom na godine starosti ispitanika. Kod većine subskala se može vidjeti da sa porastom broja godina starosti visina skora se sve više smanjuje, što nije slučaj sa subskalom negativan stav prema društvenim mrežama. Brasel i Gips (2011) smatraju da promjene u virtuelnom ponašanju i vremenu provedenom na društvenim mrežama nastaju zvog promjena u percepciji i kogniciji. Oni nude fiziološko objašnjenje prema kojem se fleksibilnost mozga smanjuje sa godinama pa je ljudima teže adaptirati se na takav ritam rada društvenih mreža. Međutim, to objašnjenje se uglavnom primjenjuje na starije osobe, odnosno one iznad 60 godina starosti. Drugo, uvjerljivije objašnjenje je i jednostavnije i odnosi se na različite stepene usvajanja različitih društvenih medija.

Stepen obrazovanja ispitanika se pokazao kao značajnom karakteristikom i podaci pokazuju kako raste stepen obrazovanja tako raste i korištenje društvenih mreža i Interneta. Kada je u pitanju stepen obrazovanja takođe se može uočiti obrazac u kojem studenti postižu najviše skorove na subskalama koje su statistički značajne, dok ispitanici sa završenom samo osnovnom školom na svim skalama postižu najniže skorove. Razlog se traži u tome što obrazovaniji ispitanici žele više informacija koje pokušavaju pronaći na društvenim mrežama. Međutim, treba uzeti u razmatranje i kategoriju ispitnika koji postižu najviše skorove, odnosno studente. U tom slučaju se radi o osobama koji ulaze u novu fazu života upisivanjem na fakultet, upoznavaju veliki broj novih ljudi, pokušavaju ostvariti kontakt sa njima i formirati grupe u kojima će biti prihvaćeni, a to je u 21. vijeku najlakše ostvariti putem društvenih mreža.

Posljednja sociodemografska karakteristika se nije pokazala kao značajnom za virtuelno ponašanje na društvenim mrežama, što nije u skladu sa rezultatima koje su dobili Hruska i Maresova (2020) koji impliciraju da osobe boljeg materijalnog stanja imaju više slobodnog vremena i u većem stepenu koriste društvene mreže. Nedostatak razlika s obzirom na materijalni status ispitanika se objašnjava neujednačenošću uzorka.

## ZAKLJUČCI

Ovo istraživanje je imalo za cilj da se ispita povezanost autoritarnosti i virtuelnog ponašanja na društvenim mrežama, kao i da se ispitaju razlike u virtuelnom ponašanju na društvenim mrežama s obzirom na sociodemografske karakteristike (pol, godine starosti, stepen obrazovanja, materijalni status). Utvrđeno je da postoji statistički značajna povezanost između autoritarnosti i dva oblika virtuelnog ponašanja na društvenim mrežama: virtuelnog otuđivanja i negativnog stava prema društvenim mrežama.

Istraživanje je pokazalo da postoje statistički značajne razlike u virtuelnom ponašanju na društvenim mrežama s obzirom na neke sociodemografske karakteristike. Tako, rezultati

istraživanja signaliziraju da postoje polne razlike u virtuelnom ponašanju, gde muškarce u uzorku, u odnosu na žene, značajno češće definiše virtuelno otuđivanje, socijalizacija putem društvenim mreža i samoprezentacija u cilju postizanja seksualne stimulacije. Nađene su i statistički značajne razlike u virtuelnom ponašanju na društvenim mrežama s obzirom na godine starosti ispitanika: kod svih starosnih grupa ispitivani oblici virtuelnog ponašanja su najizraženiji kod mlađih, a sa starošću opadaju, osim kod negativnog stava prema društvenim mrežama, gde je obrnut slučaj. Ispitanici različitih obrazovnih profila u uzorku se statistički značajno razlikuju u odnosu na četiri oblika virtuelnog ponašanja: zavisnost od društvenih mreža, virtuelno otuđivanje, socijalizacija putem društvenih mreža i samoprezentacija u cilju postizanja seksualne stimulacije.

Teorijski doprinos ovog istraživanja ogleda se u potvrđivanju teorijskih i empirijskih pretpostavki kao i doprinosu postojećim saznanjima o povezanosti ispitivanih varijabli, ali i u smislu doprinosa saznanjima o razlikama u virtuelnom ponašanju na društvenim mrežama s obzirom na sociodemografske karakteristike. Rezultati dobijeni u ovom istraživanju predstavljaju podlogu za sprovođenje novih istraživanja, kao i preduzimanja aktivnosti koje će doprinijeti adekvatnijem razumijevanjem veze između osobine autoritarnosti i virtuelnog ponašanja na društvenim mrežama, ali i mogućnosti objašnjenja i predviđanja ponašanja koja su u vezi sa ispitivanim varijablama.

U budućim istraživanjima bi bilo poželjno da se obuhvate još neke socio-demografske karakteristike koje bi mogle uticati na virtuelno ponašanje na društvenim mrežama, takođe uzorak je relativno mali i neujednačen po nekoliko socio-demografskih karakteristika (pol, mjesto stanovanja, materijalni status) pa je poželjno da se proširi kako bi se omogućila generalizacija na ostatak populacije.

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# THE RELATIONSHIP OF AUTHORITARIANITY AND VIRTUAL BEHAVIOR ON SOCIAL NETWORKS

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**ABSTRACT**

The main goal of this research was to check whether there is a statistically significant correlation between authoritarianism and virtual behavior on social networks, as well as whether there are differences in virtual behavior on social networks with regard to sociodemographic characteristics. A total of 242 respondents, 65 male and 177 female respondents participated in this study. The age of the respondents ranged between 16 and 66 years and the average age was 33 years. The instruments used in the research are: a questionnaire for collecting data on sociodemographic characteristics of respondents designed for this research, Autoritarnost-questionnaire (for testing authoritarianism) i VPDM-questionnaire (a questionnaire for testing virtual behavior on social networks). The research results showed that there is a statistically significant connection between authoritarianism and two forms of virtual behavior on social networks, namely virtual alienation and negative attitude towards social networks. Also, significant differences were found in virtual behavior on social networks with regard to gender, age and education.

**Keywords:** authoritarianism, virtual behavior, social networks, correlation, differences.

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# EMOCIONALNA INTELIGENCIJA U KONTEKSTU ZADOVOLJSTVA POSLOM

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## SAŽETAK

Emocionalna inteligencija je značjna za sve sfere ljudskog života, te je svoju praktičnu primjenu našla i u poslovanju preduzeća.U novije vrijeme značaj emocionalne inteligencije u organizacijama se prepoznaje kao ključni faktor uspješnog rada organizacije u smislu da utiče da se pojedinac pokrene i nastavi sa aktivnostima uprkos preprekama, da se uspješno nosi sa nezadovoljstvom, upravlja svojim načinom razmišljanja, saosjeća sa drugima, doprinosi smanjenju dvosmislenosti socijalne interakcije

Sa druge strane, jedan od najvažnijih zadataka svake organizacije je povećati efikasnost zaposlenih jer na taj način organizacija postiže svoje ciljeve. Da bi se postigla efikasnost i ostvarili organizacijski ciljevi, nije dovoljno imati samo visoko motivisane zaposlene, već i njihovo zadovoljstvo poslom mora biti na visokom nivou. Brojni faktori utiču na zadovoljstvo poslom, kako oni organizacijski kao što su posao sam po sebi, prijatni radni uslovi, radne kolege, sistem nagrađivanja, organizaciona struktura tako i lični faktori kao što su osobine i karakteristike ličnosti zaposlenog, usklađenost ličnih osobina i posla, ukupno zadovoljstvo životom, satus u organizaciji, godine starosti i staž.

Cilj ovog rada je ispitati da li postoji povezanost između nivoa emocionalne inteligencije zaposlenih i zadovoljstva poslom, da li pojedinci sa višim nivoom emocionalne inteligencije imaju i veće zadovoljstvo poslom jer su oba područja od velikog značaja za uspješno funkcionisanje organizacije. Cilj je takođe utvrditi da li postoji statistički značajna razlika u zadovoljstvu poslom između zaposlenih različie starosne strukture i godina radnog staža. U istraživanju su učestvovali zaposleni u poslovnim subjektima različitih djelatnosti iz Republike Srpske. Podaci su prikupljeni uz pomoć testa emocionalne inteligencije kao i upitnika zadovoljstva poslom koji je konstruisan za potrebe ovog istraživanja.

**Ključne riječi:** emocionalna inteligencija, zadovoljstvo poslom, organizacijsko ponašanje.

## UVOD

Savremeno poslovno okruženje zahtijeva od ljudskih potencijala ne samo akademska znanja i kompetencije, kognitivne vještine i sposobnosti, adekvatan nivo obrazovaja i stručnost za posao koji im je dodijeljen, već i umiješnost kojom se svaki pojedinac nosi sa samim sobom ali i sa drugima, osobine inicijativnosti, empatije, prilagodljivosti, uvjerljivosti, kontrole emocija tako da se one adekvatno ispoljavaju i omoguće ljudima koji rade zajedno da napreduju ka zajedničkom cilju (Goleman, 1999).

Emocionalna inteligencija na poslu se može okarakterisati kao sposobnost prepoznavanja, opstanka i kontrole pokretačkih snaga, jasnog komuniciranja, inicijative za donošenje odluka, rješavanje problema i odnosa sa drugim pojedincima na takav način da taj odnos rezultira postignućem. Ove kompetencije omogućavaju pojedincu da posmatra i kontroliše emocije, obezbedi ravnotežu i dostojanstvo, formuliše ciljeve, promoviše empatiju, obezbedi rješavanje sukoba i promoviše kompetencije neophodne za vođstvo kao i uspešno učešće u grupi (Elias, 2004). Bradberry i Greaves (2009) su izrazili da je emocionalna inteligencija sposobnost koja

podrazumijeva prepoznavanje emocija kod drugih kao i tačne procjena i upravljanje svojim emocijama u odnosu na druge pojedince i grupe.

Istraživanja otkrivaju da emocionalna inteligencija ima značajan utiecaj na liderske uloge i uspjeh pri zapošljavanju, te da je glavna varijabla za uspješan život koja doprinosi boljim performansama pojedinaca (Zijlmans et al., 2011).

Goleman navodi da je analiza emocionalne inteligencije kod muškaraca i žena pokazala da su žene u prosjeku svjesnije vlastitih emocija, da pokazuju više empatije i vještije su u odnosima sa drugima.S druge strane, muškarci su samouvjerljiviji, optimističniji, lakše se prilagođavaju i bolje podnose stres (Goleman, 1999). Ipak istraživanja pokazuju da postoji mnogo više sličnosti, nego razlika u pogledu emocionalne inteligencije kod žena i muškaraca.Neki muškarci pokazuju empatiju kao i najsenzitivnije žene, dok su neke žene podjednako sposobne podnijetei stres kao i emocionalno najstabilniji muškarac. Genaralno gledano, kako navodi Goleman, postoje jake i slabe tačke jednog i drugog pola, ali govoreći o ukupnoj emocionalnoj inteligenciji, ne postoji razlika među polovima (Goleman, 1999).

Nivo emocionalne inteligencije nije određen genetski niti se razvija samo u djetinstvu. Za razliku od koeficijenta inteligencije koji se neznatno mijnja, kako navodi Goleman, poslije desete godine života, emocionalna inteligencija je naučena i nastavlja se razvijati kako živimo i učimo iz iskustva.

Emocionalna inteligencija je značjna za sve sfere ljudskog života, te je svoju praktičnu primjenu našla i u poslovanju preduzeća.U novije vrijeme značaj emocionalne inteligencije u organizacijama se prepoznaje kao ključni faktor uspješnog rada organizacije u smislu da utiče da se pojedinac pokrene i nastavi sa aktivnostima uprkos preprekama, da se uspješno nosi sa nezadovoljstvom, upravlja svojim načinom razmišljanja, saosjeća sa drugima, doprinosi smanjenju dvosmislenosti socijalne interakcije

Sa druge strane, jedan od najvažnijih zadataka svake organizacije je povećati efikasnost zaposlenih jer na taj način organizacija postiže svoje ciljeve. Da bi se postigla efikasnost i ostvarili organizacijski ciljevi, nije dovoljno imati samo visoko motivisane zaposlene, već i njihovo zadovoljstvo poslom mora biti na visokom nivou. Zadovoljan zaposleni motivisan je za dalje aktivnosti na jedan način, dok nezadovoljan pojedinac svoju dalju motivaciju gradina nekim drugačijim sadržajima i orijentacijama. Pojam zadovoljstva poslom, u naučnu literaturu, je 1935.godine uveo Hopok (Hoppock, 1935; prema Wright, 2006), navodeći

da je zadovoljstvo poslom kombinacija psiholoških i fizioloških okolnosti, kao i okolnosti okruženja koje uzrokuju da zaposleni kaže: „Ja sam zadovoljan svojim poslom“.

Zadovoljstvo poslom predstavlja opšti afektivni odnos pojedinca prema svom poslu ali i prema cjelokupnoj radnoj situaciji. Obično se odnosi na stavove pojedinog zaposlenika, ali se isto tako može odnositi i na stav neke određene grupe (Sambol, 2009., 53.). Zadovoljstvo poslom može obuhvatat samo jedan aspekt posla ili se može shvatiti kao sveobuhvatni stav. To znači da zaposlenici mogu biti zadovoljni jednim aspektom posla, na primjer, saradnicima, a nezadovoljni drugim aspektom kao što je mjesečna plata. Dakle, dva su pristupa zadovoljstvu poslom : holistički i facetni pristup (Wright, 2006). Holistički pristup zadovoljstvo poslom posmatra kao jednodimenzionalni konstrukt.

Zadovoljstvo poslom , prema ovom pristupu, predstavlja generalizovani stav pojedinca prema poslu odnosno jedno centralno osjećanje vezano za posao koje je rezultati iskustva na poslu. Facetni pristup zadovoljstvo poslom posmatra kao višedimenzionalni konstrukt. – Zadovoljstvo poslom se, prema ovom pristupu, posmatra iz aspekta radne situacije i uključuje ispitivanje relevantnih aspekata posla koji doprinose ukupnom zadovoljstvu poslom kao što su plata, načina rukovođenja, odnosa sa saradnicima,mogućnosti napredovanja, stručno usavršavanje, ostali zaposleni i slično.

Brojni faktori utiču na zadovoljstvo poslom, kako oni organizacijski kao što su posao sam po sebi, prijatni radni uslovi, radne kolege, sistem nagrađivanja, organizaciona struktura tako i lični faktori kao što su osobine i karakteristike ličnosti zaposlenog, usklađenost ličnih osobina i posla, ukupno zadovoljstvo životom, satus u organizaciji, godine starosti i staž.

O organizacijskim faktorima relevantnima za zadovoljstvo poslom govori i poznata Herzbergova dvofaktorska teorija motivacije prema kojoj su loši ekstrinzični faktori (tzv. higijenici), tj. niska plata, loši uslovi rada ili kvaliteta rukovođenja, izvori nezadovoljstva na poslu, a s njihovim zadovoljenjem osoba ne postaje automatski zadovoljna, već samo prestaje biti nezadovoljna. S druge strane, postoje faktori intrinzične prirode (tzv. motivatori), poput zanimljivosti posla, mogućnosti odlučivanja, smislenosti rada i dr., s čijim zadovoljavanjem osoba postaje zadovoljna svojim poslom (Janićijević, 2008).

Rezultati ispitivanja odnosa demografskih faktora zaposlenih i zadovoljstva poslom uglavnom nisu konzistentni. Francesko i Mirković navode da su stariji ljudi sa dužim radnim stažom zadovoljniji poslom. Razlog nije taj što sa godinama starosti i staža čovjek postaje bolji u poslu koji obavlja, pa, shodno tome, daje bolje rezultate i više je nagrađivan, već kao razlog navode kognitivnu disonancu.Ljudi koji ostaju duže na svom poslu čak iako u početku nisu bili zadovoljni, racionalizuju svoju inertnost time što sebe ubijede da su zadovoljni tim poslom (Franceško i Mirković, 2008). Istraživanja su pokazala da zadovoljstvo poslom raste sa povećanjem godina radnog staža i starosti ali ne linearno. Na početku radnog vijeka, do tridesete godine zadovoljstvo poslom se naglo povećabva zbog uspjeha koji čovjek doživljava i napredovanja u karijeri.Oko četrdesete godine kada čovjek dooživljava vrhunac svog uspjeha izadovoljstva poslom, gubi mnoge iluzije o poslu i manje je zadovoljan.. To zadovoljstvo se ponovo povećava u drugoj polovini pete decenije (Franceško i Mirković, 2008). Šarić (1982) je utvrdio da su poslom zadovoljniji zaposleni sa kraćim radnim stažom, dok Tanasijević (2011) navodi da zaposleni sa dužim radnim stažom pokazuju veće zadovoljstvo poslom. U pogledu stručne spreme ,istraživanja pokazuju da su poslom zadovoljniji zaposleni sa višom stručnom spremom (Falcone, 1991; Šarić, 1982). Prema istraživanju Mirković i Čekrlija (Mirković i Čekrlija, 2015) muškarci pokazuju veće zadovoljstvo kada je u pitanju visina plate, mogućnost napredovanja, beneficije, saradnici, komunikacija u odnosu na žene.

Cilj ovog rada je ispitati da li postoji povezanost između nivoa emocionalne inteligencije i zadovoljstva poslom, jer su oba područja od velikog značaja za uspješno funkcionisanje organizacije, da li pojedinci sa višim nivoom emocionalne inteligencije imaju i veće zadovoljstvo poslom u pogledu svih šest aspekata zadovoljstva poslom: posao sam po sebi, sistem nagrađivanja, prijatni radni uslovi, kolege na poslu i komunikacija, rukovođenje, mogućnost napredovanja i beneficije. Cilj je takođe utvrditi da li postoji statistički značajna razlika u zadovoljstvu poslom i šest aspekata zadovoljstva poslom između zaposlenih različite starosne strukture,godina starosti, godina radnog staža i obrazovanja.

## METOD

### Uzorak i procedura

Istraživanje je sprovedeno na prigodnom uzorku od 248 osoba zaposlenih u proizvodnji, zdravstvu, prosvjeti, bankarstvu, trgovini, javnoj administraciji u Republici Srpskoj. Struktura uzorka prema polu, starosti, nivou obrazovanja i dužini radnog staža prikazana je u Tabeli 1.

Istraživanje je sprovedeno od januara do marta 2023. godine. Ispitivanje je vršeno grupno u organizacijama u kojima su ispitanici zaposleni u trajanju od oko 20 minuta.Same organizacije kao i zanimanja ispitanika koji su bili učesnici u istraživanju su različita i obuhvataju oblast zdravstva, obrazovanja, informacionih tehnologija, bankarstva, uslužne i admisnistrativne poslove u okviru privatnog i javnog sektora. Učestvovanje u istraživanju je bilo dobrovoljno i anonimno.

Tabela 1. Struktura uzorka prema polu, starosti, nivou oobrazovanja i dužini radnog staža za N=248.

| Socio – demografski faktori | | Frekvenca | Procenat |
|---|---|---|---|
| **Pol** | Muški | 111 | 44.8 |
| | Ženski | 137 | 55.2 |
| **Godine starosti** | do 30 | 45 | 18.1 |
| | 31-40 | 52 | 21.0 |
| | 41- 50 | 108 | 43.5 |
| | 51-60 | 23 | 9.3 |
| | 61 i više | 20 | 8.1 |
| **Dužina radnog staža** | do 10 godina | 73 | 29.4 |
| | 11-20 | 100 | 40.3 |
| | 21 i više | 75 | 30.3 |
| **Stručna sprema** | Osnovna | 11 | 4.4 |
| | Zanat | 5 | 2.0 |
| | Srednja | 72 | 29.0 |
| | Viša | 19 | 7.7 |
| | Visoka | 103 | 41.3 |
| | Magistar | 21 | 8.5 |
| | Doktor nauka | 17 | 6.9 |

## Varijable

Status nezavisne varijable u ovom istraživanju imaju individualne karakteristike zaposlenih: Dimenzije emocionalne inteligencije (samosvijest, upravljanje emocijama, samomotivacija, saosjećanje -empatija, socijalne vještine).

Demografske karakteristike.Demografske karakteristike zaposlenih ispitivane u ovom istraživanju su: pol, starost, stepen obrazovanja, zanimanje i dužina radnog staža

Status zavisne varijable u ovom istraživanju ima stav o zadovoljstvo poslom (posao sam po sebi, sistem nagrađivanja, prijatni radni uslovi, kolege na poslu i komunikacija, rukovođenje, mogućnost napredovanja i beneficije.

## Instrumenti

- **Upitnik za prikupljanje opštih socio – demografskih podataka** o ispitaniku sadtrži pet pitanja koja se odnose na: pol, godine starosti, stručna sprema, godine radnog staža, zanimanje.
- **Test emocionalne inteligencije**. Sastoji se od 50 tvrdnji grupisanih u pet podskala: Ss – samosvijest (tvrdnje br.1,6,11,16,21,26,31,36,41,46; primjer tvrdnje: ,,Odmah sam svjestan sam kada izgubim samokontrolu.” ), Eu – upravljanje emocijama (tvrdnje br.2,7,12,17,22,27,32,37,42,47; primjer tvrdnje: ,, Ljudi teške naravi me ne ljute.”), Sm – samomotivacija (tvrdnje br. 3,8,13,18,23,28,33,38,43,48; primjer tvrdnje: Uvijek se mogu motivisati da radim teške zadatke.”), Se – saosjećanje, empatija (tvrdnje br. 4,9,14,19,24,29,34,39,44,49; primjer tvrdnje: ,,Uvijek mogu sgledati stvari sa aspekta druge osobe.”), Sv – socijalne vještine (tvrdnje br. 5,10,15,20,25,30,35,40,45,50; primjer tvrdnje: ,,Ja sam odličan slušalac.”). Zadatak ispitanika je da na petostepenoj skali Likertovog tipa biraju odgovor na ponuđenu koji ih najbolje opisuje (1 – uopšte se ne slažem, neznatno se slažem, neodlučan sam, uglavnom se slažem, u potpunosti se slažem). Skor za svaku subskalu se formira kao ukupna suma odgovora ispitanika na svim tvrdnjama koje čine subskalu. Koeficijent unutrašnje konzistencije (Cronbach alfa) za cijelu skalu na uzorku ovog istraživanja iznosi $\alpha = .926$
- **Upitnik o zadovoljstvu poslom**. Sadrži dvadeset šest tvrdnji grupisanih u šest subskala koje mjere zadovoljstvo poslom sa šest aspekata posla: Posao sam po sebi (2,18,27,8), Sistem nagrađivanja (1,9,19,20), Prijatni radni uslovi (11,17,21), Kolege na poslui komunikacija (3,7,13,14,22,25), Rukovođenje (4,6,10,15,23), Mogućnost napredovanja

i beneficije (12,16,24). Zadatak ispitanika je da na petostepenoj skali Likertovog tipa procjeni u kojoj mjeri se slaže sa svakom navedenom tvrdnjom (od 1 = uopšte se ne slažem do 5 = potpuno se slažem). Na osnovu podataka dobijenih ovom skalom može se izračunati sedam nezavisnih skorova. Šest skorova čine rezultati ispitanika na pojedinačnim subskalama, i formiraju se kao linearna kombinacija procjena na tvrdnjama koje čine subskalu. Sedmi skor je sumacioni skor ispitanika na svim tvrdnjama i predstavlja opštu mjeru zadovoljstva poslom. Koeficijent unutrašnje konzistencije (Cronbach alfa) za cijelu skalu na uzorku ovog istraživanja iznosi α = .922

Obrada podataka

**Obrada podataka je obavljena u statističkom softveru SPSS 26.0.Od statističkih metoda korišćene su:**

- Metode deskriptivne statistike
- MannWhitey U Test
- Kruskal- Volisov test
- Spirmanov koeficijent korelacije

## REZULTATI

Rezultati deskriptivne analize pokazuju da je distribucija rezultata ispitanika na skalama: posao sam po sebi, zadovoljstvo uslovima rada, kolegama i komunikacijom kao i mogućnostima napredovanja pomjerena prema višim vrijednostima, dok je zadovoljstvo rukovođenjem i sistemom nagrađivanja pomjerena prema nižim vrijednostima (Tabela 2.)

Shodno dobijenim pokazateljima ispitivanja normalnosti distribucije rezultata na skali svim subskalama zadovoljstva poslom kao na skali emocionalne inteligencije koje je ukazalo na statistički značajno odstupanje od normalne raspodjele svih rezultata uzorka ispitivanja,u daljoj analizi korišteni neparametrijski postupci za statističku analizu podataka.

Tabela 2. Deskriptivna pokazatelji za varijable korištene u istraživanju.
Table 2. Descriptive indicators for the variables used in the research.

| | N | Min | Max | M | SD | Skjunis | Kurtozis |
|---|---|---|---|---|---|---|---|
| Posao sam po sebi | 248 | 6 | 20 | 14.40 | 3.64 | -.304 | -.392 |
| Sistem nagrađivanja | 248 | 4 | 20 | 12.32 | 4.38 | .070 | -.609 |
| Uslovi rada | 248 | 5 | 15 | 10.29 | 1.92 | -.489 | .275 |
| Kolege i komunikacija | 248 | 9 | 26 | 18.70 | 2.90 | - .808 | .151 |
| Rukovođenje | 248 | 12 | 25 | 16.59 | 2.72 | .406 | -.478 |
| Mogućnost napredovanja | 248 | 8 | 20 | 13.40 | 2.59 | - .174 | .433 |
| Valid N | 248 | | | | | | |

Kako bi se utvrdilo da li postoje statistički značajne razlike u zadovoljstvu poslom prema socio-demografskim obilježjima: pol, starost, godine radnog staža, stepen stručne spreme primjenjivani su: Mann- Whitneyev U – test i Kruskal- Volisov test.

Za ispitivanje postojanja korelacije između nivoa emocionalne inteligencije zaposlenih i zadovoljstva poslom korišten je Spirmanov koeficijent korelacije.

U cilju utvrđivanja korelacije Emocionalne inteligencije zaposlenih i ukupnog zadovoljstva poslom kao i šest aspekata zadovoljstva poslom: posao sam po sebi, sistem nagrađivanja, prijatni radni uslovi, kolege na poslu i rukovođenje, mogućnost napredovanja, izračunat je Spirmanov koeficijent korelacije.

Tabela 3. Spirmanov koeficijent korelacije za emocionalnu inteligenciju i ukupno zadovoljstvo poslom.
Table 3. Spearman's correlation coefficient for emotional intelligence and overall job satisfaction.

| Spirman's rho | | EI | ZP |
|---|---|---|---|
| | Correlation | 1 | .141* |
| | Sig. (2-tailed) | | .028 |
| | N | 248 | 248 |

* Correlation is significant at the 0.01 level (2-tailed).

Emocionalna inteligencija je, prema nalazima istraživanja, u pozitivnoj korelaciji sa ukupnim zadovoljstvom poslom (r = .141). Dakle, što je kod osobe razvijenija emocionalna inteligencija, izraženije je ukupno zadovoljstvo poslom.

Analiza dobijenih korelacija na pojedinim podskalama zadovoljstva poslom je pokazala značajnu korelaciju između emocionalne inteligencije zaposlenih i pet aspekata zadovoljstva poslom. Korelacija sa emocionalnom inteligencijom nije dobijena na skali uslovi za rad.

Emocionalna inteligencija zaposlenih je, prema nalazima ovog istraživanja, u pozitivnoj korelaciji sa zadovoljstvom samim poslom (r = .142), sistemom nagrađivanja u organizaciji (r = .130), komunikacijom u organizaciji (r = .140) i mogućnošću napredovanja (r = .150)., dok je u negativnoj korelaciji (r = -.139). sa zadovoljstvom rukovođenjem (Tabela 4).

Tabela 4. Spirmanov koeficijent korelacije za emocionalnu inteligencij i šest aspekata zadovoljstva poslom.
Table 4. Spearman correlation coefficient for emotional intelligence and six aspects of job satisfaction.

| Spirman's rho | | EI | Posao sam po sebi |
|---|---|---|---|
| | Correlation | 1 | .142* |
| | Sig. (2-tailed) | | .026 |
| **Spirman's rho** | | **EI** | **Sistem nagrađivanja** |
| | Correlation | 1 | .130* |
| | Sig. (2-tailed) | | .0243 |
| **Spirman's rho** | | **EI** | **Uslovi za rad** |
| | Correlation | 1 | .109 |
| | Sig. (2-tailed) | | .089 |
| **Spirman's rho** | | **EI** | **Komunikacija** |
| | Correlation | 1 | .140* |
| | Sig. (2-tailed) | | .029 |
| **Spirman's rho** | | **EI** | **Rukovođenje** |
| | Correlation | 1 | .139* |
| | Sig. (2-tailed) | | .030 |
| **Spirman's rho** | | **EI** | **Napredovanje** |
| | Correlation | 1 | .150* |
| | Sig. (2-tailed) | | .019 |
| **Total** | | **248** | **248** |

*. Correlation is significant at the 0.05 level (2-tailed)

Kako bi se utvrdilo da li postoje razlike u ukupnom zadovoljstvu poslom i šest aspekata zadovoljstva poslom zaposlenih koji se razlikuju prema demografskim obilježjima: pol, starost, nivo obrazovanja i dužina radnog staža sprovedena Mann Whitey U Test i Kruskal- Volisov test.U ovom istraživanju nije pronađena statistički značajna razlika ni na jednom od demografskih faktora: pol, godine starosti, godine radnog staža, stepen stručne spreme u pogledu zadovoljstva poslom.Ovakvi nalazi su djelimično u suprotnosti sa nalazima ranijih istraživanja koja nalaze da je npr. pol i godine radnog staža zaposlenika značajan faktor koji pravi razliku u zadovoljstvu poslom.

S obzirom da su uzorak činili zaposlenici različitih zanimanja, iako to nije bila primarni cilj ovog istraživaja, uočene su izvjesne značajne razlike u pogledu zadovoljstva poslom kod ispitanika različitih zanimanja.

## ZAKLJUČCI

Prvi cilj ovog istraživanja je bio utvrditi da li postoji korelacija između emocionalne inteligencije i ukupnog zadovoljstva poslom kao i šest pojedinačnih faktora zadovoljstva poslom.

Dobijeni rezultati pokazuju da između emocionalna inteligencija i ukupnog zadovoljstva poslom postoji značajna korelacija koja je pozitivnog smijera što znači da što je viši nivo emocionalne inteligencije kod zaposlenog, to je njegovo ukupno zadovoljstvo poslom veće, čime je potvrđena naša pretpostavka.

Dobijeni rezultati ne iznenađuju i u skladu su sa postavljenom hipotezom ali i nekim ranijim navodima u literaturi. Kako navodi Goleman, umiješnost kojom se svaki pojedinac nosi sa samim sobom ali i sa drugima, osobine inicijativnosti, empatije, prilagodljivosti, uvjerljivosti, kontrole emocija tako da se one adekvatno ispoljavaju i omoguće ljudima koji rade zajedno da napreduju ka zajedničkom cilju su potrebni savremenom poslovnom okruženju. Emocionalne inteligencije u organizacijama se, kako se navodi u literaturi, prepoznaje kao ključni faktor uspješnog rada organizacije u smislu da utiče da se pojedinac pokrene i nastavi sa aktivnostima uprkos preprekama, da se uspješno nosi sa nezadovoljstvom, upravlja svojim načinom razmišljanja, saosjeća sa drugima, doprinosi smanjenju dvosmislenosti socijalne interakcije, što je potvrđeno i u ovom israživanju.

Negativan smijer korelacije je utvrđen na podskali rukovođenje što implicira potrebu za ispitivanjem korelacije, ali i uticaja emocionalne inteligencije rukovodilaca kao i stilova rukovođenja na zadovoljstvo zaposlenih.

Sociodemografski faktori:pol godine radnog staža, godine starosti, stepen stručne spreme, se nisu, u ovom istraživanju, pokazali kao značajni faktori koji prave razliku u ukupnom zadovoljstvu poslom.

Uočena korelacija između zamimanja ispitanika i zadovoljstva poslom (r = .182) značajna je na nivou 0.01, kao i statistički značajne razlike između ispitanika sa različitm zanimanjem u pogledu zadovoljstva poslom, upućuju na dodatno i detaljnu mogućnost istraživanja u okviru ovog segmenta na uzorku ispitanika iz Republike Srpske, što nije bio sam cilj ovog rada.

S obzirom na relativno mali broj ispitanika, što je svakako jedno od ograničenja ovog rada, ne možemo uopštavati podatke , ali možemo govoriti o tome da dobijeni rezultati , u praktičnom smislu, upućuju na značaj podsticanja razvoja emocionalne inteligencije jer, kako navodi Goleman, emocionalna inteligencija je naučena i nastavlja se razvijati kako živimo i učimo iz iskustva. Uvođenje treninga emocionalne inteligencije, treninga emocionalne pismenosti zaposlenih bi, u smislu postizanja većeg ukupnog zadovoljstva poslom, ali i cjelokupnim životom zaposlenih, što svakako utiče na motivaciju zaposlenih (Tanasijević, 2011) produktivnost radnika, u sklopu plana razvoja zaposlenih, trebalo da uđe u program svake organizacije.

Takođe, uočena je korelacija između zamimanja ispitanika i zadovoljstva poslom (r = .182) značajna na nivou 0.01 što upućuje na dodatno i detaljnu mogućnost istraživanja u okviru ovog segmenta, što nije bio sam cilj ovog rada.

Doprinos ovog rada je, uvažavajući činjenicu da u savremenom i užurbanom poslovanju mali broj menadžera obraća pažnju na zaposlene i zanemaruje činjenicu da je ljudski potencijal najvažniji faktor uspješnog poslovanja, u naglašavanju važnosti ulaganja organizacije u formiranje sektora za ljudske resurse ili bar u jednu osobu unutar organizacije koja će biti osposobljena da se sistematski i kontinuirano brine o zaposlenima, njihovoj motivaciji, razvoju i daje im veći značaj u cijelom poslovanju.

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# EMOTIONAL INTELLIGENCE IN THE CONTEXT OF JOB SATISFACTION

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**ABSTRACT**

Emotional intelligence is significant for all spheres of human life. Therefore, it has also found its practical application in the company's business operations. In recent times, the importance of emotional intelligence in organizations has been recognized as a key factor of successful work of the organization in the sense that it influences the individual to initiate and continue with activities despite obstacles, to cope with dissatisfaction successfully, manages his way of thinking, empathizes with others and contributes to reducing the ambiguity of social interaction. On the other hand, one of the most important tasks of any organization is to increase the efficiency of employees because this is how the organization achieves its goals. In order to achieve efficiency and attain organizational goals, it is not enough to have only highly motivated employees, but also their job satisfaction must be at a higher level. Numerous factors influence job satisfaction; both organizational such as job satisfaction itself, pleasant working conditions, coworkers, reward system, organizational structure and personal factors such as an employee characteristics and personality traits, the compatibility of personal traits and work, overall life satisfaction, the status in the organization, age and seniority. The aim of this work is to examine whether there is a connection between the level of emotional intelligence of employees and job satisfaction, whether individuals with a higher level of emotional intelligence also have higher job satisfaction because both areas are of great importance for the successful functioning of the organization. The aim is also to determine whether there is a statistically significant difference in job satisfaction between employees of different age and years of employment. Employees in business entities from different activities from the Republic of Srpska participated in the research. The data was collected using an emotional intelligence test as well as a job satisfaction questionnaire designed for the purpose of this research.

**Keywords:** emotional intelligence, job satisfaction, organizational behaviour.

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# REJ-OSTERITOV TEST SLOŽENE FIGURE (ROCF): KOMPARATIVNA ANALIZA PRIMJENE NA ZDRAVOM ISPITANIKU I ISPITANIKU SA DIJAGNOZOM

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## SAŽETAK

Rej-Osteritov test složene figure (ROCF) se primjenjuje u istraživačke svrhe za ispitivanje razvoja vizuo-perceptivne organizacije, vizuelne kratkoročne i dugoročne memorije, kao i egzekutivnih funkcija. Cilj ovog rada je da se prikažu rezultati istraživanja primjene ROCF testa, te da se interpretiraju i uporede dva slučaja primjene ROCF-a: na ispitaniku iz zdrave i psihopatološke populacije. Ispitanici su izabrani tako da budu istih godina i pola. Iz psihopatološke populacije izabrana je ispitanica sa dijagnozom autističnog spektra. Rezultati su potvrdili rezultate prethodnih istraživanja. Zdrava ispitanica je koristila strategiju crtanja karaktersitičnu za osobe bez neuropsiholoških poteškoća, u crtanju i skorovanju nije bilo odsupanja. Ispitanica sa autizmom, iako funkcionalna, na ROCF testu imala je težak pad sposobnosti planiranja i organizacije, kao i sposobnosti pamćenja relevantnih vizuelnih informacija, uz korištenje inferiornije strategije crtanja.

**Ključne riječi:** Rej-Osteritov test složene figure, istraživanja, autizam.

## UVOD

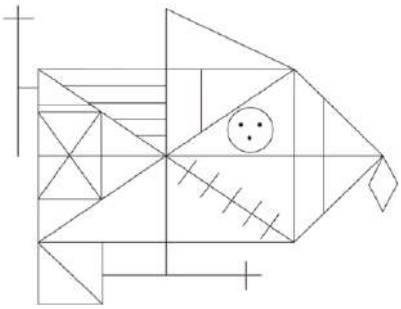
Neuropsihološki testovi nude vrijedne podatke kako u kliničkoj praksi tako i u istraživačke svrhe. Među njima je vrlo popularan i široko korišćen Rej-Osteritov (Rey-Osterrieth) test složene figure (ROCF). Konstruisao ga je Rej, a standardizovao Osterit (Douka et al., 2019). Sama figura je osmišljena kao složeni vizuelni dizajn i predstavlja dobar indikator sposobnosti planiranja i organizacije, kao i sposobnosti pamćenja relevantnih vizuelnih informacija (Shin et al., 2006; Ackerman, 1990) (Slika 1). Zbog toga je ovaj test prvenstveno namjenjen za ispitivanje vizuo-perceptivne organizacije, vizuelne kratkoročne i dugoročne memorije i egzekutivnih funkcija osoba sa različitim kognitivnim smetnjama, u koje spadaju i osobe sa lateralizovanim moždanim disfunkcijama (McConley et al., 2008). Rej-Osteritov test složene figure se sastoji iz dva dijela. U prvom dijelu ispitaniku se daje nalog da što preciznije precrta složeni geometrijski stimulus na praznom listu papira bez pomjeranja papira i modela, pri čemu koristi nekoliko različitih boja koje mu daje ispitivač. Prilikom crtanja, ispitaniku se daju bojice različitih boja. Tako je omogućena procjena strategije crtanja figure. Osterit je utvrdio sedam kvalitativno različitih strategija kopiranja figure (Krstić, & Gojković, 1994):

- crtež započet velikim pravougaonikom, a na njega se potom nadovezuju ostali elementi;
- crtež započet nekim od dijelova koji se nalaze u okviru ili se naslanjaju na pravougaonik, a nastavak čini pravougaonik sa svim ostalim elementima;
- crtanje spoljašnjeg okvira bez naglašavanja pravougaonika, pa se onda kopiraju unutrašnji elementi;
- nadovezivanje elemenata jedan na drugi;
- kopiranje pojedinih dijelova figure bez organizovanja cjeline;
- zamjena figure crtežom nekog drugog predmeta;
- škrabanje.

Budući da strategije broj 1, 2 i 3 predstavljaju strategiju sagledavanja crteža kao cjeline u koji se potom ubacuju pojedini dijelovi, a strategije 5, 6 i 7 nedostatak bilo kakve strategije, navedene strategije se mogu svesti na tri:

- Strategija crtanja figure po geštaltu;
- Strategija crtanja figure dio-po-dio;
- Crtanje pojedinačnih elemenata bez organizovanja cjeline figure.

Evaluacijom podataka dobijaju se ukupno četiri skora: skor dobijen u zavisnosti od primjenjene strategije pri precrtavanju figure (kategorička varijabla koja se sastoji od 3 opisane kategorije), skor koji čini ukupno vrijeme potrebno za crtanje figure (kontinuirana varijabla), skor koji se odnosi na to kako je figura postavljena u prostoru, tj. da li je postavljena na isti način kao i model, ili je rotirana za 90°, odnosno 180° (kategorička varijabla koja se sastoji od 3 kategorije) i skor koji čini ukupan broj poena. Figura je podjeljena na 18 elemenata, a svaki od njih se, zavisno od preciznosti kopiranja, ocjenjuje sa 2, 1, 0.5 ili 0 poena. Maksimalni broj poena je 36 (Krstić i Gojković, 1995). ROCF se sastoji od nekoliko jedinica koje se perceptivno mogu podijeliti na globalne ili lokalne elemente (Slika 1.). Globalni elementi su veliki pravougaonik, dijagonale, horizontalne i vertikalne linije i veliki trougao desno od pravougaonika. Globalni elementi su fundamentalni za organizaciju figure, a uspješna reprodukcija ROCF-a zahtjeva prije svega crtanje ovih elemenata, jer oni predstavljaju strukturni okvir ostalih lokalnih elemenata. Lokalni elementi se mogu dalje hijerarhijski podijeliti na jedinice sastavljene od oblika ili linija koje formiraju koherentan geštalt unutar glavne figure (npr. mali pravougaonik sa unutrašnjim krstom, mali trougao iznad velikog pravougaonika, krug sa tri tačke) ili jednostavni detalji napravljeni od jednolinijskih segmenata.



Slika 1. Izgled Rej-Osteritove figure.
Figure 1. Layout of the Ray-Osterit figure.

U toku izvođenja vizuo-konstruktivnih zadataka učestvuju dva sistema: vizuelni i motorni. Vizuelni sistem favorizuje konfiguraciono procesiranje, a motorni sistem sekvencijalno ili prema dijelovima orijentisano procesiranje. Sekvencijalno motorno programiranje je povezano sa funkcijom lijeve hemisfere, a konfiguraciono procesiranje (prema Geštalt obrascu) sa funkcijom desne hemisfere. Waber i Bernstein su utvrdili neke zakonitosti razvoja vizuokonstruktivnih funkcija:

1. Preadolescentna djeca, orijentisana prvenstveno na vizuelni modalitet u toku procesiranja vizuelne informacije, su najfrekventnije koristila strategiju kopiranja po geštaltu i produkovala su više konfiguraciono zapamćenih produkata nego djeca ograničena na motorni sistem u toku obrade informacije, dok su djeca ograničena na motorni sistem koristila najčešće strategiju kopiranja dio-po-dio;

2. Vizuelni modalitet obrade informacija tokom razvoja počinje da dominira nad motornim. Waber ističe da progresivna integracija figuralnog i motornog koda zavisi od efikasnosti funkcije korpusa kalozuma. Iako procedura kopiranja angažuje prvenstveno procese lijeve hemisfere, enkodiranje reflektuje ravnopravnije učešće obe hemisfere, jer obe hemisfere učestvuju podjednako u analizi vizuelnih podataka, ali to čine na različite načine (Waber, & Bernstein, 1995).

## KLINIČKA PRIMJENA U NEUROLOŠKIM BOLESTIMA I REZULTATI PRETHODNIH ISTRAŽIVANJA

Rezultati dosadašnjih istraživanja su pokazali da se kod djece sa razvojem poboljšava strategija precrtavanja, povećava se broj tačno precrtanih elemenata, a vrijeme potrebno da se obavi zadatak smanjuje (Kirk, 1985; Prvčić, & Tadinac Babić, 1999). Naime, pri procenjivanju složenih figura, djeca do sedme godine ili ignorišu detalje i usmjeravaju se na cjelinu figure, ili obrnuto: usmjeravaju se na detalje i ignorišu cjelinu. Različite studije su pokazale da djeca od 5 i 6 godina posmatraju kompleksnu figuru kao zamršenu slagalicu sastavljenu od mnogo malih dijelova (Waber, & Bernstein, 1995; Krik, 1985). Promjene se događaju na uzrastu između 7 i 10 godina, kada djeca postaju svjesna da je cjelina sastavljena od međusobno povezanih dijelova i kada počinju pojedinačne elemente da uklapaju u cjelinu (Best, 1985). Sprovedena istraživanja su utvrdila da se sa razvojem poboljšavaju performanse u toku izvođenja zadatka precrtavanja složenog, apstraktnog vizuelnog stimulusa, ali je ostalo otvoreno pitanje praćenja razvojnog trenda odloženog pamćenja figure i odnosa mjera koje su obuhvaćene ispitivanjem precrtavanja figure i odloženog pamćenja. Ispitivanja djece sa parcijalnom epilepsijom pokazuju da djeca sa desnohemisferno fokusiranim napadima koriste u prosjeku nezrele strategije precrtavanja figure, kao i značajno manji broj elemenata u poređenju sa djecom sa epileptičnim fokusom u lijevoj hemisferi (Vuksanović, & Vuković, 2002), dok studije usmjerene na ispitivanje djece sa teškoćama učenja su pokazala prvenstveno probleme povezane sa strategijom precrtavanja figure (Waber, & Bernstein, 1995; Seidman, et al., 2003).

Neurodegenerativne i cerebrovaskularne bolesti mogu izazvati kognitivna oštećenja, kao što su Alchajmerova bolest, demencija Levijevog tijela, frontotemporalna demencija, demencija Parkinsonove bolesti i bolest malih krvnih sudova mozga. Klinički podtipovi blagog kognitivnog oštećenja (MCI) su prekursorski oblici različitih demencija, a rano prepoznavanje je od velikog značaja za upravljanje bolestima. ROCF se široko koristi za procjenu vizuelno-konstruktivne sposobnosti i vizuelnog pamćenja povreda mozga ili kognitivnih poremećaja. Alchajmerova bolest (AD) je neurodegenerativna bolest koju karakteriše progresivno kognitivno oštećenje i poremećaji ponašanja. Oštećenje pamćenja je njegova osnovna kognitivna karakteristika. Struktura ili funkcija parijetalnog režnja može se promijeniti u ranoj fazi, tako da test vizuelnoprostorne sposobnosti može biti tačniji od drugih testova u razlikovanju AD od ne-AD. Neke studije su potvrdile da ROCF ima dobar dijagnostički i prognostički potencijal za AD (Salvadori et al., 2019). Paula i saradnici proučavali su, učinak ROCF kopije kod pacijenata sa AD i zaključili da je povezan sa niskim metabolizmom u bilateralnim temporalno-parijetalnim, okcipitalnim i desnim frontalnim kortikalnim područjima, posebno u zonama BA40 i BA7 (Brodmannova zona) (Paula et al., 2016). Rezultati pokazuju da ROCF odražava funkciju zadnjeg temporalno-parijetalnog korteksa i naglašava ulogu vizuoprostorne obrade u AD (Porto et al., 2008). Vaskularna demencija (VaD) je drugi glavni uzrok demencije poslije AD i može se spriječiti. Bolest malih krvih sudova mozga je čest uzrok VaD, a lezija se nalazi u subkortikalnom području. To može dovesti do razaranja kortikalne striatalne petlje i smanjene funkcije frontalnog režnja, što dovodi do smanjene pažnje i brzine obrade informacija. Zbog toga bi se procjena kognitivne skale trebalo više fokusirati na kognitivne domene kao što su izvršna funkcija, pažnja i vizuelno-prostorne sposobnosti. VaD i AD imaju zajedničke patogene faktore i patološke mehanizme; posebno kada je klinička slika pacijenta sa AD pomiješana sa vaskularnim faktorima, klinička identifikacija je složenija. Prethodne studije su otkrile da pacijenti sa subkortikalnim vaskularnim blagim kognitivnim oštećenjem (v-MCI) imaju loš učinak u ROCF kopiranju (Salvadori et al., 2016). Salvadori i saradnici su koristili Bostonski kvalitativni sistem bodovanja kako bi dalje istražio razloge i otkrio da pacijenti v-MCI pokazuju više nedostataka u planiranju i organizaciji nego pacijenti sa aMCI. Njihove reprodukcije su više fragmentovane i sadrže više perseveracija. Prema tome, ROCF ih može dobro razlikovati (Salvadori et al., 2019).

Parkinsonova bolest (PD) je uobičajena neurodegenerativna bolest sa složenim kliničkim simptomima, uključujući motoričke simptome kao što su rigidnost mišića i tremor u mirovanju, nemotoričke simptome kao što su hiposmija, konstipacija, poremećaj ponašanja i kognitivna oštećenja itd. (Dickson et al., 2009). Kognitivno oštećenje (PD-MCI) je češće, a 70–80%

pacijenata sa PD može napredovati u demenciju sa teškom disfunkcijom izvršne funkcije. Pacijenti sa PD također su imali loš učinak na ROCF odloženom opozivu, što je objašnjeno neuspjehom vraćanja memorije usljed razaranja frontostrijatalne petlje. Vizuoprostorno oštećenje je također rana karakteristika PD-MCI, a pokazalo se da testovi kopiranja figura predviđaju progresivni kognitivni pad PD, kao što su petouglovi i kocke (Diebo et al., 2015). ROCF također ima dobre mogućnosti skrininga i dijagnostike za PD-MCI i može se koristiti kao prediktivni faktor (Steinfeld et al., 2015). Demencija Levijevog tela (DLB) je druga najčešća neurodegenerativna demencija poslije AD, a njene glavne manifestacije su oštećenje pamćenja, Parkinsonov sindrom i halucinacije. Ima isti patofiziološki mehanizam kao PD. Dijagnoza tipičnih PDD i DLB zasniva se na redosljedu pojavljivanja demencije i Parkinsonovih simptoma, ali je u kliničkoj praksi teško razlikovati. To je zato što se njihovi simptomi preklapaju i nisu tipični. Međutim, studije su otkrile da DLB i PDD imaju različite kognitivne karakteristike (Martini et al., 2020). DLB ima teže kognitivno oštećenje od PDD, posebno pažnje, vizuelno-prostorne sposobnosti i jezika. Objašnjeno je da imaju različite AD kopatološke nivoe, a ROCF test kopiranja ih može dobro razlikovati.

Mali mozak ne samo da koordinira kretanje, već uključuje i kognitivne procese, uključujući vizuelno-prostorne sposobnosti. Povreda malog mozga pokazuje loše vizuelno-prostorne vještine. Studije funkcionalne povezanosti u stanju mirovanja pokazuju vezu između malog mozga i parijetalnog režnja uključenih i vizuelno-prostornu integraciju. Mali mozak može doprinjeti oblikovanju organizacije kako bi se promovisala efikasna vizuelnoprostorna integracija i percepcija dok kodira oblike. Slapik i saradnici su otkrili da je ROCF kopiranje kod cerebelarne ataksije bilo loše, ali je naknadno prisjećanje bilo normalno, a tačnost opoziva je povezana sa brzinom obrade (Slapik et al., 2019). To pokazuje da strategija kopiranja kompenzuje performanse prisjećanja, a strategija organizacije može uticati na performanse ROCF-a više nego na vizuelno-prostorne veštine. ROCF se također koristi za procjenu vizuoprostorne memorije kod amiotrofične lateralne skleroze. Povreda prefrontalnog režnja može se pojaviti u ranoj fazi i manifestuje se kao smanjenje izvršnih funkcija. Što je teža disfunkcija izvršnih funkcija, lošiji je učinak ROCF-a. Blaga traumatska povreda mozga (mTBI) može izazvati različite kognitivne, bihejvioralne, fizičke ili emocionalne simptome. Nakon očekivanog perioda oporavka od 2–12 nedelja, 10–20% pacijenata sa mTBI i dalje ima uporne simptome nakon potresa mozga, što značajno utiče na njihov kvalitet života i društvenu integraciju (Tsermentseli et al., 2012). Procesi vizuelne i verbalne memorije su dve najteže oštećene kognitivne funkcije poslije mTBI. ROCF pomaže u razlikovanju različitih procesa vizuelnog pamćenja (uključujući trenutno prizivanje, odloženo prizivanje i prepoznavanje). L'Ecuier-Giguere i saradnici su otkrili da pacijenti sa mTBI imaju kratkotrajno i dugotrajno oštećenje vizuelne memorije kada crtaju ROCF, dok je funkcija vizuelnog prepoznavanja relativno zadržana (L'Ecuyer-Giguere et al., 2020). I verbalni i koeficijent inteligencije performansi izgleda da su povezani sa performansama vizuelne memorije. Objašnjeno je da prisjećanje zavisi od hipokampusa, a poznato od medijalnog temporalnog korteksa. Pored toga, ROCF (ili njegov ekvivalent) se također koristi za procjenu konstruktivne apraksije kod starijih pacijenata sa fokalnim tumorima mozga (benignim ili malignim), koji su česti kod parijetalnih i parijeto-okcipitalnih lezija (Fornara et al., 2018). Konstrukciona apraksija je neuropsihološki sindrom definisan kao očigledno oštećenje sposobnosti izgradnje, sklapanja ili crtanja dvodimenzionalnih ili trodimenzionalnih modela (simpleksnih ili složenih), sintetizujući njegove pojedinačne elemente u kompletan objekat. Ovaj zadatak zahtjeva analizu i reprodukciju prostornog odnosa između pojedinih elemenata pod vođstvom perceptivnih ili mentalnih modela, koji uključuju različite oblasti mozga (npr. potiljačni režanj, parijetalni režanj i frontalni režanj) (Cubelli, & Della Sala, 2018). ROCF, koji uključuje više kognitivnih domena, smatra se najpouzdanijim testom za određivanje konstruktivne apraksije. Retrospektivna literatura pokazuje da fokalni tumori mozga mogu uzrokovati ukupne kognitivne deficite. ROCF može biti zahvaćen ovom opštom povredom, a ne postoji specifična korelacija sa stranom i lokacijom lezije, što čini zadatak obrade previše teškim (Fornara et al., 2018).

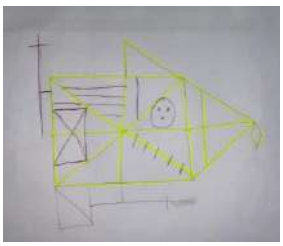
ROCF se također koristi za procjenu vizuelno-prostornih sposobnosti, učenja, vizuelnog pamćenja i izvršne disfunkcije kod nekih psihijatrijskih bolesti, uključujući poremećaj pažnje i hiperaktivnost, poremećaj u ishrani i šizofreniju. Poremećaj pažnje i hiperaktivnosti (ADHD) je

neurorazvojni poremećaj djece i adolescenata. Karakterišu ga kognitivni deficiti u dorsolateralnom prefrontalnom korteksu koji regulišu izvršne funkcije, što se manifestuje smanjenom radnom memorijom i pažnjom. Hiun i saradici (Hyun et al., 2018) koristili su digitalni ROCF za procjenu vizuelnoprostorne radne memorije adolescenata sa ADHD-om. Otkrili su da je vrijednost odstupanja (razlika u pikselima između originalne slike i slike šablona) ADHD-a različita od vrijednosti kontrolne grupe i da je u negativnoj korelaciji sa vizuelnoprostornim indeksom i indeksom radne memorije. Međutim, nije bilo razlike u odstupanju neposrednog prisjećanja između dve grupe, što ukazuje na nedostatak memorije kod pacijenata sa ADHD. ROCF se takođe postepeno koristio u treningu izvršne funkcije djece sa ADHD-om. Nakon obuke, učinak pacijenata sa ADHD-om u zadacima izvršne funkcije može se uporediti sa onima normalne djece. ROCF je pouzdana mjera za procjenu izvršne funkcije djece i adolescenata (Nyongesa, 2019). ROCF je takođe korišćen za procenu kognitivnih deficita kod poremećaja u ishrani (anoreksija nervoza i bulimija nervoza), kao što su poremećaji izvršnih funkcija, vizuelno-prostorne sposobnosti, učenja, pamćenja, jezika i pažnje. Poslednjih godina studije su pokazale da su one povezane sa slabom centralnom konzistentnosti. Hipoteza slabe centralne konzistentnosti je kognitivna teorija koja se odnosi na stil obrade koji se fokusira na detalje, a ne na sveukupno, što je uobičajeno kod pacijenata sa anoreksijom nervozom. Lang i saradnici su otkrili da se indeks centralne konzistentnosti zasnovan na Boothovom bodovanju može bolje koristiti za procjenu slabe centralne konzistencije poremećaja u ishrani (Lang et al., 2016). Međutim, previše pažnje se posvećuje iscrtavanju redoslijeda elemenata, ignorišući ukupnu figuru, a metoda bodovanja je previše komplikovana. U početku, Goder i saradnici su otkrili da su pacijenti sa šizofrenijom imali loš učinak na ROCF prisjećanju, što je u skladu sa gledištem o disfunkciji temporalnog režnja (Göder et al., 2004). Organizacioni deficiti su povezani sa deficitom vizuelne memorije kod šizofrenije. ROCF je takođe korišćen za mjerenje potencijala učenja kod šizofrenije, koji se definiše kao sposobnost sticanja kognitivnih vještina i njihovog korišćenja za rješavanje problema pod odgovarajućim okolnostima. Organizaciona strategija kopiranja ROCF-a može mu dati intenzivne smjernice (Nyongesa, 2019).

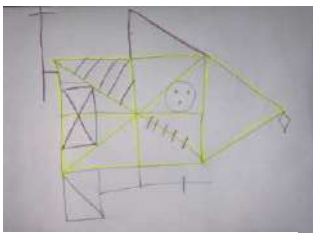
## REZULTATI I DISKUSIJA

### Prikaz slučaja - Primjena ROCH na zdravom ispitaniku

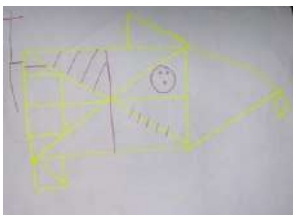
Isptanica LJ.M., 31 godina, iz Banja Luke, završila ekonomski fakultet, po zanimanju diplomirani ekonomista, stalno zaposlena. Udata, majka jednog djeteta, desnoruka. Ispitanica je u crtanju koristila strategiju započinjanja crtanja velikog pravouganonika i zatim dodavanja ostalih detalja, te spada u proceduralni tip 1 (Slike 1, 2 i 3). Skorovi koje je ispitanica postigla su 35 (copy), na ponovljenim crtanjima 25 i 26 (Tabela 1). Koeficijent koji iznosi -0,07 ukazuje da kod ispitanice nema odstupanja u pogledu vizuelnog pamćenja i da su sposobnosti planiranja, organizacije i sposobnosti pamćenja vizuelnih informacija adekvatne. Ovo potvrđuje koeficijent na ponovljenom crtanju koji iznosi 0,32.



Slika 2. Izgled ROCH-a kod ispitanice LJ.M. (kopiranje).
Figure 2. The appearance of ROCH in the subject LJ.M. (copying).



Slika 3. Izgled ROCH-a kod ispitanice LJ.M. (odloženo pamćenje).
Figure 3. Appearance of ROCH in the subject LJ.M. (delayed memory).



Slika 4. Izgled ROCH-a kod ispitanice LJ.M. (odloženo pamćenje poslije 45 minuta).
Figure 4. Appearance of ROCH in subject LJ.M. (delayed memory after 45 minutes).

Tabela 1. Ostvareni bodovi na ROCH kod ispitanice LJ.M. i ispitanice T.O.
Table 1. Scores obtained on the ROCH by the subject LJ.M. and respondents T.O.

| DETALJI | ISPITANICA LJ. M. | | | ISPITANICA T. O. | | |
|---|---|---|---|---|---|---|
| | Kopiranje | Odloženo | Odloženo (45 min) | Kopiranje | Odloženo | Odloženo (45 min) |
| 1.Krst u gornjem lijevom uglu | 2 | 1 | 2 | 1 | 1 | 1 |
| 2.Veliki pravougaonik | 2 | 2 | 2 | 1 | 1 | 0,5 |
| 3.Dijagonalni krst | 2 | 2 | 2 | 0,5 | 0 | 0 |
| 4. Horizontalna sredina pravougaonika | 2 | 2 | 2 | 2 | 1 | 0 |
| 5.Vertikalna srednja linija pravouganika | 2 | 2 | 2 | 1 | 0 | 0,5 |
| 6.Mali pravougaonik lijevo u velikom pravougaoniku | 2 | 2 | 1 | 0,5 | 0,5 | 0,5 |
| 7.Mali segment iznad malog pravougaonika 6 | 2 | 2 | 2 | 1 | 0,5 | 0 |
| 8.Četiri paralelne linije u velikom pravougaoniku | 2 | 1 | 2 | 2 | 0 | 0,5 |
| 9.Trougao iznad velikog pravougaonika | 2 | 2 | 2 | 0,5 | 0,5 | 0 |
| 10.Mala vertikalna linija u velikom pravougaoniku | 2 | 0 | 0 | 0,5 | 0 | 0 |
| 11.Krug sa tri tačke u velikom pravougaoniku 2 | 2 | 1 | 2 | 1 | 0,5 | 0,5 |
| 12. Pet paralelnih linija unutar pravougaonika 2 | 2 | 2 | 2 | 2 | 1 | 0,5 |
| 13.Strane trougla uz desnu ivicu velikog pravougaonika | 1 | 1 | 1 | 1 | 1 | 0,5 |
| 14.Romb postavljen nanize iz vrha trougla 13 | 2 | 2 | 2 | 0,5 | 1 | 1 |
| 15.Vertikalna linija u trouglu 13, paralelna sa desnom vetikalnom linijom | 2 | 0 | 0 | 1 | 0,5 | 1 |
| 16.Horizontalna linija u trouglu 13, koja se nastavlja na liniju 4, desno | 2 | 0 | 0 | 1 | 0,5 | 1 |
| 17.Krst nacrtan lijevo ispod velikog pravougaonika | 2 | 2 | 0 | 1 | 1 | 0 |
| 18. Kvadrat nacrtan lijevo ispod, priljubljen uz 2 | 2 | 1 | 2 | 0 | 0,5 | 0,5 |
| **MAKSIMUM: 36** | **35** | **25** | **26** | **15,5** | **10,5** | **8,0** |

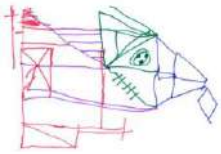
**Primjena ROCH na ispitaniku sa uspostavljenom dijagnozom autizma**

Autizam je doživotno neurorazvojno stanje koje karakterišu deficiti u društvenoj komunikaciji i interakciji, uz opsesivne/stereotipne obrasce ponašanja, interesovanja ili aktivnosti (American Psychiatric Association [APA], 2013). Pojedinci sa autizmom često manifestuju dokaze o karakterističnom atipičnom obrascu vizuelne percepcije i obrade vizuelnih informacija. U Kanerovoj originalnoj raspravi, on je opisao ovu osobinu kao „nemogućnost doživljavanja cjeline

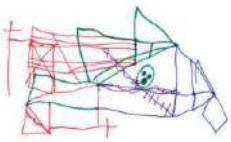
bez pune pažnje na sastavne dijelove“ (Kanner, 1943; prema Cardillo et al., 2022). Preferencija za lokalno orijentisanu obradu često je prijavljivana kao osnovna karakteristika pojedinaca sa autizmom, u skladu sa teorijom slabe centralne koherencije (Happe, & Frith, 2006; prema Cardillo et al., 2022) i modelom poboljšanog perceptualnog funkcionisanja (Mottron et al., 2006; prema Cardillo et al., 2022). Obe teorije pripisuju lokalni stil obrade pojedincima sa autizmom, ali se fokusiraju na različite osnovne razloge: globalni deficit obrade prema prethodnoj teoriji i poboljšanu sposobnost lokalne obrade prema ovom posljednjem (McKenzie et al., 2018; prema Cardillo et al., 2022). Osobe sa autizmom mogu imati pristrasnost da se u početku posvete lokalnom nivou stimulusa, ali su u stanju da obrađuju globalne informacije kada se od njih zatraži da prisustvuju globalnom nivou. Ovi nalazi podržavaju zaključke izvučene iz testova koji pokazuju da se prirodna lokalna pristrasnost obrade kod autizma može prevazići namjernom svjesnom mišlju (ili podsticanjem/ukazivanjem) kod nekih osoba sa autizmom (Cardillo et al., 2022).

Ispitanica T. O. rođena 1993. godine, lice je sa dijagnozom autizma (F 84.0). Živi u gradskoj sredini sa majkom, nema braću i sestre. Djelomično je verbalna, koristi jezik na neuobičajen način, tako da se svka riječ završava sa *ić*, prisutna eholalija i ponavljanje jedne riječi. Uspostavlja kontakt očima, ali je veoma kratkotrajan. Ima izažene stereotipije poput lupanja olovkom od sto, ubzano hodanje/trčanje, diranje kose. Ima adekvatno usvojene higijenske navike, samozbrinjavanje je zadovoljavajućeg nivoa. Upečatljiva je neadekvatna regulacija emocionalnog i bihevioralnog odgovora na frustraciju, često vrišti i baca predmete. Akademske vještine su djelomično razvijene, zna da čita, piše i crta, ali je neophodna motivacija i podsticaj za te aktivnosti. Svaki radni dan dolazi u Dnevni centar za autizam u Banja Luci, kako bi svoje vrijeme provela sa ostalim korisnicima i učestvovala u mnogobrojnim aktivnostima koje se svakodnevno provode.

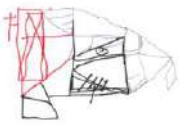
Ispitanica je, uz kontinuiranu motivaciju i podsticaj, uspjela da završi crtanje kompleksne figure u tri navrata. Kada je riječ o prvom crtanju (copy) ispitanica je u crtanju koristila 4 boje, započela je sa crvenom, zatim je koristila ljubičastu, zelenu i plavu. Na osnovu redoslijeda crtanja, može se zaključiti da ispitanica koristi strategiju crtanja bez organizovane strukture, te spada u proceduralni tip 4 (Slike 5, 6 i 7). Ukupan sirovi skor koji se ispitanica postigla na kopiranju komplekse figure iznosi 15,5, dok je na ponovljenim crtežima imala skor 10,5 i 8 (Tabela 1). Na osnovu izračunatog koeficijenta, ispitanica ima skor koji iznosi -13,07 koji ukazuje na težak pad sposobnosti planiranja i organizacije, kao i sposobnosti pamćenja relevantnih vizuelnih informacija.



Slika 5. Izgled ROCH-a kod ispitanice T.O. (copy).
Figure 5. Appearance of ROCH in subject T.O. (copy).



Slika 6. Izgled ROCH-a kod ispitanice T.O. (prisjećanje).
Figure 6. Appearance of ROCH in subject T.O. (remembering).



Slika 7. Izgled ROCH-a kod ispitanice T.O. (prisjećanje poslije 45 min).
Figure 7. Appearance of ROCH in subject T.O. (recall after 45 min).

## ZAKLJUČCI

ROCF je sveobuhvatan alat za neuropsihološku procjenu koji uključuje više kognitivnih domena i na njega manje utiču jezik i kultura. Trenutno su razvijene različite verzije i metode bodovanja, a istraživači mogu da biraju u skladu sa različitim kliničkim i istraživačkim svrhama. ROCF može proučavati kognitivne deficite kod pacijenata sa demencijom i drugim bolestima mozga i dalje istraživati razloge lošeg učinka u kopiranju i pamćenju. Posebno razvoj digitalnog testa složenih slika može kvantitativno da procjeni proces crtanja i dodatno razjasni strategiju crtanja pacijenta upoređivanjem putanje vrha olovke, prostornog rasporeda i sličnosti završenog crteža.

Ovaj rad predstavlja prikaz rezultata istraživanja primjene ROCH figure, te interpretaciju, analizu i poređenje performansi na ROCH testu kod zdrave ispitanice i ispitanice sa dijagnozom autizma. Zdrava ispitanica i ispitanica sa dijagnozom su približnih godina i uslova života, te istog pola. Ispitivanje ROCH testom je bilo daleko jednostavnije sa ispitanicom iz zdrave populacije, koja je sa potpunim razumijevanjem instrukcija obavila sve zadatke vezane za crtanje kompleksne figure. Ispitanica je u svom crtanju koristila strategiju crtanja koji polazi od globalnog dijela, konture pravouganoika, na koji je dodavala ostale detalje, što predstavlja proceduralni tip crtanja karakterističan za redovnu populaciju. Skorovi koje je postigla su u skladu sa očekivanjima, obzirom da je ispitanica visokoobrazovana, te dolazi iz urbane sredine. U interpretaciji rezultata njenog testiranja nema odstupanja. Kod ispitanice sa autizmom, bilo je potrebno mnogo više iskustva, energije i upornosti kako bi se ispitivanje obavilo do kraja. Kao što je i očekivano, ispitanica sa dijagnozom postigla je niže skorove na svim kriterijumima ispitivanja. Njen koeficijent ukazuje na težak pad sposobnosti vizuelnog pamćenja, što potvrđuje rezultate prethodnih istraživanja (McKenzie et al., 2018). Na osnovu prethodnog iskustva u radu sa ispitanicom, primjećen je specifičan stil crtanja koji se odlikuje brzim potezima olovkom i često duplim ili slojevitim linijama i konturama crteža. Ovaj stil crtanja se dosljedno može primjetiti u sva tri crteža na ROCH testu. Takođe se kod ispitanice primjećuje i lokalna pristrasnost obradi određenih dijelova figure, što je u skladu sa prethodnim istraživanjima (Cardillo et al., 2022). Naime, u toku crtanja prvo se fokusirala na jedan dio, te zatim uz podsticaj i motivaciju je prelazila na drugi, te je crtež završen bez organizovane strukture.

Značaj ovog rada ogleda se u tome da je još jednom potvrđena široka upotrebljivost ROCH testa crtanja kompleksne figure. U ovom radu prikazani su po jedan slučaj iz redovne, zdrave populacije i populacije sa dijagnozom, u ovom slučaju iz autističnog spektra. Naredna istraživanja na ovu temu bi trebala uzeti u obzir veći broj ispitanika, kao i obuhvatiti širi spektar psihopatologije, kako bi se dobio veći uvid u specifičnosti koje ROCH test crtanja kompleksne figure može da ustanovi.

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# REY–OSTERRIETH COMPLEX FIGURE TEST (ROCF): COMPARATIVE ANALYSIS OF APPLICATION ON RESPONDENT WITH AND WITHOUT A DIAGNOSIS

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**ABSTRACT**

Rey–Osterrieth complex figure test (ROCF) is used for research purposes to examine the development of visuo-perceptual organization, visual short-term and long-term memory, as well as executive functions. The aim of this paper is to present the results of research on the application of the ROCF test, and to interpret and compare two cases of application of the ROCF: on subjects from a healthy and psychopathological population. Respondents were selected to be of the same age and gender. From the psychopathological population, a subject with a diagnosis of autistic spectrum was selected. The results confirmed the results of previous research. The healthy subject used a drawing strategy characteristic of people without neuropsychological difficulties, there were no deviations in drawing and sketching. The subject with autism, although functional, on the ROCF test had a severe decline in the ability to plan and organize, as well as the ability to remember relevant visual information, with the use of an inferior drawing strategy.

**Keywords:** Ray-Osterit complex figure test, research, autism.

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# KOGNITIVNO-BIHEJVIORALNI TRETMAN SOCIJALNE ANKSIOZNOSTI: STUDIJA SLUČAJA

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## SAŽETAK

Kognitivno-bihejvioralna teorija tvrdi da pojedinac određenim dijelom stvori socijalnu anksioznost tako što preuveliča posljedice svog neuspjeha I javnog nastupa pred publikom. Socijalna anksioznost ili strah od javnog nastupa jedan je oblik tjeskobe i označava normalnu reakciju, stanje budnosti i stimulaciju svjesnosti na opasnost. Ova reakcija na opasnost može izazvati budnost, borbenost, povlačenje ili bijeg, što jednim dijelom pomaže pri prevladavanju poteškoća, međutim drugim dijelom može biti izuzetno neugodno stanje. S tim u vezi, od najveće koristi jeste promijeniti percepciju I stav prema socijalnoj anksioznosti.

U ovom radu prikazana je kognitivno-bihejvioralna terapija u tretmanu socijalne anksioznosti kod 19-godišnje djevojke. Tretman je trajao mjesec I po, tačnije sprovedeno je pet seansi. Terapija se sastojala od sljedećih kognitivno-bihejvioralnih tehnika: ublažavanja straha od javnog nastupa kroz promjenu percepcije I psihoedukaciju, vježbanje vještine vođenja prezentacije, prebacivanje fokusa I slično. Značajno je napomenuti da se radi o klijentici sa izuzetno razvijenim ličnim kapacitetima I resursima, stoga je tretman relativno brzo završen, a postavljeni početni ciljevi ispunjeni.

Procjena efekta sprovedenog kognitivno-bihejvioralnog tretmana rađena je na osnovu kliničke evaluacije, subjektivnog izvještavanja klijentice kao i standardnim upitnicima za psihološku procjenu. U ovom radu primjenjivali su se sledeći upitnici: AAQII, SGSE, CORE, YSQ I SCL-90. Na svim upitnicima ostvaren je izuzetan napredak, ali isti navodi I sama klijentica.

**Ključne riječi**: kognitivno-bihejvioralna psihoterapija (KBT), socijalna anksioznost, javni nastup studija slučaja.

## UVOD

Socijalni anksiozni poremećaj je pretjerani strah koji osoba doživljava u različitim socijalnim situacijama u kojima postoji mogućnost procjenjivanja od strane drugih ljudi (Leahy, Holland i McGinn, 2014; prema Živčić-Bećirević i Jakovčić, 2015). Ovo je jedan od najčešćih anksioznih poremećaja i četvrti najčešći psihijatrijski poremećaj, sa životnom prevalencijom u rasponu od 3 % do 13 %. Problem se javlja u različitim socijalnim interakcijama, kao što je upoznavanje novih ljudi, situacijama javnog izlaganja pred drugim ljudima (držanje seminara, pjevanje,..) te izražavanja neslaganja s drugima i obraćanje autoritetu (Živčić-Bećirević i Jakovčić, 2015). Emocionalni i bihejvioralni spektar simptoma uključuje perzistirajući strah od situacija u kojima osoba može biti osuđivana, osramoćena, intenzivan strah od razgovora s nepoznatim ljudima, strah od pojave tjelesnih simptoma, kao što je crvenilo, znojenje, drhtavica I drhtanje glasa, nedostatak vazduha.

Socijalna anksioznost je anksiozni poremećaj koji posebno zahvata adolescentsku i studentsku populaciju. Prisutnost socijalne anksioznosti rizičan je faktor za kasniji razvoj depresivnog poremećaja i povećane sklonosti ka zavisnostima (Cole, Peeke, Martin, Truglio i Seroczynski, 1998; prema Zetović, 2020). Dell'Osso, Abelli, Pini i sar. (2014; prema Grgić, 2017) dolaze do rezultata da čak 28,6 % studenata postiže visok rezultat na ljestvici socijalne anksioznosti. Iako je javni nastup uobičajena akademska aktivnost, socijalna anksioznost se kod studenata najčešće manifestuje upravo u obliku straha od javnog izlaganja koji pretežno umanjuje njihova akademska postignuća. Sve to može dovesti do izbjegavajućih ponašanja, koja imaju ulogu u održavanju ovog poremećaja, što dugoročno ima negativne učinke. Vrlo je vjerovatno da će se

kod ovakvih osoba razvijati I pojačati osjećaj neadekvatnosti I nekompetentnosti. Rizični činioci za nastanak socijalne fobije su psihijatrijski poremećaji roditelja, pretjerivanje u zaštićivanju ili odbacivanju od strane roditelja, nepostojanje bliskog odnosa s odraslom osobom tokom djetinjstva, zlostavljanje u djetinjstvu I slično. Perfekcionistička uvjerenja mogu biti značajan faktor u održavanju anksioznosti i razvoju depresije, a posebno se povezuje sa socijalnom fobijom gdje se pokazalo kako pojačava pojavu ruminacije negativnih socijalnih interakcija ili negativnu interpretaciju pozitivnih interakcija (Kalazić, 2018).

Brojna istraživanja potvrđuju učinkovitost kognitivno-bihejvioralne terapije u tretmanu socijalne fobije. Empirijski potvrđeni tretmani za socijalnu fobiju uključuju kognitivne strategije, trening socijalnih vještina, tehnike opuštanja, te strategije izlaganja. Kognitivna terapija usmjerava se na problematične načine razmišljanja te propituje takve obrasce naučenog razmišljanja. To uključuje rad na negativnim mislima i vjerovanjima o sebi i drugima, koja stoje u njihovoj podlozi. Izlaganje uključuje postepeno uključivanje u situacije koje osobi izazivaju strah, radi navikavanja tj. da bi se umanjila nelagoda izazvana objektom straha.

## METODOLOŠKI OKVIR ISTRAŽIVANJA

### Ciljevi i plan tretmana

Socijalna anksioznost/strah od javnog nastupa

(Cilj: normalizacija i validacija postojećih osjećanja; psihoedukacija o emocijama i reakciji organizma na osnovu onoga što nam je važno; fiziološka edukacija; učenje vještine vođenja prezentacije; stavljanje fokusa na nju u toku prezentacije, a ne na publiku i druge ljude.)

Strah od nepoznatih događaja/ situacija.

(Cilj: osmišljavanje posvećenih akcija.)

### Plan tretmana

Neophodna je psihoedukacija o fiziološkoj reakciji organizma u toku javnog nastupa, a potom vježbanje vještine vođenja prezentacije kroz osmišljavanje akcija koja su u skladu sa klijenticinim vrijednostima. Pored toga, bitno je stavljanje fokusa na ono što je zaista važno u toku prezentacije, a ne na publiku. Svakako je bitno proći kroz normalizaciju I validaciju klijenticinih emocija I ponašanja kada je riječ o javnom nastupu, ali I o nepoznatim događajima/situacijama. Bitno je stalno vraćanje I podsjećanje na vrijednosti. Na kraju, važno je osvijestiti klijentici da veliki dio stvari već uspješno obavlja uprkos neprijatnim osjećanjima kroz koja prolazi prilikom obavljanja istih.

### Radne hipoteze

- Raditi na ublažavanju straha od javnog nastupa kroz promjenu percepcije i psihoedukaciju.
- Raditi na vještini vođenja prezentacije i izlaganja.
- Osmišljavanje konkretnih akcija koje bi uticale na poboljšanje vještine vođenja prezentacije.
- Raditi na stavljaju fokusa na sebe i vođenje prezentacije, umjesto na publiku.
- Raditi na usklađivanju ponašanja sa vrijednostima.
- Raditi na osvještavanju već postojećeg ponašanja u skladu sa vrijednostima.

### Uzorak istraživanja

Klijentica S. E., žensko, ima 19 godina, neudata, rođena u Kaknju, trenutno živi u Sarajevu zbog studija. Student je prve godine Medicinskog fakulteta, odsjek farmacija. Oduvijek je bila odličan učenik. Ima stariju sestru (5 godina), a ovu relaciju opisuje kao korektnu i zadovoljavajuću. Živi u potpunoj porodici, gdje su odnosi između članova funkcionalni. Uočavaju se dobri porodični resursi. Majka predstavlja autoritet u porodici, ali istovremeno pruža veliku podršku, empatiju i ljubav. Otac najveći dio vremena provodi na poslu, stoga su klijentica i sestra više privržene majci, te sa njoj o svemu razgovaraju. Odnos majke i oca je solidan, sa povremenim konfliktima oko uobičajnih životnih događaja.

Prijateljski odnosi odlični, ima dosta poznanstava, koja lako sklapa, a što se tiče pravog prijateljstva onako kako ga ona definiše, postoje tri osobe, ti odnosi traju od djetinjstva i vrlo je ponosna na njih.

U stabilnoj je emotivnoj vezi oko 3 godine, a taj odnos se sa vremenom izgrađivao. Postojao je problem oko komunikacije, gdje klijentica nije znala da na adekvatan način ispolji svoje potrebe i osjećanja, stoga je posjećivala psihologa i radila na asertivnoj komunikaciji.

Na osnovu prvog susreta, može se zaključiti da je riječ o osobi koja je vrlo ekstravertna, prijatna, kulturna, komunikativna, vrijedna i otvorena ka iskustvu. Pored toga što je vrlo mlada, ima veliki broj hobija i čini se kao vrlo zanimljiva osoba, puna entuzijazma. Vrlo svjesna svojih pozitivnih strana, ali isto tako i onih na kojima bi se trebalo raditi.

Pored uzetih anamnestičkih podataka, provjeravaju se i očekivanja od terapije.

**Glavne tegobe na koje se žali**

Glavni razlog javljanja klijentice na terapiju jeste strah od javnog nastupa, odnosno prezentovanja određenih radova u školi I na fakultetu. Kasnije u radu, navodi I strah od vožnje, koji je doveden u vezu sa primarnim strahom.

**Istorija sadašnjih tegoba**

S.E. je osoba koja je vremenom, zbog svog perfekcionizma, razvila strah od javnog nastupa. Simptomi, poput straha, stida tuge, lupanja srca i pritiska u grudima, javljaju se svaki put prilikom izlaganja prezentacije i “procjenjivanjem” od strane autoriteta. Uprkos ovim neprijatnim osjećanjima, klijentica ipak završava svoje prezentacije do kraja, te uzima nove i iznova ih izlaže. Slični simptomi pojavljuju se i prilikom nepoznatih stvari (npr. vožnja autom po nepoznatom terenu ili putevima). Bitno je napomenuti da ovakav način funkcionisanja ne čini klijenticu pasivnom, te uprkos tome ona postupa u skladu sa svojim vrijednostima.

Psihijatrijska istorija

Kod klijentice nije zabilježena istorija psihijatrijskih poremećaja, kao ni u anamnezi kompletne porodice.

Istorija ličnog i socijalnog funkcionisanja

S.E.je ekstravertna, komunikativna i osoba sa širokim interesovanjima. Većinu vremena provodi sa prijateljima, partnerom i porodicom. Pored toga, redovno izvršava svoje akademske obaveze i tome posvećuje dosta vremena. Na kraju, dosta pažnje poklanja i svojim hobijima u kojima uživa.

U anamnezi nije vidljiva disfunkcionalnost porodičnih odnosa. Podrška i ljubav je postojala sa obe strane. Ovaj bazični odnos napravio je dobru podlogu za buduće klijenticino funkcionisanje, što se uočava u svim sferama njenog života.

Nije sklona konzumiranju psihoaktivnih supstanci. Iz navedenog može se zaključiti da S.E. posjeduje stabilne porodične, lične i socijalne resurse.

Medicinska istorija

S.E. nema nikakvih medicinskih problema koji bi mogli uticati na njeno psihološko stanje.

Mentalni status

Klijentica uredne spoljašnjosti, visoka, normalne građe. Riječ je o vrlo elokventnoj i inteligentnoj osobi. Odlikuju je optimizam, srdačnost, otvorenost i kultura. Nije vidljivo sniženo raspoloženje, upravo suprotno. U kontaktu postoji vidljivo povjerenje, gdje se jasno vidi želja za usvajanjem novih znanja i vještina, radi napredovanja ličnih kapaciteta i rješavanja određenih psiholoških poteškoća. Detaljna i konkretna u iznošenju problema i ciljeva rada.

Precipitatori

Bitno je napomenuti da je klijentica došla na psihoterapiju jer je prepoznala važnost iste, te istakla da uvijek može na nečemu da se radi. Samim tim je pokazala izrazitu psihološku zrelost, stabilnost, snažne lične kapacitete i resurse te otvorenost ka novim znanjima. Najznačajniji precipitator navedenog problema jeste priredba koja se desila u trećem razredu osnovne škole. Tada je klijentica svirala klavir, te mnogo griješila, što se njoj u tom momentu činilo "užasno", htjela je da "propadne u zemlju". Moguće da je taj događaj ostavio značajan utisak na klijenticu, jer je do tada uvijek bila "perfektna". Iz tog razloga, navedeni događaj se može povezati sa sadašnjom problematikom. Simptomi su identični sa onim koji su danas u takvim situacijama prisutni.

Sadašnji aktivirajući događaji

Sadašnji aktivirajući događaji jesu javni nastupi, prezentacije radova, nepoznate situacije. Dakle, događaji u kojima se vrši procjena od strane autoriteta. To u klijentici izaziva emocije poput straha, stida, ljutnje i tuge, pri čemu se od kognicija pojavljuju sledeće: "Ovo se dešava samo meni", "Sramota me", "Želim da pobjegnem", "Zašto sam morala ovo da prihvatim", "Šta će drugi misliti o meni" i slično. Važno je napomenuti kako klijentica ipak postupa u skladu sa svojim vrijednostima i ne izbjegava ovakve situacije.

Bazične iracionalne filozofije ili kognitivne šeme

U osnovi klijenticine iracionalne filozofije postoji uvjerenje da sve što radi mora biti savršeno. Moglo bi se reći da taj obrazac proističe iz djetinjstva kada ju je majka pretjerano hvalila za sve što uradi, što je ostala praksa sve do danas, npr. kada bi S.E. skuvala nešto majka bi rekla kako je savršeno, prelijepo, kako ništa ljepše nije jela, da samo ona zna to tako napraviti i slično. Takve I slične pohvale bi koristila u svemu što bi klijentica uradila. Sada, klijentica navodi kako drugi ljudi tako ne reaguju na njena ponašanja (npr. kažu da je lijepo, ukusno, dobro), što za S.E. nije zadovoljavajuće i onda smatra da nešto ne radi kako treba. Upravo iz te sklonosti perfekcionizmu pojavio se strah prilikom procjenjivanja od strane drugih ljudi, jer želi sve da ih "zadivi".

Snage

Klijentica je izuzetno motivisana i zainteresovana za rad, te otvorena ka novim iskustvima. Zadaću radila redovno i detaljno. Isto tako, u svakodnevnim aktivnostima, primjenjivala je sadržaj sa terapije. Rad sa ovakvim profilom osobe je proticao veoma jednostavno i na obostrano zadovoljstvo.

Mjerni instrumenti

U ovom radu korišteni su sljedeći mjerni instrumenti: AAQII, SGSE, CORE, YSQ I SCL-90.

**Postupak istraživanja**

Tehnike/procedure

Tehnike koje su se koristile u radu jesu sledeće: psihoedukacija o fiziološkim procesima u organizmu tokom javnog nastupa, vježbanje vještine vođenja prezentacije, osmišljavanje akcije u skladu sa ciljem I vrijednostima, domaće zadaće, ACT matrica, tehnike defuziranja, mindfulness, dijeljenje ličnih iskustava I različite vrste metafora. Pored toga, vrlo često je bila neophodna normalizacija I validacija klijenticinih osjećanja I ponašanja.

**TOK TRETMANA**

**Prva seansa (13.12.2022.)**

Na prvoj odnosno inicijalnoj seansi sa klijenticom S.E. smo prošle proces upoznavanja I upoznata je sa načinom rada savjetovališta. Nakon što je pristala na snimanje našeg razgovora, krenule smo sa radom.

Klijentica S.E. ima 19 godina, rođena je u Kaknju, trenutno živi u Sarajevu zbog studija. Student je prve godine Medicinskog fakulteta, odsjek farmacija. Obrazovanje joj je jača strana,

uvijek je bila odličan učenik. Navodi da je tačno znala svoj cilj te da ima dobre organizacijske sposobnosti. Najbolje funkcioniše kada ima dosta obaveza. Pored fakulteta voli da ima još neka zanimanja i hobije. Uživa u kuhanju, ide na slovenački jezik, slaže puzzle, voli da čita knjige, gleda filmove i druži se sa prijateljima. Na balkonu uvijek voli da nešto uređuje, sadi biljke i slično.

Porodične odnose opisuje kao vrlo stabilne i podržavajuće. Odrasla je u potpunoj porodici, sa starijom sestrom (5 godina). Majku navodi kao autoritet, ali isto tako je predstavlja i kao drugaricu, jer joj govori sve tajne. Majku, sestru i sebe čak opisuje kao tri sestre. Otac nije toliko uključen u njihov život, ali ne navodi konkretnu problematiku. Ističe kako je odnos majke i oca čudan, nekad se vole najviše na svijetu, a nekad se svađaju, jer mama „drami oko svega“. Može se zaključiti da su porodični odnosi prilično funkcionalni.

Ima dosta prijatelja na fakultetu i vrlo je ekstravertna. Pored njih, ima i 3 najbolje drugarice, koje predstavlja kao prave prijatelje. U emotivnom odnosu je već 3 godine i tvrdi kako je sad taj odnos doveden do savršenstva. Postojao je prekid u određenom periodu, nakon čega je klijentica imala dva susreta sa psihologom. Razlog raskida je bio to što klijentica nije iskazivala svoja osjećanja, želje i potrebe da bi kada joj se „skupi“ sve postupala prema partneru neprikladno. Govorila mu je ružne riječi i bila prilično drska, što je njega dosta vrijeđalo. Taj problem je riješen uz pomoć asertivne komunikacije, te sada o svemu otvoreno razgovaraju i vrlo su povezani i bliski.

Razlog javljanja u savjetovalište opisuje kao odličnu priliku da radi na sebi, jer je psihoterapija obično skupa, a uvijek ima nešto gdje bi mogla da se poboljša i napreduje. Trenutni problem jeste trema pred javni nastup. Sa klijenticom sam prošla kroz ACT matricu. Poslednji događaj bio je prezentacija iz hemije. Od emocija su bile prisutne: strah, stid, ljutnja, tuga. Misli su sledeće: „Ovo se dešava samo meni“, „Sramota me“, „Želim da pobjegnem“, „Zašto sam morala ovo da prihvatim“, „Šta će drugi ljudi misliti o meni“ i slično. Od senzacija prisutno podrhtavanje glasa, lupanje srca, pritisak u grudima, kao da joj je neko stavio određeni teret. Slično sjećanje u prošlosti vezano za ovaj događaj postoji. Naime, riječ je o priredbi na kojoj je svirala klavir (treći razred osnovne škole). Bilo je potrebno da se odsvira napamet, bez nota, a klijentica nije nikako voljela klavir, nikad nije vježbala sama, jedino na časovima. Mnogo je griješila, pa nastavljala i tako u krug, a tu je bilo dosta poznatih ljudi i smatra da se obrukala i osjećala je strašan stid. Od tada i počinje da se javlja trema od javnog nastupa. Roditelji su joj pružili podršku u tom momentu, nisu je osuđivali. Iako nije voljela svirati klavir, bilo je strah reći majci da više ne želi, jer su časovi dosta skupi.

Iako su subjektivno prisutni ovi simptomi, klijentica svaki nastup dovede do kraja, a do sada joj niko i nije rekao da se vidjelo kako je „umirala od treme“. Kada bi se riješila straha, S.E. smatra da bi njene prezentacije bile dosta kvalitetnije, ubacila bi stvari koje bi zainteresovale publiku, dala bi svoj maksimum, govorila bi tečno, djelovala samouvjereno i slično. Sve to joj je vrlo važno zbog drugih ljudi, kako ne bi stekli utisak da je slaba. Kao primjere navodi i to da bi dosta stvari uradila kada ne bi postojalo mišljenje sredine: ofarbala kosu u neku ludu boju, obukla nešto drugačije, možda napravila i neki drugi izbor fakulteta, iako joj niko od porodice nije nametao taj izbor.

Na osnovu klijenticinog izlaganja, urađena je normalizacija i validacija te psihoedukacija o emocijama, o tome kako je prirodna reakcija organizma da reaguje u skladu sa situacijom i na osnovu toga koliko nam je nešto važno. Osviješteno je da ona ipak završi do kraja svaki nastup pred publikom, uprkos njenom subjektivnom doživljaju. Seansa je završena sa izuzetnom srećom klijentice, djelovalo je kao da joj je trebala validacija da je sa njom i njenim emocijama sve u redu.

Može se zaključiti da je riječ o izuzetno inteligentnoj, prijatnoj i ekstravertnoj osobi. Iako je vrlo mlada, njena otvorenost ka iskustvu i usavršavanju je fascinantna. Lični resursi na vrlo zavidnom nivou.

**Druga seansa (21.12.2022.)**

Na današnjoj seansi, izvršena je psihoedukacija sa klijenticom. Prije svega, fiziološka edukacija, gdje je klijentici objašnjeno da dio sa senzacijama, emocijama i mislima nije pod uticajem naše voljne kontrole, već je pod uticajem autonomnog nervnog sistema. Svako procjenjivanje od strane drugih osoba u nama budi nelagodu. Ono nad čim imamo uticaj jeste pravljenje pauza u toku prezentovanje, udahnuti vazduh, popiti vodu, ispričati primjer, pitati publiku da li im je do sad ispričano jasno i slično.

Drugi dio edukacije se odnosi na vještinu držanja prezentacije, nad kojim imamo kontrolu. Preduslov za vježbanje ove vještine jeste prihvatanje prvog dijela. Potom je bitno staviti fokus na prezentaciju, a ne na to kako nas doživljavaju drugi ljudi i da li smo „dobri“ prema njihovim kriterijumima. Urađena je vježba pune svjesnosti kako bi klijentica zamislila sledeću prvu situaciju prezentovanja, gdje bi doživjela sva ta osjećanja, senzacije, misli, a i dalje ostajala u toj situaciji.

Identifikovale smo i konkretna ponašanja koja bi klijentica radila, a to su: vježbe pune svjesnosti, pripremanje dosta primjera iz stvarnog života kako bi prezentacija bila kvalitetnija (to će pomoći klijentici da bude i opuštenija), razgovor sa publikom (da li vam je ovo bilo jasno, ima li neko svoj primjer; to sve će pomoći klijentici da udahne vazduh i napravi pauzu kako bi joj bilo lakše nastaviti), izlaganje pred poznatom osobom par dana prije prezentacije. Ovo sve je klijentica dobila i za zadaću.

Bitno je napomenuti da je klijentica pokazala veliko olakšanje i oduševljenje nakon ove seanse, jer je dobila nove uvide.

**Treća seansa (10.01.2023.)**

Nakon pauze od dvije sedmice, zbog praznika, na današnjoj seansi provjerila sam sa klijenticom kako je prošlo izlaganje prezentacije koje je imala protekle sedmice. Prezentacija je bila preko zooma, te klijentica tvrdi kako je to bila olakšavajuća okolnost, ali da joj je svakako mnogo lakše nakon psihoedukacije. Takođe, navodi da je vježbala ponašanja koja smo identifikovale prošli put, a koja su u skladu sa postavljenim ciljem. Ističe kako bi joj pomogle i vježbe pune svjesnosti, te sam joj poslala mejlom snimljenu vježbu o mislima bez napora i vježbu za disanje. Te iste vježbe, dobila je i kao zadaću.

**Četvrta seansa (16.01.2023.)**

Na početku seanse, provjeravam zadaću. Naime, klijentici su poslane vježbe pune svjesnosti i navodi kako su joj iste veoma prijale, te da je uvidjela koliko u danu uopšte ne udahne duboko, niti se opusti, kao u ovim vježbama.

Razgovarale smo o novoj situaciju vezanoj za strah od vožnje, kao i za strah od određenih sportova (klizanje). Prosla sam sa klijenticom ACT matricu, gdje je ustanovljeno da navodi identične misli, emocije, senzacije, porive i sjećanja, kao i za strah od javnog nastupa, što sam dovela u vezu i objasnila klijentici. Čak ovdje takođe navodi da joj je sve to važno zbog toga da bi se svidjela drugima, što je identična vrijednost kao i kod straha od javnog nastupa. Navodi kako ju je majka uvijek mnogo hvalila sta god da uradi, a u realnom životu pomisli da nešto ne radi kako treba kada je ostali ljudi ne pohvale onako kako ona misli da treba (kako je to majka radila, sa puno entuzijazma i ljubavi).

Prošle smo normalizaciju i validaciju klijenticinih osjećanja, a potom i psihoedukaciju, prvo o navedenim strahovima, a potom i o tome da različiti ljudi različito reaguju i pokazuju emocije, što ne govori o tome da S.E. radi nešto pogrešno, već da je to samo naučena reakcija tih ljudi.

Na kraju, S.E. ističe kako je oduševljena psihoterapijom i našim načinom rada, te da su joj tehnike i psihoedukacije mnogo pomogle, a uvidjela je i sopstvene resurse, na koje prije nije uopšte obraćala pažnju ili ih je podrazumijevala.

Zajedno smo došle do zaključka kako bi bilo dobro da imamo još jednu seansu kako bi analizirale sve do sada postignuto, eventualno bi klijentica razmislila o čemu bi još željela da razgovara.

**Peta seansa (26.01.2023.)**

Provjerila sam sa klijenticom da li je razmislila o čemu bi eventualno danas razgovarala, jer je imala potrebu da u narednih par dana ipak razmisli postoji li još neka situacija koju bi željala da podijeli. Međutim, za sad tvrdi da ne postoji.

Uradile smo kratak sažetak i analizu dosadašnjeg rada, te sam pitala klijenticu za eventualne nejasnoće, ali nije ih bilo. Oduševljena je ovakvim načinom rada, puno novih stvari je naučila i smatra da je psihoterapijom čak dobila puno više nego što je očekivala. Najviše su joj pomogle vježbe pune svjesnosti koje je redovno primjenjivala i vježba pred drugim osobama kada je riječ o vještini vođenja prezentacije. Dobila je uvid koliko joj je fokus bio na pogrešnim stvarima, umjesto na njoj i prezentaciji, a o tome nikada ranije nije razmišljala. Pored ovih uvida, osvijestila je jake lične, porodične, prijateljske i partnerske kapacitete. Sagledala je na drugi način i sebe, postala je svjesna koliko ona ipak obavlja stvari uprkos tome što su joj neprijatne i što osjeća strah.

Što se tiče straha od nepoznatih događaja/situacija, shvatila je da neke i nisu u skladu sa njenim vrijednostima, te joj samim tim nisu toliko važne, jer joj ne ometaju svakodnevnu rutinu i aktivnosti (parkiranje bočno, klizanje sa drugaricama koje to znaju i slično). Fokusirala se na sebe i ono što je njoj važno, te shvatila da ne mora, a sada i neće da se „svidi“ svima i bude „po svačijoj mjeri“.

Nakon svake seanse bude puna energije, nasmijana, odmorna i opuštena. Kritike na dosadašnji rad nema. Dogovoreno je da se ponovo javi na terapiju ukoliko smatra da postoji potreba.

**Terapijski odnos.**

Terapijski odnos je bio otvoren, podržavajući i pun povjerenja. Klijentica je vrlo motivisana za rad i redovno je radila zadaću. Na svaku seansu je gledala kao na priliku da nauči nešto novo.

Trajanje tretmana

Tretman je trajao mjesec i po, tačnije u periodu od 13.12.2022. do 26.01.2023. godine. Seanse su se održavale na sedmičnom nivou, sa pauzom od 15 dana zbog praznika i odsustva klijentice i mene. Uspostavljen je dogovor da se javlja po potrebi.

Prepreke/otpori

Nisu identifikovane nikakve prepreke ni otpori u radu. Seanse su se odvijale u kontinuitetu. Zadaće su izvršavane na vrijeme, vrlo savjesno i detaljno. Dogovori sa klijenticom tekli su vrlo jednostavno.

Prednosti

Može se zaključiti da rad sa ovakvom klijenticom ima mnogo prednosti. Riječ je o osobi koja je prethodno radila na svojim vještinama i slabijim stranama, te ima jasne uvide. Odlikuje je konkretnost, detaljnost, iznadprosječna inteligencija, odlučnost, posvećenost sopstvenim vrijednostima, te još mnogo drugih vrlina koje su se uočavale u radu.

## ANALIZA I INTERPRETACIJA REZULTATA

### Evaluacija tretmana

Prema dobijenim rezultatima, na osnovu evaluacije tretmana, kao i na osnovu promjena na bihejvioralnom nivou može se zaključiti da je klijentica ostvarila postavljene ciljeve. Klijentica obavještava o subjektivnom poboljšanju, te navodi bolje uvide i razumijevanje sopstvenih emocija te osvještavanje već postojećih resursa. Takođe, na svim testovima klijentica pokazuje napredak, iako je bitno napomenuti da su prisutne poteškoće zaista bile minimalne.

Rezultati testove koje je klijentica popunila prije prvog susreta su:

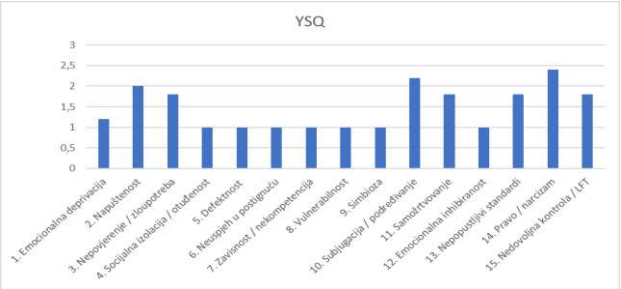
AAQII upitnik – 26
SGSE upitnik – 26

Tabela 1. Prikaz inicijalnih rezultata na upitniku CORE.
Table 1. Presentation of the initial results on the CORE questionnaire.

| | |
|---|---|
| CORE F | 24 |
| CORE P | 2 |
| CORE W | 9 |
| CORE R | 0 |
| CORE | 35 |
| CORE - R | 35 |

Tabela 2. Prikaz inicijalnih rezultata na upitniku YSQ.
Table 2. Presentation of initial results on the YSQ questionnaire.

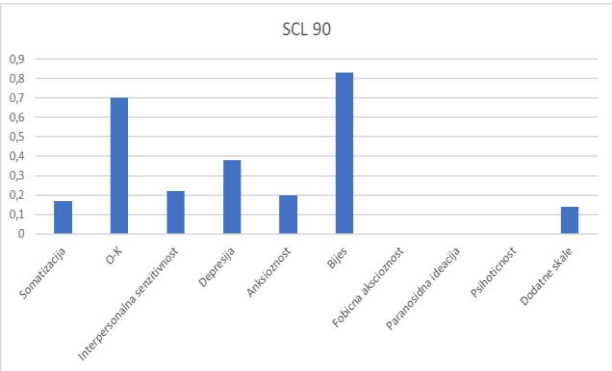
| | e.d. | nap | nep | izol | def | usp | nes | vul | Vez | Pok | žrt | e.in | sta | nar | kon |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| inicijalno | 1.2 | 2 | 1.8 | 1 | 1 | 1 | 1 | 1 | 1 | 2.2 | 1.8 | 1 | 1.8 | 2.4 | 1.8 |




Grafikon 1. Prikaz inicijalnih rezultata na upitniku YSQ.
Chart 1. Presentation of initial results on the YSQ questionnaire.

Tabela 3. Prikaz inicijalnih rezultata na upitniku SCL-90.
Table 3. Presentation of initial results on the SCL-90 questionnaire.

| | som | o - k | s. sen. | depr | Anks | host. | fob. | par. | sih. | dod. s. |
|---|---|---|---|---|---|---|---|---|---|---|
| inicijalno | 0.17 | 0.7 | 0.22 | 0.38 | 0.2 | 0.83 | 0.00 | 0.00 | 0.00 | 0.14 |




Grafikon 2. Prikaz inicijalnih rezultata na upitniku SCL-90.
Chart 2. Presentation of the initial results on the SCL-90 questionnaire.

**Rezultati testova na završnom testiranju:**

Upitnik prihvatanja I akcije – AAQII

Na ulaznom testiranju klijentica na ovom upitniku ostvaruje skor 26, a maksimalno je 49. Što je veći rezultat na ovom testu, veća je i psihološka nefleksibilnost klijenta. Nakon sprovedenom psihološkog tretmana, sada skor iznosi 13, što govori da je došlo do znatnog poboljšanja u psihološkoj fleksibilnosti.

AAQII upitnik – 13 (završno)

Skala opšte samoefikasnosti – SGSE

Ovaj upitnik ukazuje na samoefikasnost klijenta, što su viši skorovi, veći je osjećaj samoefikasnosti. Kod klijentice S.E. inicijalni skor iznosi 26, dok se završni u određenoj mjeri povećao I iznosi 32. To govori u prilog poboljšanju ličnog osjećaja samoefikasnosti kod klijentice.

SGSE upitnik – 32 (završno)

Upitnik za ispitivanje opštih psihopatoloških teškoća - CORE

Ovaj upitnik sadrži 34 čestice koje su podjeljene u četiri dimenzije: subjektivna dobrobit, problemi/simptomi, svakodnevno funkcionisanje I rizična ponašanja. Osim subjektivne dobrobiti, unutar svake dimenzije postoje klasteri čestica. Dimenzija problemi/simptomi obuhvata: depresivnost, anksioznost, tjelesne probleme I traumatizaciju. Dimenzija svakodnevnog funkcionisanja obuhvata tri klastera: opšte funkcionisanje, socijalno funkcionisanje I bliskost. Na kraju, dimenzija rizičnih ponašanja obuhvata: ponašanja rizična za pojedinca I druge.

Inicijalnim testiranjem klijentica na dimenziji subjektivna dobrobit ostvaruje skor 24, dok se završnim testiranjem pokazuje napredak sa skorom 28. Na dimenziji problemi/simptomi ne postoji promjena na oba testiranja, a I sami skorovi su zanemarivi. Socijalno funkcionisanje inicijalnim testiranjem iznosilo je 9, a završnim 10. Dimenzija rizičnih ponašanja nije bila prisutna ni na inicijalnom ni na završnom testiranju.

Tabela 4. Prikaz završnih rezultata na upitniku CORE.
Table 4. Presentation of the final results on the CORE questionnaire.

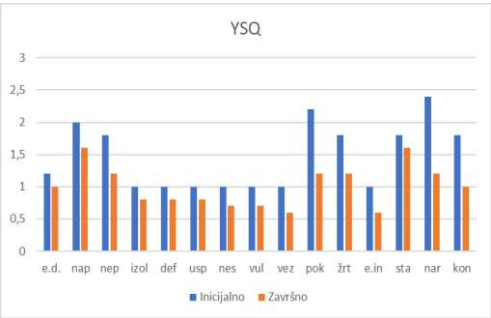
| | |
|---|---|
| CORE F | 28 |
| CORE P | 2 |
| CORE W | 10 |
| CORE R | 0 |
| CORE | 40 |
| CORE – R | 40 |

Skala maladaptivnih šema – YSQ

Što se tiče rezultata na ovom upitniku može se reći da ni prilikom inicijalnog testiranja nisu prisutni visoki skorovi. Na završnom testiranju skorovi su dodatno sniženi na svim skalama. Analizirajući dosadašnji rad sa klijenticom I ove rezultate može se zaključiti da klijentica nije bila sklona razvoju maladaptivnih šema, koje nastaju kao rezultat negativnih interakcija ili iskustava sa značajnim osobama u djetinjstvu, te služe kao okvir za procesuiranje kasnijih ponašanja. U prilog tome govori zadovoljavajući porodični I socijalni kontekst u kojem je klijentica odrastala.

Tabela 5. Prikaz inicijalnih I završnih rezultata na upitniku YSQ.
Table 5. Presentation of initial and final results on the YSQ questionnaire.

| | e.d. | nap | nep | izol | def | usp | nes | vul | vez | pok | žrt | e.in | sta | nar | kon |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Inicijalno | 1.2 | 2 | 1.8 | 1 | 1 | 1 | 1 | 1 | 1 | 2.2 | 1.8 | 1 | 1.8 | 2.4 | 1.8 |
| Završno | 1 | 1.6 | 1.2 | 0.8 | 0.8 | 0.8 | 0.7 | 0.7 | 0.6 | 1.2 | 1.2 | 0.6 | 1.6 | 1.2 | 1 |



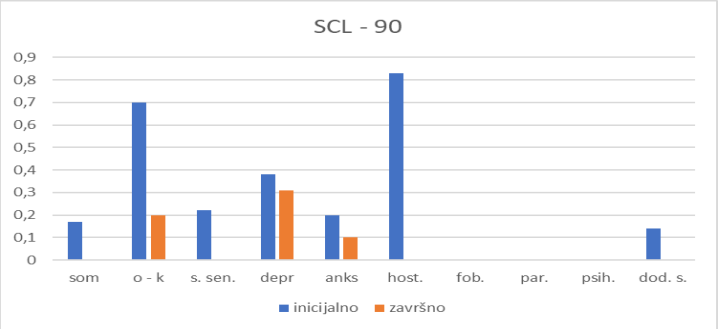

Grafikon 3. Prikaz inicijalnih I završnih rezultata na upitniku YSQ.
Chart 3. Presentation of initial and final results on the YSQ questionnaire.

Symptom Check List (SCL – 90)

Iz tabela I grafikona može se zaključiti da ni na ovom upitniku ne postoje značajno visoki skorovi. Hostilnost, koja je zauzela najviši skor, na završnom testiranju nije ni bila prisutna. Ovakav blago povišen skor može se dovesti u vezu sa klijenticinom otežanom ispoljavanju svojih potreba I osjećanja, što dugoročno dovodi do neadekvatnog komuniciranja sa drugim ljudima, u ovom slučaju konkretno sa partnerom. Ostale vrijednosti I inicijalno I završno su zanemarive I vrijednosno vrlo male.

Tabela 6. Prikaz inicijalnih i završnih rezultata na upitniku SCL-90.
Table 6. Presentation of initial and final results on the SCL-90 questionnaire.

| | som | o - k | s. sen. | depr | anks | host. | fob. | par. | psih. | dod. s. |
|---|---|---|---|---|---|---|---|---|---|---|
| inicijalno | 0.17 | 0.7 | 0.22 | 0.38 | 0.2 | 0.83 | 0.00 | 0.00 | 0.00 | 0.14 |
| završno | 0.00 | 0.20 | 0.00 | 0.31 | 0.1 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |




Grafikon 4. Prikaz inicijalnih I završnih rezultata na upitniku SCL-90.
Chart 4. Presentation of initial and final results on the SCL-90 questionnaire.

## ZAKLJUČCI

Ovim istraživanjem željela se ispitati učinkovitost kognitivno-bihejvioralne psihoterapije (KBT), njenom primjenom na klijentici sa socijalnom anksioznošću. Samim tim, pružene su smjernice za dalja istraživanja koja se tiču ove teme. Prethodna brojna istraživanja potvrđuju učinkovitost kognitivno-bihejvioralne terapije u tretmanu socijalne anksioznosti (Živčić-Bećirević i Jakovčić, 2015). S tim u vezi, hipoteza ovog kvalitativnog istraživanja, odnosno očekivana pretpostavka da će kognitivno-bihejvioralne tehnike (KBT) dovesti do poboljšanja je ispunjena. Analiza i interpretacija rezultata potvrđuje ishode prethodnih istraživanja i teorijskih pretpostavki. Potvrđeno je da je kognitivno-bihejvioralna terapija metoda izbora kod socijalne anksioznosti.

Prema dobijenim rezultatima, na osnovu evaluacije tretmana, kao I na osnovu promjena na bihejvioralnom nivou može se zaključiti da je klijentica ostvarila postavljene ciljeve. Klijentica obavještava o subjektivnom poboljšanju, te navodi bolje uvide i razumijevanje sopstvenih emocija te osvještavanje već postojećih resursa. Takođe, na svim testovima klijentica pokazuje napredak, iako je bitno napomenuti da je riječ o osobi koja je prethodno radila na poboljšanju svojih psiholoških kapaciteta. Prikazani ostvareni ciljevi i rezultati u ovod studiji potvrđuju već dokazanu efikasnost KBT u tretmanu socijalne anksioznosti.

Uspješnost tretmana je ostvarena. Uspostavljen je dogovor da se javlja po potrebi. Da bi se navedeni zaključak mogao generalizovati te da bi se mogla potvrditi eksterna valjanost primjenjenih KBT principa i tehnika za rješavanje sličnih psiholoških problema treba se dobiti potvrda ponavljanjem ovakvih rezultata i istraživačkih poduhvata.

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# COGNITIVE-BEHAVIORAL TREATMENT OF SOCIAL ANXIETY: A CASE STUDY

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**ABSTRACT**

Cognitive-behavioral theory claims that an individual creates social anxiety to a certain extent by exaggerating the consequences of his failure and public performance in front of the audience (Labaš, 2021; according to Konig, Peulić, Matijević, 2018). Social anxiety or fear of public speaking is a form of anxiety and denotes a normal reaction, state of alertness and stimulation of awareness to danger (Labaš, 2021). This reaction to danger can cause vigilance, combativeness, withdrawal or flight, which on the one hand helps in overcoming difficulties, but on the other hand can be an extremely uncomfortable state. In this regard, it is most beneficial to change the perception and attitude towards social anxiety. This paper presents cognitive-behavioral therapy in the treatment of social anxiety in a 19-year-old girl. The treatment lasted a month and a half, more precisely, five sessions were conducted. The therapy consisted of the following cognitive behavioral techniques: alleviating the fear of public speaking through a change in perception and psychoeducation, practicing presentation skills, shifting focus, and the like. It is important to note that this is a client with extremely developed personal capacities and resources, therefore the treatment was completed relatively quickly, and the set initial goals were met. The evaluation of the effect of the implemented cognitive-behavioral treatment was done on the basis of clinical evaluation, subjective reporting of the client as well as standard questionnaires for psychological assessment. The following questionnaires were used in this work: AAQII, SGSE, CORE, YSQ and SCL-90.

**Keywords**: cognitive-behavioral psychotherapy (CBT), social anxiety, public speaking, case study.

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# PRIKAZ SLUČAJA KOGNITIVNO-BIHEJVIORALNE TERAPIJE PANIČNOG POREMEĆAJA U KOMORBIDITETU SA HIPOHONDRIJOM

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## SAŽETAK

Kognitivno-bihejvioralna terapija je naučno zasnovan princip za koju istraživanja pokazuju da je efikasna za širok raspon problema. Terapeut i klijent zajedno rade na identifikovanju i razumijevanju problema u terminima odnosa između misli, osjećanja i ponašanja. Pristup je obično usmjeren na teškoće "ovdje i sada". Problem kojem se pristupa mora biti precizno definisan, kao i cilj na kojem se tokom terapije radi. Razvoj ovog pristupa tekao je kroz tri talasa: prvi su predstavljale bihejvioralne terapije, drugi su kognitivne terapije, dok su treći „mindfulness"terapije zasnovane na prihvatanju i punoj svjesnosti.

Ovaj rad predstavlja prikaz slučaja paničnog poremećaja kod 22-godišnje djevojke u komorbiditetu sa hipohondrijom, uz upotrebu kognitivno-bihejvioralne terapije (KBT), naročito trećeg talasa (ACT). U radu je opisan plan i tok tretmana, sa odgovarajućim tehnikama. Bitna karakteristika paničnog poremećaja su ponavljani napadi ozbiljne anksioznosti koji nisu ograničeni na posebnu situaciju ili skup okolnosti, pa su stoga nepredvidivi. Panična anksioznost se odnosi na situacije gdje ne postoji objektivna opasnost. Komorbiditet predstavlja postojanje dva ili više psihijatrijskih poremećaja kod iste osobe, bez obzira na vrijeme i odnos pojave tih poremećaja, a u ovom konkretnom slučaju povezan je sa hipohondrijom.

Tretman je trajao tri I po mjeseca, podijeljen u trinaest seansi. Svi postavljeni ciljevi su ostvareni, te klijentica izvještava o subjektivnom poboljšanju.

Procjena efekta sprovedenog kognitivno-bihejvioralnog tretmana rađena je na osnovu kliničke evaluacije, kao i standardnim upitnicima za psihološku procjenu, a to su: AAQII, SGSE, CORE, YSQ, SCL-90 i UPH.

**Ključne riječi:** kognitivno-bihejvioralna psihoterapija (KBT), panični poremećaj, prikaz slučaja, komorbiditet, hipohondrija.

## UVOD

Kognitivno-bihejvioralna terapija zauzima značajno mjesto u psihoterapiji. U kognitivno-bihejvioralnom pristupu značajan naglasak se stavlja na empirijsku validaciju, pri čemu se u istraživanjima i svakodnevnoj kliničkoj praksi koriste grupni i pojedinačni nacrti, te upravo iz tog razloga predstavlja terapiju izbora u tretiranju različitih poremećaja (Hawton i sar., 2008). Ovaj oblik terapije ima svoje temelje u eksperimentalnim metodama, pa se početne seanse koriste za postavljanje početnih hipoteza i planiranja tretmana. Kognitivno-bihejvioralna terapija kombinuje dva pristupa, prvi je kognitivni koji se odnosi na način na koji ljudi razmišljaju, a drugi je bihejvioralni koji predstavlja objašnjenje njihovog ponašanja (Kranjec, 2015).

Tretman anksioznih poremećaja u kognitivno-bihevioralnoj terapiji obično uključuje psihoedukaciju, učenje tehnika opuštanja i utvrđivanje važnih kognicija i njihovu promjenu (Hawton i sar., 2008). Kognitivni model anksioznosti zasnovan je na pretpostavci da je pogrešno procesiranje informacija centralna karakteristika mišljenja kod osoba s anksioznim poremećajem (Kranjec, 2015). Anksioznost kao emocionalni poremećaj javlja se kod osoba koje na kognitivnom

planu konzistentno precjenjuju opasnost situacije i/ili podcjenjuju vlastite sposobnosti da izađu na kraj s ugrožavajućim situacijama (Beck, & Emery, 1985; prema Krnetić, 2006). U rezultatima nekih ostraživanja osobe s anksioznim poremećajem podvrgnute su kognitivno-bihejvioralnoj terapiji, od strane terapeuta pripravnika koje su nadzirali stručni terapeuti. Takođe, napravljena je meta-analiza određenog broja kognitivno-bihejvioralnih terapija provedenih u kontrolisanim uslovima. Rezultati su pokazali da je, u nekontrolisanim uslovima, od 96 pacijenata, kod 61% njih došlo je do poboljšanja dok se 52.5% pacijenata u potpunosti oporavilo. Rezultati su nešto manji od onih koji su dobiveni meta-analizom: kod 73.9% pacijenata s anksioznim poremećajem došlo je do poboljšanja, kod 69% stanje se značajno popravilo, a 58% pacijenata se može smatrati potpuno oporavljenima. Iz toga se može zaključiti kako je kognitivno-bihevioralna terapija izrazito uspješna u liječenju anksioznosti. Može se zaključiti da istraživanja potvrđuju efikasnost KBT-a, bez obzira na njeno trajanje ili način primjene (Ishikawa i sar., 2008; Kranjec, 2015).

U sklopu anksioznih poremećaja panični napadi su najistaknutiji tip odgovora na strah (American Psychiatric Association [APA], 2014). Panični napad je iznenadna i intenzivna epizoda nelagode i/ili straha koju prate različiti tjelesni simptomi (lupanje srca, drhtanje, doživljaj gušenja, znojenje, bol u prsima, mučnina, vrtoglavica, naleti vrućine ili hladnoće, slabosti) i kognitivni simptomi (strah od gubitka kontrole, strah od smrti, depersonalizacija i derealizacija). Ovi napadi počinju iznenada i kratkotrajni su. Rijetko traju duže od trideset minuta, pri čemu se vrhunac anksioznosti dostiže nakon 10 minuta ili kraće (Leahy i sar., 2014; prema Glinac, 2022). Dijagnoza paničnog poremećaja postavlja se tek nakon što se isključe mogući medicinski uzroci, u koje se ubrajaju hipoglikemija, hipertireodizam, reakcije na prekomjeran unos kofeina, apstinencijski sindrom nakon upotrebe alkohola ili sedativa. Panični poremećaj uzrokovan je kombinacijom nasljednih faktora, biohemijskim disbalansima u mozgu i stresom. Izenadan gubitak ili velike životne promjene mogu predstavljati okidače za pojavu paničnih napada (Born, 2012). Nakon prvog paničnog napada klijenti sa paničnim poremećajem postanu pretjerano usmjereni na tjelesne doživljaje panike, počnu brinuti na katastrofičan način o posljedicama tjelesnih doživljaja, što ima za posljedicu razvoj stalno prisutne anksioznosti u očekivanju budućih paničnih napada (Leahy i sar., 2014).

Tok paničnog poremećaja tipično se komplikuje komorbiditetom sa nizom drugih poremećaja, osobito sa anksioznim poremećajima. Kliničke značajnosti paničnog poremećaja ne razlikuju se između muškaraca i žena. Panični poremećaj je povezan s visokim nivoom socijalne, radne i tjelesne onesposobljenosti, značajnim ekonomskim troškovima i najvećim brojem medicinskih posjeta među anksioznim poremećajima (APA, 2014). Dosadašnja istraživanja ukazuju na značajan stepen komorbiditeta kod pacijenata sa anksioznim poremećajima i to sa drugim psihijatrijskim poremećajima i različitim somatskim oboljenjima. Kliničke studije kod pacijenata sa paničnim poremećajem i agorafobijom prikazuju visok stepen komorbiditeta i to u rasponu od 51%, preko 60% do 92%. Najčešći komorbidni poremećaji kod pacijenata sa paničnim poremećajem i agorafobijom su:

- Generalizovani anksiozni poremećaj: 42% – 68%
- Socijalna fobija: 17% – 42%
- Opsesivno-kompulzivni poremećaj: 5% – 28%
- Depresija: 22% – 91%
- Alkoholizam: 14% – 28%
- Hipohondrija: 25% – 50% (Latas i sar., 2008).

Najvažniji razlog ispitivanja komorbiditeta u svakodnevnoj kliničkoj praksi je zbog precizne i kompletne dijagnostike kod svakog pacijenta i u eventualne modifikacije liječenja osnovnog poremećaja i prilagođavanja terapijskog postupka eventualnom komorbidnom poremećaju.

Hipohondrija je strah od dobijanja teške bolesti na osnovu pogrešnog tumačenja tjelesnih simptoma ili normalnih tjelesnih funkcija. Zbog pogrešnog tumačenja nepatoloških simptoma ili normalnih tjelesnih funkcija (npr. nadutost ili grčevi u stomaku, osjećaj lupanja srca, znojenje) nastaje niz strahova. Prema najnovijem izdanju DSM-a V prijašnje dijagnoze somatizacije, nediferenciranog somtoformnog poremećaja, te hipohondrije sa somatskim simptomima svedene

su na jedinstvenu dijagnozu poremećaja somatskih simptoma. U 20% slučajeva pojedinci koji boluju od hipohondrije ne žale se na somatske simptome, već je kod njih iznimno izražen samo strah od razvoja bolesti, zbog čega im se prema DSM-u V tada postavlja dijagnoza poremećaja zdravstvene anksioznosti (Dimsdale et al., 2013).

## PRIKAZ KOGNITIVNO-BIHEJVIORALNOG TRETMANA (KONCEPTUALIZACIJA SLUČAJA)

### Klinička procjena

Podaci o klijentu

Klijentica A. B., žensko, ima 22 godine, neudata, rođena u Travniku, živi u Sarajevu gdje radi i studira. Apsolvent je na Fakultetu zdravstvenih studija, ima još 3 ispita, a bila je zaposlena kao konobar u jednom lokalnom kafiću godinu i po. Trenutno povremeno radi u jednom salonu za masažu. Bila je vrlo dobar učenik, a za sebi govori kako je bila najglasnija u razredu, te da je vrlo društvena i ekstravertna osoba.

Trenirala je košarku do 16. godine. Naime, sa 15 godina je potpisala ugovor na 7 godina u Celju, ali se zadržala samo 3 mjeseca, jer se osjećala vrlo usamljeno. Nakon toga se vratila u Travnik, gdje je nastavila da pohađa gimnaziju. Ističe da se ne kaje zbog te odluke.

A.B. nije odrasla u potpunoj porodici, jer joj je otac preminuo kada je imala 3 godine. Ima starijeg brata i majku, a ove odnose opisuje kao bliske i podržavajuće. Brat joj pomaže finansijski, jer trenutno nema stalni radni odnos.

Prijateljski odnosi zadovoljavajući, ima jedan odnos koji joj je izuzetno važan, ali i dosta poznanika, sa kojima svakodnevno provodi vrijeme. Partnerski odnosi nisu naročito uspješni. Postojalo je par kratkotrajnih veza, ne duže od 3 mjeseca. Imala je jednu ozbiljnu vezu sa 18 godina (momak je imao 26). Taj odnos opisuje kao toksičan, jer je partner bio veoma problematičan, konzumirao je alkohol i narkotike. Stiče se utisak da ima tendenciju ka izbjegavajućem obrascu ponašanja.

Na osnovu prvog susreta, može se zaključiti da se radi o osobi koja je ekstravertna, društvena, komunikativna i vrijedna. U prvom kontaktu klijent djeluje smireno, ne izražava anksioznost i nelagodu. Misaoni tok uredan. Vodi kulturan dijalog i daje dosta informacija. Pored uzetih anamnestičkih podataka, provjeravaju se i očekivanja od terapije.

Glavne tegobe na koje se žali

Klijentica se žali na panične napade, hipohondriju, nemogućnost da doživi situacije u momentu, nizak prag tolerancije na frustraciju, teškoće prilikom ponovnog vraćanja na učenje nakon dužeg perioda.

Istorija sadašnjih tegoba

A.B. je osoba koja zbog neiskazivanja svojih emocija tokom vremena razvija panične napade, a primjećuje se I prisutnost hipohondrije, što potkrepljuju problemi sa stomakom (sindrom nervoznih crijeva). Klijentica je ograničila svoje kretanje na poznate lokacije I svaki izlazak iz kuće zahtijeva posebnu pripremu (spremanja od 2-3 sata, konzumiranje hrane za koju zna da sigurno neće zasmetati stomaku I slično). Može se zaključiti da prilično mučno izgleda svaki izlazak iz kuće.

Ovakva situacija dovodi klijenticu do nemogućnosti da uživa i doživi situacije u momentu njihovog dešavanja (npr. put u Grčku).

Od senzacija prisutan pritisak u ramenima (kao da stoje dvije kugle velike), stezanje u prsima, hladan znoj koji prolazi od glave do pete, pa onda slijede naleti vrućine, a sve to dovodi do poriva za povraćanjem i izbjegavanje situacija koje dovode do ovih simptoma.

Psihijatrijska istorija

Kod klijentice nije zabilježena istorija psihijatrijskih poremećaja, kao ni u anamnezi kompletne porodice.

Istorija ličnog i socijalnog funkcionisanja

A.B. je ekstravertna, komunikativna i otvorena osoba. Trenutno najveći dio vremena provodi kući, jer nema stalni radni odnos. S tim u vezi, poduzima akcije koje se odnose na pronalazak posla. Ima prilično veliki broj socijalnih kontakata koje se trudi da svakodnevno održava. Posvetila se mnogo više fakultetu, jer sada ima vremena.

Iz anamnestičkih podataka može se zaključiti da je klijentica odrasla u prilično funkcionalnoj uprkos nepotpunoj porodici. Podrška i ljubav su jasno izraženi.

Što se tiče ličnih resursa, prilično su veliki I neophodno je njihovo jačanje kroz davanje uvida klijentici.

Ne postoji sklonost prema psihoaktivnim supstancama, niti navodi neka značajna interesovanja kao i hobije.

Iz navedenog može se zaključiti da A.B. posjeduje stabilne porodične, lične i socijalne resurse. Eventualna problematika može postojati u partnerskim odnosima.

Medicinska istorija

Osim gastrointenstinalnih poteškoća klijentica nema nikakvih medicinskih problema koji bi mogli uticati na njeno psihološko stanje.

Mentalni status

Klijentica uredne spoljašnjosti, normalne građe. Odaje utisak inteligentne i komunikativne osobe. Djeluje prijatno, ljubazno i kulturno. Nije vidljivo sniženo raspoloženje. Od prvog kontakta postoji izraženo povjerenje od strane klijentice prema terapeutu. Prisutna odlučnost i istrajnost ka rješavanju psiholoških poteškoća. Detaljna i konkretna u iznošenju problema i ciljeva rada, te daje veliki broj informacija.

Dijagnoza

Postojao je jedan odlazak kod psihologa sa 15 godina, na osnovu kojeg je klijentici postavljena dijagnoza kliničke depresije, što se ne može uzeti u obzir kao zvanična dijagnoza, upravo jer je riječ o jednom susretu.

Rezultati testove koje je klijentica popunila prije prvog susreta su:

Upitnik prihvatanja I akcije AAQII – 37

Ovaj test mjeri psihološku fleksibilnost. Što je veći rezultat na ovom testu, veća je i psihološka nefleksibilnost klijenta. Najveći skor na ovom testu iznosi 49.

SGSE upitnik – 29

Ovaj upitnik ukazuje na samoefikasnost klijenta, što su viši skorovi, veći je osjećaj samoefikasnosti. Najveći skor na ovom testu iznosi 40, a najmanji skor iznosi 10.

Upitnik za procjenu hipohondrije UPH – 56

Ovaj upitnik ukazuje na procjenu sklonosti hipohondriji.

Upitnik za ispitivanje opštih psihopatoloških teškoća - CORE

Ovaj upitnik sadrži 34 čestice koje su podjeljene u četiri dimenzije: subjektivna dobrobit, problemi/simptomi, svakodnevno funkcionisanje I rizična ponašanja. Osim subjektivne dobrobiti, unutar svake dimenzije postoje klasteri čestica. Dimenzija problemi/simptomi obuhvata: depresivnost, anksioznost, tjelesne probleme I traumatizaciju. Dimenzija svakodnevnog funkcionisanja obuhvata tri klastera: opšte funkcionisanje, socijalno funkcionisanje I bliskost. Na kraju, dimenzija rizičnih ponašanja obuhvata: ponašanja rizična za pojedinca I druge.

Tabela 1. Prikaz inicijalnih rezultata na upitniku CORE.
Table 1. Presentation of the initial results on the CORE questionnaire.

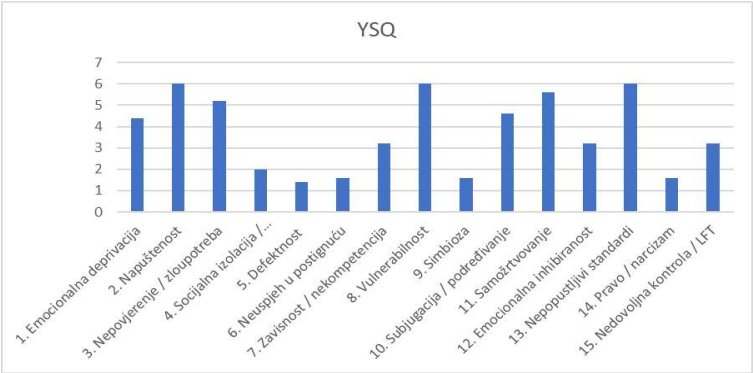
| | Skor |
|---|---|
| CORE F | 24 |
| CORE P | 53 |
| CORE W | 10 |
| CORE R | 9 |
| CORE | 78 |
| CORE - R | 87 |

Tabela 2. Prikaz inicijalnih rezultata na upitniku YSQ.
Table 2. Presentation of initial results on the YSQ questionnaire.

| | e.d. | nap | nep | izol | def | usp | nes | vul | Vez | Pok | žrt | e.in | sta | nar | kon |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| inicijalno | 4.4 | 6 | 5.2 | 2 | 1.4 | 1.6 | 3.2 | 6 | 1.6 | 4.6 | 5.6 | 3.2 | 6 | 1.6 | 3.2 |

Skala maladaptivnih shema – YSQ

YSQ služi kao klinički instrument u psihoterapiji te kao istraživački instrument u istraživanjima poremećaja ličnosti i razvojne psihopatologije. Sastoji se od 18 pojedinačnih shema, a one su grupisane u 5 kategorija koje se odnose na nezadovoljene temeljne emocionalne potrebe. Kategorije su sljedeće: odvojenost i odbačenost, narušena autonomija i postignuće, usmjerenost na druge, pretjerani oprez i inhibicija, te oštećene granice.




Grafikon 1. Prikaz inicijalnih rezultata na upitniku YSQ.
Chart 1. Presentation of initial results on the YSQ questionnaire.

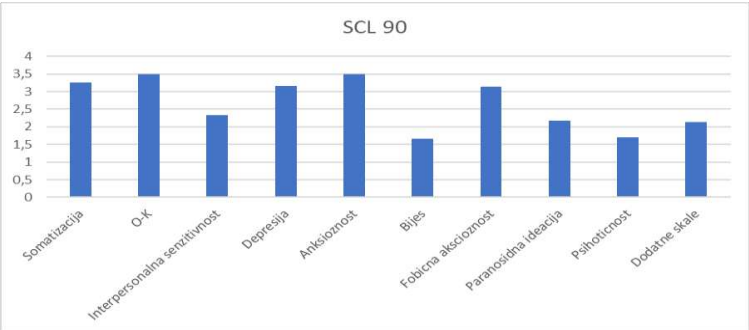
Tabela 3. Prikaz inicijalnih rezultata na upitniku SCL – 90.
Table 3. Presentation of the initial results on the SCL - 90 questionnaire.

| | som | o - k | s. sen. | depr | Anks | host. | fob. | par. | psih. | dod. s. |
|---|---|---|---|---|---|---|---|---|---|---|
| inicijalno | 3.25 | 3.5 | 2.3 | 3.2 | 3.5 | 1.7 | 3.1 | 2.2 | 1.7 | 2.1 |

Symptom Check List (SCL – 90)

Ovaj upitnik se koristi za procjenu širokog spektra psiholoških problema i simptoma psihopatologije. Pored toga, koristi se u mjerenju napretka i ishoda psiholoških tretmana. Sastoji se od 90 pitanja kojima se procjenjuju simptomi somatizacije, opsesivne-kompulsivnosti,

interpersonalne osjetljivosti, depresije, anksioznosti, bijesa, fobične anksioznosti, paranoidne ideacije, psihotičnosti, te dodatne skale koje služe za procjenu drugih aspekata simptoma.




Grafikon 2. Prikaz inicijalnih rezultata na upitniku SCL – 90.
Chart 2. Presentation of the initial results on the SCL - 90 questionnaire.

**Formulacija slučaja**

Precipitatori

Značajnu ulogu u razvoju klijenticinih napada panike i anksioznosti ima smrt oca. Iako je on preminuo kada je ona imala samo 3 godine, iz terapije se čini da dosta stvari povezuje upravo sa tim događajem. U periodu od 3. do 10. godine postojali su periodi buđenja i vrištanja u snu, a u tom periodu klijentica navodi kako nema sjećanja. Može se reći da je potiskivanje tako snažnih emocija kroz vrijeme dovelo do paničnih napada.

Sadašnji aktivirajući događaji

Sadašnji aktivirajući događaji su nepoznate situacije i mjesta. To je dovelo klijenticu do toga da se kao izuzetno ekstravertna osoba povuče. Postoje posebne pripreme za izlazak iz kuće, koje traju oko 2-3 sata, a one uključuju određenu vrstu hrane i pića, kako bi eliminisala potrebu za odlazak u toalet. Primjer za to jeste putovanje u Grčku, kojeg se vrlo malo sjeća, zbog konstantnog razmišljanja o toaletu i stomaku.

U ovakvim situacijama prisutne su sledeće misli: „Zašto se meni ovo dešava?“, „Zašto ja?“, „Ima li ovdje negdje wc?“, „Šta ako se obrukam pred ljudima?“, „Da li možda trebam dobiti ili sam u periodu menstruacija, pa se ovako osjećam?“. Ovakve misli izazivaju strah, zabrinutost i bespomoćnost. Iz tog razloga klijentica se povukla i najviše vremena provodi kući i na poznatim mjestima, poput kafića u kojem je radila. Sve ovo predstavlja začarani krug za klijenticu, koji je praćen ruminacijom i fuziranjem sa mislima i pravilima koja su dobila potvrdu.

Bazične iracionalne filozofije ili kognitivne šeme

U osnovi klijenticine iracionalne filozofije postoji uvjerenje da bi pokazivanje emocija moglo dovesti do ranjivosti. Ova filozofija dovodi klijenticu do toga da nije naročito otvorena u odnosu sa ljudima, što je karakteristično za partnerske odnose gdje ima sklonost da ode prije nego je neko povrijedi ili uradi nešto loše. Nastoji da ih “preduhitri”. Ovakvo razmišljanje je vjerovatno potkrepljeno još u ranom djetinjstvu, kada je otac preminuo. Iz velikog straha od svakog narednog napuštanja kao i prepuštanja u odnose sa drugima klijentica je sklona potiskivanju svojih emocija, što je vrlo vjerovatno dovelo do paničnih napada.

Snage

Klijentica je izuzetno motivisana i zainteresovana za rad, te otvorena ka novim iskustvima. Od prve seanse je izuzetno uključena i spremna za saradnju. Zadaću radila redovno i detaljno. Isto tako, u svakodnevnim aktivnostima, primjenjivala je sadržaj sa terapije. Prisutna odlučnost ka promjeni.

Radne hipoteze

- Raditi na promjeni percepcije paničnih napada kroz psihoedukaciju i posvećene akcije.
- Raditi na ublažavanju sklonosti ka hipohondriji.
- Raditi na doživljavanju situacija u momentu kroz vježbe pune svjesnosti, kao i vježbanje pune svjesnosti u svakodnevnim aktivnostima.
- Raditi na jačanju praga tolerancije na frustraciju kroz određene tehnike.
- Raditi na jačanju i uviđanju ličnih resursa i snaga.

## CILJEVI I PLAN TRETMANA

Napadi panike

(Cilj: psihoedukacija o napadima panike radi promjene percepcije i primjena različitih tehnika zbog ublažavanja istih.)

Hipohondrija

(Cilj: ublažavanje sklonosti ka googlanju simptoma, preuveličavanju određenih simptoma i izmišljanju bolesti.)

Nizak prag tolerancije na frustraciju

(Cilj: jačanje praga tolerancije na frustraciju kroz razne tehnike i kroz osvještavanje vrijednosti.)

Nemogućnost da se dožive situacije u momentu

(Cilj: vježbe pune svjesnosti i vježbanje iste u svakodnevnim aktivnostima.)

Povratak na fakultet i učenje nakon dužeg perioda

(Cilj: identifikovati važnost polaganja ispita.)

### Plan tretmana

Neophodna je psihoedukacija o paničnim napadima, a potom i primjene različitih tehnika radi ublažavanja istih, poput vježbanja pune svjesnosti, tehnike „paradoks pretjerivanja“, tehnike „šta ako“ i slično. Ove tehnike bi pomogle u dekatastrofizaciji misli koje dovode do paničnih napada. Svakako je bitno proći kroz normalizaciju i validaciju klijenticinih emocija i ponašanja. Ove tehnike korištene su i kod hipohondrije, upravo radi uviđanja besmislenosti. Pored toga, od izuzetne važnosti je izgradnja resursa, stabilizacija i osnaživanje u “ovdje i sada” kontakt sa vrijednostima. Vrlo često su korištene i različite vrste metafora kao i dijeljenje ličnih iskustava.

## TOK TRETMANA

Prva seansa (14.12.2022.)

Na prvoj odnosno inicijalnoj seansi sa klijenticom A.B. obavljen je proces upoznavanja i upoznata je sa načinom rada savjetovališta. Nakon što je pristala na snimanje seansi, rad je počeo.

A.B. je rođena u Travniku i ima 22 godine. Trenutno živi u Sarajevu, gdje radi i studira. Apsolvent je na Fakultetu zdravstvenih studija, ima još 4 ispita, a zaposlena je kao konobar u jednom lokalnom kafiću godinu i po. Trenirala je košarku do 16. godine. Naime, sa 15 godina je potpisala ugovor na 7 godina u Celju, ali se zadržala samo 3 mjeseca, jer se osjećala vrlo usamljeno, čak je posjetila i psihologa, gdje joj je na osnovu jednog razgovora postavljena dijagnoza kliničke depresije. Nakon toga se vratila u Travnik, gdje je nastavila da pohađa gimnaziju. Ističe da se ne kaje zbog te odluke. Bila je vrlo dobar učenik i najglasnija u razredu. Sebe opisuje kao veoma društvenu i ekstravertnu osobu, koja ne voli mnogo vremena da provodi u kući.

Klijentica nije odrasla u potpunoj porodici, imala je 3 godine kada joj je otac preminuo prirodnom smrću. Živjela je sa majkom i starijim bratom. Njihove međusobne odnose opisuje kao bliske, podržavajuće i pune povjerenja. Iako nije riječ o potpunoj porodici, ovi odnosi djeluju kao funkcionalni. Pored toga, klijentica navodi kako zbog proživljene trauma zbog smrti oca nema

sjećanja od 3. do 10. godine. Naveče su postojali periodi buđenja i vrištanja u snu. U kasnijem uzrastu se javila ljutnja zbog te situacije.

Što se tiče prijateljskih odnosa, ima jednu najbolju drugaricu i taj odnos joj je jako važan. Ostatak vremena najviše provodi i druži se sa ljudima iz kafića u kojem radi. Navodi prekid prijateljstva sa drugaricom sa kojom se poznaje od 4. godine, jer se istoj nije sviđao njen način života, tačnije to što radi u kafiću i pije.

Partnerski odnosi nisu naročito uspješni. Postojalo je par kratkotrajnih veza, ne duže od 3 mjeseca. Imala je jednu ozbiljnu vezu sa 18 godina (momak je imao 26), to joj je bio prvi momak. Taj odnos opisuje kao toksičan, jer je partner bio veoma problematičan, konzumirao je alkohol i narkotike. Odnos je trajao pola godine, a za to vrijeme majka i brat su pokušavali na sve načine da je sklone od njega, međutim bilo je neuspješno, dok ona sama nije odlučila da joj on ne treba u životu. Od tog odnosa, nijedan muškarac joj nije probudio takve emocije da bi mogla biti sa njim duže u vezi. Djeluje kao izbjegavajući tip, jer navodi kad primjeti previše emocija bježi, a i pohvale teško prihvata (kada joj partner govori da je najljepsa, najbolja i slično u njoj izaziva gađenje).

Može se zaključiti da klijentica ima priličnu svijest o sebi i svom ponašanju (jasno joj je da stagnira na trenutnom poslu i planira da najavi otkaz). Djeluje prijatno i vrlo otvoreno razgovara o svom životu. Misao tok uredan.

Na sledećoj seansi potrebno razgovarati o razlozima javljanja u savjetovalište, jer je postojalo mnogo detalja oko klijenticinog života o kojima je bilo važno razgovarati na prvom susretu.

Druga seansa (21.12.2022.)

Urađena je ACT matrica sa klijenticom, u vezi razloga njenog javljanja na terapiju. Kao problem navodi situaciju koja se desila u periodu korone, prije 2-3 godine kada su morali da se isele iz studentskog doma. Prilikom ponovnog vraćanja u dom, klijentica je primjetila probleme sa stomakom, tačnije počela je izbjegavati nepoznate situacije i mjesta, u blizini kojih se ne nalazi toalet. Njeno kretanje se odvijalo ovako: soba-restoran u domu-kafić u kojem radi-soba. Od tada se mnogo povukla i to traje sve do sad. Pripreme za izlazak iz kuće traju otprilike oko 2 i po sata, ne može uraditi ništa spontano, pojesti ili popiti ono što želi prije izlaska iz kuće da joj ne bi zasmetalo stomaku i slično. Mučan joj je postao svaki odlazak u grad. Čak je nedavno putovala u Grčku, te ističe da nije doživjela to putovanje na pravi način, samo je mislila o toaletu i stomaku.

Prisutne su sledeće misli: „Zašto se meni ovo dešava?“, „Zašto ja?“, „Ima li ovdje negdje wc?“, „Šta ako se obrukam pred ljudima?“, „Da li možda trebam dobiti ili sam u periodu menstruacija, pa se ovako osjećam?“. Ovakve misli izazivaju strah, zabrinutost i bespomoćnost. Od senzacija prisutan pritisak u ramenima (kao da stoje dvije kugle velike), stezanje u prsima, hladan znoj koji prolazi od glave do pete, pa onda slijede naleti vrućine. Porivi su plakanje (najviše), bježanje iz situacije i jednom se desio nagon za povraćanje. Od sjećanja navodi očevu smrt, kada se ponašala na sličan način. U takvoj situaciji, ukoliko je na radnom mjestu, će se umiriti, prestaće razgovarati, disaće duboko, uzeti u ruku nešto da se igra (upaljač obično), cupka nogom, sjedi i pije. Cilj koji bi voljela da postigne na terapiji jeste da se vrati životu od prije 2-3 godine, da bude ona od prije, da nema problem izaći iz kuće i da shvati zašto joj se sve to dešava. Kada bi se ponašala u skladu sa svojim ciljem to bi ovako izgledalo: viđala bi češće prijatelje, spavala bi manje, išla bi na planinu, vratila bi se na treninge u teretanu, putovala bi, prespavala kod nekog, smanjila bi alkohol, potrudila se da pronađe posao u stuci, provodila više vremena sa mamom i bratom, javila bi se ljudima sa kojima je izgubila kontakt. Sve to joj je važno zbog spontanosti, jer ukoliko ima nju, upoznavaće ljudi i širiti kontakte, što joj je važno zbog karijere, a pored toga gradiće i bliske odnose.

Stiče se utisak da klijentica na ovaj način pokušava da uspostavi određenu kontrolu, što je potrebno ispitati u toku daljeg rada.

Treća seansa (12.01.2023.)

Nakon pauze od dvije sedmice, zbog praznika, na današnjoj seansi je održana psihoedukacija o napadima panike. Ono što je mnogo pomoglo klijentici jeste saznanje da joj se neće nista loše desiti u tom momentu, uprkos iskustvu koje jeste neprijatno i zastrašujuće. Nakon psihoedukacije, urađena je vježba pune svjesnosti za disanje, koja je klijentici izuzetno prijala.

Pored toga, u dogovoru sa klijenticom osmišljene su akcije u skladu sa ciljem i vrijednostima, a to je trenutno spremanje ispita, gdje bi dnevno učila 3-4 sata. Ujutru bi organizovala svoj dan, kako bi mogla stići sve i držati se plana učenja.

Bitno je napomenuti da je A.B. dala otkaz na poslu, na kojem je uvidjela stagnaciju i kada je riječ o intelektu, ali i o okruženju. Tu situaciju sam pohvalila i iskoristila za podsticanje njenih resursa i snaga.

Četvrta seansa (18.01.2023.)

Na početku seanse, provjerena zadaća (vježba pune svjesnosti), koju je klijentica primjenjivala 3 puta, u trajanju od 5-7 minuta. Potom, provjereno sa klijenticom da li je učila 3-4 sata dnevno, po dogovoru, međutim nije. Distrakciju joj je pravio boravak kod majke, htjela je da s njom provodi više vremena, telefon, knjiga, odmaranje koje joj je bilo potrebno nakon posla u kafiću. Napravile smo listu prednosti polaganja ispita:

- Manje stresa;
- Korak bliže diplomi;
- Korak bliže poslu koji želi;
- Osjećaj olakšanja i zadovoljstva.

Ova lista je klijentici bila važna kako bi se prisjetila onoga što joj je važno, uprkos tome što je neprijatno.

Urađena je i detaljnija konkretizacija postavljenog cilja („da se vratim životu od prije 2-3 godine, da ponovo budem ja ja, da nemam problem izaći iz kuće; da shvatim zašto mi se dešavaju ovi napadi.) “:

Da mi fokus bude u sadašnjem trenutku (A.B. govori kako zbog okupiranosti mislima koje ima ne zna da uživa u onome što joj se trenutno dešava, npr. putovanje u Santorini nije doživjela na pravi način, jer su joj misli o tome da li će joj sa stomakom biti sve u redu odvlačile pažnju).

Da izgradim veći prag tolerancije na frustraciju (lako se iznervira oko sitnica, npr. ako flaša ne stoji na svom mjestu, veliki bijes se u njoj probudi).

Staviti fokus na sebe i svoj život (zbog posla u kafiću, zapostavila je fakultet i svoju porodicu).

Sve ovo joj je važno kako bi imala bolji odnos sa ljudima, jer nekad ima osjećaj da je prijatelji „trpe“ zbog ponašanja, a ne želi da bude tako. Ta vrijednost bi se odnosila na bliske odnose. Potom joj je važno da ima više tolerancije i strpljenja za majku i brata, a ta vrijednost bi bila porodica. Partnerske odnose takođe navodi kao vrijednosti, jer želi da i oni potraju duže, a ne samo tri mjeseca kao do sada. Vježbanje tolerancije na frustraciju bi dosta pomoglo njenom zdravlju. Na kraju, sve ovo joj je važno kako bi se ostvarila u poslu i karijeri.

Peta seansa (26.01.2023.)

Na početku seanse provjera zadaće (4 puta sedmično, po 15 minuta radila vježbu pune svjesnosti; punu svjesnost u svakodnevnim aktivnostima vježbala dok je pila jutarnju kafu, te cijelu veliku šolju smanjila na pola šolje, jer ju je pila sa osjećajem, u toku ručka vraćala fokus na svjesno žvakanje hrane i prepuštanje ukusima). U toku ovog procesa, shvatila je kako tek sad počinje da doživljava Grčku i Santorini, te je određeni zvukovi, pjesme i miris vraćaju tamo. Ovakav osjećaj je oduševljava. Navodi kako je i okolina primjetila promjenu u njenom ponašanju, a i sama primjeti da se vraća sebi.

Postojao je jedan manji napad prošle sedmice, gdje je imala osjećaj gušenja, nakon čega je izašla vani, prošetala i fokusirala misli na ljude koji prolaze, nakon toga se vratila kući, uradila vježbu pune svjesnosti i napad je prošao.

Poboljšanje navodi i u pripremama za izlazak iz kuće, gdje svjesno nije htjela da jede kući, već vani (od čega ima strah jer ne zna kako će njen stomak na to odreagovati), a popila je i pivo koje dugo nije (smetalo je njenom stomaku).

Ispit koji je trebala imati juče, odgođen je za sutra, ali je subjektivno zadovoljna spremanjem istog, a vodila se onim što je diskutovano na prošloj seansi.

Na kraju je pohvaljena za to što zaista radi i primjenjuje sve ono o čemu se razgovara na seansama, osvijestila je i svoje lične resure, te obavlja akcije u skladu sa svojim vrijednostima. Zadaća do naredne seanse ostaje ista (vježbe pune svjesnosti i vježbanje pune svjesnosti u svakodnevnim aktivnostima).

Šesta seansa (01.02.2023.)

Na početku provjera zadaće, koja je bila kao i prošli put (2 puta je radila vježbu pune svjesnosti, a punu svjesnost u svakodnevnim aktivnostima nastavila je praktikovati dok pije jutarnju kafu, a počela je da to radi i sa cigarom, pa je primjetila da ih manje konzumira, zatim dok se vozila trolejbusom, ističe da se trudi da što više aktivnosti upije u sebe i doživi ih svjesno).

Položila je ispit, na čemu joj je čestitano, te su osviješteni njeni resursi. Držala se plana koji je osmišljen vezano za učenje i taj ispit.

U toku prošle sedmice imala je mali napad dok je bila vani, ali nije pobjegla, već je tu ostala i govorila je samoj sebi da joj se ništa neće desiti, te prebacila pažnju na drugu aktivnost. Ubrzo je onda to sve i prošlo. Bila je vani od 15h do 22h, što prije nije praktikovala (izuzev kad je radila), te joj to predstavlja veliki napredak.

Napravljen je plan za blisku budućnost:

- Raspitati se za diplomski, izabrati temu i početi već sad raditi, da bi do juna završila;
- Gledati oglase za posao (već je danas vidjela jedan za posao u struci, gdje će se prijaviti);
- Ukoliko ne pronađe na taj način posao, druga opcija je da počne raditi fizioterapiju sa drugom u Lukavici.

Klijentica izvještava poboljšanje, uživanje u aktivnostima koje su u skladu sa njenim vrijednostima, te navodi kako pomijera svoje granice svakodnevno.

Sedma seansa (07.02.2023.)

Na današnjoj seansi provjera zadaće na početku (vježbu pune svjesnosti radila svaki dan, po 15 minuta; vježbanje pune svjesnosti u svakodnevnim aktivnostima vježbala standardno kao i prehodnih sedmice, prilikom jutarnje kafe, doručka, ručka i slično).

Navodi jedan veći napad panike koji je juče imala u šoping centru. Takav veći napad se desio nakon dužeg perioda. Od simptoma navodi stezanje u prsima i ramenima, mučnina, osjećaj nestajanja, osjećaj da će umrijeti. Na skali od 1-10, ove simptome ocjenjuje sa 9-9.5. Ovakav osjećaj kod klijentice trajao je 30-40 minuta (mnogo duže nego inače, jer smatra da nije doživjela vrhunac panike). Subjektivno navodi poboljšanje u smislu reakcije i njenog ponašanja na napad.

Danas smo radile tehniku „Šta ako?“ (dekatastrofiziranje), upravo zbog klijenticine sklonosti katastrofiziranju. Prvo je obavljena edukacija o tehnici, a potom je analizirana sporna situacija. Klijentica je navela situaciju sa trudnoćom. Naime, bila je u strahu da je ostala trudna sa momkom sa kojim se povremeno viđa. Uradile smo sva tri dijela tehnike. Prvi dio (potrebno da klijent verbalizuje katastrofični scenario): „bilo bi strašno kada bi ostala trudna sa momkom sa kojim nisam u vezi; šta ako bi se slučajno desila vanmaterična trudnoća; šta ako bi trudnoća napredovala tako da abortus nije moguć, šta ako bi došlo do razvoja sepse jer ne bi prepoznala vanmateričnu trudnoću; kako reći svojima, njihova reakcija bi bila grozna; šta ako bi mi ginekolog rekao da sam trudna i da moram iznijeti trudnoću; šta ako se ne budem mogla povjeriti nikome; šta ako ne budem mogla primjetiti da sam trudna; šta ako ne budem mogla imati djecu zato što sam abortirala“. Drugi dio (ispitati unutrašnje i spoljašnje resurse koje klijent može upotrijebiti da bi izašao na kraj sa takvim scenarijom): snalažljivost, prilagodljivost, inteligencija, tri vrlo bliska prijateljska odnosa. Treći dio (razlikovanje riječi moguće od vjerovatno): za svaku od navedenih

misli i scenarija u prvom dijelu provjerena vjerovatnoća – zaključak je da vjerovatnoća svakog navedenog scenarija ili misli minimalna, skoro nemoguća.

Ova vježba se mnogo svidjela klijentici, jednostavna je i vrlo brzo osporava iracionalnosti, te navodi da će je praktikovati i u budućnosti. Pored standardne zadaće (vježbe pune svjesnosti i vježbanje pune svjesnosti u svakodnevnim aktivnostima), ima zadatak da osmisli situaciju koju će proći kroz sledeću tabelu (Tabela 4):

Tabela 4. Vježba – osmišljavanje situacije.
Table 4. Exercise - designing the situation.

| Katastrofični scenario | „Šta ako?“ rečenica | Šta bih mogla u tom slučaju da uradim? | Kolika je vjerovatnoća da ću npr. pasti na ispitu ako naučim predviđeno gradivo |
|---|---|---|---|

Ova tehnika takođe može da posluži klijentici da napravi planove kako bi se nosila sa određenim negativnim ishodima ili posljedicama kojih se plaši, što bi joj dalo doživljaj veće kontrole povodom te situacije i redukcije straha.

Osma seansa (13.02.2023.)

Zadaća pune svjesnosti praktikovana u toku protekle sedmice. Drugi dio zadaće odnosio se na tehniku „Šta ako“ i to je ovako izgledalo:

Tabela 5. Vježba – “Šta ako”.
Table 5. Exercise - "What if".

| **Katastrofični scenario** | **„Šta ako?“ rečenica** | **Šta bih mogla u tom slučaju da uradim?** | **Kolika je vjerovatnoća da ću npr. pasti na ispitu ako naučim predviđeno gradivo?** |
|---|---|---|---|
| Neću naći posao u struci. | Šta ako ne nađem posao u struci? | Mogla bih se prekvalfikovati | Moguće je, ali je malo vjerovatno, jer ne moram raditi samo u Sarajevu. |
| Neću moći zadržati partnera. | Šta ako ne budem mogla zadržati partnera? | Mogla bih se posvetiti sebi i postati najbolja verzija sebe | Minimalna |
| Doživjeću srčani ugrušak u krvi. | Šta ako se to desi? | Mogla bih to spriječiti zdravijim načinom života, smanjiti kafu i cigarete. | Minimalna, skoro nemoguće, jer sam prije mjesec dana radila nalaze krvi i idealni su. |
| Moraću u toalet u nekoj situaciji u kojoj nemam pristup istom. | Šta ako se ne budem mogla iskontrolisati? | Pronađem toalet. | Minimalna, jer je malo vjerovatno da u ovom vijeku ne mogu negdje pronaći toalet. |

Klijentica izvještava da joj ova tehnika ima dosta smisla, kao i sve ovo do sad što je primjenjivano u radu. Paničnih napada nije bilo u toku protekle sedmice.

Deveta seansa (21.02.2023.)

Na današnjoj seansi klijentica prepričava put za Beograd i način na koji je doživjela ovo putovanje. Imala je manje napade panike prije polaska, u autobusu i u Beogradu, ali su svi bili kratkotrajni, nije bježala iz situacije, te im ne pridaje veliki značaj. Trudila se da bude prisutna u svakom momentu i da doživi grad, za razliku od putovanja u Grčku. Upijala je svako dešavanje tamo i dopustila sebi da uživa. Navodi kako se dugo tako nije provela. Zaključeno je da je ovaj put došao kao izlaganje, u kojem je klijentica primjenila sve ono o čemu se govorilo na seansama i što je naučila u terapiji.

Danas je planirana tehnika paradoks pretjerivanja, koja je takođe u funkciji dekatastrofiziranja. Potrebno je da klijentica zamisli neku situaciju i njen najgori mogući

ishod/scenario, a zatim da taj scenario preuveliča do očigledno nerealnih razmjera. Preuveličavanje je potrebno navoditi sa naglašenim humorom, kako bi uvidjela besmislenost toga (bitno je da slika bude opisana živo i upečatljivo). Klijentica se nije mogla sjetiti trenutno takve situacije, iz tog razloga je taj zadatak dobila za zadaću. Primjer takvog scenarija poslan je klijentici, kako bi lakše mogla da uradi zadaću.

Deseta seansa (28.02.2023.)

Na današnjoj seansi provjerena zadaća sa klijenticom, odnosno tehnika paradoks pretjerivanja. Klijentica je navela dva primjera:

Slala je biografiju u jednu ordinaciju, međutim nisu joj odgovorili, pa joj je brat predložio da ode lično, što je klijentica doživjela veoma stresno (scenario: otišla sam u ordinaciju tražiti posao – odbili su me – ismijavali su me – ponižavali su me – objavili su me na svojoj stranici – završilo je u novinama – čitava država mi se smijala – nisam nigdje mogla naći posao – umrla sam od gladi);

Brat je nije podržao u odluci da radi posao koji nije u struci (scenario: suprostavila sam se bratu u vezi posla – nije me podržao u odluci – izvrijeđao me – prekinuo me finansirati – njegovo društvo me se odreklo – čitava porodica me se odrekla).

Na osnovu zadaće klijentica se uvjerila u besmislenost njenih misli i scenarija. Bilo joj je jako smiješno dok je sve ovo pisala. Ova tehnika joj je više pomogla od tehnike „Šta ako“, jer ide dosta dublje, ali smatra da svakako može kombinovati obe.

Ovo je deseta seansa, iz tog razloga je napravljen kratki rezime svega onoga što smo radile i provjereno su sa klijenticom očekivanja od terapije i šta joj je odgovaralo, a šta eventualno nije. Pored toga što je dobila nove uvide i osvijestila mnogo stvari, klijentica navodi kako joj je pomoglo to što na seansama može sve da kaže, bez uzdržavanja i što postoji objektivnost koju nema sa prijateljima i porodicom. Sve tehnike su joj pomogle, ne postoji tehnika koja joj nije odgovarala. Promjenu u ponašanju primjeti i njega okolina. Zadnjih 7 dana nije ni bilo napada panike. Primjetila je da su u poslednje vrijeme došle do izražaja emocije koje je dugo sakrivala, a smatra da je to zbog praktikovanja vježbi pune svjesnosti.

Na kraju, klijentici su pročitani početni ciljevi I doveli su se u vezu sa trenutnom situacijom, gdje je ona bila oduševljena, jer je dobila još jedan uvid u svoj napredak.

Jedanaesta seansa (14.03.2023.)

Na današnjoj seansi klijentica izvještava kako je pronašla posao u struci, u jednom masažnom salonu. Zadovoljna je svim uslovima, kao i kolegama. Danas joj je bio prvi dan, ali je naučila dosta novih stvari, što će joj biti značajno kasnije u radu. Pored toga, klijentica će imati obavezu i ispunjeno vrijeme, što će smanjiti pojavu katastrofičnih misli.

U toku prošle sedmice klijentica je poslala poruku da je dobila najjači panični napad do sada, gdje se nakon njega osjećala par dana loše, bila u grču i imala bolove u cijelom tijelu. Prvo je počelo sa bolom ispod rebra, a kada je taj bol prestao krenulo je plakanje, mučnina i osjećaj treperenja po cijelom tijelu. Napad se javio iznenada, ne postoji okidač. Ponovo je izvršena psihoedukaciju na šta ima direktan uticaj, na šta nema toliko direktan uticaj, a na šta nema uopšte. Uticaj uopšte nemamo na to kada se pojavi okidač za takvu reakciju u klijentici, zato što je to uslovljeno I odgovor je nervnog sistema. Djelimični uticaj se ima na uvid tog okidača koji se pojavljuje, te klijentica uviđa da je posmatrač okidača i reakcije u sebi. Potpunu kontrolu imamo jedino nad svojim ponašanjem.

Uprkos ovakvom napadu, klijentica izvještava da ih ipak mnogo bolje podnosi nego prije, te navodi svoju promjenu u kompletnom ponašanju. Iz tog razloga, ponovljeni su početni ciljevi rada kako bi klijentica osvijestila svoj napredak kroz konkretne primjere.

Dvanaesta seansa (21.03.2023.)

Na današnjem susretu klijentica je vraćena na prethodni napad panike, osviješteno joj je kako se njen odnos prema istom promijenio. Uvidjela je kako je to nešto na šta nema uticaj i kako ih svaki put preživi, kakav god da je intenzitet. Pored toga, objašnjeno joj je da panični napad posmatra kao nešto što ima svoj početak, vrhunac i završetak (popuštanje simptoma).

Pokrenuta je temu relapsa, o kojem se već govorilo, te su joj objašnjene i faze promjene i napredka. Jedna od početnih faza napredka u terapiji jeste edukacija. Sledeća etapa jeste promjena odnosa prema paničnom napadu, prvo na misaonom planu, tačnije da više to ne tretira kao katastrofu, već neprijatnost. Potom dolazi faza emotivne promjene, koja se kreće od paničnih napada koji su bili preplavljujući do toga da budu nelagodni. Na kraju slijedi izlaganje, gdje se na iskustvenim nivou mijenja odnos prema paničnom napadu.

Predloženo je da se terapija privede kraju, ukoliko nema novih tema i smatra da je spremna za to. Klijentica je bila saglasna, ističe da je i ona razmišljala o tome. Iz tog razloga održaće se još jedna seansa kako bi prodiskutovale o završnim testovima.

Trinaesta seansa (28.03.2023.)

Ovo je bila poslednja seansa sa klijenticom, na kojoj smo analizirale dosadašnji rad i testove. Na svim testovima postoji izuzetno poboljšanje i napredak. Klijentica izvještava da je već nakon mjesec dana osjetila promjenu, prvo u povećanju praga tolerancije na frustraciju, a onda je primjetila smanjenje napada panike. Pored toga anksioznost se značajno smanjila. Subjektivno navodi poboljšanje u svim oblastima.

Dogovoreno je da se javi ponovo na terapiju ukoliko bude imala potrebu.

Terapijski odnos

Terapijski odnos je bio otvoren, podržavajući i pun povjerenja. Klijentica je vrlo motivisana za rad, redovno je radila zadaću i poštovala svaki dogovor. Često je isticala kako joj ovaj odnos nudi objektivnost njenih osjećanja i ponašanja, a istovremeno se osjeća vrlo prijatno i opušteno.

Tehnike/procedure

Tehnike koje su se koristile u radu jesu sledeće: psihoedukacija o paničnim napadima, ACT matrica, tehnike defuziranja, vježbe pune svjesnosti I vježbanje svjesnosti u svakodnevnim aktivnostima, tehnika “šta ako”, tehnika “paradoks pretjerivanja”, te različite vrste metafora i dijeljenje ličnih iskustava. Pored toga, vrlo često je bila neophodna normalizacija i validacija klijenticinih osjećanja i ponašanja.

Prepreke/otpori

Nisu identifikovane nikakve prepreke ni otpori u radu. Seanse su se odvijale na sedmičnom nivou, u kontinuitetu. Zadaće su izvršavane na vrijeme, vrlo savjesno i detaljno. Dogovore je bilo vrlo lako uspostaviti i realizovati.

Prednosti

Može se zaključiti da je glavna prednost u radu sa ovom klijenticom bila njena spremnost i odlučnost na promjenu, koja se mogla uočiti već od prvog dana terapije. Riječ je o osobi koja ima dobre uvide, ali i vrlo lako postupa u skladu sa sopstvenim vrijednostima uprkos neprijatnostima. Odlikuje je izuzetna upornost.

Trajanje tretmana

Tretman je trajao tri i po mjeseca, tačnije u periodu od 14.12.2022. do 28.03.2023. godine. Seanse su se održavale na sedmičnom nivou, sa pauzom od 15 dana zbog praznika i odsustva klijentice i mene. Uspostavljen je dogovor da se javlja po potrebi, eventualno da se uvedu kontrolne seanse.

## ANALIZA I INTERPRETACIJA REZULTATA

Evaluacija tretmana

Prema dobijenim rezultatima, na osnovu evaluacije tretmana, kao I na osnovu promjena na bihejvioralnom nivou može se zaključiti da je klijentica ostvarila postavljene ciljeve. Klijentica obavještava o subjektivnom poboljšanju, te navodi bolje uvide i razumijevanje sopstvenih emocija te osvještavanje već postojećih resursa. Pored toga, pogled na panične napade je potpuno

promijenjen u odnosu na početak rada. Sklonost hipohondriji se smanjila, te sada mnogo više uživa u momentu i pripreme za izlazak iz kuće su se smanjile, a nekada ih i nema.

Takođe, na svim testovima klijentica pokazuje izuzetan napredak.

Upitnik prihvatanja i akcije – AAQII

Na ulaznom testiranju klijentica na ovom upitniku ostvaruje skor 37, a maksimalno je 49. Nakon sprovedenog psihološkog tretmana, sada skor iznosi 20, što govori da je došlo do znatnog poboljšanja u psihološkoj fleksibilnosti.

AAQII upitnik – 20 (završno)

Skala opšte samoefikasnosti – SGSE

Kod klijentice A.B. inicijalni skor iznosi 29, dok se završni u određenoj mjeri povećao i iznosi 31. To govori u prilog poboljšanju ličnog osjećaja samoefikasnosti kod klijentice.

SGSE upitnik – 31 (završno)

Upitnik za procjenu hipohondrije

Rezultat na polovini rada iznosio je 56, dok na završnom testiranju iznosi 51. Iz razgovora sa klijenticom može se zaključiti da postoji određeni napredak, jer više nema toliko potrebu da googla simptome, da izmišlja bolesti, postavlja sama sebi dijagnoze, čak iznosi da se počela smijati svemu tome.

UPH upitnik – 51 (završno)

Upitnik za ispitivanje opštih psihopatoloških teškoća - CORE

Inicijalnim testiranjem klijentica ostvaruje skor CORE 78 I CORE-R 87, dok se završnim testiranjem taj skor znatno smanjio na CORE 44 I CORE- R 51.

Tabela 6. Prikaz završnih rezultata na upitniku CORE.
Table 6. Presentation of the final results on the CORE questionnaire.

| | **Skor** |
|---|---|
| CORE F | 13 |
| CORE P | 32 |
| CORE W | 6 |
| CORE R | 7 |
| CORE | 44 |
| CORE - R | 51 |

Skala maladaptivnih shema – YSQ

Što se tiče rezultata na ovom upitniku inicijalnim testiranjem bili su prisutni visoki skorovi na sledećim shemama: emocionalna deprivacija, napuštenost, nepovjerenje, zavisnost, vulnerabilnost, subjugacija/podređivanje, samožrtvovanje, emocionalna inhibiranost, nepopustljivi standardi i nedovoljna kontrola/ LFT. Visoki skorovi na ovim dimenzijama mogu se povezati sa gubitkom oca, sklonosti ka izbjegavajućem obrascu ponašanja u partnerskim odnosima, kao i nedovoljnom tolerancijom na frustraciju.

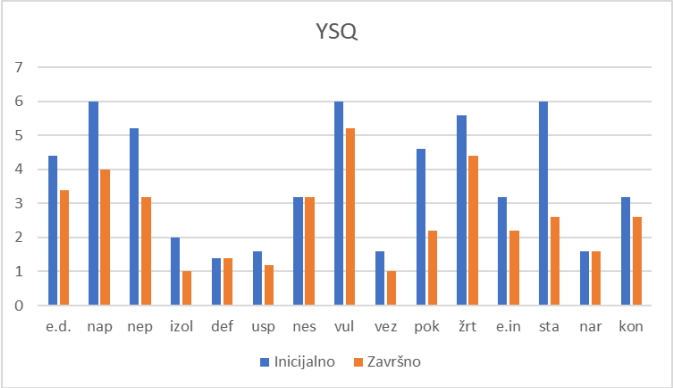
Na završnom testiranju, na svim dimenzijama su sniženi skorovi, a naročito na shemama od značaja. Upravo na ovaj način I klijentica izvještava napredak.

Symptom Check List (SCL – 90)

Iz tabele i grafikona može se zaključiti da na ovom upitniku ne postoje značajno visoki skorovi. Najveći skorovi prilikom inicijalnog testiranja bili su na dimenzijama O-K i anksioznost, što i jeste razlog javljanja na terapiju, međutim završnim testiranjem postoje znatna smanjenja. Pored toga, rezultati ostalih dimenzija završnim testiranjem su takođe smanjene.

Tabela 7. Prikaz završnih rezultata na upitniku YSQ.
Table 7. Presentation of final results on the YSQ questionnaire.

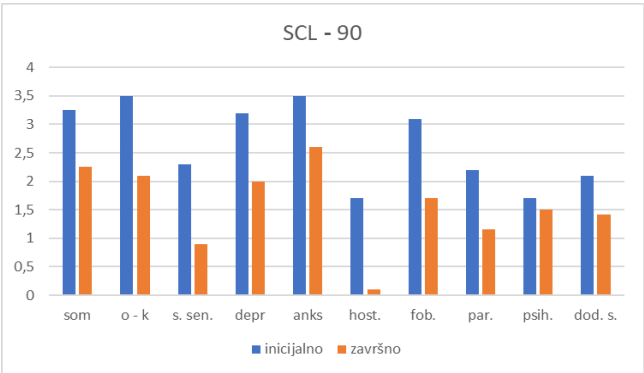
| | **e.d.** | **nap** | **nep** | **izol** | **def** | **usp** | **nes** | **vul** | **vez** | **pok** | **žrt** | **e.in** | **sta** | **nar** | **kon** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Inicijalno | **4.4** | **6** | **5.2** | 2 | 1.4 | 1.6 | **3.2** | **6** | 1.6 | **4.6** | **5.6** | **3.2** | **6** | 1.6 | **3.2** |
| Završno | 3.4 | 4 | 3.2 | 1 | 1.4 | 1.2 | 3.2 | 5.2 | 1 | 2.2 | 4.4 | 2.2 | 2.6 | 1.6 | 2.6 |




Grafikon 3. Prikaz završnih rezultata na upitniku YSQ.
Graph 3. Presentation of the final results on the YSQ questionnaire.

Tabela 8. Prikaz završnih rezultata na upitniku SCL – 90.
Table 8. Presentation of the final results on the SCL - 90 questionnaire.

| | som | o - k | s. sen. | depr | anks | host. | fob. | par. | psih. | dod. s. |
|---|---|---|---|---|---|---|---|---|---|---|
| inicijalno | 3.25 | 3.5 | 2.3 | 3.2 | 3.5 | 1.7 | 3.1 | 2.2 | 1.7 | 2.1 |
| završno | 2.25 | 2.1 | 0.9 | 2 | 2.6 | 0.1 | 1.71 | 1.16 | 1.5 | 1.42 |




Grafikon 4. Prikaz završnih rezultata na upitniku SCL – 90.
Chart 4. Presentation of the final results on the SCL - 90 questionnaire.

## DISKUSIJA ZAKLJUČCI

U ovom radu prikazan je tretman klijentice sa paničnim poremećajem u komorbiditetu sa hipohondrijom koji je sproveden u skladu sa načelima kognitivno-bihejvioralne terapije. Klijentica je naučila određene vještine i tehnike kako bi bila što spremnija za izlaganje onim situacijama koje je izbjegavala zbog straha od ponovljenih napada panike. . Pored toga, pogled na panične napade je potpuno promijenjen u odnosu na početak rada. Sklonost hipohondriji se smanjila, te sada mnogo

više uživa u momentu i pripreme za izlazak iz kuće su se smanjile, a nekada ih i nema. Takođe, na svim testovima klijentica pokazuje izuzetan napredak. Iz tih razloga ispunjena je hipoteza ovog kvalitativnog istraživanja, što ide u prilog analizi i interpretaciji rezultata. Budući da su ostvareni svi ciljevi koji su bili postavljeni može se zaključiti da je tretman bio uspješan.

Primjenom širokog spektra kognitivnih i bihejvioralnih tehnika, klijentica je postepeno učila da smanji osjećaj napetosti i intenzitet anksioznog doživljaja pri novim situacijama. Takođe, klijentica je potpuno promijenila percepciju u odnosu na hipohondriju. Istovremeno, preispitujući iracionalna uvjerenja i stavove koji su zaslužni za održavanje anksioznosti, mijenjala se pogrešna slika o ličnim resursima, kapacitetima I njenim kompetencijama. Tokom ovog terapijskog tretmana potvrđena je efikasnost kognitivno-bihejvioralne terapije u tretmanu paničnog poremećaja u komorbiditetu sa hipohondrijom.

Kako bi se održao postignuti napredak, neophodno je klijente podsticati da se angažuju u aktivnostima koje su od značaja za njihov svakodnevni život, odnosno sa aktivnostima koje su u skladu sa njihovim vrijednostima. Na taj način doprinosi se jačanju ličnih kompetencija, što dugoročno pomaže u borbi sa simptomima anksioznosti I napadima panike.

Kognitivno-bihejvioralna terapija jedna je od najčešće primjenjivanih i najistraživanijih metoda terapije, što potvrđuju i rezultati ranije sprovedenih istraživanja. Njena temeljna pretpostavka jeste da ljudi pripisuju značenja različitim događajima iz okoline, a kada su ta značenja iskrivljena mogu postati uzroci poremećaja. Ovaj rad je pokušao pružiti uvid u najuticajnije savremene kognitivno-bihejvioralne pristupe kroz prikaz konkretnog slučaja.

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# CASE REPORT OF COGNITIVE-BEHAVIORAL THERAPY OF PANIC DISORDER IN COMORBIDITY WITH HYPOCHONDRIA

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**ABSTRACT**

Cognitive-behavioral therapy is a science-based principle that research shows is effective for a wide range of problems. The therapist and client work together to identify and understand the problem in terms of the relationship between thoughts, feelings and behavior. The approach is usually focused on the „here and now“ difficulties. The problem to be approached must be precisely defined, as well as the goal to be worked on during the therapy. The development of this approach went through three waves: the first represented behavioral therapies based on classical and operant conditioning, the second were cognitive therapies based on changing cognitions and social learning, and the third were "mindfulness" therapies based on acceptance and full awareness. This paper presents a case of panic disorder in a 22-year-old girl, with the use of cognitive-behavioral therapy (CBT), especially the third wave (ACT). The paper describes the plan and course of treatment, with appropriate techniques. An essential characteristic of panic disorder is repeated attacks of severe anxiety that are not limited to a particular situation or set of circumstances and are therefore unpredictable. Panic anxiety refers to situations where there is no objective danger. Comorbidity refers to the psychiatric disorders in the same person, regardless of the time and relationship between the occurrence of these disorders.The treatment lasted three and a half months, divided into thirteen sessions. All set goals were achieved, and the client reports on subjective improvement. The assessment of the effect of the implemented cognitive-behavioral treatment was done on the basis of clinical evaluation, as well as standard questionnaires for psychological assessment, namely: AAQII, SGSE, CORE, YSQ, SCL-90 and UPH.

**Keywords**: cognitive-behavioral psychotherapy (CBT), panic disorder, case report, comorbidity, hypochondria.

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# PSYCHEDELIC DRUGS AND PSYCHOLOGY

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**ABSTRACT**

Scientific interest in psychedelic drugs has increased exponentially over the past decade. Just in the last few years, small controlled clinical trials examining the potential therapeutic utility of psilocybin-assisted therapy in patients suffering from anxiety, depression, and substance abuse have reported extremely positive outcomes. Hallucinogen has perhaps been most widely used in scientific literature and is the legal designation used to classify these substances in many countries. Unfortunately, it also is a misnomer because these compounds rarely evoke true hallucinations and do not normally impair reality testing. Furthermore, a wide range of psychoactive substances, including cannabinoids, dissociative anesthetics, anticholinergics, and entactogens such as MDMA, can produce "hallucinogenic" effects. Hence, LSD-like drugs are often referred to as classical hallucinogens or serotonergic hallucinogens in order to distinguish them from other drug classes.

**Keywords:** psychedelic drugs, LSD, MDMA, hallucinogen.

## What are psychedelics?

The term psychedelic was first coined by the British psychiatrist Humphrey Osmond in conversation with the author Aldous Huxley in 1956. Osmond had introduced Huxley to the cacti-derived psychoactive drug mescaline in 1953, after which Huxley wrote the classic book The Doors of Perception to Heaven and Hell. Their research and their personal accounts with mescaline, and later with lysergic acid diethylamide (LSD), contributed to the then revolutionary idea in the psychiatric community that changes in mental states are due changes in neurochemistry. Humprhey and Huxley engaged in a quest to replace terms that were previously used for these compounds, such as psychotic-mimetic (i.e. psychosis mimicking compounds) or hallucinogen (i.e. hallucination-inducing compounds), with a new term that they intended to be "more inclusive": a term that would not solely describe their ability to elicit psychosis-like symptoms or hallucinations, but also their ability to evoke experiences that have psychodynamic, aesthetic and spiritual significance.

The word psychedelic was derived from combining the Greek words psyché, meaning "mind" or "soul", with dêlos, meaning "to manifest" or "to make visible". It refers to the notion that these compounds can bring into the awareness a wide spectrum of latent psychological content, that can both strongly positive or negative in emotional valence – hence the idea that they let the individual who takes them "fathom hell or soar angelic". Osmond presented the term "psychedelic" for the first time at a scientific conference in 1957 (Osmond, 1957), and Huxley illustrated this view in an elaboration on his personal experience with mescaline, in 1954, in his book The Doors of Perception: *"But what I had expected did not happen. I had expected to lie with my eyes shut, looking at visions of many-colored geometries, of animated architectures, rich with gems and fabulously lovely, of landscapes with heroic figures, of symbolic dramas trembling perpetually on the verge of the ultimate revelation. But I had not reckoned, it was evident, with the idiosyncrasies of my mental make-up, the facts of my temperament, training, and habits." (Huxley, 1954, The Doors of Perception, pp.3)*

Drugs considered "classic" psychedelics include lysergic acid diethylamide (LSD), psilocybin (the major psychoactive constituent of magic mushrooms), mescaline (a psychoactive constituent of peyote and San Pedro cacti) and DMT (a major psychoactive ingredient in the Amazonian brew

ayahuasca). All these compounds share the property of stimulating the serotonin 2A receptor (Vollenweider et al. 1998; Aghajanian, & Marek, 1999).

**Psychedelics in modern times**

Although Europe is home to various psycho-active plants and psilocybin-containing mushrooms, knowledge about psychedelics in modern times only started to break through into mainstream science in the first half of the 20th century. Some argue that the infamous witch-hunts spanning the 15th to the 18th century in Europe played a role in eradicating ceremonial psychedelic-plant use (Rudgley, 2014). The sudden rise in interest in psychedelics in the 20th century was catalyzed by (1) the birth of ethnopharmacology, and (2) the discovery of LSD.

One of the most significant contributions for the former may be the work of Richard Evans Schultes. Via more than 450 publications in the early- and mid-20th century, Schultes increased awareness within the western scientific community about the traditional usages of various psychedelic plants around the world (Schultes et al., 2001).

The discovery of LSD centers around Albert Hofmann and his work in Sandoz laboratories in Basel, Switzerland (Hofmann, 1980). In search of a novel blood circulatory stimulant, Hofmann synthesized a range of derivatives from ergot alkaloids in 1938, one of which being LSD-25. On April 16$^{th}$, 1943, Hofmann accidentally intoxicated himself while reassessing his earlier works with LSD. He felt dizzy and went home. Three days later Hofmann intentionally ingested 250 mcg of LSD, to test whether it was this drug that caused the symptoms he experienced earlier. What he believed would be a miniscule dose, turned out to be what is now known as 10 times the amount of a threshold psychoactive dose. Hofmann described his experience as both frightening and fascinating. After reassurance of his physiological health by his doctor, he described how he experienced “an uninterrupted stream of fantastic pictures, extraordinary shapes with intense, kaleidoscope-like play of colors". But it was what he experienced the day after that that provided an inspiration for the many therapeutic investigations that would soon follow. Hofmann describes in his autobiography that he woke up the next day with a remarkable mental clarity, and wrote:

*“A sensation of well-being and renewed life flowed through me. The world was as if newly created. All my senses vibrated in a condition of highest sensitivity.” (Hofmann 1980, LSD: My Problem Child, pp.15).*

Soon LSD was actively marketed under the name “delysid” to psychiatrists and researchers, as an adjunct for psychotherapy and as a tool to study psychosis.

**The function of therapeutic experiences**

Despite earlier reports on mescaline, it was the discovery of the psycho-active effects of LSD in 1943 that sparked a great international interest in the therapeutic potentials of psychedelics. Busch and Johnson (1950) were the first to report on the therapeutic use of LSD, describing the effects of LSD as increasing the patient’s “expressiveness” and as “permitting re-examination of significant experiences of the past, which were sometimes relived with frightening realism” (Busch and Johnson, 1950). This was the beginning of numerous experiments on the therapeutic usage of psychedelics, culminating into an estimated 40 000 patients with mood- and addiction disorders to have been treated with LSD and other psychedelics by the late 1960s (Grinspoon, & James, 1981).

Psychiatrists who performed these experiments noticed that psychedelics could produce diverse types of experiences across patients and sessions. The characteristic perceptual effects of psychedelics are well recognized, but it was other effects, in particular the effects on the individual’s emotionality, that ignited the strongest motivation amongst psychiatrists to consider their therapeutic utility. These observations inspired the hypothesis that psychedelics work by weakening the usual psychological defense-mechanisms (also referred to as “ego dissolution”), and thereby uncover (usually “repressed”) emotions, memories, and thoughts. It was believed this effect of psychedelics would “speed up” psychotherapy. Eisner and Cohen (1958) reported that under LSD “frequently whole sequences unroll before the patient's eyes as though they had been stored on microfilm” (Eisner, & Cohen, 1958). Feld et al. (1958) concluded from their observations that "LSD-25 has the astonishing quality of bringing into focus the patient's repressed emotional

attitudes, conflicts, etc., and permits their re-activation" (Feld et al., 1958). Abramson (1956) remarked that "emotions hitherto camouflaged were brought out, without the intense guilty fears that had kept them submerged" (Abramson, 1956). And Kurland et al. (1971) wrote:

*"The major dimension of drug-altered reactivity with therapeutic relevance is the affective or emotional sphere: intense, labile, personally meaningful emotionality is uniformly produced, with periodic episodes of overwhelming feeling." (Kurland et al., 1971, "Psychedelic LSD Research." pp.6)*

Researchers often pointed out the apparent unpredictability and diversity of the emotional effects engendered by psychedelics, and the challenges this brought for therapeutic work. LSD was found to be able to produce states of profound well-being, as well as states of immense anxiety; tranquil states of mind, as well as those riddled with confusion and paranoia; moments filled with intense euphoria, as well as episodes of explosive anger (Terrill, 1962). These observations fueled the emerging view in the psychiatric community that these compounds can produce psychosis-like symptoms. Corresponding to this view, in a series of initial clinical trials, LSD was administered to patients with severe alcoholism with the intention to experimentally induce a "psychosis-like state". It was thought that the LSD-state would to a large extent resemble the alcoholism-induced psychosis, Delirium Tremens (DT), and the hypothesis was that this experience would produce a "psychological shock" that would frighten patients away from their drinking behavior (Osmond, 1957).

The outcomes of these experiments did, however, not confirm this hypothesis. First, compared to DT, LSD was found to differ markedly in its capacity to produce a "nebulous sense of wonderment", an increased "aesthetic appreciation" of music and art, an increased perception of "new values", and "a sense of quiet meditation" (Ditman, & Whittlesey, 1959). Secondly, out of the variety of experiences LSD could produce, it was not negative or "frightening" experiences that were associated with clinical improvements, but rather the opposite. Patients who showed the strongest improvements were described to have a certain type of experience that was characterized by such enhanced feelings of "wonder" and a sense of "transcending" their usual sense of self. Unger (1963) stated:

*"Nearly invariably, whenever dramatic personality change has been noted following the use of these drugs, it has been associated with this kind of experience, that is one called transcendental or visionary" (Unger, 1963, "Mescaline, LSD, Psilocybin, and Personality Change a Review." Psychiatry 26, pp.111-25).*

And Terrill (1962) noted:

*"When therapeutic changes did occur, they were often of a qualitatively different order than those which occur in traditional psychotherapy. Under the influence of LSD, the individual goes through highly intense and unusual experiences which may very well change the way in which he views life" (Terrill, 1962, The Nature of the LSD Experience.: The Journal of Nervous and Mental Disease." L. W. W. 135 (5): 425–39).*

Psychedelics were found useful by psychiatrists not only for their acute psychological effects, but in particular for their capacity to facilitate enduring therapeutic change after the session, ranging from weeks, months, or longer (Terrill, 1962; Unger, 1963; Kurland et al., 1971). The type of experience under LSD that was found to promote such therapeutic changes most reliably, was argued to exhibit this "self-transcending" quality (Kurland et al., 1971). It was these experiences that were thought to allow the individual to obtain a sudden shift in perspective on themselves, charged with emotionality, motivating a change in behavior accordingly. The general consensus arose that it was not the drug, but the experience that the drug can facilitate, which is therapeutic (Hoffer, 1965). By the mid-1960s, researchers identified the types of experiences that were considered most therapeutic, and these can be roughly classified into two main categories (Schmiege, 1963):

1) Autobiographical experiences: characterized by an emotional "release" or "catharsis", the experience of vivid and emotionally charged personal memories and insights into one's own personal life. These experiences were often interpreted within a psychodynamic framework.

2) Peak experiences: characterized by a sense of dissolving or transcending one's sense of usual self, culminating into a sense of union, and feelings of bliss and spirituality. These experiences are sometimes also referred to as "spiritual-type experiences", "mystical-type experiences", or "psychedelic-peak experiences", and were often interpreted within a humanistic framework.

**Psycholytic therapy and psychedelic therapy**

At that moment in time, by the late 1960s, broadly speaking two different therapeutic approaches had evolved via which these views manifested into practice: the "psycholytic" method, mainly practiced in Europe, and the "psychedelic" method, mainly practiced in the United States. These approaches differed in the dosages administered, the amount of sessions conducted, and the structure of the sessions themselves (Grof, 1980):

1. Psycholytic therapy was characterized by lower dosages, with the intention to preserve sufficient "ego-functioning" for the patient in order to actively engage with the therapist during the sessions. Generally speaking, the primary goal here was to use the drug as an adjunct to psychotherapy, with the emphasis on facilitating "autobiographical experiences". Typically, patients underwent multiple psychedelic assisted therapy sessions to reach the therapeutic objectives. Music was often used in psycholytic approaches, but more frequently intermitted by conversations or periods of silence.

2. Psychedelic therapy was characterized by higher dosages, with the intention to dissolve "ego-functioning", and for the individual to "immerse" fully in the unfolding experience. The primary goal here was to facilitate a "peak experience" that would result in enduring changes in personality, mood, and behavior. Typically, patients underwent one or a small number of sessions, and would listen to music for the majority of the time during these sessions - often with eyes closed to increase introspection.

In practice, autobiographical- and peak experiences often co-occurred within both psycholytic and psychedelic methods, and within one session. A good example of this can be found in an excerpt from a case reported by Kurland et al. (1971), describing the treatment of a patient with alcoholism with a high dose of LSD (450 mcg). This excerpt demonstrates the use of various therapeutic elements, such as the significance of both autobiographical and peak experiences, and how the therapists utilize non-drug variables to provide adequate therapeutic support:

*"I was now very conscious of the fact that the music was creating variations of great beauty in my mind. It was such beauty that words can't describe it. The word "magnificent" kept running through my mind. I felt that I was being overwhelmed by beauty. I stated that I was undergoing the most magnificent experience of my life. By this point, I had lost all sense of time. What seemed like an eternity later, but possibly only a minute or so in actual time, I became aware that my mood had changed. I suddenly saw myself near the bottom of a huge filthy pit. It seemed to be bottomless and was crawling with horrible things such as octopi and enormous, odd, shaped frogs. I tried to crawl my way out of the pit and finally got near the top. Looking down, it was horrible - worse than I have ever visualized hell. Huge vats and casks containing whiskey were being poured into this slimy pit. It seemed that all the whiskey in the world was being dumped there. I began to cry. A feeling of deep guilt and remorse had come over me. The doctor had me sit up. In discussion with him, I realized the significance of this episode for my own experience with alcohol. After my crying spell, I felt relieved and cleaner inside.*

*Once again, I reclined on the couch. The music became more meaningful to me than anything I had ever heard before. A tremendous feeling of exaltation came over me. It kept growing in intensity. I felt rapture and ecstasy. Each moment I thought I had reached the zenith of rapture and joy; then the intensity and ecstasy would increase. It was overwhelming! There are no words to describe my feelings.*

*Then, while I was in this state, all became still and quiet. A sense of cleanliness and purity swept over me. I was alone and at peace. At this precise moment, I felt that all was holy and pure. I felt humble and insignificant. I was completely awed! It was the greatest, most magnificent experience of my life. I knew then that life has meaning and riches and rewards. I felt as though I*

*had been reborn. Probably never again will I undergo such an experience. But I don't care – once in a lifetime is more than any mortal can hope for. I then began to think about mankind in general. I realized that what I had experienced was potentially in everyone, and I felt compassion, warmth, and understanding for my fellow man. […] I cried. I remember wishing that my wife could be at my side, so I could tell her and show her how I now felt. I knew then that I had been throwing my life away, and that there was so much I could do to change things for the better." (Kurland et al., 1971, "Psychedelic Therapy Utilizing LSD in the Treatment of the Alcoholic Patient: A Preliminary Report." The American Journal of Psychiatry 123 (10): 1202–9).*

**Modern psychological and psychotherapeutic research with psychedelics**

Compared with conventional pharmacotherapy (i.e., psychiatric medication), the strongest contrast is that in psychedelic therapy the aim is not to administer the compound repeatedly and continuously, but only on one or a few occasions, with the objective to facilitate sustained improvements (i.e., clinical remission that extends beyond the acute drug effects during the therapy sessions). Compared to conventional psychotherapy, the strongest contrast is, first of all, that a drug is administered, and secondly, that this drug has powerful acute subjective effects: The lengthily periods of introspection and intense emotionality facilitated by psychedelics do not merely aid the usual way psychotherapy is performed, but instead yield dramatic consequences on the way the therapeutic sessions are performed, including their structure, duration and the role of the therapists.

The views that led to the development of the procedures that characterize psychedelic therapy sessions in the 1950s and 1960s are to a large extent derived from direct clinical observations, case studies, or experiments that were not well-controlled. In addition, the practice was often informed by theoretical frameworks that are not always supported by sufficient scientific evidence. One example of this is psychodynamic hypotheses around ego-functioning, and the then-popular idea that psychedelics weaken "ego-defense mechanisms", resulting in a regression to an earlier emotional and intellectual mode of cognition. This has led to a therapeutic method that is construed from various concepts and assumptions that await empirical validation.

Addressing this is important, given psychedelic therapy receives an increasing amount of empirical support for its safety and efficacy, and is being implemented at increasingly larger scales in the years ahead (i.e., larger numbers of therapists and patients will be working within this therapeutic framework). Studies are therefore warranted that not only establish safety and efficacy of the procedures, but also scrutinize the assumptions inherent within these procedures and to further an empirically grounded development of the therapeutic working model.

**The variety of subjective effects of psychedelics**

Several modern studies have investigated acute subjective effects of psychedelics in healthy volunteers using questionnaires and behavioral experiments, demonstrating that they can occasion changes in perception, cognition, and emotion (Vollenweider et al., 1998; Carhart Harris et al., 2011; Kometer et al., 2012) and in a dose-dependent manner (Carhart-Harris et al., 2011; Hasler et al., 2004; Griffiths et al., 2011). The acute subjective effects of psychedelics are often assessed via the altered state of consciousness questionnaire (ASC), that measures changes in distinct factors of conscious experience (Dittrich, 1998; Studerus et al., 2010). One major factor of effects of psychedelics are changes in perception, including different sensory modalities (i.e., visual, auditory, tactile) (Studerus et al., 2011; Schmid et al., 2015; Carhart-Harris et al., 2016), but also changes in the perception of time (Wittmann et al., 2007; Wackermann et al., 2008). Imagination is often reported to be highly vivid, and eyes-closed imagery of an "elementary" nature (i.e., colors and patterns) and of a "complex" nature (i.e., concrete objects, landscapes, or entities) are both common (Carhart-Harris et al., 2011; Schmid et al., 2015; Studerus et al., 2011).

Cognitive- and behavioral experiments have demonstrated that impaired attention (Carter et al., 2005) and response inhibition (Quednow et al., 2012) after psilocybin, enhanced divergent thinking after ayahuasca (Kuypers et al., 2016), and increased spread of semantic activation under LSD (Family et al., 2016). Several studies have also assessed cognitive effects of psychedelics via

self-report questionnaires, showing increased cognitive disorganization (Carhart-Harris et al., 2016), disordered thinking (Studerus et al., 2011), muddled thinking (Carhart-Harris et al., 2011), and insightfulness (Carhart-Harris et al., 2016; Studerus et al., 2011; Studerus et al., 2012).

In an effort to reconcile the "paradoxical" capacity of psychedelics to induce both "positive" effects (positive mood, enhanced creative thinking, insightfulness, etc.) and "negative" effects (impaired cognition, muddled thinking, etc.), these cognitive effects of psychedelics have been conceptualized as a modulatory effect on cognitive flexibility (Carhart-Harris et al., 2016; Carhart-Harris et al., 2014). Indirect support for the view that psychedelics enhance cognitive flexibility comes from a study that demonstrates psilocybin increases switching rate when attending ambiguous stimuli (Carter et al., 2007), and a study that demonstrated increased divergent thinking under ayahuasca (Kuypers et al., 2016).

Together, these studies illustrate the diverse spectrum of subjective effects psychedelics can have. This variety was one of the motivations in the 1950s and 1960s, to try to exert some degree of control over the experience via, for example, utilizing nondrug variables. Some recent studies show support for this, demonstrating that acute drug effects can be predicted by several factors other than drug dose, including the mind-set of the individual, and the individual's personality traits (Studerus et al., 2012).

**The effects of psychedelics on emotion and mood**

The effect of psychedelics on emotionality was an important motivation to investigate their therapeutic potential, and modern studies have demonstrated that psychedelics increase emotionality via different research paradigms. Using mood rating scales, Hasler et al. (2003) showed significant increases in "emotional excitability" under psilocybin (Hasler et al., 2003), and Schmidt et al. (2015) demonstrated increases in "happiness" under LSD (Schmid et al., 2015). These findings were confirmed and corroborated by Dolder et al. (2016) who compared two separate dosing regimens (100 mcg and 200 mcg of LSD) and reported a dose response relationship for increases in emotional excitability (Dolder et al., 2016), confirming earlier observations of dose-dependency on emotionality (Studerus et al., 2011).

The study by Schmid et al. (2015) also showed socio-emotional effects after LSD, such as increased closeness, trust, and openness (Schmid et al., 2015). Dolder et al (2016) performed behavioral assessments targeting changes in socio-emotional information processing under LSD, and reported impaired recognition of fearful and sad faces, but enhanced emotional empathy (Dolder et al., 2016). Kometer et al. (2012) reported a comparable emotional information bias in a study showing that psilocybin produced a significant enhancement in positive mood and decreases accurate recognition of negative facial expression (Kometer et al., 2012). A study by Preller et al. (2016) may be interpreted along similar lines, by showing reduced feelings of social pain under psilocybin within in a behavioral social exclusion task (Preller et al., 2016).

**The effects of psychedelics on ego-functioning**

One major reported effect of psychedelics is a temporary dissolving of boundaries between self (i.e., the "me") and object (i.e., the "not me"). This effect has been referred to as disturbed ego-functioning, ego-disintegration, or ego-dissolution, and was emphasized by many early researchers as an important underlying mechanism via which psychedelics may work therapeutically. It has recently been argued that, because of this effect, psychedelics represent an opportunity to study the mechanisms via which the human brain produces a coherent sense of self or ego (Carhart-Harris, & Friston 2010; Lebedev et al., 2015).

Earlier questionnaire studies have also indicated prominent effects of psychedelics on ego-functioning, in particular via high ratings on the distinct ASC factor "oceanic boundlessness", defined as "positively experienced derealization and depersonalization" (Dittrich, 1998; Studerus et al., 2010), and via increased ratings for "impaired control and cognition" (Schmid et al., 2015), an important marker for disturbed ego-functioning. Finally, ego-dissolution has been related to enhanced suggestibility under LSD (Carhart-Harris et al., 2014) – an effect that has also been prominently hypothesized in early research as a potential therapeutic action of psychedelics.

**The capacity of psychedelics to facilitate autobiographical experiences**

The capacity of psychedelics to facilitate autobiographical experiences has not given much attention yet in modern research. Carhart-Harris et al (2011) demonstrated increased vividness for autobiographical memories (Carhart-Harris et al., 2012), and ratings in questionnaires that relate to autobiographical experiences, such as "I saw scenes from my past" are shown to be enhanced under psilocybin (Carhart-Harris et al., 2011)

**The capacity of psychedelics to facilitate peak experiences**

Overall, pronounced subjective effects that are consistently reported include experiences of "blissful" emotions, a "sense of unity", and feelings of "spirituality" (Schmid et al., 2015; Studerus et al., 2011; Carhart-Harris et al., 2016), and these effects have been related to the ego-boundary dissolving effects of psychedelics (Nour et al., 2016). Although these studies suggest that psychedelics can produce subjective effects, that can be categorized under peak experiences, important work has been done by Griffiths et al. (2006; 2008; 2011), who explicitly studied the occurrence of peak experiences under psychedelics, and tested early hypothesis that these experiences are associated with sustained changes (up to months/years) in mood, behavior, and personality. The hallmark study of Griffiths et al. (2006) demonstrated that psilocybin is able to facilitate peak experiences (named by the authors as "mystical-type experiences") with sustained personal meaning, in individuals who have never taken a psychedelic drug before (Griffiths et al., 2006). Subsequent studies replicated these findings and associated these experiences with enduring positive changes in outlook, personality, and behavior (Griffiths et al., 2008; Griffiths et al., 2011)

72% of the participants who received psilocybin for their first time reported the experience to be in their top 5 of most meaningful experiences in their lives, and 65% reported improved well-being 14 months afterwards. MacLean et al. (2011) showed that only those individuals who experienced a strong, or "full" mystical-type experience, as defined by the Mystical Experience Questionnaire (MEQ), presented a significant increase in the personality trait "openness", 14 months after the experience (MacLean et al., 2011).

These studies provide support for the hypothesis brought forth by earlier research that psychedelics can facilitate peak experiences and support the view that peak experiences are associated with sustained positive changes. In addition, the studies showed that enduring positive changes can be instantiated by administering psilocybin only once or on a few occasions, and that these changes can occur in constructs, such as personality traits, that are normally considered stable in adulthood.

**Clinical trials with psychedelics**

In recent years, a number of clinical studies have focused on the treatment of addiction- and mood disorders, and end-of-life care, using psychedelic therapy. Studies for psychedelic therapy for treating addiction have been implemented for tobacco-dependence and alcohol dependence (Johnson et al., 2014; Bogenschutz et al., 2015). Johnson et al (2014) conducted an open-label pilot study to the efficacy of psilocybin-assisted psychotherapy for smoking cessation and included 15 participants that had an average of six previous quitting attempts, and who smoked on average of 19 cigarettes per day for 31 years. The study showed that 12 of 15 participants (80%) completely abstained from smoking at a 6-month follow-up (Johnson et al., 2014), and 10 of 15 participants-maintained abstinence at 12-month follow-up (Johnson et al., 2016). At the 12-month follow-up, 13 participants (86.7%) rated their experience with psilocybin to be "among the five most personally meaningful and spiritually significant experiences of their lives" (Johnson et al., 2016). Furthermore, the participants who rated high on measures for mystical-type experiences, personal meaning, and spiritual significance, also showed the strongest sustained reductions in craving (Garcia-Romeu et al., 2014), supporting the hypothesis that positive therapy outcomes are mediated by peak experience.

Bogenschutz et al (2015) performed the first open-label pilot study to test safety and efficacy of treating ten patients with alcohol-dependence with psilocybin (Bogenschutz et al., 2015).

Patients showed a significant increase in drinking-abstinence following psilocybin, and these reductions were maintained at a 36-week follow-up. The general intensity of drug-effects during the psilocybin experience significantly predicted reductions in drinking and in craving 5 weeks later. Finally, Krebs and Johanson (2012) performed a meta-analysis on studies using LSD to treat alcoholism in the 1950s and 1960s, including six studies describing the treatment of 536 patients, and showed improvements up to 6 months after one dose of LSD (Krebs, & Johansen 2012).

There are two open-label pilot studies that have assessed safety and efficacy of the use of psychedelics to treat major depression, one using the DMT-containing Amazonian plant-brew ayahuasca (Osório et al., 2015) and one using psilocybin (Carhart-Harris et al., 2016). Osorio et al. (2015) administered ayahuasca to six patients with mild to severe depression and showed significant reductions in measures for depression up to 21 days after administration. Carhart-Harris et al (2016) administered psilocybin to patients with treatment resistant depression, who were in treatment on average of 18 years, and showed a 67% response rate (n=8) at 1 week after treatment with psilocybin, of which seven patients met the formal criteria for remission. Seven patients (58%) maintained their response for up to 3 months after the experience and five patients (42%) remained in full remission (Carhart-Harris et al., 2016).

Another application of psychedelic therapy concerns its use in end-of-life care, to improve quality of life in patients diagnosed with a terminal illness, by treating co-morbid diagnosis of anxiety-disorders and distress. Grob et al (2011) administered psilocybin to twelve subjects with advanced-stage cancer who had a diagnosis of acute stress or anxiety disorder due to their illness (Grob et al., 2011). The study showed significant improvements in mood at 6 months' prior the experience, but the effect-size was small, nor did the outcomes correlate with measures for peak experiences (Grob et al., 2011). The authors argue that the findings may reflect the relatively low dose that was used (0.2 mg/kg), compared with dosages used by Griffith et al. (2006; 2008; 2011) (approx. 0.5mg/kg). Gasser et al. (2014; 2015), provided two psychedelic therapy sessions with LSD to patients with end-of-life anxiety, and showed significant reductions in trait and state anxiety at the 2 month and 12-month follow-up (Gasser et al., 2014; Gasser et al., 2015). The authors note, however, that only 3 out of 8 patients in the experimental group reduced anxiety-measures to a level below the diagnostic cut-off (Gasser et al., 2014). In a separate 12-month follow-up study, Gasser et al. (2015) reported that 66.7% reported that LSD facilitated access to emotions, deepened introspection, and insights, and changed personality and values. The authors note that the observed therapeutic changes were "mainly dependent on a related encompassing of emotional experiences" (Gasser et al., 2015). The most comprehensive studies towards the efficacy of psychedelic therapy in end-of-life care are two recent double-blind placebo controlled clinical trials (Griffiths et al., 2016; Ross et al., 2016). Griffiths et al. (2016) showed acute improvements after high-dose sessions (30 mg/70 kg), with 80% of the 51 participants showing clinically significant decreases in depressed mood and anxiety at the 6-month follow-up (Griffiths et al., 2016). Ross et al. (2016) demonstrated clinically significant reductions in depression or anxiety after one dose of psilocybin (0.3 mg/kg) that sustained in 60–80% of participants at the 6.5-month follow-up (Ross et al., 2016).

Finally, in a small open-label pilot-study, Moreno et al. (2006) administered psilocybin to nine patients with obsessive compulsive disorder (OCD). Symptom severity was measured at baseline and at 4-, 8- and 24-hours post-administration. All subjects demonstrated acute reductions in symptoms, ranging from 23% to 100% reduction. Compared to baseline, at 24- hours post-administration 88.9% maintained a reduction in symptoms equal or larger than 25%, and 66.7% maintained a reduction in symptoms equal or larger than 50% (Moreno et al., 2006).

**Safety and efficacy of psychedelics**

The results of these clinical studies show promising prospects. Although the sample-sizes are small, the fact that remission and abstinence has been maintained for long periods after a single or a few sessions, is "unheard of" in psychiatry (Bogenschutz, & Johnson, 2016). Particular notice must be given to the severity of the conditions of the patients in these studies, such as long-term

drug-dependency (Johansen, & Krebs, 2015; Johnson et al., 2014) or treatment-resistance (Carhart-Harris et al., 2016).

Another important contribution of these pilot-studies is their demonstration of safety within patient populations. So far there are no adverse events reported, apart from temporary anxiety and thought confusion in some volunteers during the sessions. Needless to say, although the current data suggests a good safety-profile, the strict selection criteria and small study population sizes may have influenced these findings, and studies in larger populations are warranted. But the emerging picture suggests that psychedelics can be safely administered when appropriate guidelines are adhered to. Indirect support for the safety profile of psychedelics comes from meta-analyses that showed mental health complications following psychedelic drug use amongst users to be rare (i.e., no evidence for increased rates of mental health problems in populations who use psychedelics) (Krebs, & Johansen, 2013; Johansen, & Krebs, 2015).

## CONCLUSIONS

"We are all here to experience happiness," Albert Hofmann liked to say when asked about the meaning of life. His answer sounds so simple and easy, like the Socratic imperative to "Know thyself!"

Imagine taking a medicine that alters your mind and facilitates the generation of new thoughts and new ways of looking at the world. Imagine taking a medicine that facilitates solving problems of life, be they personal or professional. Imagine taking medicine for the purpose of spiritual prophylaxis, the cleansing of the spirit that has been clogged up by life.

When we expand our consciousness, we liberate ourselves from the slavery that is inherent in all cultural and institutional systems. The slavery derives from repetition of daily life until the behavior becomes institutionalized, thereby creating culture. Rigidified, institutionalized culture is the ultimate peer pressure, which stifles, dominates, and controls both creativity and consciousness expansion. Once a person ingests a psychedelic medicine and experiences the Deep Within and expanded consciousness, there is no going back to narrow consciousness and constricted thinking. What has been seen cannot be unseen. Once we experience alternate realities, we can never again say this is the only one reality. When we experience ourselves as electrochemical beings of light, as molecules stuck together taking material form, our lives take on new meaning.

Psychedelic medicine can facilitate our using the power of the mind to change our very genetic structure. We can change the slings and arrows of outrageous genetic misfortune into a Cupid's bow of a sculpted self.

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# STRESS AND AUTOIMMUNE DISEASES

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## ABSTRACT

The continuation of life depends on the ability of an organism to maintain a state of dynamic equilibrium or homeostasis. Homeostasis is constantly disturbed by entropic forces, the stressors: the state of threatened homeostasis is called stress. A complex set of behavioral and physical reactions the adaptive response is employed by the organism to reestablish balanced physiological conditions. In antiquity, Hippocrates regarded health as harmonious balance of the four key elements of life – water, fire, air, and earth – and defined states of imbalance among these elements as disease. He also described the adaptive response as the "healing power of nature." (Chrouses, & Gold, 1992).

The actual term stress was originally adopted from physics by Hans Selye. In physics, it describes the resistance of a body to applied pressure, following Hook's law of elasticity. An acting force may distort a body elastically in linear fashion or, if applied excessively in quality, quantity, or time, may produce nonlinear deformations. Similarly, stress may be a transient and time – limited responses of the organisms, whereas the physiological and behavioral defense mechanisms, rendering them inefficient or deleterious.

Unraveling the mechanisms and pathways that the immune system uses for communication between its various parts has proven to be fascinating and complicated endeavor that is far from completion. Studies of the structure and function of the immune system have produced information that can provide investigators with important lessons in psychoneuroimmunology. Indeed, education is an integral component of the function of the immune system; once the immune system has encountered an antigen, instructions are given so that the experience will be remembered.

Stress plays an important role in individual and species survival, but it also participates in the development and aging of every individual. The quality, intensity, and duration of stress are important in determining the positive or negative effects on the organism. There are two main condition of the stress system that led to pathology: an excessive and prolonged or a defective adaptive response to a stressor. In both cases, the dose – response relation between the potency of a stressor and the adaptive response of the organism is shifted to the left or right respectfully. There are pathological conditions of the stress system leading to disease and, vice versa, disease that alter the activity of the stress system in pathological fashion.

**Keywords**: stress, autoimmune diseases, pathology.

## INTRODUCTION

It is frequently assumed that psychological stressors are a concern of especially modern origins, or at least that they have become more prominent with recent advances in society and technology. It is commonly assumed that with the accelerating progress of civilization, more and more people are afflicted with mental and physical disorders. Historical accounts, however, suggest that such ideas about stressors, civilization, and disease have been common for quite some time.

The tendency to view life in stressful terms may be even more basic to human condition than is readily apparent. The Greek myth of Sisyphus is enlightening in this regard. The perpetual work of pushing a boulder up a mountain - only to have gravity bring it back down after each and every effort - captures some of the qualities and characteristics linked to modern views of psychological stressors. Perhaps there is something fundamental about human condition and psyche that fosters a

perception of the world as a place rife with unrelenting demands that can never be fully met, resulting in subjective states of fatigue and distress, and eventually leading to ill health.

Stress plays an important role in individual and species survival, but it also participates in the development and aging of every individual. The quality, intensity, and duration of stress are important in determining the positive or negative effects on the organism. There are two main condition of the stress system that lead to pathology: an excessive and prolonged or a defective adaptive response to a stressor. In both cases, the dose – response relation between the potency of a stressor and the adaptive response of the organism is shifted to the left or right respectfully. There are pathological conditions of the stress system leading to disease and, vice versa, disease that alter the activity of the stress system in pathological fashion. The adaptive response to stress has three components. First, stress has to be sensed. Sensory neural and hormonal pathways have developed to connect the outside world and the rest of the body to the central nervous system. Hypersensitivity or hyposensitivity to stressors may cause disproportionate responses, resulting in pathology. Therefore, disorders characterized by altered perception of signals to the stress system cause insufficient responses to natural challenges, with the consequent development of secondary disease. The second component covers the calculation and integration of the information input, and the third component covers the response. The activation of these stress system is necessary to overcome homeostasis – threatening events, but excessive and prolonged activation may be self-destructive.

**What is stress?**

Structures that include components of a network of neural and endocrine responses that are activated adaptively during stress have been collectively called the stress system. The central components of the stress system are located in the hypothalamus and the brain stem, the phylogenetically speaking oldest parts of the brain. These centers receive information inputs of internal and external origins and compute the appropriate responses, which are affected by two main pathways: the endocrine hypothalamic – pituitary adrenal (HPA) axis and the neural systematic sympathetic – adrenomedullary (SA) and parasympathetic system. Their central regulators and peripheral end products, corticotrophin release hormone (CRH), glucocorticoids, and catecholamines, are key hormones in the reestablishment and maintenance of cardiovascular, metabolic, immune and behavioral homeostasis.

Stress is a phenomenon that has quite different meaning at different times under different circumstances for different individuals. Stress is a function of three main interactive and often interdependent variables: 1) excitability/arousal; 2) perceived aversiveness and 3) uncontrollability.

Psychological stress can lead to adverse immunological changes providing one psychological pathway through which major and minor life changes might result in and increased incidence of infectious and malignant diseases. However, most individuals who experience major life changes do not become ill, or they only experience short illness episodes. Actual organically based episodes of illness are a function of differential exposure to pathogens and/or carcinogens, genetics, as well as the prior health of the individual, particularly immune function.

The adrenal cortex produces glucocorticoids in response to stressors through the hypothalamic-pituitary axis. Individuals with an adrenocortical insufficiency such as Addison's disease have physiological difficulty handling stress. In addition, an overabundance of glucocorticoids during stress also can have major physiological consequences. Research on the relationships among central nervous system (CNS), immune system and endocrine system provide evidence of physiological pathways, including the glucocorticoids, and other "stress hormones" such as the catecholamines, prolactin, and growth hormone, through which distress may modulate immune function.

The definition proposed by the distinguished Berkley psychologist, Richard Lazarus is perhaps apposite for many stressful situations in man – that is, "a condition or feeling experienced when a person perceives that demands exceed the personal and social resources the individual is able to mobilize." Hans Selye, sometimes called the "father of stress", coined, and defined "stress" as "the nonspecific response of the body to any demand." For some, Selye's definition is "too

biological" and ignores cognitive and psychological factors, a criticism that seems to stem from the misconception that cognition is not a function of the brain. For others, Selye's definition is too general. However, Selye's publication show that he understood psychological or cognitive stress. Furthermore, the generality of Selye's definitions makes it pertinent for the molecular, genotypic, and phenotypic analysis of stress and stress responses across all species from bacteria to man.

Selye (1956, 1974) adopted a physiological approach to conceptualizing stress. Based on his research, he formulated General Adaptation Syndrome (GAS), a sequence of physiological response that occurs when humans and animals experience stress. He also observed that the GAS response occurs in three stages which he identifies as alarm, resistance, and the stage of exhaustion. There were serious limitations to this GAS model. Psychologists and behavioral scientists questioned Selye's exclusive emphasis on physiological process, finding his explanation restrictive, reductionist, and in some sense, tautological. Consequently, the concept of stress has been re-examined from a more psychological perspective, stimulating a broader conceptual framework, and leading to definitions of stress as a psycho-physiological process (e.g., Cox, 1978; Fisher, 1986; Lazarus, 1990).

The contribution of Walter Bradford Cannon, working at Harvard in the 1920s and 1930s, are arguably of equal importance for our understanding of the stress response. Thus, Cannon first proposed the term homeostasis (from Greek homoios, or similar, and stasis, or position) for the coordinated physiological processes that enable the organism to cope with the stressful challenge by maintaining or quickly restoring steady state within the organism (Cannon, 1930). Cannon also coined the term "fight or flight" to describe an animal's response to threat. Homeostasis, "stability through consistency", which has dominated physiological and medical thinking since 1859 (Claude Bernard's "milieu interieur") seems in several circumstances (e.g., work-induced increase in cardiovascular load) to be giving way to allostasis, which provides "stability through change." Homeostasis depends on negative feedback control system: allostasis refers to dynamic maintenance of homeostasis by appropriate central nervous regulation of the cybernetic set points that adjust physiological parameters to meet various stress/challenges.

**Autoimmune diseases**

Autoimmune diseases arise when one's immune system actively targets and destroys self-tissue resulting in clinical disease. Common examples include Systematic Lupus Erythematosus, Type 1 Diabetes, Rheumatoid Arthritis and Multiple Sclerosis. While different in clinical features and may involve different origins the underlying mechanism is the failure of the immune tolerance of the adaptive immune system. The immune system is designed to protect us from foreign pathogens such as viruses and bacteria, and in particular the adaptive immune system mounts antigen specific attack on targets. The underlying mechanism that enables recognition and response to unknown targets is the generation of antigen receptors on lymphocytes through process of random gene recombination. A negative consequence of this process is the generation of self-reactive receptors capable of responding to self-antigens and causing pathology. Although the number of mechanisms such as clonal deletion and other immune regulation are in place to eliminate or counter the action of these self-reactive clones, several known factors can interfere and breakdown these regulatory mechanisms.

Autoimmune disease can result when there is a failure of control mechanisms regulating the responses. It has been recognized for well over 100 years that there is an association between CNS and the immune system, as it relates to the development of autoimmune disease. One author reported on association between Multiple sclerosis (MS) and the appearance of affective disturbances. Since that time, many reports have appeared in the psychological literature attesting to the fact that the stress and psychological factors contribute to the appearance of exacerbation of human autoimmune disease. Obviously, any discussion of the contribution of human autoimmune disease does not lessen the importance of such factors as genetics, immunology aberrations, viral infections, drug interactions, or other environmental factors.

Systemic autoimmune diseases, such as systemic lupus erythematosus (lupus, SLE), rheumatoid arthritis and systemic sclerosis (scleroderma), occur in up to 5-8% of the human

population. Based on frequency of occurrence, they are the third most common diseases after cardiovascular pathologies and cancers. The overwhelming majority of cases of autoimmune diseases are in women (Fairweather, & Rose, 2004). Nowadays, great attention is paid to studying the impact of environment on the development of autoimmunity and autoimmune diseases. This is due to the increased influence of anthropogenic factors on the quality of human life. There is a good reason to suppose that repeated exposure of people to low doses of heavy metal compounds may promote the development of such diseases (Havarinasab et al., 2005). Humans can be exposed to these noxious substances from atmospheric pollution, food, cosmetics (Bagenstose et al., 1999; Bigazzi, 1998; Pelletier et al., 1994; Rowley, & Monestier, 2005), dental amalgams (Eneström, & Hultman, 1995; Guzzi et al., 2008; Pigatto, & Guzzi, 2010), thimerosal-containing vaccines (Mutter, & Yeter, 2008) and through the regular contacts with materials in manufacturing processes (da Costa et al., 2008).

Psychosomatic disorders were previously thought to be a separate group of disorders in which stress and psychological distress led to disease. Examples were peptic ulcer, arthritis, and dermatitis. It is now recognized that all diseases may have social, psychological, and behavioral aspects as well as physical organic features.

**Rheumatoid arthritis as an example of stress–related diseases**

Stress is now recognized as an important risk factor in the pathogenesis of autoimmune rheumatic diseases, including, rheumatoid arthritis (RA). The activation of the stress response system influences the close relationship between the hypothalamic – pituitary adrenal axis, the sympathetic nervous system, and the immune system. The quality of the relationship between patient and his family, along with other social factors, were found to be useful prognostic factors in patients with RA. Coping strategies are important for the daily routine and for the psychological wellbeing of chronic patients. They enable the patient to adapt to the problems and stressors arising from the disease, such as pain, fatigue, limitation in mobility, difficulties in daily life activities, and threats to the patient's self – esteem.

**Pathways Between Stress and the Immune System**

How could stress "get inside the body" to affect the immune response? First, sympathetic fibers descend from the brain into both primary (bone marrow and thymus) and secondary (spleen and lymph nodes) lymphoid tissues (Felten, & Felten, 1994). These fibers can release a wide variety of substances that influence immune responses by binding to receptors on white blood cells (Ader et al., 1995; Felten, & Felten, 1994; Kemeny et al., 1992; Rabin, 1999). Though all lymphocytes have adrenergic receptors, differential density and sensitivity of adrenergic receptors on lymphocytes may affect responsiveness to stress among cell subsets. For example, natural killer cells have both high-density and high affinity β2-adrenergic receptors, B cells have high density but lower affinity, and T cells have the lowest density (Anstead et al., 1998; Landmann, 1992; Maisel et al., 1989). Second, the hypothalamic–pituitary–adrenal axis, the sympathetic–adrenal–medullary axis, and the hypothalamic–pituitary–ovarian axis secrete the adrenal hormones epinephrine, norepinephrine, and cortisol; the pituitary hormones prolactin and growth hormone; and the brain peptides melatonin, β-endorphin, and enkephalin. These substances bind to specific receptors on white blood cells and have diverse regulatory effects on their distribution and function (Ader et al., 2001). Third, people's efforts to manage the demands of stressful experience sometimes lead them to engage in behaviors— such as alcohol use or changes in sleeping patterns—that also could modify immune system processes (Kiecolt-Glaser, & Glaser, 1988). Thus, behavior represents a potentially important pathway linking stress with the immune system.

Maier and Watkins (1998) proposed an even closer relationship between stress and immune function: that the immunological changes associated with stress were adapted from the immunological changes in response to infection. Immunological activation in mammals results in a syndrome called sickness behavior, which consists of behavioral changes such as reduction in activity, social interaction, and sexual activity, as well as increased responsiveness to pain, anorexia, and depressed mood. This syndrome is probably adaptive in that it results in energy

conservation at a time when such energy is best directed toward fighting infection. Maier and Watkins drew parallels between the behavioral, neuroendocrine, and thermoregulatory responses to sickness and stress. The common thread between the two is the energy mobilization and redirection that is necessary to fight attackers both within and without.

**Mechanisms of Stress Effects on the Immune System**

Virtually nothing is known about the psychological pathways linking stressors with the immune system. Many theorists have argued that affect is a final common pathway for stressors (e.g., S. Cohen et al., 1995; Miller, & Cohen, 2001), yet studies have enjoyed limited success in attempting to explain people's immune responses to life experiences on the basis of their emotional states alone (Bower et al., 1998; Cole et al., 1996; Miller et al., 1999a; Segerstrom et al., 1998). Furthermore, many studies have focused on the immune effects of emotional valence (e.g., unhappy vs. happy; Futterman et al., 1994), but the immune system may be even more closely linked to emotional arousal (e.g., stimulated vs. still), especially during acute stressors (S. Cohen et al., 2000). Finally, it is possible that emotion will prove to be relatively unimportant and that other mental processes such as motivational states or cognitive appraisals will prove to be the critical psychological mechanisms linking stress and the immune system (cf. Maier et al., 2003).

In terms of biological mechanisms, the field is further along, but much remains to be learned. A series of studies in the mid-1990s was able to show via beta-adrenergic blockade that activation of the sympathetic nervous system was responsible for the immune system effects of acute stressors (Bachen et al., 1995; Benschop et al., 1994). Apart from these findings, however, little is known about biological mechanisms, especially with regard to more enduring stressors that occur in the real world. Studies that have attempted to identify hormonal pathways linking stressors and the immune system have enjoyed limited success, perhaps because they have utilized snapshot assessments of hormones circulating in blood. Future studies can maximize their chances of identifying relevant mediators by utilizing more integrated measures of hormonal output, such as 24-hr urine collections or diurnal profiles generated through saliva collections spaced throughout the day (Bauman, & Grunberg, 1995; Stone et al., 2001). Future studies could also benefit from a greater emphasis on behavior as a potential mechanism. This strategy has proven useful in studies of clinically depressed patients, in which decreased physical activity and psychomotor retardation (Cover, & Irwin, 1994; Miller et al., 1999), increased body mass (Miller et al., 2002), disturbed sleep (Cover, & Irwin, 1994; Irwin et al., 1992), and cigarette smoking (Jung, & Irwin, 1999) have been shown to explain some of the immune dysregulation evident in this population. There is already preliminary evidence, for instance, that sleep loss might be responsible for some of the immune system changes that accompany stressors (Hall et al., 1998; Ironson et al., 1997).

**Last note on stress**

Stress is a real or percieved challange, either endogenonus or exogenous, that perturbs body equillibrium or homeostasis. The stressor may range from overcrowding traffic congestion, violence, bereavement, redundancy, or unemployment to physical, chemical, biological or psychological insults. Whether the person can adopt to or cope with the stress will depend of the nature and severity of the stressors and the person's physical and mental state, which in turn depends on genetic, experimental, social and enviormental factors.

Stress can shape various types of behavior in the individual long after exposure to the stressors itself has been terminated. It has become increasingly clear that stress serves as one of the main triggers for psychiatric and non-psychiatric disorders, including depression, anxyety, psychosis, drug abuse and dementia.

There has been a revolution in medicine concerning how we think about the diseases that now afflict us. It involves recognizing the interactions between the body and the mind, the ways in which emotions and personality can have a tremendous impact on the functioning and health of virtually every cell in the body. It is about the role of stress in making some of us more vulnerable to disease, the ways in which some of us cope with stressors, and the crucial notion that you cannot

really understand is the disease in vacuo, but rather only in the context of the person suffering from that disease.

We have come to recognize that vastly complex of our biology and our emotions, the endless ways in which our personalities, feelings, and thoughts both reflect and influence events in our body. One of the most interesting manifestations of this recognition is understanding that extreme emotional disturbances can adversly affect us. Put in parlance with which we have grown familiar, stress can make us sick, and a critical shift in medicine has been the recognition that many of the damaging diseases of slow accumulation can be either caused or made far worse by stress.

When we activate the stress – response out of fear or something that turns out to be real we congratulate ourselves that this cognitive skill allows us to mobilize our defenses early. And these anticipatory defenses can be quite protective, in that a lot of what the stress – response is about preparative. But when we get into a physiological uproar and activate these stress – responses for no reason at all, or over something we cannot do anything about, we call it things like „anxyety“, „neurosis“, „paranoia“ or „needless hostility“. Thus, the stress – response can mobilize not only in response to physical or psychological insults, but also in expectation of them. It is this generality of the stress – respons that is the most surprising – a physiological system activated not only by all sorts of physical disasters but by just thinking about them as well.

Stress response can become more damaging than the stressor itself, especially when the stress is purely psychological. This is a critical concept, becuase it underlines the emergence of much stress – related diseases.

There is no universal method for managing stress. Since stress is highly individual and depends on our life history and our interpretation of situation as threathening or nonthreatening, there is no method that can in any overall sense, manage stress effectively in the same way for everyone.

Stress has become a household word, and we are flooded with messages about how it can be prevented, eliminated, managed or just lived with.

## CONCLUSION

Autoimmune disorders are clearly heterogeneous conditions and have multifactorial etiologies. The role of psychosocial factors, particularly the influence of life events and personality dispositions, has been frequently investigated in relationship to disease onset and progression. Many of the early studies were retrospective and anecdotal. However, despite the limitations of the literature, psychosocial stress likely plays a role in the onset and course of autoimmune disorders, although the magnitude and direction of the effect may be variable across specific disorders and may depend on other individual characteristics. Research examining the role of psychosocial stress has been more extensive for some disorders, but not others. A great deal of research has been conducted in RA, which was originally viewed as one of the classic psychosomatic disorders.

What should be apparent by now is that for any disease, there are multiple factors that in different combinations can bring about the same type of abnormal function. The immune system is a key player because it can cause damage while responding to pathogens, other forms of tissue insult, or more directly in the form of autoimmunity. In addition, psychosocial factors, genetic characteristics, and exposure to nonliving aspects of the environment all play roles. All diseases reject the contribution of these factors, with temporal arrangements or configurations that can be relatively unique across individuals.

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# *MEDICAL SCIENCES*
# *MEDICINSKE NAUKE*

ORIGINALAN NAUČNI RAD – ORIGINAL SCIENTIFIC PAPER DOI: 10.7251/PIMZ2301579J

# UTICAJ METEOROLOŠKIH FAKTORA NA NASTANAK TEŠKIH AKUTNIH EGZACERBACIJA HRONIČNE OPSTRUKTIVNE BOLESTI PLUĆA: VREMENSKA SERIJA IZ NOVOG SADA, SRBIJA

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## SAŽETAK

Uvod: Promenljive vrednosti meteoroloških fakora mogle bi da imaju uticaj na nastanak akutne egzacerbacije hronične opstruktivne bolesti pluća (AEHOBP), ali je mali broj dostupnih studija koje su se bavile ovom tematikom. Cilj ove studije bio je da se ispita da li su ovakvi efekti prisutni kod bolesnika koji žive na teritoriji Grada Novog Sada, Srbija.

Metodologija: U ovoj vremenskoj seriji analizirane su istorije bolesti 552 bolesnika koji su hospitalno lečeni u Institutu za plućne bolesti Vojvodine zbog teške AEHOBP neinfektivne etiologije u periodu 2017-2022. Prikupljeni su podaci o prosečnim dnevnim vrednostima temperature vazduha, relativne vlažnosti vazduha, atmosferskog pritiska i brzine vetra na teritoriji Novog Sada za celokupan navedeni period. Za statističku analizu korišćen je *quasi-Poisson* generalizovani linearni model zajedno sa DLNM modelima.

Rezultati: Za svako povećanje vazdušnog pritska od 5 mBar relativni rizik (RR) za nastanak AEHOBP hospitalizacije iznosio je 0,80 (95% CI 0,441,46), za porast temperature od 5°C RR je iznosio 1,09 (95% CI 0,94-1,27), za porast relativne vlažnosti vazduha od 10% RR je iznosio 0,97 (95% CI 0,58-1,62) i za povećanje brzine vetra od 1 m/s RR iznosio je 1,06 (95% CI 0,51-2,21). U pojedinačim i kumulativnim lag-modelima, kao i multi-prediktorskim modelima takođe nisu nađeni statistički značajni rezultati.

Zaključak: U našem uzorku nije pokazana povezanost između meteoroloških faktora i teških AEHOBP. Neophodna su dodatna istraživanja koja će uključiti veći broj ispitanika sa različitih geografskih teritorija.

**Ključne reči**: temperatura vazduha, relativna vlažnost vazduha, atmosferski pritisak, brzina vetra, akutne egzacerbacije hronične opstruktivne bolesti pluća.

## UVOD

Hronična opstruktivna bolest pluća (HOBP) je heterogeno plućno oboljenje koje se karakteriše perzistirajućim respiratornim simptomima (otežano disanje, kašalj, produkcija sputuma) koji su posledica nastalih abnormalnosti disajnih puteva (bronhitis, bronhiolitis) i/ili alveola (emfizem), izazivajući hroničnu i često progresivnu opstrukciju protoka vazduha (Global Initiative for Chronic Obstructive Lung Disease [GOLD], 2023). HOBP je jedan od vodećih globalnih javnozdravstvenih problema s visokim stopama oboljevanja i umiranja, ali i velikim socijalnim i ekonomskim opterećenjem, čemu najveći doprinos daju akutne egzacerbacije HOBP

(AEHOBP). Iako se u literaturi može naći više definicija AEHOBP, većina njih se u osnovi zasniva na akutnom pogoršanju respiratornih simptoma koje je van uobičajenih svakodnevnih varijacija, zahteva primenu dodatne terapije, te doprinosi ubrzanom pogoršanju plućne funkcije i progresiji osnovne bolesti, većem broju hospitalizacija i smrtnih ishoda, povećanju troškova lečenja, kao i smanjenju kvaliteta života obolelih (Javorac et al., 2021).

Najčešći pokretač nastanka AEHOBP su bakterijske ili virusne infekcije (50-70%), mada se u ovom smislu sve više razmatra i uticaj neinfektivnih faktora iz životne sredine bolesnika, poput aerozagađenja i meteroroloških faktora (Crisafulli et al., 2018). Uticaj zagađujućih materija vazduha životne sredine na morbiditet usled AEHOBP je do sada ispitan u velikom broju studija čiji rezultati uglavnom ukazuju na negativne efekte i partikularnog (Pini et al., 2021) i gasovitog aerozagađenja (Qu et al., 2019) na nastanak AEHOBP. Sa druge strane, zastupljenost istraživanja koja su ispitivala uticaj meteoroloških faktora na nastanak AEHOBP je značajno manja u literaturnim izvorima. Čak i kada su sprovođena istraživanja u ovoj oblasti, naučnici su najčešće ispitivali efekat temperature vazduha, dok je uticaj drugih meteoroloških faktora, kao i sezonskih varijacija ovih faktora, značajno ređe ispitivan. Imajući to u vidu, cilj našeg istraživanja bio je da se utvrdi uticaj izlaganja određenim meteorološkim faktorima (atmosferski pritisak, temperatura vazduha, relativna vlažnost vazduha i brzina vetra) na nastanak teških AEHOBP (onih koje zahtevaju hospitalno lečenje) na uzorku pacijenata sa prebivalištem u Gradu Novom Sadu, Srbija.

## MATERIJAL I METODE

Ispitivanu populaciju činili su bolesnici koji su u periodu od 15.05.2017. godine do 15.05.2022. godine bili hospitalizovani u Institutu za plućne bolesti Vojvodine (IPBV) zbog AEHOBP. Uvidom u elektronske istorije bolesti ovih bolesnika (koristeći zdravstveni informacioni sistem *jZIS* koji je u upotrebi u IPBV), prikupljeni su osnovni sociodemografski podaci i informacije u vezi sa aktuelnom hospitalizacijom na osnovu kojih se moglo odrediti da li je u osnovi AEHOBP infektivni uzročnik ili ne (ukupan broj leukocita, neutrofila i limfocita, i vrednosti CRP (C-reaktivnog proteina) i fibrinogena u krvi pacijenata). U statističkoj obradi analizirane su samo one AEHOBP hospitalizacije za koje je utvrđeno da nisu bile uzrokovane infektivnim agensom.

Podaci o prosečnim 24-časovnim vrednostima ispitivanih meteoroloških faktora su javno dostupni i preuzeti su sa *web* stranice Republičkog hidrometeorološkog zavoda Srbije (www.hidmet.gov.rs), a na osnovu izmerenih vrednosti iz postojeće meteorološke stanice „Rimski Šančevi" na teritoriji Grada Novog Sada (45°20'N, 19°51'E, nadmorska visina 84m). Kako su kao pridruženi faktor u u modelima sa više prediktora korišćene i pojedine zagađujuće materije vazduha životne sredine, analizirani su i podaci o njihovim prosečnim 24-časovnim koncentracijama dobijeni od strane referentne institucije (Institut za javno zdravlje Vojvodine) koja vrši svakodnevna merenja na mernim stanicima na teritoriji Grada Novog Sada za Gradsku upravu za zaštitu životne sredine, kao i od strane Agencije za zaštitu životne sredine (SEPA), koja takođe vrši merenja na dve reprezentativne merne stanice na teritoriji Grada Novog Sada. Za potrebe ovog istraživanja analizirani su podaci sa stanica koje su lokalizovane na strateškim mestima u gradu tako da detektuju aerozagađenje koje potiče većinski od bliskog izvora zagađenja, odnosno saobraćaja (*urban traffic*, UT), odnosno koje detektuju bazično (prosečno) aerozagađenje unutar stambenih područja, poreklom od više različitih izvora zagađenja: individualna ložišta, industrija, saobraćaj, privreda (*urban background*, UB).

Za ispitivanja povezanosti izlaganja prediktorima (odabrani meteorološki faktori) sa ispitivanim kriterijumom (broj AEHOBP hospitalizacija neinfektivne etiologije), korišćen je quasi-Poisson generalizovani linearni model zajedno sa nelinearnim modelima sa distribuiranim kašnjenjem (*Distributed Lag Nonlinear Models*, DLNM) (Gasparrini, 2011), s obzirom da ovaj tip analize dozvoljava postojanje nelinearnih veza između prediktora i kriterijuma, ali i veza lag-ova (kašnjenja) i kriterijuma. Za svaki prediktor izračunat je kumulativni relativni rizik (eng. *relative risk* ili *risk ratio*, RR) za nastanak posmatranog kriterijuma pri svakom povećanju temperature vazduha od 5°C, relativne vlažnosti vazduha od 10%, vazdušnog pritiska od 5 mBar i brzine vetra od 1 m/s. Izračunate vrednosti RR su interpretirane u odnosu na postavljene referentne vrednosti

ispitivanih prediktora (0 za sve prediktore, osim vazdušnog pritiska gde je referentna vrednost 975 mBar).

Kako bi se utvrdio efekat kašnjenja (lag efekat), u analizi su prvo primenjeni modeli sa jednim prediktorom (*single-predictor* modeli) sa različitim danima kašnjenja (jednodnevni modeli zaostajanja – od lag0 do lag7 i modeli kumulativnog zaostajanja – od lags0-1 do lags0-7), pošto je moguće da je potrebno neko vreme da bi posmatrani prediktori iz spoljašnje sredine mogli da izazovu negativne zdravstvene efekte na respiratorni sistem. Na primer, lag0 odnosi se na srednje dnevne vrednosti ispitivanog meteorološkog faktora na dan kada se desio posmatrani kriterijum (hospitalizacija zbog AEHOBP); lag1 na vrednosti prethodnog dana i tako dalje. Slično tome, kumulativni lags0-1 predstavlja prosečnu vrednost posmatranog prediktora u tekućem i prethodnom danu, dok lags0-7 predstavlja prosečnu vrednost kriterijuma tokom prethodnih osam dana od momenta nastanka posmatranog kriterijuma. Uticaj efekata kašnjenja je u većini modela procenjivan kao nelinearan, s izuzetkom uticaja lag-a za brzinu vetra. Formule korišćene u single-predictor modelima su date u nastavku:

$$log(g[E(y_t)]) = \alpha + \beta VP_{t,l} + RDan + ns(Datum, df = 5), \quad (1)$$
$$log(g[E(y_t)]) = \alpha + \beta Temp_{t,l} + RDan + ns(Datum, df = 5), \quad (2)$$
$$log(g[E(y_t)]) = \alpha + \beta RVV_{t,l}. + RDan + ns(Datum, df = 5), \quad (3)$$
$$log(g[E(y_t)]) = \alpha + \beta BV_{t,l}. + RDan + ns(Datum, df = 5), \quad (4)$$

gde je $y_t$ – kriterijum (zavisna varijabla); $[E(y_t)]$ – očekivana vrednost zavisne varijable za određeni dan *t*; *log* – vezna funkcija (transformacije kriterijuma); α – odsečak (intercept); *β* – regresioni koeficijent za prediktor; VP – prosečna dnevna vrednost vazdušnog (atmosferskog) pritiska na određeni dan *t*; Temp. – prosečna dnevna vrednost temperature vazduha za određeni dan *t*; RVV – prosečna dnevna vrednost relativne vlažnosti vazduha za određeni dan *t*; BV – prosečna dnevna vrednost brzine vetra za određeni dan *t*; RDan – prediktor (radni dan ili vikend) za određeni dan *t*; ns(Datum) – prirodni splajn datuma u svrhu kontrole sezonskih faktora; df – stepen slobode.

Da bi se procenila stabilnost uticaja ispitivanih meteoroloških faktora na nastanak posmatranog kriterijuma iz *single-predictor* modela, korišćeni su modeli sa više prediktora (*multi-predictor* modeli). U *single-predictor* modelima se ne uzimaju u obzir ovakvi potencijalni udruženi efekti, dok je to moguće u *multi-predictor* modelima. Formula korišćena u multiprediktorskim modelima data je u nastavku:

$$log(g[E(y_t)]) = \alpha + \beta PM_{2,5}(UB)_{t,l} + \beta SO_2(UT)_{t,l} + \beta NO_2(UT)_{t,l} + \beta Temp._{t,l} + \beta RVV_{t,l.} + RDan + ns(Datum, df = 5), \quad (5)$$

gde je $y_t$ – kriterijum (zavisna varijabla); $[E(y_t)]$ – očekivana vrednost zavisne varijable za određeni dan *t*; *log* – vezna funkcija (transformacije kriterijuma); α – odsečak (intercept); *β* – regresioni koeficijent za prediktor; $PM_{2,5}$(UB) – prosečna dnevna koncentracija suspendovanih čestica dijametra ≤2,5 μm iz UB okruženja na određeni dan *t*; $SO_2$(UT) – prosečna dnevna koncentracija sumpor dioksida iz UT okruženja na dan *t*; $NO_2$(UT) – prosečna dnevna koncentracija azot dioksida iz UT okruženja na dan *t*; Temp. – prosečna dnevna vrednost temperature vazduha za određeni dan *t*; RVV – prosečna dnevna vrednost relativne vlažnosti vazduha za određeni dan *t*; RDan – prediktor (radni dan ili vikend) za određeni dan *t*; ns(Datum) – prirodni splajn datuma u svrhu kontrole sezonskih faktora; df – stepen slobode.

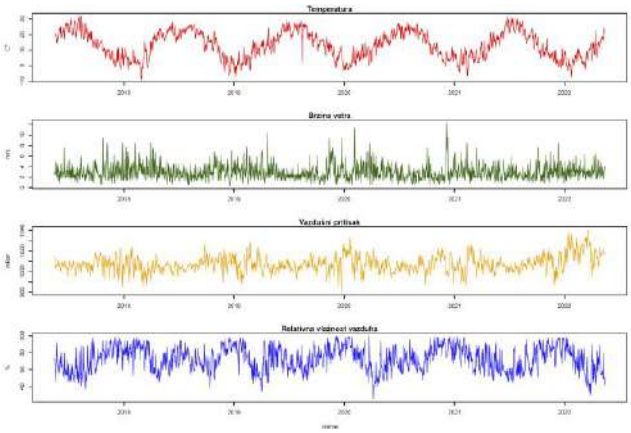
Ovo istraživanje je sprovodeno uz poštovanje etičkih načela Helsinške deklaracije, i odobreno je od strane Etičkog odbora (broj 115-IV/1, od 06.04.2021. godine) i Stručnog saveta (broj 113-III/1, od 06.04.2021. godine) Instituta za plućne bolesti Vojvodine.

## REZULTATI

Analizom medicinske dokumentacije utvrđeno je da je u ispitivanom petogodišnjem periodu bilo ukupno 2.957 prijema u IPBV zbog postavljene sumnje na AEHOBP (zbog bilo koje etiologije). Nakon što su iz analize isključene hospitalizacije za koje medicinska dokumentacija nije bila potpuna, hospitalizacije koje su bile indikovane zbog nekog drugog oboljenja koje se inicijalno manifestovalo slično kao AEHOBP, hospitalizacije pacijenata koji nisu imali mesto prebivališta na teritoriji Grada Novog Sada, kao i hospitalizacije za koje je utvrđeno da je u osnovi AEHOBP infektivni agens, došlo se do ukupnog broja od 552 hospitalizacije zbog teške AEHOBP koje su bile adekvatne za konačnu statističku obradu.

U ispitivanom uzorku pacijenata koji su hospitalizovani zbog AEHOBP, najzastupljenije su bile osobe ženskog pola (58,7%), pacijenti stariji od 65 godina (68,12%), kao i pacijenti sa dve ili tri pridružene bolesti (oko 64%), od kojih su najčešće bile kardiovaskularne bolesti (80,8%), zatim maligna oboljenja (16,12%), bolesti gastrointestinalnog trakta (15,76%), šećerna bolest (12,86%) i depresija (12,32%). Prosečna starost bolesnika prilikom prijema je iznosila 68,87 godina (SD ± 9,56). Samo 14% bolesnika iz uzorka je dalo podatak da nikada nisu konzumirali cigarete, dok je za one koji su aktivni ili bivši pušači prosečan broj paklo/godina iznosio 41,22 (SD ± 28,51, u opsegu 0-150).

Prosečna temperatura vazduha za navedeni vremenski period iznosila je 12,6°C (–8,90-31,80), vazdušnog pritiska 1008,87 mBar (979,40-1041,10), relativne vlažnosti vazduha 71,44% (25,00-100,00) i brzine vetra 2,9 m/s (0,30-12,40). Na Grafikonu 1 prikazane su vremenske serije sa prosečnim dnevnim vrednostima ispitivanih meteoroloških faktora.




Grafikon 1. Vremenske serije prosečnih dnevnih vrednosti meteoroloških parametara u ispitivanom petogodišnjem periodu.
Graph 1. Time series of average daily values of meteorological parameters in the examined five-year period.

Korelacije između različitih prediktora i posmatranog kriterijuma su prikazane u formi vrednosti Spearmanovog koeficijenta rang korelacije ρ, budući da varijable nemaju normalnu raspodelu. U Tabeli 1 se može uočiti da sa korekcijom ne postoji nijedna značajna korelacija posmatranih prediktora sa kriterijumom. Bez korekcije, značajne korelacije postoje (vazdušni pritisak i temperatura), ali su one ipak zanemarljive (vrlo mala veličina efekta).

Tabela 1. Matrica korelacija između broja AEHOBP hospitalizacija (uključujući efekte kašnjenja) i meteoroloških faktora (vrednosti u tabeli se odnose na izračunate koeficijente korelacije).
Table 1. Matrix of correlations between the number of AEHOBP hospitalizations (including delay effects) and meteorological factors (values in the table refer to calculated correlation coefficients).

| | BP | lag1 | lag2 | lag3 | lag4 | lag5 | lag6 | lag7 | VP | Temp. | RVV | BV |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| BP | | 0,01 | 0,04 | 0,04 | 0,07 | 0,00 | 0,05 | 0,03 | -0,04 | 0,03 | 0,01 | 0,02 |
| lag1 | 0,01 | | 0,01 | 0,04 | 0,04 | 0,07 | 0,00 | 0,05 | -0,03 | 0,03 | 0,02 | -0,01 |
| lag2 | 0,04 | 0,01 | | 0,01 | 0,04 | 0,04 | 0,07 | -0,01 | -0,02 | 0,04 | 0,01 | -0,04 |
| lag3 | 0,04 | 0,04 | 0,01 | | 0,01 | 0,04 | 0,04 | 0,07 | -0,03 | 0,04 | -0,01 | -0,02 |
| lag4 | 0,07** | 0,04 | 0,04 | 0,01 | | 0,00 | 0,03 | 0,04 | -0,06 | 0,05 | 0,00 | -0,02 |
| lag5 | 0,00 | 0,07** | 0,04 | 0,04 | 0,00 | | 0,00 | 0,03 | -0,05 | 0,04 | 0,02 | 0,03 |
| lag6 | 0,05* | 0,00 | 0,07** | 0,04 | 0,03 | 0,00 | | 0,00 | -0,05 | 0,05 | -0,01 | -0,01 |
| lag7 | 0,03 | 0,05* | -0,01 | 0,07** | 0,04 | 0,03 | 0,00 | | -0,05 | 0,04 | 0,01 | 0,04 |
| VP | -0,04 | -0,03 | -0,02 | -0,03 | -0,06* | -0,05* | -0,05* | -0,05* | | -0,33** | -0,01 | -0,13** |
| Temp. | 0,03 | 0,03 | 0,04 | 0,04 | 0,05* | 0,04 | 0,05* | 0,04 | -0,33** | | -0,58** | -0,17** |
| RVV | 0,01 | 0,02 | 0,01 | -0,01 | 0,00 | 0,02 | -0,01 | 0,01 | -0,01 | -0,58** | | -0,03 |
| BV | 0,02 | -0,01 | -0,04 | -0,02 | -0,02 | 0,03 | -0,01 | 0,04 | -0,13** | -0,17** | -0,03 | |

*Legenda:* BP – broj prijema zbog AEHOBP; VP – prosečna dnevna vrednost vazdušnog (atmosferskog) pritiska; Temp. – prosečna dnevna vrednost temperature vazduha; RVV – prosečna dnevna vrednost relativne vlažnosti vazduha; BV – prosečna dnevna vrednost brzine vetra; * - statistički značajan koeficijent korelacije na nivou p<0,05; ** - statistički značajan koeficijent korelacije na nivou p<0,01.

Za svaku promenu u posmatranim prediktorima izračunat je prosečni kumulativni RR (lags0-7) za nastanak teške AEHOBP neinfektivne etiologije koja zahteva hospitalizaciju. U ovakvom tipu statističke analize ne koriste se testovi značajnosti, ali se statistički značajnim rezultatom mogu smatrati one vrednosti RR kod kojih 95% interval poverenja ne obuhvata vrednost 1 (što je ekvivalento vrednosti p<0,05). Vrednosti izračunatih RR u *single-predictor* i *multi-predictor* modelima su date u Tabeli 2, gde se može uočiti da nisu dobijeni statistički značajni razultati ni za jedan od posmatranih prediktora.

Tabela 2. Prosečni kumulativni RR za nastanak teške AEHOBP neinfektivne etiologije pri odgovarajućoj promeni vrednosti ispitivanih meteoroloških faktora.
Table 2. Average cumulative RR for the occurrence of severe AEHOBP of non-infectious etiology with the corresponding change in the value of the investigated meteorological factors.

| Zavisna varijabla (kriterijum) | Prediktor | RR | 95% interval poverenja RR donja granica | gornja granica | Promena prediktora |
|---|---|---|---|---|---|
| | *Single-predictor modeli* | | | | |
| | VP | 0,80 | 0,44 | 1,46 | 5 mBar |
| | Temp. | 1,09 | 0,94 | 1,27 | 5°C |
| | RVV | 0,97 | 0,58 | 1,62 | 10% |
| | BV | 1,06 | 0,51 | 2,21 | 1 m/s |
| Broj prijema | *Multi-predictor modeli sa urban background aerozagađenjem* | | | | |
| | Temp. | 1,10 | 0,86 | 1,41 | 5°C |
| | RVV | 1,37 | 0,67 | 2,82 | 10% |
| | *Multi-predictor modeli sa urban traffic aerozagađenjem* | | | | |
| | Temp. | 1,17 | 0,93 | 1,46 | 5°C |
| | RVV | 1,6 | 0,77 | 3,30 | 10% |

*Legenda:* VP – vazdušni (atmosferski) pritisak; Temp. – temperatura vazduha; RVV – relativna vlažnost vazduha; BV – brzina vetra; RR – relativni rizik. Nema statistički značajnih rezultata.

U modelima sa jednim prediktorom, i u pojedinačim (od lag0 do lag7), kao i u kumulativnim (od lags0-1 do lags0-7) lag modelima, takođe nisu utvrđeni statistički značajni efekti promena vrednosti vazdušnog pritiska, temperature vazduha, relativne vlažnosti vazduha i brzine vetra na nastanak teških AEHOBP. U *multi-predictor* modelima, razmatrani meteorološki faktori su bili temperatura i relativna vlažnost vazduha, s obzirom da su oni pokazali statistički značajne efekte na neke druge posmatrane kriterijume (smrtni ishodi usled AEHOBP, rezultati nisu pokazani u ovom rukopisu). U modelima gde su kao pridruženi faktori posmatrane zagađujuće materije iz *urban background* ili *urban traffic* okruženja ($PM_{2,5}$, $SO_2$ i $NO_2$), nije pokazan statistički značajan efekat ni temperature ni relativne vlažnosti vazduha na porast broja AEHOBP hospitalizacija, kako u pojedinačnim, tako i u kumulativnim lag modelima.

## DISKUSIJA

Analizom prikupljenih podataka u našem istraživanju utvrđeno je da izlaganje bilo kom od posmatranih meteoroloških faktora (vazdušni pritisak, temperatura vazduha, relativna vlažnost vazduha i brzina vetra) nije ni povećavalo, niti smanjivalo rizik od nastanka AEHOBP hospitalizacija. Ovakvi rezultati, bez utvrđenog statističkog značaja, dobijeni su i u modelima sa jednim, i u modelima sa više posmatranih prediktora.

Pregledom dostupne literature je pronađen izvestan broj studija u kojima je prikazan efekat izlaganja određenim meteorološkim parametrima na nastanak AEHOBP, pri čemu je najveći broj studija bio usmeren na ispitivanje efekata temperature vazduha, dok su ostali meteorološki faktori ređe ispitivani. Međutim, generalno posmatrano, postoji mali broj vremenskih serija ili *case-crossover* studija u kojima je izolovano ispitivan efekat temperature vazduha na nastanak AEHOBP, već se ona uglavnom razmatra kao pridruženi faktor u modelima sa više prediktora (Song et al., 2022), ili prilikom analiziranja AEHOBP hospitalizacija u toku tople i hladne sezone, a na osnovu čega se mogu izvući indirektni zaključci o efektima temperature vazduha na nastanak teške AEHOBP (de Miguel-Díez et al., 2019). Međutim, da bi se precizno odredila povezanost između temperature vazduha i morbiditeta usled AEHOBP, potrebno je uzeti u obzir podatke o temperaturi vazduha tokom cele godine, a ne samo tokom trajanja tzv. tople ili hladne sezone. U većini takvih studija utvrđen je statistički značajan efekat niskih i/ili visokih temperatura na nastanak teških AEHOBP koje zahtevaju hospitalizaciju, mada su dostupne i one studije u kojima, kao i u našoj, negativni efekti izlaganja bilo kojoj vrednosti temperature nisu utvrđeni. Tako, u jednoj kineskoj studiji (Li et al., 2021), utvrđeno je da i ekstremno visoke i ekstremno niske temperature vazduha mogu da se dovedu u vezu sa povećanim kumulativnim rizikom od nastanka AEHOBP hospitalizacija, ali su jedino niže temperature vazduha (ispod 8°C) pokazale statistički značajan efekat; do sličnih rezultata su došli i istraživači u drugoj, takože kineskoj studiji (Zhao et al., 2019), gde je utvrđeno da je izlaganje niskim temperaturama vazduha udruženo sa statistički značajnim povećanjem kumulativnog rizika (lags0-7) za nastanak AEHOBP u poređenju sa visokim temperaturama, pri čemu je izračunati RR za ekstremno niske temperature (niže od 12,6°C) iznosio 1,12 (95% CI 1,01-1,24%), dok je za estremno visoke temperature (više od 30,3°C) RR takođe bio povišen (1,11), ali statistički neznačajan (95% CI 0,91-1,37). Negativni efekti nižih temperatura vazduha na nastanak AEHOBP prikazani su i u istraživanju koje je sprovedeno na Tajvanu (Wang, & Li, 2015), a u kom je utvrđeno da je kumulativni RR (lags0-7) za nastanak AEHOBP pri izlaganju nižim temperaturama vazduha (18°C) iznosio 1,08 (95% CI 1,01-1,14), pri čemu su ovi efekti bili izraženiji kod pacijenata mlađih od 65 godina u odnosu na starije pacijente, mada je u istoj studiji utvrđeno i da izlaganje visokim temepraturama vazduha (30°C) može uticati na povećan kumulativni rizik od nastanka AEHOBP (RR 1,07 (95% CI 1,03-1,11). Još jedna tajvanska studija je ukazala na neželjene efekte viših temperatura vazduha (Zafirah et al., 2021), u kojoj su žene sa HOBP starosti 40-64 godina imale statistički značajno povećan rizik od javljanja službama za pružanje hitne medicinske pomoći zbog AEHOBP prilikom izlaganja temperaturama vazduha od 27°C u trajanju od 4 dana (lags0-3), dok je najmanji rizik za nastanak HOBP (za oba pola i sve uzrasne kategorije) bio pri izlaganju temperaturama vazduha od 16°C. U studiji Lin i saradnika utvrđeno je da se svakim povećanjem temperature vazduha za 1°C iznad pražne vrednosti od 29°C povećava i rizik od hospitalizacija zbog AEHOBP za 7,6%, pri

čemu je efeakt povišenih temperatura vazduha trajao do 14 dana i bio izraženiji kod pacijenata starije životne dobi (Lin et al., 2009).

Patofiziološki mehanizam ili mehanizmi kojim bi se mogli objasniti negativni efekti nižih temperatura vazduha na nastanak AEHOBP još uvek nisu precizno definisani. Potencijalna objašnjenja uključuju povećan rizik od nastanka respiratornih virusnih infekcija u hladnijim uslovima, smanjeno bavljenje fizičkim aktivnostima na otvorenom tokom hladnijeg vremena, povećano lučenje sluzi u respiratornom epitelu, oštećenje epitela disajnih puteva sa posledičnim funkcionalnim i strukturnim remodulacijama, kao i direktni refleksni bronhokonstriktorni efekat niskih temperatura, što sve može dodatno uticati na pogoršanje već oštećene plućne funkcije kod ovih bolesnika i posledični nastanak AEHOBP (Song et al., 2022). Moguća objašnjenja efekata povišenih temperatura vazduha na nastanak AEHOBP mogu biti intenziviranje inflamatornog procesa u disajnim putevima, ali i hiperventilacija koja kod izlaganja visokim temperaturama vazduha predstavlja jedan od fizioloških mehanizama odavanja viška apsorbovane temeprature u spoljašnju sredinu, a koja može može pogoršati tegobe kod pacijenata sa HOBP usled nastanka dinamičke hiperinflacije i posledičnog poremećaja plućne funkcije; takođe, treba uzeti u obzir i mogućnost direktnih bronhospastičnih efekata visoke temperature vazduha (Anderson et al., 2013). Međutim, postoje i studije u kojima efekti niskih (Lee et al., 2019) i visokih temperatura vazduha (Zhang et al., 2020) nisu dovedene u vezu sa nastankom AEHOBP, kao što je to bio slučaj i u našem istraživanju, što sve govori u prilog činjenice da su neophodna dodatna istraživanja u ovoj oblasti.

Uticaj ostalih meteoroloških faktora na nastanak AEHOBP je retko ispitivan. Dostupni rezultati o efektima relativne vlažnosti vazduha su u velikoj meri heterogeni, tako da postoje dokazi o štetnom efektu povišenih (Tian et al., 2019), sniženih (Tseng et al., 2013), i povišenih i sniženih vrednosti relativne vlažnosti vazduha (Lam et al, 2018), ali i studije u kojima, kao i u našem istraživanju, relativna vlažnost vazduha nije imala efekte na pogoršanje HOBP (Zhang et al, 2020), zbog čega je teško izvući nedvosmislene zaključke o efektima relativne vlažnosti vazduha na nastanak AEHOBP. Isto se može reći i za efekte atmosferskog pritiska i brzine vetra na nastanak AEHOBP. U studiji Li i saradnika analizirani su efekti meteoroloških faktora na javljanje zdravstvenim službama zbog AEHOBP koja nisu zahtevala hospitalizaciju, pri čemu se rizik od nastanka AEHOBP statistički značajno smanjio pri porastu brzine vetra iznad vrednosti 4 mile/h (Li et al, 2021), dok u ranije pomenutoj tajvanskoj studiji (Tseng et al., 2013) brzina vetra nije statistički značajno uticala ni na porast ni na pad broja AEHOBP hospitalizacija, s tim da su veće vrednosti atmosferskog pritiska bile u pozitivnoj korelaciji sa povećanom stopom egzacerbacija. Takođe, u drugoj studiji sa Tajvana (Lin et al., 2018), utvrđeno je da snižene vrednosti atmosferskog pritiska tokom tople sezone predstavljaju značajan faktor rizika za nastanak AEHOBP – sa svakim porastom vrednosti atmosferskog pritiska od 1 hPa, smanjila se i verovatnoća nastanka AEHOBP (OR 0,84 (95% CI 0,74-0,96)).

Prilikom tumačenja naših rezultata neophodno je uzeti u obzir i određena ograničenja našeg istraživanja. Pre svega, statističkim analizama je obuhvaćen relativno mali broj AEHOBP hospitalizacija neinfektivne etiologije koje su poreklom iz jednog centra - moguće je da su usled manjeg broja ispitanika potcenjeni efekti pojedinih meteoroloških faktora. Nadalje, kako je ovo istraživanje bilo osmišljeno kao ekološka studija, korišćeni su podaci o prosečnim dnevnim vrednostima izabranih meteoroloških faktora koji su izmereni u jednoj (i jedinoj) meteorološkoj stanici na teritoriji Grada Novog Sada, uz pretpostavku da je celokupna populacija bila izložena ovim faktorima u istoj meri. Iako je ovo princip koji se koristi u većini vremenskih serija, upotreba ovakvog statističkog metoda sa sobom nosi i određen rizik pristrasnosti, jer opisano izlaganje ne odražava u potpunosti objektivnu individualnu izloženost meteorološkim faktorima. Takođe, u studiji nisu kontrolisani drugi promenljivi faktori koji bi mogli uticati na povezanost promena meteoroloških uslova i nastanka AEHOBP, poput uslova života, mogućnosti klimatizacije prostorija u kojima su pacijenti boravili pre hospitalizacije, aktivnosti svakodnevnog života i dužina vremena koju su proveli na otvorenom, specifičnost načina ishrane, socioekonomski status i sl. U našoj studiji je posmatrano kumulativno izlaganje prediktoru osam dana od dana prijema zbog AEHOBP, dok neka istraživanja ukazuju da lag efekti izlaganja pojedinim meteorološkim

faktorima (npr. temperaturi) mogu iznosti i do 30 dana (Tseng et al., 2013; Zhang et al., 2020), što je još jedno od potencijalnih objašnjenja rezultata našeg istraživanja. S druge strane, uzimajući u obzir da postoji mali broj studija koje su obrađivale ovu problematiku, naši rezultati nesumnjivo doprinose povećanju ukupne sume znanja o efektima meteoroloških faktora na nastanak AEHOBP. Takođe, prema našim saznanjima, u našoj studiji su prvi put izdvojeno analizirane hospitalizacije zbog AEHOBP neinfektivne etiologije, što našu studiju čini jedinstvenu u svetu. Uzimajući u obzir dokazanu povezanost između pojedinih meteoroloških parametara (pre svega temperature i relativne vlažnosti vazduha) sa nastankom respiratornih infekcija, moguće je da je sam dizajn naše studije doprineo dobijanju rezultate u kojima nije utvrđena statistički značajna povezanost izlaganja meteorološkim faktorima sa nastankom AEHOBP.

## ZAKLJUČCI

U ovom istraživanju nije dokazana povezanost između izlaganja određenim meteorološkim faktorima i nastanka teških AEHOBP neinfektivne etiologije. Uzimajući u obzir heterogenost rezultata u dostupnoj literaturi, neophodna su dodatna multicentrična istraživanja sa većim brojem posmatranih ishoda u cilju preciznije procene uticaja meteoroloških faktora na nastanak AEHOBP.

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# THE INFLUENCE OF METEOROLOGICAL FACTORS ON THE DEVELOPMENT OF SEVERE ACUTE EXACERATIONS OF CHRONIC OBSTRUCTIVE PULMONARY DISEASE: A TIME SERIES FROM NOVI SAD, SERBIA

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## ABSTRACT

Introduction: Variable values of meteorological factors may influence the development of acute exacerbations of chronic obstructive pulmonary disease (AECOPD), but there are few studies available on this subject. This study's objective was to determine whether such effects are existent in patients residing in Novi Sad, Serbia. Methods: In this time-series, the medical histories of 552 patients hospitalized at the Institute for Pulmonary Diseases of Vojvodina between 2017 and 2022 for severe AECOPD of non-infectious etiology were analyzed. For the entire period, data on the average daily values of air temperature, relative humidity, atmospheric pressure, and wind speed on the territory of Novi Sad were collected. For statistical analysis, a quasi-Poisson generalized linear model along with DLNM models were utilized. Results: For each increase in atmospheric pressure of 5 mBar, the relative risk (RR) for the occurrence of AEHOBP hospitalization was 0.80 (95% CI 0.44–1.46); for an increase in temperature of 5°C, the RR was 1.09 (95% CI 0.94–1.27); for an increase in relative air humidity of 10%, the RR was 0.97 (95% CI 0.58–1.62); and for an increase in wind speed of 1 m/s, the RR was 1.06 (95% CI 0.51–2.21). Individual and cumulative lag models, along with multi-predictor models, produced no statistically significant results as well. Conclusions: In our sample, there was no correlation between meteorological factors and severe AECOPD. There is a need for additional research involving a greater number of respondents from various geographic regions.

**Keywords**: air temperature, relative humidity, atmospheric pressure, wind speed, acute exacerbations of chronic obstructive pulmonary disease.

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# IZOPROTERENOL STRUKTURA, ANTIOKSIDATIVNA SVOJSTVA I INTERAKCIJE SA PROTEINIMA

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## SAŽETAK

Izoprenalin (izoproterenol) je neselektivan β-adrenerički agonist poznat po svojim terapeutskim efektima uključujući povećanu brzinu rada srca i srčane snage, bronhodilataciju i poboljšanu perifernu cirkulaciju. Pored svojih osnovnih funkcija koje ima u okviru nervnog sistema i regulaciji fizioločkih procesa, izoproterenol ispoljava i antioksidativna svojstva. U ovom istraživanju kombinovane su eksperimentalne tehnike (UV-Vis i FTIR spektroskopija) i teorijski proračuni (molekulski doking i DFT proračuni) da bi se ispitale strukturne i funkcionalne karakteristike izoproterenola. Odgovarajući nivo teorije (M05-2X/6-311++G(d,p)) je ustanovljen na osnovu poređenja eksperimentalno određenih i teorijski izračunatih vrednosti za dužinu veze i uglova u katjonu izoproterenola. Antioksidativna aktivnost izoproterenola prema $DPPH^{\bullet}$ je procenjena posredstvom UV-Vis spektroskopije. U poređenju sa svojim prirodnim analozima (epinefrin i norepinefrin), izoproterenol pokazuje energetski stabilnije ortosterično vezivanje za β-adrenergički receptor. Analiza molekulskim dokingom je otkrila da π-π kontakti sa aminokiselinama i vodonično vezivanje koje uključuje hidroksilne i aminokiselinske grupe igraju važnu ulogu u njegovom vezivanju. Ovo istraživanje unapređuje naše razumevanje antioksidativnih svojstava izoproterenola, pružajući uvid u njegov potencijalni značaj u uslovima povezanim sa oksidativnim stresom. Osim toga, strukturalni nalazi doprinose budućem razvoju novih terapijskih agenasa sa poboljšanom antioksidativnom aktivnošću i farmakološkim karakteristikama.

**Ključne reči**: izoproterenol, spektorskopske tehnike, molekulski doking, antioksidativna aktivnost, ortosteričko vezivanje.

## UVOD

Izoproterenol odnosno izoprenalin (ISO) je sintetički simpatomimetik koji stimuliše aktivnost simpatičkog dela autonomnog nervnog sistema (poboljšanje periferne cirkulacije, bronhodilatacija, tahikardija i stimulacija kontarktilnosti miokarda). Strukturno pripada kateholaminima, monoamini, sačinjenih od katehola i jedne amino grupe na alifatičnom nizu. Katehol (1,2-dihidroksibenzen ili orto izomer benzendiola) sastoji se iz benzenovog prstena čiji susedni atomi ugljenika imaju supstituisane hidroksilne grupe. Rastvorljivi su u vodi i 50% njih je vezano za protein u plazmi. Od adrenalina i noradrenalina razlikuje se samo za dve, odnosno tri alkil grupe vezane odmah u produžetku amino grupe alifatičnog lanca. Ubraja se u neselektivne β-adreneričke agoniste. β-adrenergički agonisti su vrsta supstanci ili lekova koji se vezuju za β-adrenergičke receptore u organizmu i izazivaju njihovu aktivaciju. β-adrenergički receptori su klasa receptora koji se nalaze na površini ćelija i reaguju na neurotransmitere epinefrin i norepinefrin. Kada se β-adrenergički agonisti vežu za ove receptore, oni oponašaju efekte epinefrina i norepinefrina, što dovodi do različitih fizioloških odgovora. Aktivacija β-adrenergičkih receptora može imati nekoliko efekata na različite organske sisteme u telu. U kardiovaskularnom sistemu mogu povećati srčanu frekvenciju, snagu srčanih kontrakcija i suziti krvne sudove, što dovodi do povećanja krvnog pritiska. U respiratornom sistemu mogu opustiti i proširiti bronhijalne cevi, olakšavajući disanje. Ova osobina se često koristi kod lekova za lečenje respiratornih stanja kao što je astma. Efekat na nervni sistem ispoljava se u povećanoj budnosti, pažnji i fokusu, jer aktiviraju određene puteve u mozgu. Metabolički efekti se uglavnom ogledaju u razlaganju glikogena u glukozu, što

dovodi do povišenih nivoa šećera u krvi. β-adrenergički agonisti se koriste u različite medicinske svrhe, kao što je lečenje astme, bronhitisa, srčanih stanja i određenih poremećaja u oftalmologiji. Takođe se mogu koristiti u medicinskim hitnim slučajevima, kao što je teška alergijska reakcija (anafilaksija) kako bi se brzo podigao krvni pritisak i povratio normalan srčani ritam. tj. izazivaju iste efekte kao i prirodni hormoni adrenalin i noradrenalin (Olmo et al., 2020).

Osim svojih osnovnih funkcija u nervnom sistemu i fiziološkoj regulaciji, ISO takođe pokazuje antioksidativna svojstva. U ovom istraživanju, fokus nam je bio na strukturi ISO, kako bismo procenili njegovu antioksidativnu aktivnost i istražili njegove interakcije sa proteinima. Koristili smo kombinaciju eksperimentalnih tehnika, uključujući spektroskopiju u ultraljubičasto-vidljivoj oblasti (UV-Vis) i infracrvenu (FTIR) spektroskopiju, zajedno sa teorijskim metodama izračunavanja kao što su molekulski doking (MD) i DFT (teorija funkcionala gustine). Antioksidativna aktivnost ISO u odnosu na 2,2-difenil-1-pikrilhidrazil radikala ($DPPH^{\bullet}$) procenjena je pomoću UV-Vis spektroskopije.

## MATERIJAL I METODE

### Hemikalije

Za eksperimentalni deo ove studije svi upotrebljeni rastvarači bili su „spektroskopskog stepena čistoće“, dok su ostale hemikalije bile p.a. stepena čistoće: Apsolutni etanol ($C_2H_6O$, p.a. ≥ 99.8%, CAS: 64-17-5, Zorka pharma, Srbija), 2,2-difenil-1-pikrilhidrazil - DPPH ($C_{18}H_{12}N_5O_6$, Lot.: S90790-379, CAS: 1898-66-4, Sigma Aldrich, SAD), metanol ($CH_4O$, p.a. > 99.8%, CAS: 67-56-1, Centrohem, Srbija), (-)-izoproterenol hidrohlorid ($C_{11}H_{17}NO_3 \cdot HCl$, hromatografske čistoće > 98%, CAS: 5984-95-2, Sigma Aldrich, SAD). U svim eksperimentalnim istraživanjima i proračunima koristiće se izoproterenol hidrohlorid, odnosno protonovani molekul izoproterenola, a u tekstu će se označavati skraćenicom ISO.

### UV-Vis spektroskopija

Elektronski spektari uzoraka snimani su u kvarcnoj kiveti optičkog puta 10 mm pomoću UV-Vis spektrofotometra Thermo Scientific Evolution 220. U ovom radu je UV-Vis spektroskopija iskorišćena za dobijanje elektronskog spektra 0,3 mM vodenog rastvora ISO u spektralnoj oblasti od 200 do 600 nm, kao i za određivanje antikosidativne aktivnosti ISO prema stabilnom dugoživućem radikalu $DPPH^{\bullet}$.

### Antioksidativna aktivnost

Hemijski test koji procenjuje efikasnost uklanjanja $DPPH^{\bullet}$ slobodnog radikala je dobar pokazatelj antioksidativne aktivnosti. Zasnovan je na sposobnosti antioksidansa da redukuje $DPPH^{\bullet}$ stabilni radikal doniranjem atoma vodonika ili elektrona. Tamno-ljubičasta boja rastvora $DPPH^{\bullet}$ potiče od elektronske apsorpcije $DPPH^{\bullet}$ sa maksimumom na 517 nm. Prilikom neutralizacije, rastvor DPPH dobija bledo-žutu boju ili se u potpunosti obezboji. Iz tog razloga se pomenuta promena boje rastvora i promena intenziteta apsorpcije sa maksimumom na 517 nm koristi za procenu antioksidativne aktivnosti. Procena antioksidativne aktivnosti izvršena je pomoću sledeće jednačine:

$$\text{procenat redukcije}\,(\%) = \frac{\left(\mathrm{DPPH}^{\bullet}\right)_0 - \mathrm{DPPH}_i}{\left(\mathrm{DPPH}^{\bullet}\right)_0} \cdot 100\%$$

$(DPPH^{\bullet})_0$ – intenzitet apsorpcionog pika (max na 517 nm) rastvora $DPPH^{\bullet}$ slobodnog radikala, $DPPH_i$ – intenzitet apsorpcionog pika (max na 517 nm) rastvora $DPPH^{\bullet}$ slobodnog radikala i različite količine uzorka antioksidansa, u ovom slučaju izopreterenola (ISO).

Za potrebe procene antioksidativne aktivnosti ISO napravljena je serija rastvora. Koncentracija $DPPH^{\bullet}$ drzana je konstantnom ($10^{-4}$ M), dok su se koncentracije ISO kretale u opsegu od 0 do 100 μM. Ukupna zapremina svakog rastovra je bila 3 mL. UV-Vis spektri

navedene serije rastvora snimani su u kvarcnoj kiveti debljine 10 mm u spektralnoj oblasti od 300 do 700 nm.

IC50 vrednost je određivana očitavanjem sa krive procenat redukcije DPPH$^{\bullet}$ u funkciji od koncentracije ISO. Koncentracija ISO za koju intenzitet poreklom od apsorpcije DPPH$^{\bullet}$ na 517 nm padne na 50% predstavlja IC50 vrednost.

**Infracrveni spektri**

Infracrveni spektar za ISO je dobijen u transparenciji propuštanjem infracrvene svetlosti kroz uzorak. Uzorak je pripremljen u obliku tablete presovanjem smeše 198 mg sprašenog KBr i 2 mg ISO. Snimanje je obavljeno na Avatar 370 – Thermo Nicolet FTIR spektrometru u spektralnoj oblasti od 4000 do 400 cm$^{-1}$ pri rezoluciji od 2 cm$^{-1}$, broj snimanja 32.

**Teorijska analiza**

Struktura protonovanog izoprenalina optimizovana u programskom paketu Gaussian na osnovu kristalografske strukture iz Kembridžke kristalografske baze podataka (Cambridge Crystallographic Data Center, CCDC). Korišćeni su funkcionali B3LYP, M06-2X i M05-2X, CAM-B3LYP, B3PW91 zajedno sa 6-311++G(d,p) bazisnim skupom (skup talasnih funkcija koji opisuje jedan sistem). Optimizacija je vršena bez geometrijskih ograničenja i izostanak imaginarnih frekvencija je pokazao da je dobijena struktura minimum na potencijalnoj površi. Vibracioni modovi su analizirani u GausView programu. Conductor-like Polarizable Continuum Model (CPCM) model rastvarača je korišćen za optimizacije strukture u etanolu. Elektronski prelazi su modelovani vremenski zavisnom teorijom funkcionala gustine (Time Dependent Density Functional Theory – TD-DFT) na M06-2X/6-311++G(d,p) nivou teorije.

Optimizovani ISO (nivo teorije M05-2X/6-311++G(d,p)) u svojstvu liganda je korišten za doking proračune na strukturi (PDB broj 2Y02 ) (Warne et al., 2011) β1-adreneričkog receptora. Receptor je prethodno očišćen od molekula vode i liganada u programu BIOVIA Discovery Studio (Dassault Systèmes BIOVIA, 2017). Priprema receptrora i liganda za doking proračune obavljena je u programu AutoDockTools4 (Morris et al., 2009), a ona je obuhvatala računanje parcijalnih naelektrisanja za svaki atom liganda i receptora i definisanje parametara proračuna. Doking malog molekula ISO je sproveden po celokupnoj zapremini očišćene strukture β1-adreneričkog receptora u programskom paketu AutoDockVina (TrotT et al., 2009). Vizuelna inspekcija i analiza adukta između ISO i 2Y02 receptora zajedno sa intermolekulskim interakcijama je obavljena pomoću BIOVIA Discovery Studio. Isti postupak je primenjen za doking proračun liganda karmoterola i β1-adreneričkog receptora iz kristalografske strukture 2Y02, kao i epinefrina i norepinefrina.

## REZULTATI I DISKUSIJA

**Optimizacija strukture**

Odabir odgovarajućeg nivoa teorije je vršen na osnovu poređenja kristalografske i optimizovane strukture. Za optimizaciju su upotrebljeni funkcionali koji se često koriste za uspešno opisivanje strukture sličnih jedinjenja (B3LYP, M05-2X i M06-X, CAM-B3LYP, B3PW91). Kristalografska struktura je preuzeta iz baze podataka (CCDC: WELYOB) (Kingsford-Adaboh et al., 1993). Strtuktura ISO se sastoji od aromatičnog prstena sa dve hidroksilne grupe i alifatičnog niza koji sadrži hidroksilnu grupu, amino grupu i isopropil ostatak. Ovi strukturni parametri su važni za moguće interakcije ISO sa proteinima zbog mogućnosti građenja vodoničnih veza kroz grupe sa elektronegativnim supstituentima. Poređenje kristalografske i optimizovane strukture vršeno je na osnovu srednje vrednosti apsolutne razlike u strukturnim parametrima (dužine veza i uglovi). U Tabeli 1 su prikazane vrednosti eksperimentalnih i teorijskih vrednosti ovih strukturnih parametara.

Tabela 1. Vrednosti dužina veza i uglova očitanih iz kristalne strukture protonovanog ISO (CCDC: WELYOB) i onih koji su dobijeni DFT proračunima korsiteći različite funkcionale za isti bazisni set (311++G(d,p)).

Table 1. Values of bond lengths and angles read from the crystal structure of protonated ISO (CCDC: VELIOB) and those obtained by DFT calculations using different functionals for the same basis set (311++G(d,p)).

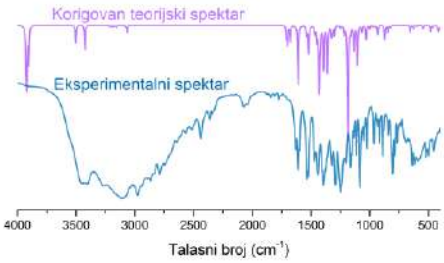
| **Funkcional** | **R vrednosti za** | | **MAE vrednosti za** | |
|---|---|---|---|---|
| | **Dužinu veze** | **Uglove** | **Dužinu veza** | **Uglove** |
| m052x | 0,955 | 0,939 | 0,018 | 1,523 |
| m062x | 0,955 | 0,934 | 0,019 | 1,617 |
| B3LYP | 0,951 | 0,934 | 0,022 | 1,602 |
| CAMB3LYP | 0,955 | 0,935 | 0,019 | 1,596 |
| B3PW91 | 0,949 | 0,934 | 0,021 | 1,607 |
| Najbolji rezultati | 0,955 | 0,939 | 0,018 | 1,523 |
| Optimalan funkcional | m052x | m052x | m052x | m052x |

Na osnovu prikazanih rezultata zaključeno je da struktura optimizovana na M05-2X/6-311++G(d,p) nivou teorije najbolje opisuje kristalografsku strukturu. Isti nivo teorije je prethodno upotrebljen za optimizaciju struktura sličnih jedinjenja (Dimić et al., 2018). Optimizovana struktura je prikazana na Slici 1. Ova izdužena struktura je posledica rasporeda molekula u kristalu i pretpostavlja se da ne odgovara strukturama koje su u rastvoru, posebno zbog rasporeda dve hidroksilne grupe na aromatičnom prstenu. Različite intramolekulske interakcije mogu dodatno stabilizovati ovu strukturu kao što je intramolekulska vodonična veza između hidroksilne i amino grupe na alifatičnom nizu.

Slika 1. Optimizovana struktura ISO na M05-2X/6-311++G(d,p) nivou teorije.
Figure 1. Optimized ISO structure at the M05-2X/6-311++G(d,p) level of theory.

**Infracrveni spektri**

Eksperimentalni IC spektri su snimljeni tehnikom KBr pastile za čvrsti uzorak u oblasti od 4000 do 400 $cm^{-1}$, dok su teorijski spektri izračunati za izolovan molekul u vakuumu. Teorijski i eksperimentalni spektri su prikazani na Slici 2.



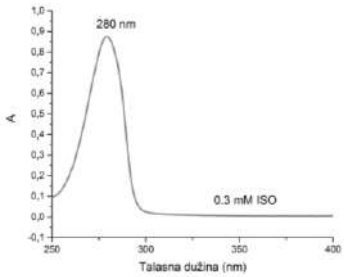

Slika 2. Eksperimentalni i teorijski (na B3LYP/6-311++G(d,p) nivou) IC spektar ISO.
Figure 2. Experimental and theoretical (at the B3LYP/6-311++G(d,p) level) IR spectrum of ISO.

Na osnovu Slike 2 može biti zaključeno da se teorijski spektar dobro poklapa sa eksperimentalnim. U eksperimetalnom spektru najintenzivnije trake potiču od O-H i N-H istežućih vibracija na 3105 i 3453 $cm^{-1}$ koje su dodatno proširene zbog vodoničnih veza formiranih između molekula u čvrstoj fazi. U teorijskom spektru ove trake se nalaze na 3919 i 3500 $cm^{-1}$. Trake istežućih vibracija O-H i N-H veza su u eksperimelntanom spektru pomerene batohromno u odnosu na teorijski zbog intermolekulskih interakcija u čvrstoj fazi koje nisu uključene u

optimizaciju pojedinačnih molekula u gasnoj fazi u vakuumu. Prilikom građenja vodonične veze u čvrstom stanju, O-H i N-H veze postaju duže što pomera maksimume ka nižim vrednostima. U oblasti većih vrednosti talasnih brojeva postoje i C-H istežuće vibracije, iznad 3000 $cm^{-1}$ su vibracije C-H grupa sa aromatičnog prstena, a ispod 3000 $cm^{-1}$ trake C-H istežućih vibracija alifatičnog niza. Prilikom poređenja spektara zaključeno je da je položaj trake C-O istežuće vibracije dobro reprodukovan u teorijskom spektru u odnosu na eksperimentalni (1108 i 1085 $cm^{-1}$). Položaji ostalih vibracija su takođe dobro reproukovani. Ovi rezultati zajedno sa otpimizacijom i poređenjem sa kristalografskom strukturom pokazuju da se struktura ISO na M05-2X/6-311++G(d,p) nivou teorije može koristiti dalje za teorijska ispitivanja i interakcije sa proteinima.

**UV-Vis spektri i antioksidativna aktivnost**

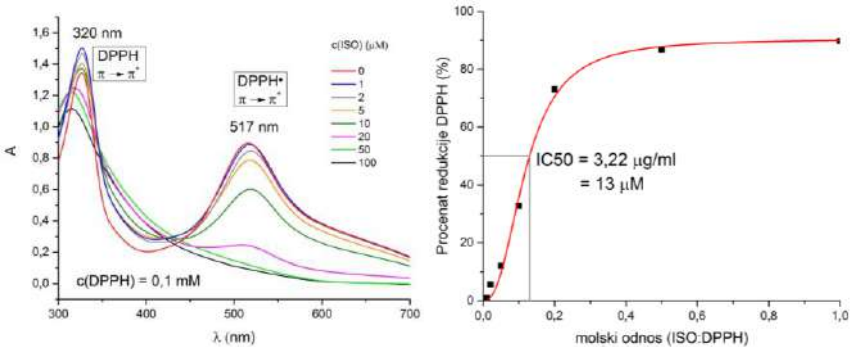
Ispitivanje antioksidativne aktivnosti ISO prema $DPPH^{\bullet}$ analizirano je primenom Ulj-Vid spektroskopije. Jedan od osnovnih uslova za korišćenje ovog testa je da nema preklapanja u trakama elektronskih prelaza između radikala i ispitivane supstance. Zbog toga su snimljeni UV-Vis spektri 0,3 mM rastvora ISO i prikazani na Slici 3. Elektronski spektar ISO je jednostavan i sastoji se od trake na 280 nm koja potiče od n→π prelaza u molekulu. Sličan elektronski spektar se dobija za jedinjenja sa sličnom strukturom. Položaj ovog maksimuma ne zavisi značajno od grupa prisutnih na alifatičnom nizu (Dimić et al., 2020).




Slika 3. Eksperimentalni i teorijski (na B3LYP/6-311++G(d,p) nivou) IC spektar ISO.
Figure 3. Experimental and theoretical (at the B3LYP/6-311++G(d,p) level) IR spectrum of ISO.

Spektri prikazani na Slici 4 (levo) pokazuju apsorpcione spektre radikala u prisutvu ISO. Spektar radikala ima dva apsorpciona maksimuma na 320 i 517 nm. Maksimum na 517 nm se koristi za određivanje koncentracije prisutnog radikala. Za ovu analizu je važno napomenuti da ne postoji preklapanje maksimuma ISO i radikala, odnosno da smanjenje vrednosti apsrobancije maksimuma na 517 nm direktno ukazuje na smanjenje količine prisutnog radikala koje zavisi od koncentracije dodatog gasioca u koncentraciji od 0 do 100 μM. Prilikom dodatka gasioca nema pojave novih traka niti promene položaja apsorpcionih maksimuma što ukazuje na to da nema pojave novih vrsta u rastvoru sem redukovanog oblika DPPH. Procenat redukcije, izračunat prema formuli opisanoj u Metodama i metodologiji, je prikazan u zavisnosti od koncentracije dodatog gasioca na Slici 4 desno. Određivanje IC50 vrednosti je važno za poređenje antioksidativne aktivnosti različtih jedinjenja i ukazuje na koncentraciju antioksidansa koja je potrebna da bi se redukovala polovina prisutnog radikala. Grafik zavisnosti procenta gašenja od molskog odnosa ima oblik karakteristične sigmoidalne krive, odnosno u početku postoji brzi porast procenta gašenja sa povećanjem molskog odnosa, dok je pri kraju kriva zaravnjena do vrednosti od 90%. Vrednost IC50 parametra za ISO iznosi 3,22 μg $ml^{-1}$, odnosno 13 μM. Dobijena vrednost je vrlo bliska vrednostima za dopamin, epinefrin i norepinefrin koji se smatraju dobrim antioksidansima u poređenju sa standardnim supstancama kao što su vitamin C i α-tokoferol (Dimić et al., 2017). Ovo takođe ukazuje na to da je za aktivnost najvažnije prisustvo hidroksilnih grupa na aromatičnom prstenu pošto su one zajednički strukturni parametar za navedena jedinjenja. Hidroksilna grupa na alifatičnom nizu i supstituenti na amino grupi ne utiču značajno na aktivnost. Ovo je posledica toga što prenos atoma vodonika sa hidroksilne grupe na aromatičnom prstenu stvara radikal

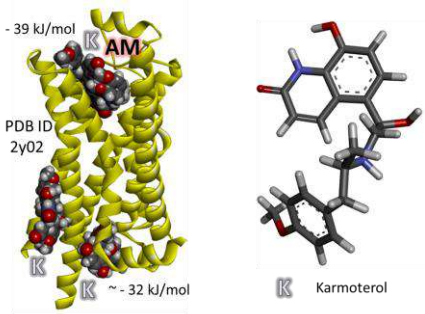
antioksidansa koji je dodatno stabilizovan kroz delokalizaciju naelektrisanja i spinske gustine na aromatičnom prstenu.




Slika 4. Eksperimentalni i teorijski (na B3LYP/6-311++G(d,p) nivou) IC spektar ISO.
Figure 4. Experimental and theoretical (at the B3LYP/6-311++G(d,p) level) IR spectrum of ISO.

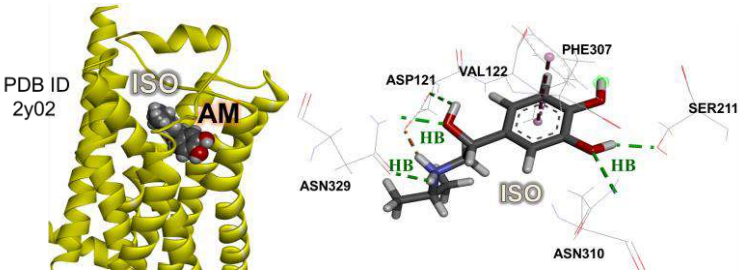
**Molekulski doking**

Molekul ISO se pokazao kao dobro antioksidativno sredstvo. Stoga, bi bilo bi korisno proveriti kakve interakcije on ostvaruje sa proteinima, zatim značaj pojediniačnih funkcionalnih grupa ISO u zapaženim intermolekulskim interakcijama i na kraju koja od postojećih funkcionalih grupa dominira u međumolekulskim interakcijama sa proteinom. Pri fiziološkim uslovima u organizmu molekul ISO je protonovan noseći ukupnu vrednost naelektrisanja +1. Od funkcionalnih grupa koje mogu uspostaviti značajnije međumolekulske interakcije izdvajaju se benzenov prsten, protonovana amino grupa, dve hidroksilne grupe supstituisane na aromatičnom prstenu i jedna na alifatičnom nizu (Slika 1). S obzirom da je ranije korišćena za proučavanje interakcija sa neurotransmiterom noradrenalinom (Dimić et al., 2020), za ulogu receptora odabrana je struktura β1-adrenergičkog receptora (β1-AR) sa PDB kodom 2Y02. Poznato je da AutoDockVina daje dobre rezultate u sistemima proteina i malog molekula koji ne sadrže atome metala. Podobnost Vine za naš sistem proveren je prilikom doking proračuna za molekul karmoterol, ligand iz kristalografske strukture 2Y02, na čistu strukturu β1-AR receptora (redoking). Karmoterol je nekateholaminski ligand koji pored ostalog sadrži u sebi grupe koje ima i ISO: aromatičan prsten, alifatčan niz, sekundarnu amino grupu, hidroksilne grupe kao supstituente na aromatičnom prstenu i na alifatičnom nizu. Nakon redokinga karmoterol se vezao na više pozicija u okviru jednog β1-AR receptora. Dva energijski najpovoljnije orijentacije (–38,9 i –35,6 kJ/mol) karmoterola su smešene u kateholaminskom vezivnom mestu (Slika 5), dok se energetski manje povoljnija (oko –32,2 kJ/mol) mesta za vezivanje nalaze na suprotnom kraju β1-AR receptora. Pošto je značajna razlika između Gibsovih slobodnih energija vezivanja, u realnim uslovima karmoterol se mora vezati tamo gde je po proračunu energijski najpovoljnije. Realno, u kristalnoj strukturi 2Y02 i jeste takav slučaj. U konkurenciji još osam liganada, karmoterol zauzima aktivno mesto (AM), dok su svi ostali ligandi raspoređeni na različitim mestima po površini β1-AR receptora.




Slika 5. Vezivanje karmoterola (K) za aktivno mesto AM ili kateholaminsko mesto (levo) i struktura karmoterola (desno).
Figure 5. Carmoterol (K) binding to the AM active site or catecholamine site (left) and the structure of carmoterol (right).

Doking proračuni su pokazali da se protonovani molekul ISO vezuje isključivo unutar aktivnog mesta β1-AR receptora. Takođe, u kateholaminskom vezivnom mestu ISO ima veliku konformacionu slobodu, drugim rečima, sam molekul može biti različito orijentisan. Najbolja Gibsova slobodna energija vezivanja ISO unutar aktivnog mesta procenjena je na $\Delta G = -31{,}4$ kJ/mol (Slika 6). Adrenalin i noradrenalin imaju za nijansu niže energije vezovanja –28,0 kJ-mol i –27,2 kJ/mol, respektivno. Očekujemo da prilikom vezivanja za aktivno mesto (AM) ISO ima blagu prednost. Njegove interakcije nisu previše intenzivne tako da se i dalje može vezivati reverzibilno, što je važno za terapijsku primenu. Vrednosti Gibsovih slobodnih energija vezivanja za ova tri neurotransmitera ne razlikuju se zanačajno baš zbog velike sličnosti struktura adrenalina, noradrenalina i izoprenalina. Zaista, razlika je minimalna. ISO ima duži alifatičan niz za dve, odnosno tri metil grupe. Za prikazano aktivno mesto na Slici 6 levo vezuju se kateholamini, pa je poznato kao kateholaminsko mesto.




Slika 6. Vezivanje ISO za aktivno mesto AM ili kateholaminsko mesto (levo) i detaljan prikaz interakcija u aktivnom mestu (desno).
Figure 6. Binding of ISO to the AM active site or catecholamine site (left) and a detailed view of interactions in the active site (right).

Kada se bliže analiziraju interakcije u kateholaminskom mestu, vidi se da su sve funkcionalne grupe (hidroksilne, amino grupa i aromatičan prsten) aktivne u građenju nekovalentnih interakcija sa okružujućim aminokiselinskim grupama. Najveći broj ostvarenih veza su vodonične veze. Njih mogu da ostvaruju sve tri hidroksilne grupe i amino grupa. Sekundarni amin i β-hidroksilna grupa ostvaruju vodonične veze sa ASN329 i ASP121 aminokiselinama, respektivno. Meta hidroksilna grupa (m-OH) formira vodoničnu vezu sa ASN310 i SER211. Vodonična veza sa SER215 je rezervisana za hidroksilnu grupu u para položaju (p-OH) aromatičnog prstena ISO. Protonovana amino grupa sa aminokiselinom ASP121 u svim orijentacijama ISO gradi soni most, kombinacija dve nekovalentne interakcije vodonične veze i elektrostatičkih interakcija. Hidroksilne grupe ISO dominiraju u uspostavljanju interakcija sa okružujućim aminokiselinskim ostacima aktivnog meta receptora. Te interakcije su obavezno vodonične veze, pri čemu su hidroksilne grupe ISO donori vodonkovog atoma. Može se očekivati da ISO svoje antioksidativno dejstvo ispoljava preko svojih

hidroksilnih grupa, tako što slobodnim radikalima donira atome vodonika iz svojih hidroksilnih grupa. Aromatičan prsten u ISO preferira formiranje π-π interakcija T tipa sa aminokiselinom PHE307. Epinefrin i norepinefrin takođe su smešteni u kateholaminskom vezivnom mestu i s obzirom da imaju sličnu strukturnu formulu sa ISO, sasvim očekivano ostvaruju iste tipove interakcija. Ligand iz kristalne strukture 2Y02, koji je smešten u prostoru kateholaminskog vezivnog mesta, gradi isti broj vodoničnih veza, ali svaka njegova funkcionalna grupa gradi maksimalno samo po jednu vodoničnu vezu ne uspostavljajući istovremeno druge interakcije. Funkcionalne grupe ISO liganda teže da formiraju više intermolekulskih interakcija istovemeno. Pošto je karmoterol neutralan molekul, nema sonih mostova, ali zbog prisustva više aromatičnih prstenova molekul ostvaruje više od jedne π-π veze. Međutim, pokazuje se kod manje energijski povoljnih orijentacija da se sa povećanjem broja π-π interakcija i smanjenjem broja vodoničnih veza, značajno snižava Gibsova slobodna energija vezivanja. Dakle, za optimalnu inhibiciju potrebno je uspostaviti balans između vodoničnih veza i π-π interakcija.

## ZAKLJUČCI

Izoproterenol je interesantan molekul koji ostvaruje veoma važne funkcije u jednom organizmu. Bazirano na strukturnim i funkcionalnim svojstvima izoproterenola, naše istraživanje je pružilo dokaze koji podržavaju njegove izuzetne karakteristike kao β-blokatora, neurotransmitera i antioksidansa. Fenil-grupa izoproterenola pokazuje apsorpciju na 280 nm, što ga čini pogodnim za praćenje apsorpcije $DPPH^{\bullet}$ na 517 nm. Izoproterenol pokazuje impresivnu antioksidativnu aktivnost usmerenu na $DPPH^{\bullet}$, sa IC50 vrednošću od 3,22 μg/ml. Izoproterenol se ortosterično vezuje za β1-adrenerički receptor. Interakcije koje tom prilikom ostvaruje su prilično intezivne, ali ne isuviše intenzivne za ostvarivanje reverzibilne inhibicije β1-adreneričkog receptora. Interakcije sa aminokiselinama unutar aktivnog mesta uglavnom uključuju vodonično vezivanje putem hidroksilnih grupa. Lakoća stvaranja vodoničnih veza ovih hidroksilnih grupa doprinosi antioksidativnoj aktivnosti izoproterenola prema $DPPH^{\bullet}$. Izražena donorska svojstva hidroksilnih grupa izoproterenola olakšavaju oslobađanje vodonika i neutralizaciju $DPPH^{\bullet}$ radikal.

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# ISOPROTERENOL STRUCTURE, ANTIOXIDATIVE PROPERTIES, AND INTERACTIONS WITH PROTEINS

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**ABSTRACT**

Isoprenaline (isoproterenol) is a non-selective β-adrenoreceptor agonist known for its therapeutic effects, which include increased heart rate and cardiac output, bronchodilation, and improved peripheral circulation. Apart from its primary functions in the nervous system and physiological regulation, isoproterenol exhibits antioxidant properties. This study employed a combination of experimental techniques (UV–vis, FTIR, and Raman spectroscopy) and theoretical calculation methods (molecular docking and DFT) to investigate the structural and functional properties of isoproterenol. The appropriate level of theory (M05-2X/6-311++G(d,p)) was determined by comparing experimental and theoretical bond lengths and angles. The antioxidative activity of isoproterenol towards DPPH• was assessed using UV-VIS spectroscopy and further analyzed by DFT methods to elucidate the most probable antiradical mechanism. Compared to its natural analogs (epinephrine and norepinephrine), isoproterenol demonstrates energetically more stable orthosteric binding to the β-adrenergic receptor. Molecular analysis revealed that π-π contacts with amino acids and hydrogen bonding involving hydroxyl and amino groups play an important role in its binding. This study enhances our understanding of the antioxidant properties of isoproterenol, providing insights into its potential relevance in oxidative stressrelated conditions. Moreover, the structural findings contribute to the future development of novel therapeutic agents with enhanced antioxidant activity and pharmacological profiles.

**Keywords:** isoproterenol, spectroscopic techniques, molecular docking, antioxidant activity, orthosteric binding.

# ***EDUCATION***
# *OBRAZOVANJE*

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# AMBIENT TEACHING – LEARNING ENVIRONMENT FOR GIFTED STUDENTS IN CHEMISTRY

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## ABSTRACT

Establishing a learning environment for gifted students is of great importance since it should encompass the development of their interpersonal skills, social responsibility and enable effective delivery of teaching instructions (Miedijensky, 2018). Contrary to traditional school learning through the adoption of final products of scientific research, ambient teaching is offering high degree of adoption of a scientific way of thinking and engagement of students, starting from observational procedures, to extracting and collection of materials (Lehrer, & Schauble, 2006). Our study aimed to explore the gifted students' perceptions regarding the ambient teaching as a model for learning environment. 24 gifted students from elementary schools in Kragujevac attended at the workshop in the laboratory at the Faculty of Science. The workshop was dedicated to the basic principles and laboratory operations and equipment, while problems were carefully designed to meet the cognitive needs of gifted students. Interview was used as instrument for delineation of the gifted students' perceptions regarding the ambient teaching. According to the results, majority of the students confirmed the significance and suitability of the ambient teaching for the learning chemistry as school subject, as well as they considered this way of learning more interesting than traditional method used in schools.

**Keywords**: gifted students; chemistry, ambient teaching; workshop.

## INTRODUCTION

Establishing an adequate learning environment for gifted students is of great importance since it should encompass the development of their interpersonal and technical skills, social responsibility and enable effective delivery of appropriate teaching instructions (Miedijensky, 2018). Under the circumstances of educational system reforms and fast changes at the global level, the current school shouldn't be only transmitters of the knowledge, but also constructive and transformative educational institution able to accept changes in the society and technology and outgrow its own educational frame (Anđelković, & Stanisavljević-Petrović, 2011). There is a special need for the establishment of the connections between school and their environments and inclusion of school activities in this process, particularly in the part of contextualization of the process of learning and teaching (Stanisavljevic-Petrovic, 2014). For these reasons, the institutions such as galleries, factories, museums, botanical gardens and research centres have become important resources for the formal education since they have great possibilities for the realization of teaching and learning process and acquiring the school knowledge through the experiential learning. In addition, the realization of teaching activities in different environs enables building the knowledge by means of the direct contact with the object of knowledge. Contrary to traditional school learning through the adoption of final products of scientific research, the characteristics of ambient teaching is a high degree of adoption of a scientific way of thinking and engagement of students, starting from observational research procedures, to extracting and collection of materials. The ambient teaching is encompassing the building of the knowledge through the active relationship with physical and social environment. The environment chosen is the one that contribute to the achievement of the goals set in front of the participants group, and, in the same

time, environment that provides all necessary elements included in the learning content. From the perspective of gifted students' educational needs, it is important to emphasize that this type of teaching could enable developments of problem-solving skills and encourage the use of critical thinking and creative research (Rahm, 2002; Reid, 2002). Although this concept of the learning has appeared recently in the literature (De Zan, 2005), its roots are present much longer in pedagogical practice. Still, the routine of performing the school activities outside the classroom is not sufficiently present in the Serbian education system, according to the some examples described in literature (Đokić Ostojić, 2011; Janković, 2009).

From the other hand, learning chemistry contents through the laboratory activities is very important since it makes bridges between theoretical and practical application in science teaching (Minner et al., 2010), and enables the acquiring the knowledge through the learning by inquiry. Although the laboratory activities could be a challenge for most of the pupils, the benefits for the gifted students are reflected in the increase of ability for identifying the problem, making hypotheses, gathering and analysing of data, making conclusions, as well as in assessing their own progress in this environment. However, the high cost of chemicals, not adequately equipped school laboratories, or in some cases, complete absence of school cabinets for experimental work joined with potential dangers of chemicals, are still major obstacles for the frequent application of laboratory activities not only in Serbian education system, but much wider (Scalise et al., 2011).

Herein, we present the results of our study aimed to explore the gifted students' perceptions regarding the ambient teaching as a model for learning environment of gifted students. Therefore, 24 gifted students from elementary schools in Kragujevac (Serbia) attended at the workshop organized in the laboratory at the Faculty of Science. The workshop was dedicated to the basic chemical principles and laboratory operations and equipment, and the problems and tasks were carefully designed to meet the cognitive needs of gifted students. Interview was used as an information extraction procedure to delineate the gifted students' perceptions regarding the ambient teaching. According to the results obtained, majority of the students confirmed the significance and suitability of the ambient teaching for the learning chemistry as school subject, as well as they considered this way of learning more interesting than traditional method used in school system.

## MATERIAL AND METHODS OF WORK

### Participants

The study was conducted with 24 gifted eight-grade pupils from the elementary schools from the territory of Kragujevac city (Serbia). The students were chosen by the chemistry teachers based on their personal engagement in the classes, grades, but also taking into consideration the recommendations from peers, parents and school pedagogues. The workshop was organized at the chemical laboratory in Institute for Chemistry (Faculty of Science, University of Kragujevac, Serbia). The laboratory is fully equipped with all necessary apparatus and chemicals, as well as with fume hood and safety closets. The workshop was organized by the professors, assistants and young PhD students who had a long-year experience in science teaching, application of STEM activities with school children and organization of different types of workshops. The workshop was organized around the basic chemical equipment and operations, such as: filtration, determination of solubility of organic compounds, titrations, distillation, accurate volume measuring, determination of pH, preparation of different solutions. Prior to the realization of workshop, the participants were equipped with the theoretical knowledge about the studied chemistry concepts. To encourage the students to adopt higher level approaches for learning chemistry in laboratory and think critically, the problems and tasks were designed in that way to introduce the chemical concepts by the inquire-based learning approach. Interview as qualitative research technique was used for the delivery of open-asked questions for the conversation of the participants and collection of data about subject of research.

## RESULTS AND DISCUSSION

The list of the interview questions is given in the Figure 1.

| Interview Questionnaire | |
|---|---|
| **Q1** | How often do you have opportunity to attend the classes form the school subjects outside the classroom? |
| **Q2** | What has been working in groups in lab? |
| **Q3** | According to your opinion, what are the major obstacles for the learning chemistry concepts? |
| **Q4** | List the reasons you think that performing chemical classes in laboratory is/isn't usefully in school practice? |
| **Q5** | What skills do you think you gained through the laboratory experience? |
| **Q6** | After the realization of workshop, do you think that you have bigger ability and confidence to perform laboratory activities? |
| **Q7** | How often do you have opportunity to perform laboratory activities in the chemistry classes? |
| **Q8** | Will you recommend this way of learning of chemistry as a practice that should be used more often in the regular schools? |

Figure 1. Interview Questionnaire.

Regarding the first question Q1, the majority of the students answered that they do not have often opportunity to study school subjects outside the classroom. Apart from the periodical visits to the some institutions (1 or 2 times per year), such as museums, the majority of the school classes are still organized in the school environment. Quite similar situation was observed in the students' answers to the Q7. Only small number (3 participants) of the students have answered that they had opportunity to perform laboratory activities even after each chemistry unit implying the use of those activities. Some of the answers have indicated that schools are not adequately equipped for the realization of this type of teaching. Regarding the question 3 Q3, the answers mostly refer on the absence of practical activities in the laboratory and the abstract nature of the chemical concepts. Considering the fact that respondents were gifted students, some of them also mentioned that during the regular classes they fill bored and that they need more challenging problems to solve and to connect knowledge with real-life contents. Although the majority of the students have answered that they consider the laboratory activities helpful for adoption of chemical knowledge, some of them mentioned that laboratory activities require extra time and, in some cases, merely following of lab procedures (question No 4). The list of the reasons supporting the use of lab activities as a way for learning chemistry is mainly consisted from: labs related adequately to the theoretical frameworks; students like hands-on activities and opportunity to visualize the chemistry contents; the acquired skills are useful and learning in this way is providing studding in more deep way then in the regular classes. The answers on the question 5 were diverse, from the ability to operate with some apparatus (for example, distillation), the ability to choose proper way for the separation of some of the liquid and solid substances to the measuring the substances and making differently concentrated solutions, etc. Almost all students have answered that they found the work in laboratory interesting and that this way of learning provide bigger ability and confidence for performing laboratory activities (Question 6), but some of the answers also referred that students still have fear from the work in laboratory. However, they also claimed that fear was overcome by the performing the activities in the small groups and therefore, we believe that this was one of the reasons that all students have agreed that they like team work and working in groups (Question 2). In addition, some of the students mentioned that they also filed uncomfortable at the beginning of the workshop, since the students didn't know each other before the realization of workshop. According to the students' opinions, the realization of the workshop has influenced increase of their confidence in the performing practical laboratory operations. The answers on the final question have served us to estimate the students' attitudes and reflection about the ambient teaching of the chemistry, its usefulness and relation to the traditional school classes. Majority of

the students confirmed the significance and suitability of the ambient teaching for the learning chemistry as school subject, as well as they considered this way of learning more interesting than traditional method used in school system. The feedback we obtained in this study has helped us to assess whether or not the developed workshop and laboratory program was effective in the meeting the educative needs of gifted students in chemistry, taking into consideration that learning outcomes depends not only on learning approaches but also on students' perceptions of the learning environment.

## CONCLUSIONS

Our study aimed to explore the gifted students' perceptions regarding the ambient teaching as a model for learning environment. 24 gifted students from elementary schools in Kragujevac attended at the workshop in the laboratory at the Faculty of Science. The workshop was dedicated to the basic principles and laboratory operations and equipment, while problems were carefully designed to meet the cognitive needs of gifted students. Interview was used as instrument for delineation of the gifted students' perceptions regarding the ambient teaching. According to the results, majority of the students confirmed the significance and suitability of the ambient teaching for the learning chemistry as school subject, as well as they considered this way of learning more interesting than traditional method used in schools.

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# GIFTED STUDENTS IN A REGULAR PRIMARY-SCHOOL CHEMISTRY CLASSROOM IN ŠUMADIJA DISTRICT (SERBIA) – OPPORTUNITIES AND MEETING THE NEEDS FOR FURTHER DEVELOPMENT

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## ABSTRACT

Gifted students have a range of unique abilities interwoven with the higher levels of creativity and motivation that differentiates them from the most peers in their distinctive learning and understanding abilities. In order for gifted students to fully develop their abilities, the teaching environment must be tailored to meet their special needs by implementing higher-order cognitive tasks in learning activities, so that the lack of challenge and boredom doesn't trigger some negative outcomes in the terms of disinterest, becoming disengaged and unmotivated, which ultimately leads to unfulfillment of student's potentials and underachieving (Taber, 2015). In Šumadija district gifted children have the opportunity to enroll in regular schools or be grouped in specialized classrooms by abilities (chemistry/biology; physics; mathematics; informatics). Also, gifted students can participate in a various afterschool activities intended for high-achieving and gifted students, such as Regional Centre for Talented – Kragujevac, workshops organized by Faculty of Science – Kragujevac and Petnica Science Centre – Valjevo. The main goal of this paper is to examine the position of gifted students in chemistry in our district and to evaluate real circumstances and opportunities that are presented to students through our educational system.

**Keywords**: Gifted students, chemistry, development of gifted students.

## INTRODUCTION

The development of modern society couldn't be imagined without individuals who are able to generate new ideas, apply them, as well as to explore various possible solutions and implement them in order to resolve problems of ever-growing hi-tech industry. The creativity in problem solving strategies, as well as possession of highly developed divergent thinking processes represents some of the most desirable qualities in contemporary work force. Therefore, the proper education of gifted children, as a future driving force of modern civilization, should be imperative for any success-oriented community, as gifted children express characteristics like those detected in successful entrepreneurial individuals (Shavnina, 2012).

It is well known that gifted learners possess higher levels of abilities, intelligence and achievement, which are very often not used fully as regular classroom activities are designed for students with average abilities. Also, learning activities that do not offer a gifted learner sufficient challenge can damage the students' motivation to study, and lead to boredom (Phillips, & Lindsay 2006; Gallagher et al., 1997) and even frustration (Keating, & Stanley, 1972) and disengagement (Kanevsky, & Keighley, 2003) with school classes. Consequently, very often gifted children do not develop to their full potential.

Chemistry as a subject has a great potential to meet the needs of gifted students for cognitive challenges as it abounds in a variety of problem-solving activities. In an all-inclusive classroom, on the teacher lies great responsibility to organize proper learning environment which is very often filed with many obstacles reflected in overpopulated classrooms, lack of properly equipped laboratories and unappreciation of teachers' additional effort and commitment.

The main goal of this study is to examine the position of gifted students in science (in particular, chemistry) in our district and to evaluate real circumstances and opportunities that are presented to students through our educational system.

## MATERIALS AND METHODS

### General background

The research was conducted during the Decembre of the year 2022. The study included 8th grade students from primary schools in the territory of the city of Kragujevac (Serbia) who were denoted as potentially gifted in chemistry. The territory of the city of Kragujevac covers 22 primary schools and all of them were invited to participate in this research.

### Sampling

All students included in the research sample (N=26) were 8$^{th}$ grade (age 13-14) primary school high-achieving students (both female and male).The homogeneous purposive sampling was done by their chemistry teachers from all twenty-two primary schools from the territory of the city of Kragujevac (Serbia), based on students' engagements in the classes, achievements, grades, participation in various science competitions (mostly chemistry, biology, and physics) and science camps (Petnica Science Centre and similar). Also, all students were characterized by their teachers as potentially gifted but were not tested for.

### Instrument and procedures

The instrument (questionnaire) was designed to assess the opportunities that gifted children in science related subjects (with the accent on chemistry) have for development of their talent within the framework of Serbian educational system. Results collected in the questionnaire represented students' attitudes, beliefs, and self-beliefs regarding their opportunities and activities in which they were involved. The questionnaire was composed of multiple-choice and open-ended questions. Statistical tests (median, mean value, and standard deviation) were conducted for the analysis and interpretation of data (McCrum-Gardner, 2008). Detailed statistics are given in percentages. In-depth analyses of the collected data were undertaken in order to gain insight into its content, followed by the extraction of key meanings and grouping of information into conceptual categories that lead to the making of categories into themes through constant comparison of data (Charmaz, 2006).

## RESULTS AND DISCUSSION

The opportunities for development that gifted children for natural sciences have in Serbia are well structured through the education system and properly supported through the regular public schools. The whole system relies on proper identification of gifted children by their teachers and family members. Once the child is identified as gifted it can attend selected classes through Individual Educational Plan (IEP) tailored specifically to the needs and abilities of a given child. IEP is suggested by the teacher and must be consented by the parents. The plan is created and its progress is monitored by a professional team (subject teacher, psychologist, pedagogist etc.). The child can benefit the most from the IEP, because its cognitive, social and emotional needs are met to the fullest as the student represents the main focus during the educational process. Sadly, our research has shown that no child from this study had IEP. The reason for this can be south in the fact that main responsibility, the body of work and engagement lays on the teachers, who are reluctant to take on themselves accountability for its implementation, as it would represent for them additional assignment, along with other obligations that overpopulated inclusive classroom represents.

In a regular classroom teachers can support gifted students through implementation of active learning principles and by grouping high achieving students in Additional classes which are organized as afterschool activities under the umbrella of the school. In the study the children denoted Physics (64%) as the main subject where they have the opportunities to be involved in various forms of active learning models intended for gifted children, while Geography and

Informatics were denoted with 0% (Figure 1). Children denoted the Project Base Learning as the most used method in science classes. Also, Geography was appointed as the only subject that had no Additional classes for high achieving students.

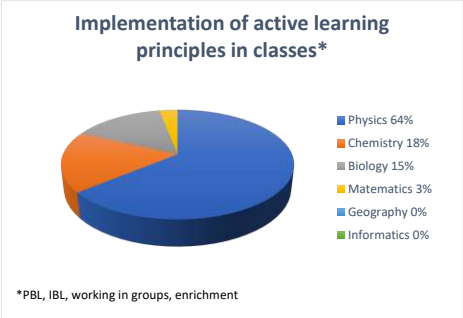


Figure 1. Graphical presentation (given in percentage (%)) of the presence of the active learning principals in classes of the natural sciences per subject.

The study has shown that children participate in all science competitions at all levels. The teachers were marked as the ones who helped them the most in preparing for competitions.

In the instrument, the group of questions was designed to determine what afterschool activities children attend that are not connected to the once that school offers. Most children attend sports and foreign language. From all art-associated activities, playing the musical instrument is the most favorable. The data are presented in Figure 2.

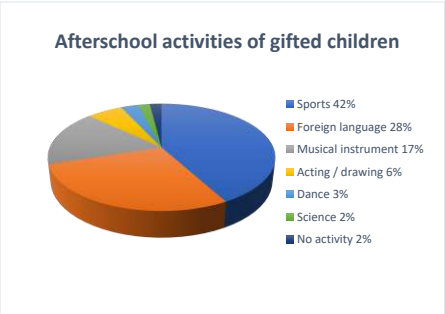


Figure 2. Graphical presentation (given in percentage (%)) of the type of afterschool activities of gifted children.

As motivation represents a crucial driving force behind human behavior it was of interest to determine whether the motivation for student's attendance of afterschool activities was internally or externally motivated. The data are presented in Figure 3. Students were mostly internally motivated, while only 10% was externally. In most cases, children denoted foreign languages as the most externally motivated activity (Foreign language 85%, Sports 10% and Musical instrument 5%).

The Serbian educational system enables gifted students from Šumadija district (and others) to attend several science camps, workshops organized by Faculty of Science – Kragujevac, become a member of the Regional Centre for Talented – Kragujevac, and Petnica Science Centre – Valjevo. Although children are very often familiar with the existence of these organizations they are not informed how and if they can enroll and are not getting the proper guidance from their science teachers. The exception were the students from the First Kragujevac's Gymnasium which has specialized classrooms for talented children. The survey has shown that children were mostly informed on existence of afterschool science related activities from their peers and relatives and that teachers are most willing to suggest the activities that can have a positive impact on their career (science competitions).

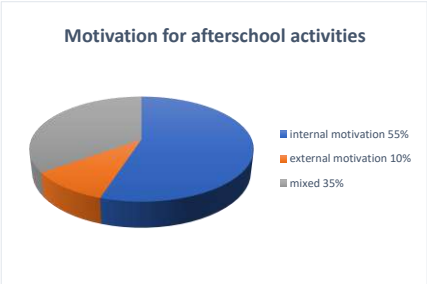


Figure 3. Graphical presentation (given in percentage (%)) of students' motivation for afterschool activities.

## CONCLUSIONS

Although in Šumadija district gifted children for natural sciences have many possibilities to improve their knowledge and develop their talent to full potential, children are generally uninformed and not getting the proper guidance from their science teachers, apart from the First Kragujevac's Gymnasium which has specialized classrooms for talented children. The survey has shown that children were mostly informed on existence of afterschool science related activities from their peers and relatives and that teachers are most willing to suggest the activities that can have a positive impact on their career. From the data presented in the pies it can be seen that the children are mainly internally motivated for afterschool activities and that children usually choose sports, foreign languages and music as activities, with science falling under 2%. The children denoted Physics (64%) as the main subject where they have the opportunities to be involved in various forms of active learning models intended for gifted children, while Geography and Informatics were denoted with 0%.

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# PSIHOLOŠKI ASPEKTI PROSTORNOSTI

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## SAŽETAK

Kvalitativna evaluacija prostornosti tiče se ugodnosti i doživljaja, odnosno komfora, a polazi iz načina percepcije prostora i njegovog potencijala za proizvodnju memorija. Takvo, psihološki poimanje prostornosti prvenstveno se tiče unutrašnjeg doživljenog aspekta i, najčešće, polazi od prvih dječijih prostornih konceptualizacija. Ovaj rad, analizirajući preverbalne i prekulturalne prostorne predstave djece sa jedne i fenomenološki uticaj na savremene arhitektonske prakse sa druge strane, kao svoju temu postavlja setove kvalitativnih vrijednosti koji se sa psihološkog aspekta uspostavljaju na relaciji ja-prostor. Na taj način se pojmovi poput mjesta, čulnosti i podsvjesnog iskustva neposredno povezuju sa kvalitativnim vrijednostima kao što su domestikalni, senzorni i afektivni komfor. Cilj rada je formiranje metodološkog obrasca za evaluaciju psihološkog aspekta prostornosti u okviru komfora proizašlih iz egzistencijalno-afektivnog kriterijuma, unutar koje se uspostavljaju i vrijednosti nižeg reda pripadajućih parametara obrazloženih pojmovima: cjelovitosti, temporalnosti, uzemljenosti, senzornosti, haptičnosti, neposrednosti i identifikabilnosti, koji podstiču i proizvode usložnjena psihološka uvezivanja sa prostorom. Rezultat rada su je metodologija sa pripadajućim kriterijumima i parametrima za vrednovanje psihološkog aspekta prostornosti koje mogu poslužiti kao tehnika za evaluaciju i unapređenje postojećih prostora, ali i kao metod za projektovanje novih kvalitetnijih prostora koji uspostavlja kompleksne psihološke konekcije korisnika i okruženja.

**Ključne riječi**: prostornost, čulnost, mjesto, komfor, iskustvo

## UVOD

Pitanje vrednovanja kvaliteta prostora u arhitekturi odnosi se na sagledavanje širokog spektra parametara koji osim fizički determinisanih aspekata treba da uključuje i doživljajne kvalitete koji se ostvaruju na relaciji prostor-korisnik kroz pojam komfora. U okviru srodnih inžinjerskih disciplina (mašinstvo, građevinarstvo, ekologija, i dr.), kao i u samoj arhitektonskoj struci, uobičajeno je vrednovanje kvaliteta prostora posredstvom mjerenja vrijednosti komfora sa parametrima koji su dominantno iz oblasti fizike (toplotni, vazdušni, zvučni i svjetlosni komfor). U graditeljskoj praksi, na osnovu standardizovanih kvantitativnih parametara, utvrđuje se nivo komfora zgrade kroz upoređivanje zadatih, univerzalnih i stvarno izmjerenih vrijednosti svakog (fizičkog) pojedinačnog komfora u nekom određenom prostoru. Vrednovanje kvaliteta neke građevine često se ustanovljava na osnovu ovih bazičnih/fizičkih komfora i bez razmatranja specifičnih konteksta i relacija koji definišu arhitektonske vrijednosti analiziranih prostora (Stupar i sar., 2017). Takva mjerenja komfora su determinisana međusobno nezavisnim parametrima koji najčešće ne uzimaju u obzir prostorno-vremenski kontekst, profil i potrebe korisnika, niti namjeru arhitekte da kroz prostor ostvari specifični komfor za specifičnog korisnika.

Dakle, pojam komfora u graditeljskoj praksi najčešće se koristi se u svom suženom i osiromašenom značenju gdje je isti predstavljen kao izdvojena realnost koja se može mjeriti, razmjenjivati, popravljati i prodavati. Prema utemeljivaču konvencionalne teorije komfora, Ole Fangeru: „Termalni komfor je proizvod koji je proizvodi i prodaje kupcu“ (Fanger., 1970; str. 69). Međutim, sudeći prema Elazabet Šou, treba imati na umu da komfor nije proizvod nego je prije dostignuće: „Komfor se mjeri zadovoljstvom, koje proizilazi iz odnosa sa prostorom, a ne iz

prostora po sebi“ (Shove, 2003, str. 24). Kao arhitekta Kristofer Aleksander komfor dovodi u vezu sa životnim cjelovitim kvalitativnim iskustvom koje ima cirkularni karakter, a tiče se unutrašnjeg posjedovanja (Alexander, 2016). Komfor je prije svega stanje, udobnost sjedinjenosti sa okruženjem, koje podrazumijeva neku vrstu brisanja tjelesnosti u smislu doživljaja pripadnosti specifičnom mjestu i trenutku. Ponovnim redefinisanjem pojma komfora kao vrijednosti koja prije svega uključuje doživljajne aspekte na relaciji korisnik-prostor, ali i sa psihološkim, sociološkim i kulturnim obrascima koji su uključeni u mehanizam prihvatanja i posvajanja prostora, komfor može da postane glavni nosilac jednog kvalitativnog pristupa dizajnu i evaluaciji prostora.

Shodno tome, u cilju restruktuiranja dosadašnjih znanja o samom polju komfora, ovaj rad želi da ukaže na spektar kompleksnih kvalitativnih doživljanih komfora, koji osim fizičkih (toplotni, vazdušni, zvučni i svjetlosni) i prostornih, uvodi psihološke, socijalne i kulturalne aspekte koji su ključni evaluatori za mjerenje kvaliteta prostora. Ovi novi kritrijumi doprinose jednoj cjelovitijoj strukturi znanja o komforu nekog prostora (arhitektonika komfora) koja obuhvata i doživljajne i pojavne vrijednosti, ali i analizira elemente strukture od opštih znanja ka samoj njihovoj primjeni u arhitekturi. Stoga su u okviru arhitektoničke strukture komfora formirana tri nova kriterijuma kao mehanizmi za vrednovanje kvaliteta prostora, a to su egzistencijalno-afektivni komfori sa psihološkog aspekta, socijalno-komunikacijski komfori sa sociološkog aspekta i grupa kulturno-označiteljskih komfora sa kulturalnog aspekta (Stupar, 2016).

Namjera ovog rada je da sa psihološkog aspekta tumačenja kvaliteta prostora, a kroz kriterijum egzistencijalno-afektivnih komfora, ukaže na jedno sveobuhvatno sagledavanje problema projektovanja i vrednovanja arhitektonskih prostora, koje prvenstveno polazi iz kvalitativno određene arhitekture, koja se može mjeriti na osnovu bogatstva psiholoških značenja koja se tiču specifičnih korisnika.

## METODOLOGIJA

U središte ovog rada se postavljaju egzistencijalno-afektivne veze sa prostorom, kojima osim kongnitivne psihologije i percepcije, treba pristupiti i iz same arhitekture koja se konstituiše iz premisa egzistencijalne filozofije i fenomenologije. Dakle, sa jedne strane se analiziraju kvaliteti koji su a-priori proizašli iz osjećanja i doživljaja sjedinjenosti sa prostorom po uzoru na dječije shvatanje prostornosti, dok sa sa druge strane istražuje veza fenomenologije i egzistencijalne filozofije na primjenu u samoj arhitekturi.

### Dječije shvatanje prostornosti

Fokus metoda je na psihološki uslovljenim aspektima doživljaja prostora objedinjenim pod grupom *egzistencijalno-afektivnih komfora*, a koji se ostvaruju u okviru odnosa ja-prostor, tj. načina na koji prostor doživljavamo/percepiramo. Takvo psihološko poimanje prostornosti, koje se prvenstveno tiče unutrašnjeg doživljanog aspekta, i, odnosi se na osjećaj uronjenosti i sraslosti sa okruženjem kao nerazdvojnog dijela sopstva, zavisno je i polazi od prvih dječijih prostornih konceptualizacija.

Djeca percipiraju prostor na specifičan način, koji karakterišu pojmovi poput čulnog utiska, afektivno obojenih odnosa, centracije/identiteta, materijalizacije prostora/svjesnosti vremena, simbola/nad-riječi, cjelokupnosti/ljudi prirode i prostora (afektivno obojenih odnosa, vizuelnih polja, igre polja, prethodeći konstantnosti opažaja) (Vigotski, 1996; Piaget, 1930; Ivić, 1978). Do treće godine, prostor ne postoji kao izdvojena materijalna stvarnost i dijete je na neki način uronjeno u okruženje i čini njegov nerazdvojni dio. Prema Pijažeu: „Dijete oživljava spoljni svijet materijalizujući ga kroz unutrašnji univerzum“ (Piaget, 1930; str. 255). Vremenom će dijete naučiti da su predmeti nezavisni od njegovog kretanja i položaja, te će se pojaviti osnovne strukture uopštenog, a zatim i osmišljenog, opažaja uslovljene izdvajanjem iz sveukupnosti okoline (paralelno sa razvijem ega i pojavom govora). Sa mogućnošću reprezentacije i apstrakcije, a nakon treće godine zajedno sa strukturiranjem govora, dijete počinje da doživljava prostor kao odvojeni entitet prema drugačijim perceptivnim pravilima, a koja imaju određene sličnosti sa pecepcijama odraslih.

Stoga shvatanje prostornosti od strane djece predstavlja izuzetno bitan okvir, u kojem kroz prostorno-čulnu senzaciju, percepciju i spoznaju, dijete obrazuje neposredan i intenzivan odnos u/sa okruženjem. U tom periodu formira se pojam kuće kao ekstenzije tijela, kroz multisenzorno i multimodalno jedinstvo prostora i vremena. Takvo iskustvo prepoznajemo kao kvalitet u dobrim kućama.

Takav prekulturalni i predjezički odnos, kao svojevrstan kvalitet, nalazi se u srži svakog kompleksnijeg poimanja prostora, koji će kasnije, posredstvom kulture i jezika, postati zavisan od brojnih socio-kulturnih činilaca. Upravo je ovako pojmljen i psihološki uslovljen komfor onaj čije mehanizme koristimo i razvijamo tokom života u relaciji ja-prostor.

**Psihološki aspekti komfora: mjesto, čulnost, memorija**

Iskustvena dimenzija u arhitekturi, oslonjena na fenomenološki pristup čini kvalitativnu okosnicu rada, gdje se poimanje prostora i prostornosti kod odraslih uspostavlja kao vremenski uslovljena kategorija zavisna od prvih dječjih prostornih konceptualizacija.[1] Blumer i Mur, polazeći od fuzije psihičkih i fizičkih granica dječjeg tijela i okruženja, ističu važnost najranijih prostornih iskustava koja „označavaju konstituisanje našeg primordijalnog i hijerarhijskog modela trodimenzionalnosti“ (Bloomer, & Moore, 1977, str. 38). Percepcija doživljaj i kvalitet ostvarenih psiholoških konekcija, po uzoru na djecu, kao i kapacitet odnosa da proizvede memoriju i aktivnost, jeste važno polazište za definisanje kriterijuma psiholoških aspekata prostora oko kojih će se formirati arhitektonski parametri i prostorni indikatori komfora proizašlih iz egzistencijalno-afektivnih komfora.

Fenomenologija u arhitekturi kao ključni pojam uspostavlja *pitanje mjesta posmatrajući prostor kao životno okruženje* koje „nije nešto što se suočava sa čovjekom, niti je spoljašnji objekat, niti unutrašnje iskustvo“ (Heidegger, 1982; str. 96). Ovako tumačeno pitanje mjesta upućuje na nerazdvojnu povezanost čovjeka i njegovog neposrednog okruženja kao egzistencijalnog stanja (Heidegger,1982). Karakter mjesta se stoga neposredno uspostavlja kao kvalitativna odrednica u arhitekturi koja ima “na umu celinu sačinjenu od konkretnih stvari koje imaju materijalnu građu, oblik, teksturu i boju”, a koje zajedno određuju „karakter okruženja“, koji je suština mjesta (Norberg-Šulc, 2009; str. 261). Definisanje mjesta kao cjelovitog, statičnog i neprolaznog fenomena, sa kojim se moguće identifikovati, uslovljava se jedan od aspekata kvalitativne analize psihološkog tumačenja komfora.

Drugi aspekt tiče se *čulnih kvaliteta prostora*, odnosno seta vrijednosti koje se neposredno kroz čulnu percepciju, putem razumskih operacija, prepliću u multičulno iskustvo prostora. Juhani Palazma stoga naglašava „umjesto pukog vizuelnog, ili pet klasičnih čula, arhitektura upliće interakciju više polja čulnog iskustva koje se međusobno miješaju“ (Palasma, 2003; str. 45). Čulno iskustvo stoga predstavlja drugi važan kriterijum uspostavljanja egzistencijalno-afektivnih komfora, a koji polaze iz psihološkog aspekta prostornosti, te koji neposredno, putem percepcije, utiču na stvaranje autentičnih memorija.

Kao treća kvalitativna vrijednost uspostavlja se iskustvo koje se tiče podsvjesne, preverbalne i prekulturne percepcije prostora, tj. memorije, a rukovođeno je najranijim prostornim konceptualizacijama. Blumerova i Murova teorija „tijela-slike“, koja briše granicu tijela i prostora, čini jednu od vrijednostih kriterijuma egzistencijalno-afektivnog komfora (Bloomer, & Moore, 1977; str. 44). Koristeći se zapažanjima koja se oslanjaju na dječje perceptivne mehanizme, a posredstvom čula kao prostornih ekstenzija, kroz miješanje tijela i okruženja, može se ukazati na različite vidove istovremenog sticanja svijesti o okolnom prostoru, ali i o samome sebi.

**Arhitektura koja ima dušu**

Prethodno opisane tri kvalitativne vrijednosti prostornosti ukazuju na značaj psihološkog uvezivanja tijela sa prostorom, te stvaranje mjesta koje kroz svoj autentični, multisenzorni i haptički potencijal zamagljuje granice unutrašnjeg i spoljnjeg svijeta. Arhitektonske realizacije sa

ovim svojsvima izdvajaju se kao kvalitetne. Jedna od arhitektonskih praksi koja na ovaj način uspostavlja dijalog sa lokacijom i korisnikom jeste rad švicarskog arhitekte Pitera Cumtora. U eri dominacije slikovne kulture, Cumtor ostaje vjeran doživljajnim kvalitetima arhitekture. Koristeći „najstarije stvari koje čine arhitekturu: materijal, konstrukciju, nošenje i nosivost, zemlju i nebo“, Cumtor istražuje prostorno-vremenske relacije koje ugrađuje u autentično mjesto, gradeći „kuće koje imaju dušu“ (Zumthor, 2003; str. 30). On kreira mjesta koja ostavljaju prostor za iskustvo i memoriju, u skladu sa čulnom prirodom ljudskog uvezivanja sa prostorom. Način na koji se kroz građeno ostvaruje smisao „nalazi se s onu stranu kompozicijskih pravila, a čulnost, miris i akustički dojam materijala, samo su arhitektonski elementi jezika u kojem moramo govoriti“ (Zumthor, 2003; str. 30).

Slika 1. Amanajuvet, Peter Zumthor.
Figure 1. Amanajuvet, Peter Zumthor.

Kroz projekat *Almanajuvet turističke rute* može da se identifikuje veliki broj arhitektonskih kvalitativnih karakteristika koje oprostoruju principe egzistencijalno-afektivnog kriterijuma (slika 1). Paviljoni su uronjeni u neodvojivu prostorno-vremensku cjelinu, gradeći cjelovito, uzemljeno i temporalno iskustvo mjesta. Kroz logičnu i jednostavnu strukturu i materijale Cumtor ostvaruje multisenzorni kvalitet višestruke čulne identifikacije korisnika sa kućom i kuće sa mjestom. Upravo u Cumtorovom djelu mogu se prepoznati parametri koji su povezani sa domestikalnim, senzornim i afektivnim potencijalima prostora. Doživljaj cjelovitog mjesta putem fuzije više čula, rukovođen preverbalnim poimanjem prostornosti, karakteristike su prostora sa visokim potencijalom egzistencijalno-afektivnih komfora.

**Egzistencijalno-afektivni kriterijumi: domestikalni, senzorni i afektivni komfor**

U odnosu na tri navedene kvalitativne vrijednosti psihološkog aspekta, komfor se tiče mjesta, čulnosti i pračulne, preverbalne povezanosti sa mjestom, tj. memorije. Objedinjeni su kroz egzistencijalno-afektivni kriterijum koji predstavlja kvalitativna svojstva, ona koji uspostavljaju višeznačne konekcije, na marginama stvarnih mjesta i iskustava koje obezbjeđuju, a doživljavaju se kao svojevrsna fuzija tijela i prostora. Navedeni aspekti i kriterijumi uobličeni su kroz set domestikalnih, senzornih i afektivnih komfora, posmatranih iz kvalieteta i intenziteta doživljajne konekcije korisnika i mjesta u kojem borave.

*Domestikalni komfor* odnosi se na set vrijednosti i parametre koji polaze od karaktera doma, odnosno „od kuće kao metafore tijela“ u smislu intenziteta i kvaliteta psiholoških konekcija koje mjesto obezbjeđuje (Bloomer, & Moore, 1977). Imperativ mjesta podrazumjeva osjećaj pripadanja, sproveden kroz *cjelovitost, temporalnost i uzemljenost*, a koji se koriste kao parametri za identifikaciju i evaluaciju domestikalnog komfora. Definisanje mjesta kao cjelovitog statičnog fenomena sa kojim se moguće identifikovati, posredstvom tijela i memorije, definiše prvi parametar cjelovitosti, koji može poslužiti za identifikaciju domestikalnosti nekog mjesta. Drugi parametar je temporalnost, koji podrazumijeva vremensku neuslovljenost, u smislu isključenosti iz savremenih tokova ubrzanog premještanja. Neizbježan proces starenja, u odnosu na vremenske uslove i istrošenost materijala, obično se ne smatra pozitivnim elementima u dizajnu, ali upravo je

preslikavanje prirodnih procesa na materijalno okruženje jedan od mogućih parametara domestikalnog kvaliteta. Treći parametar čini pojam uzemljenosti koji kao kvalitet podrazumijeva stvarno pripadanje nekom geografskom prostoru i vremenu, odnosno atmosferi koja je kreirana u okviru određenog pejzaža.

*Senzorni komfor* odnosi se na multisenzorni potencijal prostora da izazove višestruku čulnu senzaciju i da se kroz sistem percepcije uveže sa memorijom i iskustvom. U projektovanju arhitekture čulo vida i vizuelna percepcija, dominira nad donošenjem dizajnerskih odluka, dok se ostala osjetila koja ravnopravno učestvuju u percepciji mjesta potpuno zanemaruju. Prema Palasmi: „Svako iskustvo arhitekture je multi-senzorne prirode; kvalitet prostora, materije i razmjere ravnopravno se mjere okom, nosem, kožom, jezikom, skeletom i mišićima“ (Palasma, 2003, str. 45). Senzorni komfor, kroz parametre analogne ljudskim čulima, uspostavlja poželjnim multi-senzorno prostorno okruženje kao mjerilo kvaliteta. Predloženi parametri za utvrđivanje senzornog komfora, su: taktilni, olfaktivni, auditivni i vizuelni. Taktilni parametar senzornog komfora razmatra prostorne elemente i strukture koji u manjoj ili većoj mjeri podstiču dodirivanje ili osjećaj dodirivanja koji mogu da aktiviraju prve podsvjesne veze sa prostornošću. Olfaktorni parametar predstavlja važan pokazatelj kvalieta prostora. Miris koji veoma snažno utiče na emocije, i to najčešće sa jednog pre-kulturnog nivoa, u stanju je, posredstvom olfaktornog centra, da prizove sjećanja (često iz djetinjstva) kojih nismo ni svjesni. Miris i „ukus“ prostorija stoga predstavljaju važan faktor koji utiče na karakter i broj konekcija sa prostorom. Ono što je specifično za auditivni parametar jeste vrsta i ton zvuka koji se planirano koristi u svrhu povezivanja-odbijanja sa nekim prostorom. Ne radi se o mjerenju zvuučnog komfora u okviru fizičkih parametara (jačina i reverberacija) nego o potencijalu nekog prostora da pomoću zvuka izazove ili spriječi afektivne konekcije. To podrazumjeva auditivnu ugodnost u smislu organizacije i dimenzionisanja prostora na način da se svjesno projektuju određeni doživljaji zvuka u okviru prostornih cjelina. Vizuelni parametar, u arhitekturi, gotovo uvijek prenaglašen, u okviru senzornog komfora kao kvalitet podrazumjeva utišane i neutralne prostore koji svojom pojavnošću, pomoću svedenih, ponekad i zamračenih prostora dozvoljavaju multičulno iskustvo percipiranja. Korištenje multisenzornih podsticaja u projektovanju i upotrebi prostora, pri čemu postavljanje čula vida u ravan sa ravnopravnim podražajem ostalih čula čini jedan kvalitativan pomak u proizvodnji humanijeg i smislenijeg okruženja.

*Afektivni komfor*, tiče se načina na koji se tijelo kroz čulne ekstenzije uvezuje sa prostorom, a za razliku od senzornog, sproveden je na polusvjesnom nivou, gdje je, slično kao kod odojčeta, opažaj poistovijećen sa reakcijom i nije kontrolisan od strane svjesnih misaonih operacionalizacija (O’Neill, 2001; str. 4). Kroz podsvjesno saznavanje, akumulirano u tijelu i memoriji, razvija se duboko razumijevanje identiteta mjesta i jačina emotivnih konekcija. Načini podsvjesnog uvezivanja sa prostorom - haptičnosti, neposrednosti i identifikabilnosti, predstavljaju parametre afektivnog komfora. Gibson definiše haptički sistem kao „nečiju osjetljivost na uticaj okoline na njegovo tijelo posredstvom sopstvenog tijela, odnosno kao aparatus pomoću kojeg individua dobija informaciju o oboje“. Dovodeći haptički čulni sistem u vezu sa arhitekturom, Nilova, upliće integraciju mnogih čula, kao što je čulo svjesnosti položaja, dodira, balansa, zvuka, pokreta, kao i sjećanja na prethodna iskustva, a kombinuje ih u jedinstveno cjelovito „holističko“ iskustvo (O’Neill, 2001; str. 4). Simultana multimodalna percepcija, pri kojoj nismo u stanju da svjesno rukovodimo senzornim podražajima, predstavlja haptički parametar afektivnog komfora. Parametar neposrednosti karakteriše tjelesni akt u kojem korisnik učestvuje i prepušta se prostoru, kroz neposredan neverbalan dijalog tijela i okruženja, gdje je stepen, broj i karakter egzistencijalnih veza srazmjeran jačini uplitanja tijela i prostora. Parametar identifikabilnosti odnosi se na potencijal prostora da ostvari osjećaj pripadanja nekom prostoru, odnosno potencijal identifikacije sa samim prostorom. Prema Šulcu, čin identifikacije podrazumijeva „priznanje da pripadamo određenom mjestu.Kroz taj čin stanovnik usvaja jedan svijet, njegovo nastanjivanje odgovara otkrivanju sebe samoga i određivanju sopstvenog bivanja na svijetu“ (Norberg-Šulc, 2009; str. 15). Primarni mehanizam u identifikaciji sa prostorom jeste proizvodnja memorija. Međutim kada govorimo o parametru identifikabilnosti, potencijal prostora da kroz interakciju

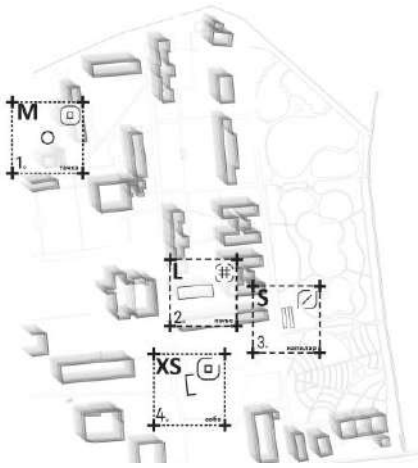
tijela i prostora pounutrašnjuje nova iskustva i proizvodi nova sjećanja predstavlja vrijednost afektivnog komfora.

*Domestikalni, senzorni i afektivni komfor*, unutar kojeg su uspostavljeni parametri temporalnosti, uzemljenosti, senzornosti, haptičnosti, neposrednosti i identifikabilnosti, formiraju metodološki obrazac sa setom alata za proizvodnju i evaluaciju usloženjenih psiholoških uvezivanja sa prostorom.

## PRIMJENA I DISKUSIJA

Kao rezultat rada, predstavljeni komfori i parametri za dizajn i vrednovanje psihološkog aspekta prostornosti mogu poslužiti kao metodologija za evaluaciju i unapređenje postojećih prostora, ali i kao metod za projektovanje novih kvalitetnijih prostora, koji izgrađuje kompleksne psihološke konekcije korisnika i okruženja. U ovom radu razmatra se mogućnost primjene predstavljene metodologije u edukativne svrhe.

U okviru izbornog premeta Arhitektonika komfora, izvođenog na Arhitektonsko-građevinsko-geodetskom fakultetu Univerziteta u Banjoj Luci, školske 2022/23. godine predstavljene tehnike i alati korišteni su za projektovanje i dizajn otvorenih prostora u okviru Univerzitetskog kampusa. Na kursu je sa studentima četvrte godine arhitekture testirana predstavljena metodologija istraživanja i projektovanja kvalitativnih arhitektoničkih komfora iz psihološkog, socijalnog i kulturalnog aspekta. Za potrebe ovog rada biće predstavljeni rezultati istraživanja iz psihološkog diskursa, domestikalnog, senzornog i afektivnog komfora sa pripadajućim parametrima.




Slika 2. Mapiranje, student Isidora Komljenović.
Figure 2. Mapping, student Isidora Komljenović.

Istraživanja studenata su rađena simultano koz tri pravca. Prvi pravac se ticao mapiranja, odnosno istraživanja postojećeg prostora kampusa, detekcije mjesta sa kojim su se studenti povezali, te izrade mape potencijalnih događaja. U oviru ovog pravca podrazumijevao se rad na mapama i istraživanje internog doživljaja i oprostorenja potencijalnih događaja i intervencija na odabranim lokacijama. Metodologija mapiranja i analize lokacija preuzeta je iz specifičnih mehanizama koji se tiču projekta Male intervencije u prostoru (Stanković et al., 2019). Lokacije su obrađene na način da im je određena lokacija, veličina, tipomorfologija, intuitvni pravac buduće intervencije, i potencijalni budžet i način izvođenja (slika 2). Na taj način dobijena je baza prostora na kojima je poželjna intervencija, dok je karakter same intervencije konstituisan naknadno u skladu sa doživljajima teorijskog bloka arhitektonike komfora.

Slika 3. Domestikalni komfor, student Anastasja Šarena.
Picture 3. Domestic comfort, student Anastasja Šarena.

Drugi pravac istraživanja odnosio se na sagledavanje, vizuelizaciju i oprostoravanje pojmova predstavljenih u okviru teorijskog bloka znanja o arhitektonici komfora i parametarima sa psihološkog aspekta prostornosti. Studentima je predstavljena cjelokupna metodologija arhitektonike komfora gdje je njihov zadatak bio da kroz skice reaguju na zadate parametre, razjašnjavajući na taj način značenje svakog od njih kroz skicu i riječi. Na taj način su kompleksni pojmovi domestikalnog komfora poput cjelovitosti temporalnosti i uzemljenosti dobili specifične forme i pojavnosti, primjenjive za aplikaciju na konkretnoj lokaciji. Prema istom mehanizmu rađeni su setovi skica za senzorni komfor i za afektivni komfor, a pomoću čega su studenti stekli precizan uvid u same parametre, ali su i proizveli novu vrijednost koja se putem značenja i oblika može povezati sa prethodno detektovanim lokalitetima (slika 3).

Slika 4. Biorebabl, student Aleksandar Marić.
Figure 4. Biorebabble, student Aleksandar Marić.

Treći pravac podrazumijeva sintezu znanja o konkretnim lokacijama i teorijskog znanja predstavljenog na kursu. Zadatak studenata jeste aplikacija pojmova, doživljaja i pojavnosti na stvarnu odabranu lokaciju, na način da konkretan projekat izazove što kvalieteniju psihološku uvazanosti sa prostorom. Studenti su aplicirali skice na kokretne lokacije, dobijajući na taj način nove i ne-unaprijed konstruisane doživljaje samog prostora. Tako su se u smislu funkcija na lokacijama našle sobe za izolaciju, tihi disko prostori, različiti elementi za neposrednu interakciju tijela i prostora kao što su radionce, ležaonice, zone za opuštanje etcs. Na slici 4. predstavljena je aplikacija psihokomfora pod nazivom Biorebabl, gdje je evidentiran način na koji se tema domestikalnog i afektivmog komfora aplicira na prostor napuštenog kružnog rezervoara u središtu kampusa. Konkretan primjer predstavlja jasnu primjenu parametara cjelovitosti, temporalnosti, neposrednosti, identifikabilnosti, haptičnosti, a očitava se kroz potencijal intervencije da na konkretnoj lokaciji minimalnom intervencijom proizvede navedene egzistencijalno-afektivne konekcije.

Važno je napomenuti da predložene reakcije na prostore nisu došle kao linearno rješavanje problema, nego su rezultat višeslojnog istraživanja između teorije i primjene na konkretnom prostoru, gdje je cilj i rješenje nije poznato unaprijed, nego se mijenja i konstituiše na osnovu

doživljajnih parametara samog autora. U daljoj razradi navedeni predlošci su razrađeni u konkretne projekte malih intervencija u prostoru sa razrađenim arhitektonskim i konstruktivnim detaljima, budžetom i dinamikom.

U konačnosti fokus ovoga rada je na primjeni metodologije komfora egzistencijalno-afektivnog kriterijuma proizašlih iz psihološkog aspekta prostornosti. Sprovođenjem metodologije na kursu i analizom dobijenih rezultata, evidentno je da predstavljeni set tehnika i alata uobličen kroz domestikalni, senzorni i afektivni komfor, osim za evaluaciju i projektovanje prostora, ima potencijal da iznese nove eksperimentalne metode edukacije u okviru nastave sa studentima starijih godina arhitekture.

## ZAKLJUČCI

U ovom radu predstavljen je složeni sistem strukture kriterijuma i parametara komfora koji u centar istraživanja uvodi kvalitete psihološkog aspekta doživljaja prostora. U uvodnom dijelu, u kratkim crtama, predstavljena je struktura cjelokupne arhitektonike komfora, da bi se u nastavku rad fokusirao na egzistencijalno-afektivni kriterijum i domestikalni, senzorni i afektivni komfor koji su nosioci psihološkoh uvezivanja tijela i okruženja. U metodološkom odjeljku obrazložena je teorijska baza konstituisanja doživljajnih konekcija na relaciji tijelo-prostor, odnosno onih vrijednosti i parametara koji su zaslužni pri određivanju kvaliteta odnosa sa određenim prostorom. Oslanjajući se na kognitivno razvojne procese u najranijem djetinjstvu, ali i na fenomenološke pristupe u arhitekturi, ponuđeni su pojmovi i alati za formiranje višeznačnih prekulturalnih konekcija, koje se u prostoru i kroz prostor prenose neverbalnim, a često i podsvjesnim dijalogom. Predstavljena je trijada psihološki uslovljenih komfora i to domestikalni, sa parametrima cjelovitosti, temporalnosti i uzemljenosti; senzorni sa parametrima olfaktornosti, auditivnosti, vizuelnosti i taktilnosti; i afektivni komfor sa pripadajućim parametrima haptičnosti, identifikabilnosti i neposrednosti. Detekcijom i primjenom navedenih alata u konkretnim prostorima moguće je izvršiti evaluaciju kvaliteta određenehih prostora u smislu broja i karaktera ostvarenih psiholoških veza. Prikazom primjene predstavljenej metodologije u okviru nastavnog procesa na izbornom predmetu Arhitektonika komfora, evidentirano je da su studenti razumjeli, posvojili i koristili stečena znanja u cilju dizajniranja prostora sa jakim psihološkim konekcijama. Predstavljeni radovi dokazuju da sama metodologija moguće koristiti i kombinovati sa drugim metodama radi uspostavljanja doživljaj multisenzornog okruženja koje ima egzistencijalno-afektivne karakteristike. Polje mogućih prožimanja i međudjelovanja elemenata arhitektoničke strukture, otvara brojne mogućnosti tumačenja, redizajniranja i primjenjivanja komfora i njihovih parametara kao instrumenta koji podupire arhitekturu u stvaranju smislenih prostora koji simultano uzimaju u obzir oba svijeta: i materijalni i doživljeni.

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# PSYCHOLOGICAL ASPECTS OF SPATIALITY

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**ABSTRACT**

The design of space and its evaluation can be examined from the way space is perceived and from its memory production potential. Such psychological notions of spatiality, which primarily concern the perceived and experienced aspect, are most often drawn from the first children's spatial conceptualizations. Analyzing preverbal and precultural spatial representations of children on the one hand, and contemporary architectural practice on the other, this paper sets as its theme groups of qualitative values that are psychologically established through interaction between users and the space they inhabit. In this way, concepts such as place, sensory experience, and subconscious experience are directly associated with qualitative values such as domestic, sensory, and affective comfort. The aim of this paper is to form a methodological pattern of architectonic structure of comfort, within which values of lower order of associated parameters are established, explained by concepts such as integrity, temporality, grounding, sensory potential, haptic qualities, immediacy, and identification, as well as spatial indicators and architectural elements that incite and produce complex psychological connections with space. As a result, the presented techniques and operational tools for evaluating the psychological aspect of spatiality can serve as a methodology for evaluation and improvement of existing spaces, but also as a method for designing new higher quality spaces, that would build more complex psychological connections between user and environment.

**Keywords**: architecture, sensory, place, comfort, experience.

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# ULOGA DIJAGRAMA U METODOLOGIJI ARHITEKTONSKOG OBRAZOVANJA

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## SAŽETAK

Osnovni cilj ovog rada je da se ispita uloga upotrebe dijagrama u okviru studio projekta kao značajne metodologije u savremenom arhitektonskom obrazovanju. Polazi se od činjenice da je za savladavanje vještine arhitektonskog projektovanja najvažnije razumijevanje samog procesa, a da je arhitektonski dijagram jedan od savremenih instrumenata koji taj proces omogućava i unapređuje.

U praksi je moguće detektovati generacije arhitekata koje promoviše dijagram i koriste ga kao osnovni projektantski alat unoseći na taj način inovacije u arhitektonski diskurs. Prema savremenom razumijevanju dijagram je reprezent složene strukture arhitektonskog mišljenja i sredstvo vizuelizacije kreativnog procesa.

Metodološki pristup u ovom radu zasnovan je na teorijskom i empirijskom istraživanju. U prvom dijelu rada postavlja se teorijski okvir fenomena dijagrama u arhitekturi, dok je drugi dio koncipiran kroz emprijsko istraživanje sprovedene kroz nastavni proces u okviru studio projekta na studijskom programu Arhitektura na Arhitektonsko - građevinsko - geodetskom fakultetu Univerzieta u Banjoj Luci. Očekivani rezultat rasprave ovog rada odnosi se na bolje razumijevanje uloge i praktične primjene dijagrama i dijagramskog mišljenja u cilju poboljšanja i unapređivanja metodologije obrazovnog procesa u oblasti arhitektonskog projektovanja.

**Ključne riječi:** arhitektura, dijagramsko mišljenje, proces projektovanja, studio projekat.

## UVOD: ARHITEKTONSKI STUDIO PROJEKAT

Osnovni zadatak arhitektonskog obrazovanja je podučavanje načina i metoda projektovanja, tj sticanje vještina kroz rad kao posebne vrste znanja. Cilj ovog istraživanja je unapređivanje prenošenja i sticanja znanja i vještine arhitektonskog projektovanja, a u okviru studio projekta kroz upotrebu arhitektonskog dijagrama kao odgovarajuće alatke za rješavanje konkretnih zadataka sa kojim se suočava arhitektonska profesija.

Studio projekat (*design studio*) glavna je komponenta studijskog programa Arhitektura i predstavlja okosnicu savremenog obrazovanja u školama arhitekture širom svijeta. On je koncipiran na principu *učenje kroz rad* (*learning by doing*) i u pedagoškom smislu razlikuje od većine drugih akademskih programa (Schön, 1987). Učenje u studio projektu zasniva se na savladavanju vještina (*competency-based learning*) koje postavljaju studente u situaciju da na kreativan i kritički način riješavaju arhitektonske i prostorne problema (*project-based studio courses*) kroz promjenljive zadatke tokom školovanja. (Salama, & Wilkinson, 2007).

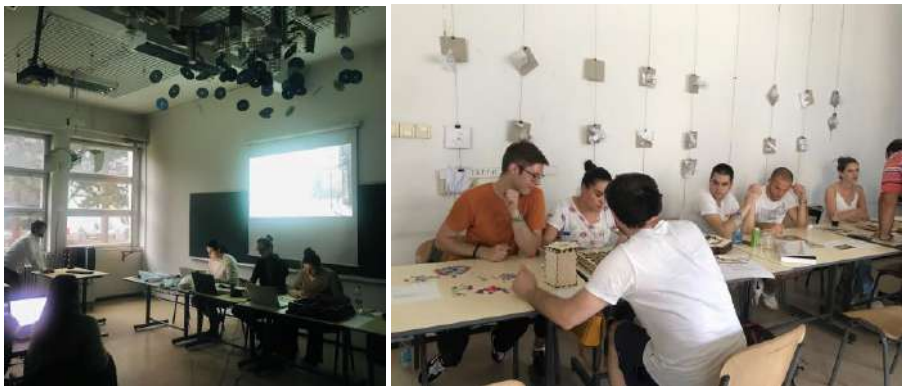
Američki filozof i profesor urbanog planiranja Šen (Donald Schön) definiše dizajn studio kroz četiri centralna koncepta učenja: - kao kulturu u kojoj studenti i nastavnici rade zajedno; - kao fizički prostor gdje se dešava podučavanje i učenje; - studio kao način podučavanja i učenja, i konačno, studio - kao program aktivnosti (Schön, 1987).

Kontekst studija gradi se na način da su studenti angažovani na rješavanja arhitektonskih i prostornih problema iz simuliranog svijeta prakse uz konstatnu saradnju sa profesorima i saradnicima. Kultura učenja u studiju je takva da studenti i nastavnici rade zajedno po principu *jedan na jedan*, razgovarajući traže moguća rješenja i to stvara interaktivnu razmjenu znanja. Ova pedagoška praksa je jedinstvena kultura učenja i karakteristična je za kreativne discipline.

U studio projektu studenti rješavaju projektne zadatke kroz rad metodom pokušaja i greške (*trial-error manner*), stoga je pedagoški pristup učenja arhitektonskog projektavanja prvenstveno iskustveni. Na taj način student se suačava sa simuliranim problemima koje promišlja uz konstatne razgovore i konsultacije sa nastavnikom i saradnicima u studiju, a koji već imaju iskustveno znanje i poznaju operativne korake u procesu projektovanja (Dulić, 2019).

U studio okruženju student stiče tri osnovne vještine u arhitektonskom obrazovanju: razvija karakterističan arhitektonski način mišljenja; usvaja jezik arhitekture kojim izražava to mišljenje i ovladava vještinom crtanja i grafičkog prikazivanja (Ledewitz 2014). Ove tri vještine savladavaju se paralelno, međusobno su zavisne i predstavljaju logički povezanu cjelinu u arhitektonskom obrazovanju. Način sticanja ovih vještina je jedino je moguć kroz praktično rješavanje problema u studio projektu. Tako stečeno iskustvo omogućava studentu da shvati sve aspekte arhitektonskog projektovanja (Schön, 1987).

Međutim, studio kao koncept obrazovanja ima i svoje probleme. Oni se javljuju kada metodologija rada u studiju nije usklađena sa načinom kako studenti koji nemaju iskustveno znanje pristupaju rješavanju problema. Iz toga razloga postoje istraživanja i stavovi da se sticanje vještina u studiju može znatno poboljšati i učiniti efikasnijim uvođenjem odgovarajućih metodologija projektovanja u postepenim fazama razvoja. Također preciziranjem tehnika i grafičkih alata i prikaza učenja omogućava bolje razumijevanje nepoznatog polja u kojem se student nalazi (Curry, 2014).



Slika 1. Učenje kroz rad u studio projektu - Arhitektonsko-građevinsko-geodetskifakultet Univerziteta u Banjoj Luci.
Figure 1. Learning through work in a studio project - Faculty of Architecture, Civil Engineering and Geodesy, University of Banja Luka.

## CRTEŽ I KOMUNIKACIJA U ARHITEKTONSKOM STUDIJU

U prethodnom poglavlju podvukli smo činjenicu da se aspekti arhitektonskog obrazovanja: arhitektonsko mišljenje, jezik arhitekture i umijeće crtanja, kao osnovne međusobno zavisne vještine, usvajaju paraleno u okviru studio konteksta kroz rad. Grafički alati i tehnike koji se koristi u procesu nastanka i uobličavanja ideje i koncepta predstavljaju svojevrsnu formu artikulacije arhitektonskog mišljenja. Studenti arhitekture ostvaruje svoje ideje kroz različite radne medije kao što su crteži, skice, dijagrami, modeli i 3D prikazi, među kojima crtež zauzima prvo i dominantno mjesto (Milić Aleksić, 2022).

Slika 2. Ruka koja misli – kreativni proces u studio projektu.
Figure 2. The hand that thinks - the creative process in a studio project.

Crtež kao grafički alat predstavlja osnovni instrument arhitektonskog mišljenja. Slobodnoručan ili digitalan, crtež predstavlja radni materijal – on je zapis mišljenja u procesu projektovanja. Saznanja i sticanja vještina u arhitektonskoj profesiji putem crteža i ostalih istraživačkih medija i radnih materijala koji se javlja u tom procesu ključni su za razvijanje apstrakcije i imaginacije neophodne za kreativne profesije. Na taj način, uspostavlja se unutrašnja komunikacija stvaraoca i njegovog radnog materijala, te radni materijal biva prenosnik ponekad i neočekivanih informacija koje usmjeravaju dalje kreativne procedure. Drugim riječima, arhitektonsko mišljenje se ostvaraju kroz arhitektonske medije, a prvenstveno kroz različite oblike crteža. Ideja postaje vidljiva kroz proces nastajanja – tako se ostvaruje veza između imaginirajućeg uma i slike koja se pojavljuje (Pallasma, 2009). Dakle, svi arhitektonski mediji su oblik proizvodnje znanja i koncepcija u samom toku kreativnog projektantskog postupka.

Arhitektonski crtež kao alat ima operativnu ulogu kao sredstvo geneze ideje ali i sredstvo reprezentacije – prikaz ideje i koncepcija. Prema tome, crtež je istraživački metod za produkciju znanja (Frascari, 2013). Crtež je i dijalog koji student ostvaruje sa samim sobom tokom procesa projektovanja, ali i osnovno sredstvo komunikacije studenta i nastavnika u studiju. Drugim riječima, model učenja u studiju se prvenstveno zasniva na vizuelnoj komunikaciju uz pomoć kritike nastavnika kroz crtež.

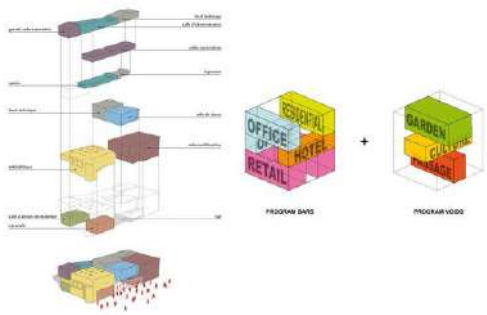
U konsultacijama *jedan na jedan* kritika nastavnika ostaje kao zapis dalje u obliku crteža iz kojih studenti bolje shvataju date komentare i sugestije za dalji rad. Dakle ukupni grafički prikazi su sredstva komunikacije i vrednovanja studentkosg rada (Crowther, 2007).

## ARITEKTONSKI DIJAGRAM KAO SAVREMENA ALATKA

Iz perspektive komunikacijskih svojstava arhitektonskih medija, dijagram se često smatra sredstvom za objašnjavanje, nečim što dolazi nakon činjenica i pojašnjava formu, strukturu ili program. Dijagramska grafička tehnika kao simplifikovana vizuelna alatka obezbjeđuje sažimanje posredovanih informacija, kao i njihov brz tok i jasno tumačenje u daljoj komunikaciji. Šematizovan i grafički reduktivan dijagram omogućava, takoreći, trenutno čitanje (Allen, 2009).

Iz perspektive savremenog razumijevanja dijagrama i dijagramskog mišljenja, pored njegove izražene reprezentacijske osobine trenutnog predstavljanja često vrlo složenih

varijabli u arhitekturi na apstraktnom i simplifikovanom nivou, dijagram istovremeno predstavlja moćan alat u generičkom smislu upravljanja tim varijablama. Iz tog razloga, dijagram jeste najkondenzovanija arhitektonska alatka za razmišljanje kada je u pitanju organizacija višestrukih elemenata.




Slika 3. Primjer arhitektonskog dijagrama kao grafički reduktivane i simplifikovana vizuelna alatka.
Figure 3. An example of an architectural diagram as a graphically reduced and simplified visual tool.

U rječniku savremene arhitekture pronalazimo definiciju da je dijagram grafički asamblaž koji precizira odnose između aktivnosti i forme, organizujući strukturu i distribuciju funkcija. Kao takvi, dijagrami su najbolja arhitektonska sredstva kako bi bila uključena sva kompleksnost stvarnosti.

Krajem sedamdestih XX vijeka, razvijajući ideju kompleksnosti stvarnosti, arhitekte Kolhas i Čumi (Koolhaas, Tschumi), u svojim eksperimentima i praksi zainteresovani za pitanje programa i događaja, okreću se razvijanju nove dijagramske tehnike u promišljanju arhitekture, postavljajući dijagram kao konačno sredstvo arhitektonske produkcije i diskursa (Allen, 2009).

Danas je moguće identifikovati čitavu generaciju savremenih arhitekata koja je promovisala dijagram kao način mišljenja i projektantski postupak, unoseći inovacije u arhitektonski diskurs. Japanski arhitekta Tojo Ito (Toyo Ito) prvi je upotrijebio termin „dijagramska arhitektura“ da bi označio arhitekturu koja se proizvodi na ovaj način. Prelomni trenutak dešava se u drugoj polovini 20. vijeka u društvu informacija, koje je uslovilo promjenu od intuitivnog mišljenja kroz skicu prema mediju dijagrama kao osnovno savremene digitalne tehnike za istraživanje, oblikovanje i reprezentaciju.

Dijagramsko mišljenje ukazuje na proces formiranja strukture raznorodnih informacija i njihovih relacija koje arhitekta treba da sagleda i uključi u svoj rad.

Veliki je broj autora u arhitektonskoj teoriji koji govore o dijagramskom mišljenju, istraživanju i projektovanju kao platformi koja unosi inovaciju za odgovor arhitekture na potrebe savremenog društva. Vidler dijagram posmatra kao specifičan crtež vezan za različite savremene arhitektonske prakse, ali ono što uočava kao zajedničko jeste upotreba logike dijagrama i korišćenje računarskih metoda za građenje koncepata (Vidler, 2000):

Arhitekta Piter Ajzenman dijagramski pristup arhitekturi razmatra kao analitičko sredstvo u savladavanju složenih i raznorodnih spoljašnjih uticaja kroz svoje unutrašnje mehanizme. Naglasak je na istraživačkom procesu i generičkom mehanizmu dijagrama, a ne na formi kao krajnjem proizvodu (Eisenman, 1999).

Teoretičar arhitekture Robert Somol (Robert Somol) u predgovoru knjige Diagram Diaries iznosi mišljenje da je dijagram postao dominantna radna alatka kao dio proizvodnje arhitekture, a ne njene reprezentacije, te da je kao takav nezaobilazan medij komunikacije u savremenoj arhitektonski praksi (Somol, 1999). On veže performativno svojstvo dijagrama za promjene u arhitektonskoj teoriji i praksi koje se dešavaju šezdesetih godina 20. vijeka. Novo razumijevanje arhitekture u tom periodu donosi i nove tehnike i metode arhitektonskog saznavanja te dijagram nadvladava osnovni arhitektonski crtež.

Holandski arhitekti Ben Berkel (Ben Berkel) i Karolina Bos (Caroline Bos) - (UNstudio) u svojoj knjizi Move, dijagrame definišu kao organizovane informacije na višestrukim nivoima, koje unapređuju generički način projektovanja (Berkel, & Bos, 1999).

Iz dosadašnjih istraživanja uočavaju se su različite uloge dijagrama: generisanje koncepata, eksternalizaciju i vizuelizaciju problema, organizovanje kognitivnih aktivnosti,

pojednostavljenje rješavanja problema i kreativnih napora, uprošćena percepcije i prenošenja ideja, predstavljanje stvarnih artefakata kojima se moze manipulisati, revidiranje i unapredivanje ideja. Dijagram u savremenom razumijevanju profesije ima performativni karakter proizvodnje, modalitet otvorenosti i dinamičnosti u skladu sa informacionim društvom u kojem živimo. U tom smislu, možemo ga posmatrati kao grafički konvertor spoljašnjih informacija u unutrašnji mehanizam mišljenja arhitekture. U tom smislu dijagram jeste savremena alatka za vizuelizaciju ulaznih podataka i na taj način i generator početnih ideja. Drugim riječima metod dijagrama jeste reprezent složene strukture arhitektonskog mišljenja i istovremeno vizuelizacija misaonog procesa.

## ULOGA DIJAGRAMA U ARHITEKTONSKOM STUDIJU

U prethodnom poglavlju dat je teorijski pregled potencijala i aktuelnosti dijagrama kao savremene grafičke alatke u arhitektonskoj profesiji. U ovom poglavlju prikazaće se uloga dijagrama u učenju arhitektonskog projektovanja u sklopu studio projekta. U praktičnom istraživanju biće prikazani rezultati rada sa studentima na trećoj godini osnovnih akademskih studija na studijskom programu Arhitektura, Arhitektonsko-građevinsko-gedetskog fakulteta Univerzitata u Banjoj Luci. Ovo istraživanje je sprovedene u okviru Studio projekat 7, školske 2022/23 godini u ljetnom semestru, kao prvo izvođenje ovog predmeta u sklopu novog akreditovanog studijskog programa Arhitektura iz 2019 godine. Prvenstveni cilj novoakreditovanog studijskog programa je bio osavremenjivanje nastave uvođenjem studio projekata kao okosnice u obrazovanju arhitekata. Nastavnici u studiju krenuli su od pretpostavke, a u skladu sa savremenim tendencijama, da rad u studio projektu zasnovan na dijagramima može da bude od velike pomoći studentima i da može da unaprijedi vještinu projektovanja u okviru studija.

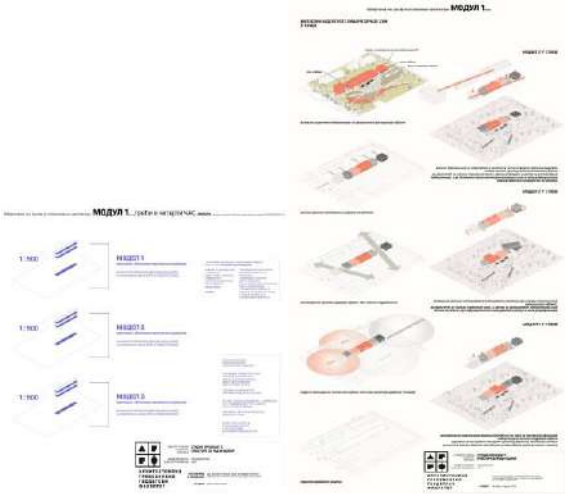
U skladu sa silabusom studio se odvijao kroz predavanja i vježbe. Na početku semestra studenti su upoznati sa strukturom i ciljevima predmeta, načinom realizacije, projektnim zadatkom, oblicima i načinom kontrolnih predaja kao i načinom ocjenjivanja. Struktura praktičnog dijela studija (vježbe) definisana je u četiri modula, kao četiri osnovne faze u projektovanju sa preciznim ciljevima i ishodima učenja:

- Modul 1 (iz lokacije do modela) podrazumijeva početne analize i istraživanja;
- Modul 2 (iz modela do koncepta) podrazumijevao je postavku programsko- prostornih sadržaja usklađenih sa oblikovnim modelima iz prethodnog modula;
- Modul 3 (od koncepta do razrade) pretpostavljao je razvoj i razradu projekta;
- Modul 4 (iz razrade i razmjere do materijalizacije života) predstavlja finalizaciju projekta i završne grafičke priloge za predaju semestralnog elaborata.

Kraj svakog modula podrazumijevao je kontrolnu predaju rada (kolokvijum) kako bi se vrednovao proces rada tokom semestra, jednako kao i konačni rezultat na kraju semestra. Također, svaki kolokvijum je podrazumijevao i komentare nastavnika i saradnika koji bi usmjeravali dalji rad studenta.

Nagalasak na upotrebi dijagrama bio je na početku semestra u okviru modula 1 i na kraju semestra u formi ispita kada su studenti prezentovali svoj projekat.

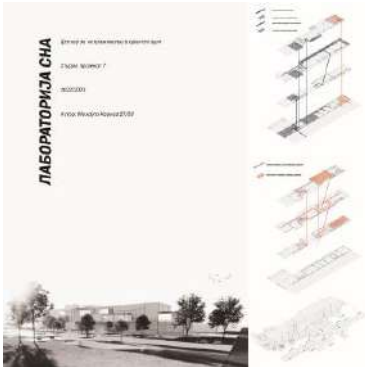
Na početku semestra studentima su predstavljeni jasno definisani konceptualni i operativni dijagrami. Ideja je bila da se u početnoj fazi projektovanja, kada su studenti suočeni sa velikim brojem informacija i nepoznanica, definišu precizni koraci u metodologiji projektovanja kroz pripremljene operativne dijagrame. Ovi dijagrami osmišljeni su tako da da podstaknu istraživanja i eksperimenete u ključnoj fazi projektovanja. Na taj način uspostavili su se precizni koraci i dijagramski alati u pristupu rješavanja projektantskih problema sa ciljem da svaki student uvidi različite mogućnosti i potencijale u procesu rada.



Slika 4. Lijevo: primjer pripremljenih dijagrama od strane nastavnika. Desno: primjer odgovora studenta na osnovu unaprijed pripremljenih dijagrama.
Figure 4. Left: an example of diagrams prepared by the teacher. Right: an example of a student's answer based on the diagrams prepared in advance.

Cilj je bio da učenje zasnovano na precizno definisanim početnim dijagramima unaprijedi razmišljanje studenata i omogući sistematičniji prikaz njihovih ideja. Rezultati koji su dobijeni tokom semestra pokazali su pozitivan uticaj primjene precizno definisanih pripremljenih dijagrama od strane nastavnika. Ovi dijagrami su omogućili lakše savladavanje složenog gradiva i pozitivno su uticali na vještine savladavanja proces projektovanja. Generalno, može se zaključiti da su data uputstva u početnoj fazi projektovanja dala bolje rezultate nego u slučaju kada su studenti upućeni da sami smisle metode dolaženja do rješenja. Cilj unaprijed definisanih dijagrama je bio da omogući studentima bolji uvid u početnoj analitičkoj fazi konceptualnih i prostornih potencijala, zatim u postavci programsko-prostornih odnosa, kao i prvih oblikovnih odnosa sa kontekstom. Pripremljeni dijagrami omogućili su bolju organizaciju različitih informacija i vizualizaciju problema sa kojima su suočeni, pa time i lakše generisanje početnih ideja - što svakako opravdava ulogu ovakve vrste dijagrama u početnoj fazi rada.

U sklopu završnog modula studenti su dalje upoznati sa različitim konceptima arhitektonskog dijagrama u smislu postprodukcije projekta i kratke grafičke forme prezentacije Za razliku od prvog modula u ovoj završnoj fazi je ostavljena sloboda da studenti sami kreiraju karakter dijagrama koji na najbolji način prezentuju njihov rad. Ovi završni postprodukcijiski dijagrami imali su za cilj da naglase osnovnu ideju i potenciraju najbitnije aspekte njihovog projekta.




Slika 5. Primjer postprodukcijskih dijagrama u sklopu završne prezentacije grafičkih radova.
Figure 5. Example of post-production diagrams as part of the final presentation of graphic works.

## ZAKLJUČCI

U prvom dijelu rada sa teorijskog stanovišta dati su prikazi savremenog arhitektonskog obrazovanja u vidu modela studio projekta i fenomena arhitektonskog dijagrama i dijagramskog mišljenja u savremenoj teoriji i praksi. U drugom dijelu rada predstavljeno je praktično istraživanje rezultata upotrebe dijagrama u nastavnom procesu u okviru studio projekta na studijskom programu Arhitektura na Arhitektonsko - građevinsko - geodetskom fakultetu Univerziteta u Banjoj Luci.

Rezultati predstavljeni u ovom istraživanju pokazali su da je uloga arhitektonskog dijagrama i dijagramskog mišljenja u metodologiji arhitektonskog obrazovanja u okviru studio projekta od višestrukog značaja. Prvenstveno, dijagram omogućava studentima da na sistematičniji način savladavaju složen proces arhitektonskog projektovanja. Istovremeno, dijagrami kao redukovani i apstrahovani grafički prikazi, omogućili su bolju i efikasniju komunikaciju između studenata i nastavnika, i na taj način bolji uvid nastavnika u arhitektonske namjere i odluke studenata. Praktično istraživanje u konkretnom slučaju je također potvrdilo da je studentima omogućeno bolje razumijevanje složene početne faze projektovanja kroz primjenu konceptualnih unaprijed pripremljenih dijagrama, koje su dobili na početku semestra. Na kraju semetra ostavljena je sloboda da studenti sami kreiraju postprodukcijske dijagrame, koji su u velikoj mjeri bili uspješni i inventivni, i na taj način uvjerljivo prezentovali svoje projekte. Možemo zaključiti da su rezultati koji smo dobili potvrdili važnu ulogu dijagramskog pristupa u metodologiji arhitektonskog obrazovanja u okviru studio projekta.

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# THE ROLE OF A DIAGRAM IN THE METHODOLOGY OF ARCHITECTURAL EDUCATION

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**ABSTRACT**

The main goal of this paper is to examine the role of a diagram within the design studio as a significant methodology in contemporary architectural education. Our starting point is the fact that in mastering the skill of architectural design, the most important thing is to understand the process itself, and that the architectural diagram is one of the modern instruments that enables and improves that process. In practice, generations of architects who promote the diagram and use it as a basic design tool, thereby introducing innovations into the architectural discourse. According to our current understanding, the diagram is a representation of the complex structure of architectural thinking and a means of visualizing the creative process. The methodological approach in this paper is based on theoretical and empirical research. In the first part of the paper, the theoretical framework of the diagram phenomenon in architecture is set, while the second part is conceived as an empirical research conducted through the teaching process within the design studio of the Architectural Studies at the Faculty of Architecture, Civil Engineering and Geodesy of the University of Banja Luka. The expected result of the discussion of this paper is a better understanding of the role and practical application of a diagram and diagrammatic thinking in order to improve and advance the methodology of the educational process in the field of architectural design.

**Keywords**: architecture, diagrammatic thinking, design process, design studio.

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# STUDENT EVALUATION OF THE QUALITY OF HIGHER EDUCATION IN BOSNIA AND HERZEGOVINA

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## ABSTRACT

The paper analyzes the student assessment of the quality of higher education in Bosnia and Herzegovina, with an emphasis on the implementation of standards for quality improvement introduced in 2012. The aim of the research is to assess the effectiveness of these measures in improving the quality of higher education in the country. The main research question is whether there is a difference in the quality of teaching before and after the introduction of quality assurance standards. In order to arrive at the results, an independent samples t-test was conducted with the calculation of the mean and standard deviation. The data used were collected using survey questionnaires, and referred to the period before the introduction of the standard (from 2008 to 2012) and after the introduction of the standard (from 2013 to 2022). The data were processed using the statistical program IBM SPSS Statistics. The obtained results show that student evaluation is a valuable tool for improving quality and that the introduction of standards and accreditation of higher education institutions are steps taken in the right direction. However, there is still room for further improvements in the quality of higher education in Bosnia and Herzegovina.

**Keywords:** quality, ENQA, higher education, standards, teaching process.
JEL classification: I23, I28

## INTRODUCTION

Quality assurance in higher education is a system that must be woven into the creation of higher education policies in all European countries. The understanding of quality and the basic predispositions of certain concepts mix, intertwine and change due to constant changes in the environment in which higher education institutions operate. The mentioned changes also occur due to the increase in knowledge within higher education systems and institutions that are gradually developing their own conceptions of quality and models of evaluation and quality management.

A key stage in the process of harmonization of higher education systems in the European area is the construction of a system for improving the quality of higher education. Standards and guidelines for quality assurance in the European Higher Education Area (SGQA/ESG) were prepared by the European Association for Quality Assurance in Higher Education (ENQA) in cooperation with EUA, EURASHE, and ESIB and at the request of the Bologna Conference held in Berlin in 2003. European standards and guidelines for quality assurance (ESG) were accepted at the conference in Bergen in 2005, which became part of the obligations of the signatory countries that had to report on their implementation at the Lisbon conference in 2007. Higher education institutions in Bosnia and Herzegovina started working on the introduction of quality assurance policy and practice as early as 2003.

The Law on Higher Education of Bosnia and Herzegovina was adopted in 2007 and contained quality requirements, and from 2009 to 2012, changes were being made that included quality assurance, when the Agency for Accreditation of Higher Education Institutions of the Republic of Srpska was established. The first evaluation of the establishment of quality in higher education in the Republic of Srpska began in 2012, and already in 2013, five higher education institutions were accredited, including two public universities and three private higher education institutions from the Republic of Srpska. Here it is important to highlight the concept of accreditation itself, which basically aims to control and ensure quality during the introduction of new programs and regular

implementation of control and supervision over the quality of already existing institutions and their programs. Accreditation is carried out after the audit establishes that the minimum standards for content and specialization are met, as well as for the professional importance of the program being introduced and the coherence and consistency of its basic concept.

ESG covers three main areas:

- Internal quality assurance organized within higher education institutions, which refers to the development, implementation, and monitoring of quality assurance processes and structures;
- External quality assurance and relevant activities, which generally deals with what should be examined within institutions of higher education, and the manner in which activities related to external quality assurance should be carried out;
- The work of external quality assurance agencies in terms of their establishment, organization, and recognition.

Their goals are to promote and support the constant improvement of the quality and standards for the provision of higher education programs, to make clear and precise information available to the public about the quality and standards of the provision of higher education and training, as well as to apply the best international practice in the assessment and auditing of higher education. education and training programs.

The long-term goals are the promotion of the mobility of students, graduates and citizens within Bosnia and Herzegovina and at the international level, equal social opportunities for all categories of students in this country, promotion of scientific research work and knowledge, and compatibility with the European Union in various fields. Accordingly, Standards and guidelines for quality assurance in higher education in Bosnia and Herzegovina were adopted. After the adoption of ESG standards in Yerevan in 2015, the Agency for the Development of Higher Education and Quality Assurance (HEA) adopted a new document related to the quality assurance system in Bosnia and Herzegovina, which is aligned with ESG standards, and in 2016 the criteria are determined for the accreditation of higher education institutions in Bosnia and Herzegovina, which are applied in the accreditation procedures of all higher education institutions (www.hea.gov.ba, 2023). In 2019, the HEA Board of Directors adopted the Decision on Norms Establishing Minimum Standards in the Field of Higher Education in Bosnia and Herzegovina (Agency for Higher Education of the Republic of Srpska [AHERS], 2023). The Agency for Higher Education of the Republic of Srpska monitored changes at the European level, acted in accordance with them, and the amendments to the Standards for Accreditation of Higher Education Institutions of the Republic of Srpska and the Standards for Accreditation of Study Programs of the First and Second Cycle of Studies were adopted in 2022 (Agency for the Development of Higher Education and Quality Assurance [ADHEQA, ]2023).

## MATERIAL AND METHODS OF WORK

In the most general sense, quality is a trait that denotes a particular object or phenomenon and distinguishes them from other objects or phenomena. There is no unique definition of quality. The reason is that quality is in fact the perception of quality. What the user perceives as quality, it is the quality (Kelly, 1997). Deming (1986) says that quality is the predictable ratio of standardization and customization with low price and market orientation, and Juran (1970) considers quality as the suitability requirements estimated by the user.

Discussion around what constitutes quality in higher education continues to be the focus of introductory comments in the literature and with good reason. Academics are concerned to be able to identify and understand concepts that form the basis of contemporary discourse in the sector and quality is just that: a concept that since the mid 80 has increasingly dominated discussions about the role and future of higher education institutions and the academics that constitute those institutions around the globe (Watty, 2002).

Quality in higher education is a multidimensional concept, which should include all its functions, activities, teaching and academic program, research and scholarship, staff, students,

building, facilities, equipment, services to the community and the academic environment (UNESCO, 1998). Quality is one of the most frequently used terms in the business world, and according to Golder, Mitra and Moorman (2012), quality is probably the most important and complex component of business strategy. Bosnia and Herzegovina's higher education institutions have been under scrutiny for a long time when it comes to quality. Therefore, the increased demand for quality higher education of students and the entire society implies that institutions in higher education are facing the pressures that the private sector has been exposed to for decades.

The quality of any educational system in any society, including Bosnia and Herzegovina, depends on the quality of higher education. According to Barnett (1994), higher education refers to the production of skilled labor, education as training for career exploration, as effective management of teaching provisions, then as a way to create life opportunities.

According to writing Goran D., in research Quality in higher education: A Review of the Research Literature, the last decade was characterized by increasing of competition among higher education institutions (Goran, 2015). High quality service is an essential prerequisite for competitiveness and survival in the market of higher education. The biggest challenge for academic institutions is which level of quality institutions must achieve in order to remain competitive in the market. To successfully overcome the aforementioned challenges higher education institutions are required to identify students' needs and understand the formation of student perceptions of service quality. Students' expectations significantly affect the assessment of service quality and students' satisfaction. For admission to higher education institutions, students' expectations are largely based on their past experiences in high school and the positive experience of students who attend or have attended that program.

In accordance with the above, research was conducted with the aim of assessing and comparing the quality of the teaching process before and after the introduction of standards for quality assurance in higher education. In addition to the above, the goal of the research is to analyze the trend of the average grades of teaching (lectures and exercises) that was realized at a private higher education institution in the Republic of Srpska.

The research is based on the general hypothesis that there is no significant difference between the quality of the teaching process before and after the introduction of standards for ensuring the quality of higher education in Bosnia and Herzegovina. A total of five variables were included in the research, namely: Teaching process, Classes, Lectures, Exercises and Period. When assessing differences in the quality of the teaching process, the dependent variable is the teaching process (Teaching process), while the other variables are independent.

The comparison was made at a private higher education institution among students of the first cycle of studies attending one of four study programs, namely: Management, Business and Business Economics, Informatics, Graphic Design and Visual Communications and Media and Economics. The research included a total of 5717 students who, in the period from 2008 to the end of 2022, evaluated the quality of the teaching process, that is, the quality of lectures and exercises performed at this higher education institution. Students of all years (first, second, third, fourth year) of study and graduate students were included in the research.

According to legal provisions, the academic year in Bosnia and Herzegovina lasts from October of the current year to October of the following year. Classes are organized in two semesters - winter (October-January) and summer (March-June). In the last week of classes, a survey of students is conducted with the aim of assessing their opinion on the quality of the teaching process, that is, on the quality of lectures and exercises that are carried out during the semester. The survey questionnaire consists of 10 questions related to the teaching process, and only three related to the quality of teaching, lectures and exercises were included in the research. Students should evaluate the quality of the lectures and exercises, as well as the quality of the entire teaching process, which includes the teacher's willingness to cooperate, the ability to motivate the student, and his interest in involving the student in scientific and research work. Students graded the mentioned criteria from 1 to 5, with 1 being the lowest and 5 being the highest. It is important to note that the period from the academic year 2008/2009 to 2012/2013 refers to the time when standards for quality assurance in higher education were not introduced in Bosnia and

Herzegovina, while the period from the academic year 2013/2014 to the end of the analyzed period (academic 2021/2022) refers to the time when quality in higher education was ensured by means of the mentioned standards.

The collection of survey questionnaires was analyzed by the Quality Assurance Commission of the higher education institution. The survey questionnaires were identical during the entire analyzed period, which enables the comparison of the obtained results. The results of the evaluation of the quality of the teaching process are available on the website of the selected higher education institution, and the higher education institution has given its consent to the anonymous analysis of the data and the publication of the results for academic purposes. Data were collected for fourteen academic years, that is, from the academic year 2008/2009 to the academic year 2021/2022. The data were processed using the statistical program IBM SPSS Statistics Version 26.

The main research question in this study is whether there was a difference in the quality of the teaching process before and after the introduction of quality assurance standards in higher education. In order to arrive at the results, an independent samples t-test was conducted with the calculation of the mean and standard deviation. Furthermore, a comparative analysis was used to monitor and compare the quality of teaching, lectures and exercises during the analyzed period. The research was conducted in the following way: first, a comparison of the quality of the teaching process was made before and after the introduction of quality assurance standards, and then the trend of teaching grades, lectures and exercises during the analyzed period was analyzed. Accordingly, the results of the research were presented.

## RESULTS AND DISCUSSION

In order to answer the question of whether there is a difference in the quality of the teaching process before and after the introduction of standards for quality assurance in higher education in Bosnia and Herzegovina, a t-test of independent samples was conducted. Data were collected on the quality of the teaching process at the higher education institution, and the quality of the teaching process was evaluated by students during fourteen academic years. The survey covered a total of 5717 students, which is about 75% of the total number of students of this higher education institution during the analyzed period. A total of 2166 students (37.89% of the total sample) participated in the surveys that were conducted before the introduction of the standards for quality assurance of higher education, and a total of 3551 students (62.11% of the total sample) participated in the surveys that were conducted after the introduction of the mentioned standards. The largest number of students are in the Management, Business and Business Economics study program (2309 students, i.e. 40.4%), followed by students from the Informatics study program (1732 students, i.e. 30.3%) and the Graphic Design and Visual Communications study program (1326 students, or 23.2%), while the least number of students are from the Media and Communication study program (350 students, or 6.1%).

The authors analyzed the average ratings of the quality of the teaching process and teaching (lectures and exercises) during the semester, and based on that, determined the average rating for the entire academic year. The research was conducted with the aim of determining whether the introduction of standards for quality assurance in higher education affected the quality of the teaching process at a selected higher education institution in the Republic of Srpska. The comparison of the quality of the teaching process was carried out using the t-test, and the obtained results are presented below.

### Results of a comparative analysis of the quality of the teaching process

During the academic years 2008/2009, 2009/2010, 2010/2011 and 2011/2012, the teaching process was implemented without agreed standards for quality improvement in higher education. In that period, the average rating of the quality of the teaching process was 4.2, with a standard deviation of 0.2. After that period, from the 2012/2013 academic year, when quality assurance standards were introduced, until the end of the 2021/2022 academic year, the average rating of the quality of the teaching process was 4.4, with a standard deviation of 0.4. Comparison of the quality

of the teaching process before and after the introduction of quality assurance standards was performed using a t-test, and the results are shown in Table 1.

Table 1. Comparison of the quality of the teaching process before and after the introduction of quality assurance standards.

| Assessment items | Before the introduction of the standard | | | After the introduction of the standard | | | Diference mean | t-Test value | p value |
|---|---|---|---|---|---|---|---|---|---|
| | Mean | St. dev. | N | Mean | St. dev. | N | | | |
| Teaching process | 4.22 | 0.21 | 2166 | 4.42 | 0.40 | 3551 | 0.305 | 0.860 | 0.003 |

A t-test of independent samples was used to compare the student evaluation of the quality of the teaching process and teaching (lectures and exercises) at a higher education institution. The results show that there is a significant difference in the average ratings of the quality of the teaching process before the introduction of quality assurance standards (Mean = 4.22, St. dev. = 0.21) and after the introduction of standards (Mean = 4.42, St. dev. = 0.40), because the obtained p value is higher than the set significance limit ($p<0.005$).

Furthermore, a comparison was made of the quality of teaching during the two observed periods, where the first period refers to the time before the introduction of quality assurance standards, and the second period to the time after the introduction of the mentioned standards. The obtained results are presented in Table 2.

Table 2. Comparison of teaching quality before and after the introduction of quality assurance standards.

| Assessment items | Before the introduction of the standard | | | After the introduction of the standard | | | Diference mean | t-Test value | p value |
|---|---|---|---|---|---|---|---|---|---|
| | Mean | St. dev. | N | Mean | St. dev. | N | | | |
| Classes | 4.16 | 0.08 | 2166 | 4.38 | 0.085 | 3551 | 0.082 | 0.376 | 0.002 |

By comparing the quality of teaching, it was determined that there is a statistically significant difference, because the average rating of the quality of teaching before the introduction of the standard was 4.16 (with a standard deviation of 0.08), and after the introduction of the standard was 4.38 (with a standard deviation of 0.082). In this case, the obtained p value is 0.002 and is lower than the set significance limit of 0.005, which confirms the existence of a difference in the quality of teaching before and after the introduction of standards for quality assurance in higher education.

The obtained results on the quality of teaching were confirmed by the analysis of the quality of lectures and exercises during the selected period, and the obtained results are presented in Table 3.

Table 3. Comparison of the quality of lectures and exercises before and after the introduction of quality assurance standards.

| Assessment items | Before the introduction of the standard | | | After the introduction of the standard | | | Diference mean | t-Test value | p value |
|---|---|---|---|---|---|---|---|---|---|
| | Mean | St. dev. | N | Mean | St. dev. | N | | | |
| Lectures | 4.19 | 0.13 | 2166 | 4.40 | 0.097 | 3551 | 0.113 | 0.071 | 0.002 |
| Exercies | 4.12 | 0.18 | 2166 | 4.35 | 0.07 | 3.551 | 0.125 | 0.136 | 0.003 |

The research determined that there is a statistically significant difference in the quality of lectures (p value = 0.002) and exercises (p value = 0.003) before and after the introduction of quality assurance standards in higher education in Bosnia and Herzegovina. In addition, the average rating of the quality of lectures before the introduction of quality assurance standards was 4.19 (with a standard deviation of 0.13), while this rating after the introduction of the standards was 4.40 (with a standard deviation of 0.097). The average assessment of the quality of the

exercises before the introduction of the mentioned standards was 4.12 (standard deviation 0.18), while after the introduction of the standards it was 4.40 (standard deviation 0.097).

The t-test was used to compare the ratings of the quality of the teaching process evaluated by students during the observed period. The results show that the teaching process realized after the introduction of quality assurance standards was better evaluated by the students. Given that there is a statistically significant difference between the ratings of the quality of the teaching process before and after the introduction of quality assurance standards, the size of the impact was determined using the eta square, which represents the proportion of variance in the dependent variable (Teaching process) explained by the independent variable of the grouping, whose value can be from 0 to 1. In this case, the eta square is 0.228 and indicates a medium influence, ie. shows that the implementation of quality assurance standards affects the quality of the teaching process by 22.8%.

**The results of the comparative analysis of the trend of the evaluation of the teaching process**

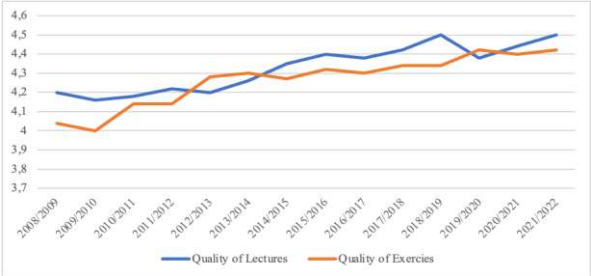
In addition to the comparison of the quality of the teaching process before and after the introduction of standards for quality assurance in higher education, the trend of the average grades of teaching, i.e. lectures and exercises, was also analyzed. The presented grades were obtained by surveying students who attended classes at a selected higher education institution in the Republic of Srpska in the period from the 2008/2009 academic year to the end of the 2021/2022 academic year.

Graph 1. The trend of teaching grades.

The graph shows the trend of the average grade. As can be seen, the quality of teaching changed in the period from the 2008/2009 academic year to the end of the 2021/2022 academic year. The quality of teaching generally had an upward trend, with the exception of the 2009/2010, 2016/2017 and 2019/2020 academic years, with a slight decrease of 0.2 in absolute value recorded in those years. The lowest grade of teaching quality was recorded at the end of 2009/2010, when it was 4.08. On the other hand, the highest grade of teaching quality was recorded at the end of the analyzed period, when it was 4.46. The conducted analysis once again confirms that the quality of teaching that was implemented after the introduction of quality assurance standards is higher than the quality of teaching that was implemented before the introduction of these standards.

In addition to the analysis of the trend of the average teaching grade, the trend of the average grade of lectures and exercises during the analyzed period was also analyzed. The obtained results are shown in Graph 2.

The data clearly show that the trend of the average rating of the quality of lectures and the average rating of the quality of exercises changed along with the average rating of the quality of teaching. Analyzing the trend of the quality of lectures, it can be observed that the assessment of the quality of lectures generally had an upward trend, and the exception was recorded during four academic years (2009/2010, 2012/2013, 2016/2017 and 2019/2020). The lowest rating of the quality of lectures was 4.16 and was recorded during the 2009/2010 academic year. The highest teaching quality rating of 4.50 was recorded during two academic years, 2018/2019 and 2021/2022. On the other hand, the average grade of the quality of the exercises ranged from 4.00 (academic year 2009/2010) to 4.42 (academic year 2021/2022) and mostly had an upward trend (the exceptions are the academic years 2009/2010, 2014/2015, 2016/2017 and 2020/2021).




Graph 2. The trend in the movement of grades of lectures and exercises.

After the overall analysis, it can be concluded that the introduction of standards for improving the quality of higher education had a positive effect on the quality of the teaching process in Bosnia and Herzegovina. Student evaluation of the quality of the teaching process showed that the average grades for the quality of teaching, that is, lectures and exercises, increased after the introduction of the mentioned standards.

## CONCLUSIONS

The research was conducted with the aim of determining whether the quality of the teaching process in higher education in Bosnia and Herzegovina has changed after the introduction of quality assurance standards. Through data analysis, which included the application of the t-test, significant results were obtained that indicate the impact of the introduction of quality assurance standards on the quality of teaching in higher education in Bosnia and Herzegovina. These results provide valuable insights and point to the importance of further research and improvement of the quality of higher education in the country.

The first key point to emphasize is that quality assurance standards have greatly contributed to the improvement of teaching quality in higher education in Bosnia and Herzegovina. This finding shows that a systematic approach to quality assurance and the setting of standards for the evaluation of the teaching process led to visible changes in the way teaching is conducted. Through the application of the t-test, significant differences were identified between the period before and after the introduction of the standards, which indicates their effectiveness in improving the quality of teaching.

However, despite the progress achieved with the introduction of quality assurance standards, there are still certain challenges and measures that need to be taken in order to further improve the quality of the teaching process in higher education. The first important measure is continuous monitoring and evaluation of teaching activities. Periodic evaluation of teachers and programs enables the identification of weak points and the opportunity for further improvement. Also, ensuring adequate resources and infrastructure for higher education, including libraries, laboratories and technological tools, is crucial for providing quality teaching.

Furthermore, it is important to develop and support teaching staff through professional development and training. Teacher education on modern teaching methods, technology and interactive approaches in teaching can result in improving the experience of students and the quality of the teaching process. In addition, promoting collaboration between universities and industry can bring the real world into the classroom and enable students to acquire practical skills and knowledge relevant to the labor market.

Furthermore, it is important to ensure transparency and openness in the process of evaluating the quality of teaching. Students should be actively involved in decision-making processes, and their feedback and opinions should be carefully considered and used to improve teaching. Introducing feedback mechanisms such as student surveys and focus groups can provide valuable insights into student perceptions of teaching quality.

Ultimately, further research and application of best practices in evaluating the quality of the teaching process in higher education in Bosnia and Herzegovina are of vital importance. With continuous efforts to introduce standards for quality assurance, support for teaching staff and active

involvement of students, we can achieve continuous progress in the quality of higher education. Only through the joint efforts of all participants can we create an educational environment that will meet the needs of students and prepare them for a successful future.

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# *OTHER TOPICS*

*OSTALE TEME*

STRUČNI RAD – PROFESSIONAL PAPER DOI: 10.7251/PIMZ2301633M

# EKOLOŠKI KRIMINALITET KAO GLOBALNA PRIJETNJA SVIJETU

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## APSTRAKT

Ekološki kriminalitet je globalni problem i ozbiljna prijetnja prvenstveno zdravstvenoj bezbjednosti. Naime, svijest građana o značaju životne sredine je na veoma niskom nivou. Stoga ćemo u radu obraditi problem divljih deponija na području Grada Doboj, njihove uzroke, posljedice kao i mjere koje treba preuzeti u cilju prevencije ekoloških krivičnih dela. U radu će biti i predstavljene moguće mjere /rješenja radi smanjenja broja divljih deponija koje značajno ugrožavaju osnovne komponente životne sredine.

**Ključne riječi:** krivično djelo, divlja deponija, kriminalitet.

## UVOD

Ekološki kriminal je poseban vid kriminala koji ima za posljedicu zagađenje životne sredine u većem obimu ili na širem području, čime se dovodi u opasnost život i zdravlje ljudi ili uzrokuje uništenje biljnog ili životinjskog svijeta većih razmjera.

Ovaj oblik kriminala nema univerzalno prihvaćenu definiciju, ali Program Ujedinjenih naroda za okoliš (UNEP) ga naziva 'nezakonitim aktivnostima koje štete životnoj sredini i usmjerene su na dobrobit pojedinaca, grupa ili preduzeća od iskorištavanja, štete, trgovine ili krađe prirodnih resursa, uključujući, ali ne ograničavajući se na teška krivična djela i transnacionalni organizovani kriminal (https://www.mreza-mira.net/vijesti/eko-vijesti/ekoloski-kriminal-kao-dio-transnacionalnog-organizovanog-kriminala/ 17.7.2023.)

Krivični zakonik Republike Srpske inkriminisao je u glavi XXIX grupu krivičnih djela protiv životne sredine tj. krivična djela iz oblasti ekološkog kriminaliteta kao što su zagađivanje životne sredine, zagađivanje životne sredine otpadnim materijama, uništenje staništa, ugrožavanje ozonskog omotača, itd. (Krivični zakonik Republike Srpske, [KZRS], 2021).

Naime, upravo divlje deponije odnosno izvršioci koje bacaju otpad vrše neku od radnji izvršenja gore navedenih djela. Važno je napomenuti, da divlje deponije direktno zagađuju podzemne vode, šume, vazduh, obradivo zemljište i druge komponente životne sredine na duži vremenski period. Vrijeme raspada nekog otpada je i preko 500 godina čime se ozbiljno ugrožava zdravstvena bezbjednost. Dakle, pravo na zdravu životnu sredinu je Ustavom zagarantovano pravo svakog čovjeka.

Stoga, autori u radu analiziraju Izvještaj o stanju divljih deponija na teritoriji Grada Doboj, kroz prizmu krivičnih djela ekološkog kriminaliteta, dajući određene preporuke i mjere u cilju prevencije i suzbijanja vršenja ovih krivičnih djela.

## STANJE DIVLJIH DEPONIJA NA PODRUČJU GRADA DOBOJ KAO EKOLOŠKI KRIMINAL POJEDINACA

Krivična djela ekološkog kriminaliteta imaju različite pojavne oblike, kojima se na različite načine ugrožava životna sredina, odnosno njene osnovne komponente tj. voda, vazduh i zemljište. Jedna od takvih pojavnih oblika jesu divlje deponije, o čemu će u daljim redovima biti govora. Naime, objekt zaštite ovih krivičnih djela je priroda u najširem smislu riječi (Petrović i Jovašević,

2005, str. 265-266). Ekološki kriminalitet je predviđen krivičnim zakonima kao skup društveno opasnih djela činjenja ili nečinjenja, koji utiču na životnu sredinu ili njene komponente, čije racionalno korištenje i zaštita obezbjeđuju normalne aktivnosti čovjeka. (Dubovnik, 1994, str. 447).

Naime, na osnovu Zakona o upravljanju otpadom (Zakon o upravljanju otpadom [ZUO], 2021), Zakona o zaštiti životne sredine (Zakon o zaštiti životne sredine [ZZŽS], 2015), Strategije upravljanja otpadom u Republici Srpskoj za period 2017-2026, Odluke Skupštine Grada (Odluka o komunalnom redu Skupštine Grada Doboja, [OKOGD], 2017) i Odluke o prikupljanju i odvoženju komunalnog otpada Grada Doboja [OPOOGD], 2017), jasno je definisano da je zabranjeno odlaganje otpada na mjesta koja nisu predviđena za to, kao i da su sva domaćinstva u obavezi da budu dio uspostavljenog sistema odvoza otpada.

Naime, 2014. godine, nakon katastrofalne poplave, pokrenute su aktivnosti oko formiranja baze podataka divljih deponija na teritoriji grada Doboja. Realizacijom Projekta „Uklanjanje divljih deponija i proširenje organizovanog prikupljanja otpada na lokacijama 6 mjesnih zajednica na teritoriji grada Doboja (Trnjačani, Čivčije Bukovačke, Opsine, Kladari, Johovac i Prnjavor Mali)“, koji je u periodu od jula 2016. godine do oktobra 2018. godine implementiran u saradnji sa UNDP BiH, mapirano je ukupno 79 divljih deponija. Implementacijom projekta na području MZ Čivčije Bukovačke i MZ Kladari, došlo se do saznanja da nisu tačne informacije o količini otpada na divljim deponijama, broju divljih deponija, niti da postoji prava baza podataka.

Na osnovu upitnika i stanja na terenu, 2017. godine počinje opsežno istraživanje gdje je evidentirano 179 divljih deponija u 54 mjesne zajednice. Ovo je ogroman broj divljih deponija i na žalost, jednom mjesečno pojavi se minimalno još jedna nova. Naravno, više od 90% divljih deponija nalazi se u ruralim područjima. 13 mjesnih zajednica se izjasnilo da na svojoj teritoriji nemaju divljih deponija, ali i same informacije sa terena su to i potvrdile. Međutim, treba uzeti u obzir da neke od ovih mjesnih zajednica, koje se vode da na svojoj teritoriji nemaju divljih deponija, svoj otpad odlažu na divlje deponije u susjednim mjesnim zajednicama. U razgovoru sa mještanima došlo se do informacija da otpad na divlje deponije, deponuju takođe i fizička i pravna lica iz Federacije BiH.

Bitno je istaći da na području grada Doboja, sve mjesne zajednice nemaju organizovan odvoz otpada te shodno tome, u odnosu na ukupan broj stanovnika, broj stanovnika koji je obuhvaćen odvozom otpada, iznosi 40.274, što znači da pokrivenost odvoza otpada, ako gledamo stanovništvo, iznosi oko 62%. Ako uzmemo u obzir broj domaćinstva, koji je obuhvaćen odvozom otpada, iznosi 14.499, onda pokrivenost odvoza otpada po broju domaćinstava, iznosi oko 63%.

Kao što je navedeno, u periodu od 16.11.2017. do 01.03.2019. godine ponovo su pokrenute aktivnosti na mapiranju divljih deponija, gdje je sada mapirano 179 divljih deponija. U junu 2019. godine sačinjen je „Izvještaj o stanju divljih deponija na teritoriji Grada Doboja“ (Odjeljenje za strateško planiranje, evropske integracije i lokalni ekonomski razvoj Grada Doboj) i kreirana baza podataka;

Istraživanjem se došlo do sljedećih informacija:

- Broj divljih deponija: 179,
- Površina zemljišta pokrivena divljim deponijama: 266.557 $m^2$ ,
- Procijenjena količina otpada na divljim deponijama: 89.940 t,
- Deponije koje ugrožavaju izvore pitke vode: 28,
- Deponije koje ugrožavaju rijeke, potoke i bare: 125,
- Deponije koje se nalaze u minskom polju ili na sumnjivoj površini: 10,
- Deponije na kojim se nalazi azbest: 49,
- Deponije na kojim se nalazi analimalni otpad: 59,
- Deponije koje se nalaze pored samog groblja : 8.

Ukupna procijenjena količina otpada, na svim divljim deponijama, iznosi 89.940 tona i tu se nalaze razne vrste otpada: komunalni, građevinski, poljoprivredni, tehnološki, bolnički, specijalni i sl. Mjesna zajednica Kostajnica po površini, kao i po količini otpada, je najugroženija na teritoriji grada Doboja. Procjenjena količina otpada u MZ Kostajnica je 35.110 t i predstavlja 39% ukupne

količine otpada na divljim deponijama. Mjesna zajednica Bare ima najmanju količinu otpada na divljim deponijama, ukupno 1 tonu. Mjesne zajednice Kostajnica i Prisade, zajedno imaju 50.530 tona otpada i to predstavlja 57% ukupne količine otpada. Treba napomenuti da je skoro sav otpad, koji se nalazi u MZ Prisade, deponovan iz grada, nakon katastrofalne poplave 2014. godine.

Naime, podaci su alarmantni i zahtjevaju hitne mjere, s obzirom da se deponijama nalazi medicinski otpad, animalni otpad, smještene su kraj izvora pitke vode itd. Dakle, imajući u vidu činjenicu da je istraživanje utvrdilo da se na deponijama nalaze i različite vrste otpada koje se nezakonito odlaže, riječ se svakako o ekološkim krivičnim djelima. Prema nekim procjenama, u svijetu se godišnje produkuje oko 350 miliona tona opasnog otpada od čega se dobar dio odnosi na medicinski otpad. (Đukić, 2014, str. 388) .U suzbijanju ove vrste kriminaliteta, veliku ulugu imaju razne inspekcije, zavodi, nevladine organizacije i druge ustanove (Korajlić, 2008.)

Grad Doboj ima 67 mjesnih zajednica i u tabeli 1 su prikazani podaci o količini i vrsti otpada po mjesnim zajednicama (Izvještaj o stanju divljih deponija na teritoriji Grada Doboj, 2019). Naime, u pogledu zbirnih podataka, ukupna zagađena površina na teritoriji grada Doboja iznosi 266.577 m2, odnosno 0,04 % od ukupne teritorije koja pripada Doboju. Najveća površina zagađena divljim deponijama je u Kostajnici i iznosi 61.717 m2 ili oko 23% od ukupne zagađene površine, dok je najmanja površina, od onih mjesnih zajednica koje imaju divlje deponije, u MZ Bare sa 17 m2.

Ako se saberu površine divljih deponija od prvih šest mjesnih zajednica (Kostajnica, Kotorsko, Podnovlje, Kladari, Paklenica Donja i Grapska Gornja), one zajedno pokrivaju 145.711 m2 ili 55% ukupne zagađene površine na teritoriji grada Doboja. Ono što je posebno interesantno, je podatak da su predstavnici MZ Kostajnica, u upitniku koji su popunili, odgovorili da nemaju divljih deponija na teritoriji svoje MZ.

Na 32 mapirane divlje deponije evidentiran je animalni otpad i na površini od 38.910 $m^{2,}$ procijenjeno je oko 6.870 tona otpada. Procentualno gledano 15% površine (38.910 $m^2$/266.557 $m^2$) je kontaminirano animalnim otpadom tj. 8% ukupne procjenjene količine (6.870 t/89.940 t).

Na osnovu svih ovih pokazatelja možemo zaključiti da se na samo 29% ukupne površine, na kojim se nalaze divlje deponije, ne nalazi opasni otpad i da samo 10%, od ukupne procijenjene količine otpada, nije kontaminirano.

Na 62 divlje deponije, koje ugrožavaju šumu, nalazi se 24.382 t otpada, ili 27% od ukupne količine cjelokupnog otpada (24.382 t/89.940 t). Divlje deponije se prostiru na 49.933 $m^2$ površine, ili 19% od ukupne površine (49.933 $m^2$ / 266.557 $m^2$) svih divljih deponija.

Na 11 divljih deponija, koje se prostiru na 5.255 $m^2$ ugroženo je minama i na tim divljim deponijama se nalazi oko 870 tona otpada. Najveći problem je u Jabučić Polju, gdje se nalazi 5 divljih deponija, koje su locirane u krugu kasarne.

Najveća divlja deponija, kojoj prijeti opasnost od mina, je u Potočanima (43-1 Poligon/Gradina). Niti jedno od ovih minskih polja, ili sumnjivih površina, nije bilo obilježeno, da bi stanovništvo moglo da ima informaciju da se tu nalazi potencijalna opasnost.

26 divljih deponija ugrožava pitku vodu, odnosno 15% od ukupnog broja divljih deponija. Te divlje deponije zauzimaju površinu od 91.650 $m^2$, što je 34% od ukupne površine (91.650 $m^2$/266.557 $m^2$) svih divljih deponija na teritoriji grada Doboja i na njima se nalazi 55.095 tona otpada, ili 61% od ukupne procijenjene količine otpada (55.095 t/89.940 t) na svim divljim deponijama.

Iz svega ovoga možemo zaključiti da 134 divlje deponije, od ukupno 179, ugrožava vodu (pitku, rijeke, potoke ili bare), što je ukupno 75% od ukupnog broja mapirnih divljih deponija. Te deponije se nalaze na površini od 239.008 $m^2$, odnosno 90% površine koja se nalazi pod divljim deponijama. Na njima se nalazi 84.520 tona otpada ili 94% od ukupne procijenjene količine otpada na divljim deponijama.

Ukupno je mapirano 8 divljih deponija, koje se nalaze pored groblja i one zauzimaju površinu od 4.082 $m^2$, odnosno 1,5% od ukupne površine pokrivene divljim deponijama. Na njima je procijenjeno oko 207 tona otpada, odnosno 0,23% od ukupne procijenjene količine otpada.

Tabela 1. Količina otpada i područje divljih deponija u gradu Doboj

| R br | Br. MZ | MZ | Zona | Površina divljih deponija (m2) | Procijenjene količine (t) |
|---|---|---|---|---|---|
| 1 | 23 | Kostajnica | Trebava | 61.717 | 35.110 |
| 2 | 24 | Kotorsko | Krnjin | 28.242 | 2.440 |
| 3 | 41 | Podnovlje | Vučijak | 18.826 | 1.489 |
| 4 | 21 | Kladari | Krnjin | 14.590 | 120 |
| 5 | 37 | Paklenica Donja | Ozren | 12.275 | 4.120 |
| 6 | 18 | Grapska Gornja | Trebava | 10.051 | 2.230 |
| 7 | 25 | Kožuhe | Trebava | 9.497 | 4.500 |
| 8 | 11 | Čivčije Bukovačke | Krnjin | 8.435 | 540 |
| 9 | 36 | Osječani | Trebava | 8.268 | 5.650 |
| 10 | 20 | Johovac | Krnjin | 7.758 | 1.510 |
| 11 | 32 | Mala Bukovica | Krnjin | 5.578 | 740 |
| 12 | 5 | Bušletić | Trebava | 5.460 | 395 |
| 13 | 45 | Pridjel Donji | Ozren | 5.120 | 510 |
| 14 | 56 | Suho Polje | Ozren | 4.350 | 20 |
| 15 | 59 | Tekućica | Ozren | 4.285 | 290 |
| 16 | 30 | Majevac | Vučijak | 4.165 | 335 |
| 17 | 40 | Paležnica Gornja | Trebava | 3.524 | 210 |
| 18 | 48 | Prnjavor Veliki | Krnjin | 3.286 | 310 |
| 19 | 8 | Čaire | Prigradska zona | 3.245 | 70 |
| 20 | 38 | Paklenica Gornja | Ozren | 2.905 | 440 |
| 21 | 64 | Usora | Gradska zona | 2.892 | 120 |
| 22 | 58 | Ševarlije | Ozren | 2.889 | 1.010 |
| 23 | 17 | Grapska Donja | Trebava | 2.840 | 500 |
| 24 | 19 | Jabučić Polje | Ozren | 2.689 | 260 |
| 25 | 50 | Ritešić | Vučijak | 2.549 | 500 |
| 26 | 51 | Sjenina | Trebava | 2.292 | 800 |
| 27 | 68 | Ne pripada nikome | Gradska zona | 2.091 | 2.700 |
| 28 | 26 | Krčevine | Gradska zona | 2.050 | 1.600 |
| 29 | 54 | Stanovi | Krnjin | 1.977 | 515 |
| 30 | 65 | Velika Bukovica | Krnjin | 1.822 | 125 |
| 31 | 2 | Boljanić | Ozren | 1.714 | 80 |
| 32 | 3 | Brezici | Ozren | 1.685 | 30 |
| 33 | 12 | Doboj Novi | Gradska zona | 1.655 | 60 |
| 34 | 60 | Tisovac | Krnjin | 1.628 | 200 |
| 35 | 27 | Lipac | Ozren | 1.573 | 300 |
| 36 | 14 | Foča | Krnjin | 1.380 | 1.000 |
| 37 | 31 | Makljenovac | Prigradska zona | 1.380 | 1.000 |
| 38 | 46 | Prisade | Prigradska zona | 1.305 | 15.420 |
| 39 | 61 | Trbuk | Ozren | 1.040 | 200 |
| 40 | 43 | Potočani | Ozren | 1.034 | 460 |
| 41 | 28 | Ljeskove Vode | Krnjin | 970 | 10 |
| 42 | 10 | Čivčije Osječanske | Trebava | 890 | 50 |
| 43 | 22 | Komarica | Krnjin | 835 | 150 |
| 44 | 16 | Grabovica | Krnjin | 786 | 365 |
| 45 | 63 | Trnjani | Vučijak | 662 | 300 |
| 46 | 42 | Poljice | Prigradska zona | 645 | 220 |
| 47 | 44 | Pridjel Gornji | Ozren | 640 | 520 |
| 48 | 66 | Zarječja | Krnjin | 430 | 60 |
| 49 | 57 | Svjetliča | Trebava | 288 | 140 |
| 50 | 52 | Sjenina Rijeka | Trebava | 108 | 40 |
| 51 | 39 | Paležnica Donja | Trebava | 107 | 10 |
| 52 | 29 | Mahala Donja | Gradska zona | 50 | 100 |
| 53 | 47 | Prnjavor Mali | Krnjin | 37 | 25 |
| 54 | 49 | Rječica | Ozren | 30 | 40 |
| 55 | 1 | Bare | Prigradska zona | 17 | 1 |
| **UKUPNO** | | | | **266.557** | **89.940** |

## PREVENCIJA EKOLOŠKOG KRIMINALITETA

Istraživanje je iniciralo nekoliko zaključaka o određenim mjerama i eventualnim rješenjima koje bi dovele do postepenog smanjivanja količine otpada, koji završi na divljim deponijama, ali isto tako bi trebalo da utiče i na one koji imaju sistemski odvoz otpada.

Naime, edukacija u vidu radionica, seminara kao i marketing kampanja su vrlo bitni u cilju prevencije a i represije prema učiniocama ovih krivičnih djela.

Selektiranja otpada je jedna od mjera koja se već godinama se pokušava provesti u Gradu Doboju, ali bezuspješno. I ovdje je problem svijest stanovnika, kao i izostanak odlučnosti, kontrole i samog kažnjavanja. Trenutno u Doboju postoji 19 zelenih ostrva, kapaciteta 2 do 5 kontejnera. Samo za grad bi bilo potrebno postaviti još 30 zelenih ostrva, dok bi u za prigradska i ruralna naselja bilo potrebno izgraditi oko 130 zelenih ostrva.

I ovaj sistem bi mogli podjeliti na nekoliko načina:

- Sortiranje u podzemnim zelenim ostrvima;
- Sortiranje po klasičnim zelenim ostrvima.
- Kombinovano sortiranje, podzemna i klasična zelena ostrva.

Postavljanje kamera je jedan od najboljih načina kako da se kontroliše bacanje otpada na postojeće divlje deponije, eventualno formiranje novih divljih deponija kao i bacanje otpada pored puta. Jedan od načina kako da se stanovništvo ali i mjesne zajednice motivišu da otpad bacaju na mjesta, koja su za to predviđena jeste nagrađivanje ali i kažnjavanje.

Komunalna policija kao i policija kao subjekti ekološke bezbjednosti treba da kažnjavaju izvršioce, čime će se izvršiti i prevencija od drugih potencijalnih izvršilaca krivičnih djela. Neke od preporuka koje bi mogle doprinijeti smanjenju i suzbijanju ekoloških krivičnih djela su:

- **Otkup PVC ambalaže ili limenki,** kao što se to radi u Evropskoj uniji. Ovo bi funkcionisalo na način da svaka radnja, koja prodaje piće, ili konzerviranu robu, postavi aparat koji je namjenjen za to ili zaposli osobe koje bi vršile povrat novca za vraćenu ambalažu.
- **Da se formira državno/enitetsko preduzeće**, koje bi se bavilo otkupom otpada. Na ovaj način bi se povećala konkurentnost na tržištu, otvorila radna mjesta, kvalitetnije uredio otkup.
- **Da se pokrene „agresivna“ kampanja,** oko zabrane bacanja otpada na mjesta koja nisu predviđena za to, ukažu na štetnost, opasnost po zdravlje.
- **Nagrađivanje svih onih koji prijave nelegalno odlaganje,** da se sredstva u visini od 50% novčane kazne, koje je predviđena ovim prekršajem odnosno krivičnim djelom, uplate osobi koja je prijavila. Ovo su samo neke od mjera koje mogu doprinijeti smanjenju nastanka divljih deponija te štetnosti koje one izazovu.

U cilju suzbijanja ove vrste kriminaliteta, bitno je utvrditi uzroke,u cilju efikasnije borbe organa gonjenja, kao što su prvenstveno pohlepa za novcem, sporost nastupanja posljedica, nedovoljna tehnička opremljenost subjekata ekološke bezbjednosti tj. policije, komunalne policije, inspekcije itd. (Gaćeša, 2018). Bitno je istaći, da ekološki kriminal sve više utiče na kvalitetu vazduha, vode i zemljišta, prijeteći opstanku vrsta i uzrokujući nekontrolisane katastrofe. S druge strane, ekološki kriminal takođe predstavlja bezbjedonosnu prijetnju velikom broju ljudi i ima značajan negativan učinak na razvoj i vladavinu prava. Uprkos ovim problemima, ekološki kriminal često ne postakne odgovarajući državni odgovor. Često se doživljavaju kao djela ‘bez žrtava’ i slučajni kriminal, često su nisko rangirani na popisu prioriteta za provođenje zakona i obično se kažnjavaju novčanim kaznama, koje su same po sebi često nejasne i niske.

## ZAKLJUČAK

Prateći iskustva iz mnogih država EU, većina njih je na različite načine pristupila rješavanju problema sa nelegalnim odlaganjem otpada, a mi smo predložili samo one koji su primjenjivi kod nas. S obzirom na malu svijest građana o zaštiti životne sredine, spori nastanak posljedice

zagađivanja životne sredine, potrebno je izvršti niz mjera kako na lokalnom nivou tako i na republičkom te i na globalnom nivou. Zatim, bitna je zajednička aktivnost svih opština/gradova u slivu rijeke Bosne. NVO ROTOR Doboj je 2017.godine pokrenuo projekat pod nazivom „Čista rijeka Bosna“, gdje su uključene sve opštine/gradovi od izvora Bosne do ušća Bosne u Savu. Kroz ove aktivnosti bi se moglo značajno smanjiti zagađivanje obale rijeke Bosne. Trenutno je urađena mobilna aplikacija, pod nazivom CRB, preko koje, između ostalog, se mogu vidjeti sve divlje deponije koje su mapirane/locirane, ali i ima mogućnost da građani sami lociraju nove divlje deponije.

Složeni nivoi vlasti naše države, institucije, zakoni, njihova nesihrinizovanost i nedovoljna saradnja su problemi koji otežavaju suzbijanje ekološkog kriminala. Odlika ekološkog kriminala je prilagođavanje novonastalnim društveno-ekonomskim i političkim odnosima posebno u Bosni i Hercegovini jer je u tranziciji. Na kraju treba reći, da svi subjekti ekološke bezbjednosti treba da budu uključeni i samo zajedničnim aktivnostima skupštine, vlade, policije, komunalne policije, obrazovnih ustanova, te nevladinih organizacija možemo doprinijeti zdravijoj životnoj sredini i smanjenju “ tamne brojke” ekološkog kriminaliteta.

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# ENVIRONMENTAL CRIME AS A GLOBAL THREAT TO THE WORLD

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**ABSTRACT**

Environmental crime is a global problem and a serious threat primarily to health security. Namely, the citizens' awareness about the importance of the environment is at a rather low level. Therefore, the paper will deal with the issue of illegal dump sites in the area of the City of Doboj, their causes, consequences, as well as the measures that are to be undertaken with the aim of preventing environmental crimes. The paper will also present potential measures/solutions for the purpose of decreasing the number of illegal dump sites which considerably endanger the basic components of the environment.

**Keywords:** criminal act, illegal dump site, crime.

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# GENERIČKE KONKURENTNE STRATEGIJE

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## SAŽETAK

Jedno od glavnih pitanja u konkurentnoj strategiji je relativna pozicija kompanije u privrednom segmentu. Pozicioniranje određuje da li će profitabilnost kompanije biti iznad ili ispod prosjeka odgovarajućeg privrednog segmenta. Kompanija koja je sposobna da se dobro pozicionira može da ostvaruje visoke stope prinosa čak i ako je struktura privrednog segmenta nepovoljna, a prosječna profitabilnost u njoj skromna.

Najznačajniji uslov za dugoročne natprosječne rezultate predstavlja održiva konkurentska prednost. Iako u poređenju sa svojim konkurentima, kompanija može da ima bezbroj prednosti i nedostataka, postoje dvije osnovne vrste konkurentske prednosti koje može da posjeduje: niski troškovi i diferencijacija. Značaj bilo koje prednosti ili nedostatka kompanije je u krajnjoj liniji posljedica njihovog uticaja na relativne troškove ili diferencijaciju. Troškovna prednost i diferencijacija sa svoje strane proističu iz strukture privrednog segmenta (Bojanić, 2010).

Predmet istraživanja ovog rada je uticaj definisanog strateškog opredjeljenja na ostvarivanje zadanih ciljeva kompanije, kao i refleksija odabrane strategije na dalju budućnost poslovanja.

Cilj istraživanja je da se pronađu osnovni preduslovi za uspješnu primjenu u generičkim konkurentnim strategijama, kao i parametri za kvalitativnu i kvantitativnu mjeru performansi. Takođe, cilj je da se ispita da li su kompanije koje posluju na polju željezničkog saobraćaja u BiH koristile generičke konkurentne strategije i istražile ključne pretpostavke za uspješnu implementaciju strategije. Izbor tržišta željezničkog transporta proizlazi iz činjenice da postoji potencijal da se ostvari konkurentska prednost u odnosu na druga transportna tržišta u BiH.

**Ključne riječi**: strategija, konkurentska prednost, diferencijacija.

## UVOD

Preduzeća koja su spremna na nove promjene i izazove izdvajaju se kao konkurentna na globalnom tržištu. Sve to dovodi do mnogih problema i izazova na koja preduzeća moraju brzo i pravovremeno reagovati (Đervida i sar., 2016). Dva osnovna vida konkurentske prednosti, zajedno sa nizom aktivnosti u okviru kojih se kompanija trudi da ih ostvari, vode do tri generičke strategije za postizanje natprosječnih rezultata u nekom privrednom segmentu: troškovnog liderstva, diferencijacije i fokusiranja. Strategija fokusiranja ima dvije varijante, fokusiranje na troškove ili na diferencijaciju (Porter, 2007). Generičke strategije prikazane su u Tabeli 1.

Svaka generička strategija podrazumijeva potpuno različit pristup ostvarivanju konkurentske prednosti, odnosno kombinaciju izbora određene vrste konkurentske prednosti kojoj se teži i širinu strategijskog cilja u okviru kojeg ta konkurentska prednost treba da se ostvari. Strategije zasnovane na liderstvu u oblasti troškova i diferencijaciji nastoje da ostvare konkurentsku prednost u velikom broju različitih privrednih segmenata, dok fokusirane strategije teže da ostvare troškovnu prednost (fokus na troškove) ili diferencijaciju (fokus na diferencijaciju) u jednom uskom segmentu. Posebne aktivnosti potrebne za sprovođenje svake generičke strategije u velikoj mjeri variraju u zavisnosti od privrednog segmenta, isto kao i generičke strategije koje se primjenjuju u nekom posebnom privrednom segmentu. I mada izbor i implementacija generičke strategije nisu ni malo jednostavni, oni predstavljaju logične puteve za ostvarivanje konkurentske prednosti koji se moraju proći u svakom privrednom segmentu (Porter, 2007).

Tabela 1. Tri generičke strategije (Porter, 2007).
Table 1. Three generic strategies (Porter, 2007).

| | | KONKURENTSKA PREDNOST | |
|---|---|---|---|
| | | **Niži troškovi** | **Diferencijacija** |
| **KONKURENTSKI OBIM** | Zadovoljenje potreba više segmenata | 1. Liderstvo u troškovima | 2. Diferencijacija |
| | Zadovoljenje potreba jednog segmenta | 3A. Fokus na troškove | 3B. Fokus na diferencijaciju |

U osnovi koncepta generičkih strategija nalazi se ideja da je konkurentska prednost srž svake strategije i da sticanje konkurentske prednosti dovodi kompaniju pred izbor – ako namjerava da ostvari konkurentsku prednost ona mora da se opredijeli za vrstu konkurentske prednosti i obim u kojem želi da je ostvari. "Svaštarenje" je najbolji recept za stratešku osrednjost i postizanje rezultata koji su ispod prosjeka jer ono često znači da kompanija u stvari nema nijednu konkurentsku prednost.

## LIDERSTVO U TROŠKOVIMA

Strategija zasnovana na liderstvu u troškovima, Porter objašnjava, je najjasnija od svih generičkih strategija. U okviru nje, kompanija se trudi da postane vodeći niskobudžetni (low-cost) proizvođač u svojem privrednom segmentu. Kompanija ima širok obim djelovanja i pokriva mnoge privredne segmente, a može da posluje i u srodnim privrednim djelatnostima i upravo ta širina je često važna za postizanje troškovne prednosti. Izvori ove prednosti su različiti i zavise od strukture privrednog segmenta. Oni mogu da uključuju ostvarivanje ekonomije obima, patentiranu tehnologiju, povlašćen pristup sirovinama i druge faktore. Na primjer, u proizvodnji televizora, troškovna prednost zahtijeva amortizaciju troškova istraživanja i razvoja, koja se postiže efikasnim proizvodnim kapacitetima, jeftinim dizajnom, automatizovanim sklapanjem i globalnim poslovanjem. Kada su u pitanju usluge obezbjeđenja, troškovna prednost zahtijeva izuzetno male režijske troškove i brojnu i jeftinu radnu snagu, a zbog velike fluktuacije radne snage i efikasnu obuku. Status jeftinog ili niskobudžetnog proizvođača uključuje mnogo više od jednostavnog praćenja krive znanja. Jeftini proizvođači moraju da otkriju i iskoriste sve izvore troškovne prednosti. Oni zato najčešće prodaju standardne proizvode bez ikakvih dodataka, a posebno se oslanjaju na obim, ili na apsolutne troškovne prednosti, bez obzira na njihov izvor (Porter, 2007).

Da bi ostvarila natprosječne rezultate, kompanija koja zauzima liderski položaj u pogledu troškova, mora da ostvari paritet ili bliskost u odnosu na konkurente, bez obzira na to što svoju konkurentsku prednost zasniva na troškovima. Paritet osnovnih elemenata diferencijacije omogućava da se troškovna prednost direktno pretvori u veće profite u odnosu na konkurente. Proksimitet, kada je u pitanju diferencijacija, znači da smanjenje cijene u cilju sticanja prihvatljivog udjela na tržištu ne neutrališe troškovnu prednost lidera koji će i dalje ostvarivati natprosječnu dobit.

Strateška logika liderstva u troškovima obično zahtijeva da kompanija zaista bude lider, a ne samo jedna od nekoliko koje se bore za tu poziciju. Mnoge kompanije su načinile ozbiljne strateške greške zato što ovo nisu shvatile. Kada više od jedne kompanije pretenduje na to da bude lider u troškovima suparništvo među njima je obično žestoko, jer se svaki procenat udjela na tržištu smatra presudno važnim. Ukoliko kompanija koja ostvari liderski položaj u pogledu troškova ne "ubjedi" ostale da odustanu od svojih strategija, posljedice po profitabilnost (a dugoročno i strukturu cijelog privrednog segmenta) mogu da budu katastrofalne, kao što je bio slučaj u mnogim petrohemijskim kompanijama. Strategija zasnovana na troškovima je strategija koja prije svega zavisi od prečeg prava, osim ako velika tehnološka promjena ne omogući kompaniji da radikalno promijeni svoju troškovnu poziciju.

## DIFERENCIJACIJA

Po Porteru, druga generička strategija jeste diferencijacija. U okviru te strategije, kompanija se trudi da zahvaljujući nekim osobinama koje kupci izuzetno cijene, stekne jedinstven položaj u svom privrednom segmentu. Ona se opredjeljuje za jednu ili više karakteristika koje mnogi kupci proizvoda tog privrednog segmenta smatraju važnim i posebno se pozicionira kako bi zadovoljila te potrebe. Nagrada za takvu posebnost je premijska cijena.

Kompanija koja može da ostvari i očuva diferencijaciju, ostvarivaće natprosječne rezultate u svom privrednom segmentu ukoliko premija na njenu cijenu premašuje dodatne troškove kojima se izložila da bi bila jedinstvena. Takva kompanija stoga uvijek mora da traga za načinima diferencijacije koji će omogućiti da njena cijena bude viša od troškova diferencijacije. Diferencijator ne smije da ignoriše svoje troškove, zato što izrazito inferiroran položaj u pogledu troškova može da mu anulira premiju na cijenu. Diferencijator stoga teži paritetu ili proksimitetu troškova u odnosu na svoje konkurente, kroz smanjenje troškova u svim oblastima koje ne utiču na diferencijaciju.

Logika strategije diferencijacije zahtijeva da kompanija izabere svojstva na osnovu kojih će se razlikovati od svojih konkurenata i na osnovu kojih se njeni rivali ne diferenciraju. Kompanija zaista mora po nečemu da bude jedinstvena, ili da se smatra jedinstvenom, ako očekuje da ostvari premijsku cijenu. Međutim, za razliku od liderstva u troškovima, ovdje u okviru istog privrednog segmenta može da se primjeni više uspješnih strategija, ukoliko postoji više karakteristika koje kupci izrazito cijene (Porter, 2007).

## FOKUS

Treća generička strategija, kako Porter navodi, je fokusiranje. Ista se u potpunosti razlikuje od ostalih, zato što se zasniva na izboru jednog uskog segmenta u okviru privredne grane. Kompanija bira jedan segment, ili grupu segmenata u okviru određene privredne grane, a zatim prilagođava svoju strategiju za rad u njima, isključujući ostale. Optimiziranjem svoje strategije u odnosu na izabrane segmente, kompanija pokušava u njima da ostvari konkurentsku prednost čak i ako je u cijelini gledano ne posjeduje.

Strategija zasnovana na fokusu javlja se u dvije varijante. Fokusiranje na troškove znači da se kompanija trudi da u izabranom segmentu ostvari troškovnu prednost, dok fokusiranje na diferencijaciju znači da se trudi da u izabranom segmentu ostvari diferencijaciju. Obje varijante ove strategije zasnivaju se na razlikama između izabranih ili ciljanih i ostalih segmenata jedne privredne grane. Ciljni segmenti moraju ili da imaju kupce s nesvakidašnjim potrebama, ili proizvodnja i sistem isporuke koji najbolje zadovoljavaju potrebe ciljnog segmenta moraju da se razlikuju od drugih segmenata privredne grane. Fokusiranje na troškove koristi razlike u troškovnom ponašanju nekih segmenata, dok fokusiranje na diferencijaciju koristi posebne potrebe kupaca u određenim segmentima. Ovakve razlike ukazuju na to da određenim segmentima ne odgovaraju konkurenti koji istovremeno zadovoljavaju i njihove potrebe i potrebe drugih segmenata. Prema tome, kompanija koja se opredijeli za fokus može da ostvari konkurentsku prednost samo ako se isključivo posveti određenim segmentima. Širina cilja je, jasno, rastegljiv pojam, ali suštinu fokusiranja predstavlja korišćenje malih odstupanja ciljnog segmenta od ostatka privredne grane. Usko fokusiranje na nešto, samo po sebi nije dovoljno za postizanje natprosječnih rezultata.

Ako u svom segmentu može da ostvari održivo liderstvo u troškovima (fokusiranje na troškove) ili u deferenciranju (fokusiranje na diferencijaciju) i ako je taj segment u strukturnom pogledu atraktivan, kompanija će ostvariti i natprosječne rezultate u svojoj privrednoj grani. Strukturna atraktivnost segmenta je neophodan uslov zato što nisu svi segmenti u jednoj privrednoj grani podjednako profitabilni. U istoj privrednoj grani često postoji prostor za nekoliko održivih strategija zasnovanih na fokusu, pod uslovom da se kompanije opredijele za različite ciljne segmente. Većina privrednih grana ima više različitih segmenata, a svaki od njih, ukoliko uključuje različite potrebe kupaca ili različit optimalni sistem proizvodnje ili isporuke, pruža mogućnost za primjenu strategije fokusiranja.

## NEOPREDELJENJE

Za kompaniju koja primjenjuje sve navedene generičke strategije, ali ni u jednoj ne ostvaruje uspjeh, može se reći da je "zastala na pola puta", odnosno da je neopredjeljena. Porter objašnjava (Porter, 2007). da ista ne posjeduje nikakvu konkurentsku prednost. Takva strateška pozicija je obično recept za ostvarivanje rezultata koji su ispod prosjeka. Neopredjeljena kompanija će biti u nepovoljnom konkurentskom položaju jer će lideri u troškovima i kompanije koje prednost zasnivaju na diferencijaciji ili fokusiranju biti bolje pozicionirane da konkurišu u bilo kojem segmentu. Čak i ako je neopredjeljena kompanija dovoljno srećna da otkrije neki profitabilan proizvod ili kupca, konkurenti koji posjeduju održivu konkurentsku prednost brzo će poništiti njenu dobit. U većini privrednih grana postoji više ovakvih, konkurenata.

Kompanija koja se nađe u ovoj vrsti neopredjeljenosti ostvarivaće dobar profit samo ako je struktura njene privredne grane veoma povoljna, ili ako bude toliko srećna da za konkurente ima kompanije koje su takođe zastale na pola puta. Takva kompanija je, međutim, po pravilu mnogo manje profitabilna od rivala koji primjenjuju jednu određenu generičku strategiju. Zrelost privredne grane obično povećava razlike u uspješnosti poslovanja između kompanija koje sprovode određenu generičku strategiju i neopredjeljenih kompanija, zato što vremenom postaje sve jasnije da su strategije primjenjivane tokom ubrzanog rasta bile loše zamišljene.

Iskušenje da se zamagli generička strategija i tako postane neopredjeljen posebno je veliko za fokusirane kompanije nakon što steknu dominaciju u svojim ciljnim segmentima. Fokus podrazumijeva svjesno opredjeljenje za ograničeni potencijalni obim prodaje. Uspjeh može da navede kompaniju da izgubi iz vida zašto je uspješna i da svoju fokusiranu strategiju podredi rastu. Umjesto toga, za kompaniju je obično bolje da pronađe nove privredne segmente u kojima može da raste koristeći iznova svoju generičku strategiju ili eksploatišući međusobne veze tih segmenata (Porter, 2007).

## PRIMJENA VIŠE OD JEDNE GENERIČKE STRATEGIJE

Svaka generička strategija predstavlja suštinski različit pristup sticanju i očuvanju konkurentske prednosti i drugačiju kombinaciju vrste konkurentske prednosti kojoj kompanija teži i obima njenog strateškog cilja. Kompanija obično mora da izabere određenu strategiju da ne bi postala neopredjeljena i tako zastala na pola puta. Koristi od optimiziranja strategije usmjerene na određeni ciljni segment (fokus) ne mogu se ostvariti ako kompanija istovremeno opslužuje veliki broj različitih segmenata (troškovna prednost ili diferencijacija). Kompanija ponekad može da bude sposobna da u okviru istog korporativnog entiteta stvori dvije sasvim odvojene poslovne jedinice od kojih svaka sprovodi drugačiju generičku strategiju.

Istovremeno postizanje liderstva u troškovima i diferencijaciji često nije moguće pošto je diferencijacija obično skupa. Da bi bila jedinstvena i mogla da diktira cijene, kompanija čija se strategija zasniva na diferencijaciji svjesno povećava troškove. S druge strane, postizanje liderstva u oblasti troškova često zahtijeva da se kompanija u izvjesnoj mjeri odrekne diferencijacije tako što će da standardizuje svoje proizvode i da smanji marketinške, režijske i druge troškove.

Porter objašnjava da smanjenje troškova ne mora obavezno da uključi žrtvovanje diferencijacije. Mnoge kompanije su otkrile kako da primjenjujući efikasnije i efektivnije postupke, ili koristeći drugačiju tehnologiju, smanje troškove, a da svoju diferencijaciju ne naruše, već je, štaviše, povećaju. Drastične uštede u troškovima ponekad mogu da se ostvare bez ikakvih posljedica po diferencijaciju ako kompanija nikada do tada nije ni pokušala da smanji troškove. Međutim, smanjenje troškova nije isto što i postizanje troškovne prednosti. Kada se suoči sa sposobnim konkurentima koji se takođe bore za liderski položaj u pogledu troškova, kompanija će na kraju stići do tačke gdje dalje smanjenje troškova zahtijeva žrtvovanje diferencijacije. Upravo to je tačka u kojoj različite generičke strategije više ne mogu istovremeno da se primjenjuju i kompanija mora da se opredijeli.

Ako uspije istovremeno da ostvari liderstvo i u troškovima u diferencijaciji, kompanija može da ostvari veliki dobitak jer koristi jedna drugu uvećavaju – diferencijcija omogućava premijske cijene, dok troškovna prednost istovremeno podrazumijeva niže troškove.

## ODRŽIVOST

Generička strategija po Porteru neće dovesti do natprosječnih rezultata ukoliko nije održiva u odnosu na konkurente, bez obzira na to što aktivnosti koje unapređuju strukturu privredne grane mogu da povećaju profitabilnost čitave te grane, čak i kada se imitiraju. Održivosti tri generičke strategije zahtijeva da se konkurentska prednost kompanije odupre eroziji izazvanoj ponašanjem konkurenata, ili razvojem industrije. „Poslovanje u funkciji održivosti je cilj poslovne politike svakog preduzeća i njegove težnje za ostvarenje tog cilja“ (Đervida i sar., 2017).

Održivost generičke strategije zahtijeva da kompanija podigne izvjesne barijere koje bi otežale imitaciju njene strategije. Pošto barijere nikada nisu nepremostive, kompanija bi u odnosu na svoje konkurente morala da se postavi kao pokretna meta, odnosno, da stalno unapređuje svoj položaj. Svaka generička strategija predstavlja i potencijalnu opasnost za druge, npr. kompanije opredjeljene za strategiju fokusiranja moraju da vode računa o konkurentima koji zadovoljavaju potrebe više segmenata – i obrnuto.

Koncept generičkih strategija zasnovan je na pretpostavci da postoji više načina na koje može da se stekne konkurentska prednost, u zavisnosti od strukture privrednog segmenta. Ako bi u okviru jednog privrednog segmenta sve kompanije slijedile principe konkurentske strategije, svaka bi morala da izabere različitu osnovu za sticanje konkurentske prednosti. I mada ne bi sve uspjele, generičke strategije bi im omogućile alternativne pravce za postizanje vrhunskih rezultata. Neki koncepti strateškog planiranja bili su usko zasnovani na samo jednom putu za sticanje konkurentske prednosti, najčešće vezanom za troškove. Takvi koncepti ne samo što ne mogu da objasne uspjeh mnogih kompanija, već mogu i da navedu sve kompanije iz jednog privrednog segmenta da se opredijele za istu vrstu konkurentske prednosti i da na isti način pokušavaju da je ostvare – uz predvidive katastrofalne rezultate. “Savremeno poslovanje podrazumijeva izmene principa korporativnog upravljanja i stvaranje svijesti o konkurentnosti“ (Đervida i sar., 2017).

## GENERIČKE STRATEGIJE I RAZVOJ PRIVREDNOG SEGMENTA

„Zbog karaktera savremenog poslovnog okruženja, sposobnost upravljanja promjenama sve više dobija na značaju. Karakteristike novog poslovnog okruženja moguće je analizirati sa stanovišta najznačajnijih pokretača promjena, implikacija njihovog uticaja i kritičnih faktora uspjeha“ (Bjelica i sar., 2012). Promjene u strukturi privrednog segmenta mogu da utiču na osnove na kojima se formulišu generičke strategije i da time poremete njihovu međusobnu ravnotežu.

Kao što je navedeno u cilju istraživanja ovog rada, potrebno je da se pronađu osnovni preduslovi za uspješnu primjenu u generičkim konkurentnim strategijama, kao i parametri za kvalitativnu i kvantitativnu mjeru performansi. Ogledno, primjer su bile kompanije koje posluju na polju željezničkog saobraćaja u BiH i generičke konkurentne strategije koje su koristile u svom poslovanju, budući da postoji potencijal da se ostvari konkurentska prednost u odnosu na druga transportna tržišta u BiH.

## JAVNO PREDUZEĆE ŽELJEZNICE FEDERACIJE BIH D.O.O. SARAJEVO

Osnovne djelatnosti Javnog preduzeća Željeznice Federacije BiH d.o.o. Sarajevo (u daljem tekstu Željeznica FBiH) su:

- obavljanje domaćeg, međuentitetskog i međunarodnog transporta putnika i tereta uključujući kombinovani transport;
- održavanje, rekonstrukcija, modernizacija, izgradnja objekata voznog parka (uključujući vuču) i druge opreme;
- djelatnosti neophodne za pružanje usluga prevoza;
- održavanje, rekonstrukcija, modernizacija i razvoj željezničke infrastrukture;
- organizacija i sigurnost željezničkog saobraćaja (www.zfbh.ba/o-nama/osnovne-informacije).

Poslovni pokazatelji dati su u Tabeli 2.

Da bi Željeznice FBiH promijenile kurs iz negativnog, prešli u pozitivno poslovanje, kao i postali konkurentniji na tržištu, menadžment je izabrao strategiju diferencijacije i fokusa,

povećavajući obim poslovanja, što je za rezultat imalo povećanje prihoda, te rast neto dobiti. Obim poslovanja je povećan kroz rast transporta roba, prevoza putnika, održavanja lokomotiva i vagona za druge korisnike, pružanje usluga na pruzi, te iznajmljivanjem lokomotiva i vagona. U 2022.godini, Željeznice FBiH prevezle su 8.053.533 tona robe, što je za 49.134 tona više nego u 2021.godini, kada je prevezeno 8.004.419 tona robe, dok su u putničkom saobraćaju, Željeznice FBiH su u 2022.godini, prevezle 360.456 putnika, što je povećanje od 170.123 putnika u odnosu na 2021.godinu, kada su Željeznice FBiH prevezle 190.333 putnika.

Tabela 2. Pokazatelji poslovanja Željeznica FBiH (LRC BiH Business inteligence System, 2022; Željeznice Federacije Bosne i Hercegovine, 2023).
Table 2. Business indicators of the FBiH Railway FBiH (LRC BiH Business inteligence System, 2022; Railways of the Federation of Bosnia and Herzegovina, 2023).

| Bilans uspjeha | 2020. | 2021. | 2022. |
|---|---|---|---|
| Poslovni prihodi | 102,198,428 | 106,550,145 | 127,900,000 |
| stopa rasta | | 4.26% | 20.04% |
| Poslovni rashodi | 118,195,505 | 113,698,827 | 126,700,000 |
| stopa rasta | | -3.80% | 11.43% |
| Ostali prihodi i rashodi | -1,511,083 | -7,201,088 | |
| stopa rasta | | 376.55% | |
| Neto gubitak/dobit | -17,508,160 | -14,349,770 | 1,200,000 |
| Broj zaposlenih | 2,987 | 2,863 | 2,698 |
| Stopa rasta | | -4.15% | -5.76% |

Najveće smanjenje troškova u poslovanju tokom 2022.g. je nastalo preuzimanjem održavanja mobilnih kapaciteta i infrastrukture, a koji su ranije obavljale privatne kompanije. Time je značajno povećana produktivnost vlastite radne snage. Takođe, znajući da je 70% privrede u BiH oslonjeno je na rad željeznica, fokus su stavili na energetski sektor, koji opet, u najvećoj mjeri zavisi od funkcionisanja željeznica, kao i agrarni sektor, gdje je za transport 760 tona pšenice iskorištena jedna željeznička kompozicija, a time je zamijenjeno 38 teretnih kamiona koji u vrijeme blokade granice i zastoju putničkog saobraćaja, čekaju na transport robe i po nekoliko dana. To doslovno govori koje su sve prednosti željezničkog sektora u odnosu na druge vidove saobraćaja.

Budući da je željeznički transport jeftiniji, kapacitarniji, pouzdaniji i ekološki prihvatljiviji od drumskog saobraćaja, privreda je jednim dijelom uvidjela da je ovaj vid transporta, za razvoj u BiH, ključan, te da se svi nivoi vlasti moraju uključiti u donošenje odluka u investiranju i modernizaciji željezničkog saobraća i infrastrukture.

## ŽELJEZNICE REPUBLIKE SRPSKE A.D. DOBOJ

Željeznice Republike Srpske a.d. Doboj (u daljem tekstu Željeznice RS) su preduzeće za javni prevoz putnika i robe i upravljanje infrastrukturom na teritoriji Republike Srpske. Kompanija je akcionarsko društvo, a u strukturi kapitala učestvuju akcioni fond, penzioni fond, fond za restituciju i privatni kapital. Poslovni pokazatelji dati su u Tabeli 3.

Tabela 3. Pokazatelji poslovanja Željeznica RS (Banjalučka berza, 2023).
Table 3. Business indicators of Railways RS (Banjalučka stock exchange, 2023).

| Bilans uspjeha | 2020 | 2021 | 2022 |
|---|---|---|---|
| Poslovni prihodi | 64,605,032 | 60,274,254 | 66,814,352 |
| stopa rasta | | -6.70% | 10.85% |
| Poslovni rashodi | 79,639,045 | 80,708,522 | 87,918,791 |
| stopa rasta | | 1.34% | 8.93% |
| Neto gubitak | -15,034,013 | -20,434,268 | -21,104,439 |
| stopa rasta | | 12% | 29% |
| Broj zaposlenih | 2,184 | 2,097 | 1,964 |

| | | |
|---|---|---|
| Stopa rasta | -4.15% | -6.77% |

Željeznice RS, iako su ostvarile rast poslovnih prihoda u 2022. godini, u odnosu na 2021.g., ali isti nije mogao pratiti povećanje ukupnih troškova, što je za rezultat imalo ponovo ishod negativnog poslovanja. Kao i Željeznice FBiH, fokus su stavile na energetski sektor i prevoz osnovnih sirovina, ali taj fokus i njegov obim nije bio dovoljan za posmatrani period.

## ZAKLJUČCI

Primijenjene dvije generičke strategije konkurentnosti u poslovanju željeznica u BiH diferencijacije i fokusa, daje određene rezultate, koji se manifestuju prvenstveno na povećanje prihoda, na brzinu i pouzdanost transporta, kada je u pitanju transport robe, te na zaštitu životne sredine kroz društveno-odgovorno poslovanje.

Izbor diferencijacije i fokusa, ne znači primarno zagarantovan poslovni uspjeh. Rast parametara poslovnog uspjeha, mora se bazirati i na održivosti. Jednokratno primjenjena strategija, koja se ne nadograđuje i širi u drugim aspektima, neće dovesti do konkurentske prednosti bilo koje grane privrede.

Budući da je analiziran željeznički transport, fokus na diferencijaciji, a da je održiv, može biti u povećanju upotrebe željezničkog saobraćaja u odnosu na drumski, uvođenju mjera za povećanje sigurnosti željezničkih pruga, razvoju i upotrebi regionalnih pruga u cilju stvaranja uslova za razvoj integrisanog javnog prevoza, čime se, pored rasta poslovnih prihoda i zadovoljstva korisnika prevoza, postiže i ušteda u potrošnji resursa i smanjuje negativan uticaj na okolinu.

Modernizacijom željezničke infrastrukture, povezivanjem u mrežu željeznica Evropske unije, kao i korišćenjem geografskog položaja, željeznički saobraćaj bi mogao biti jedan od najvažnijih generatora privrednog razvoja Bosne i Hercegovine.

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# GENERIC COMPETITIVE STRATEGIES

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**ABSTRACT**

One of the main issues in competitive strategy is the company's relative position in the economic segment. Positioning determines whether a company's profitability will be above or below the average of the corresponding economic segment. A company that is capable of doing well positions can achieve high rates of return even if the structure of the economic segment is unfavorable, and the average profitability in it is modest.

The most important condition for long-term above-average results is sustainable competitiveness an advantage. Although compared to its competitors, the company may have countless advantages and disadvantages, there are two basic types of competitive advantages it can have: low costs and differentiation. The significance of any strengths or weaknesses of the company is ultimately a consequence of their impact on relative costs or differentiation.

Cost advantage and differentiation, on the other hand, arise from the structure of the economy segment.

The subject of research in this paper is the impact of a defined strategic commitment on implementation of the company's set goals, as well as the reflection of the chosen strategy on the further future of the business. The goal of the research is to find the basic prerequisites for successful application in generics competitive strategies, as well as parameters for qualitative and quantitative measures of performance.

Also, the goal is to examine whether the companies operating in the field of railway transport in BiH used generic competitive strategies and explored the key prerequisites for a successful one strategy implementation. The choice of the rail transport market stems from the fact that there is potential to gain a competitive advantage over other transport markets in BiH.

**Keywords:** strategy, competitive advantage, differentiation.

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