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GREEN 2026

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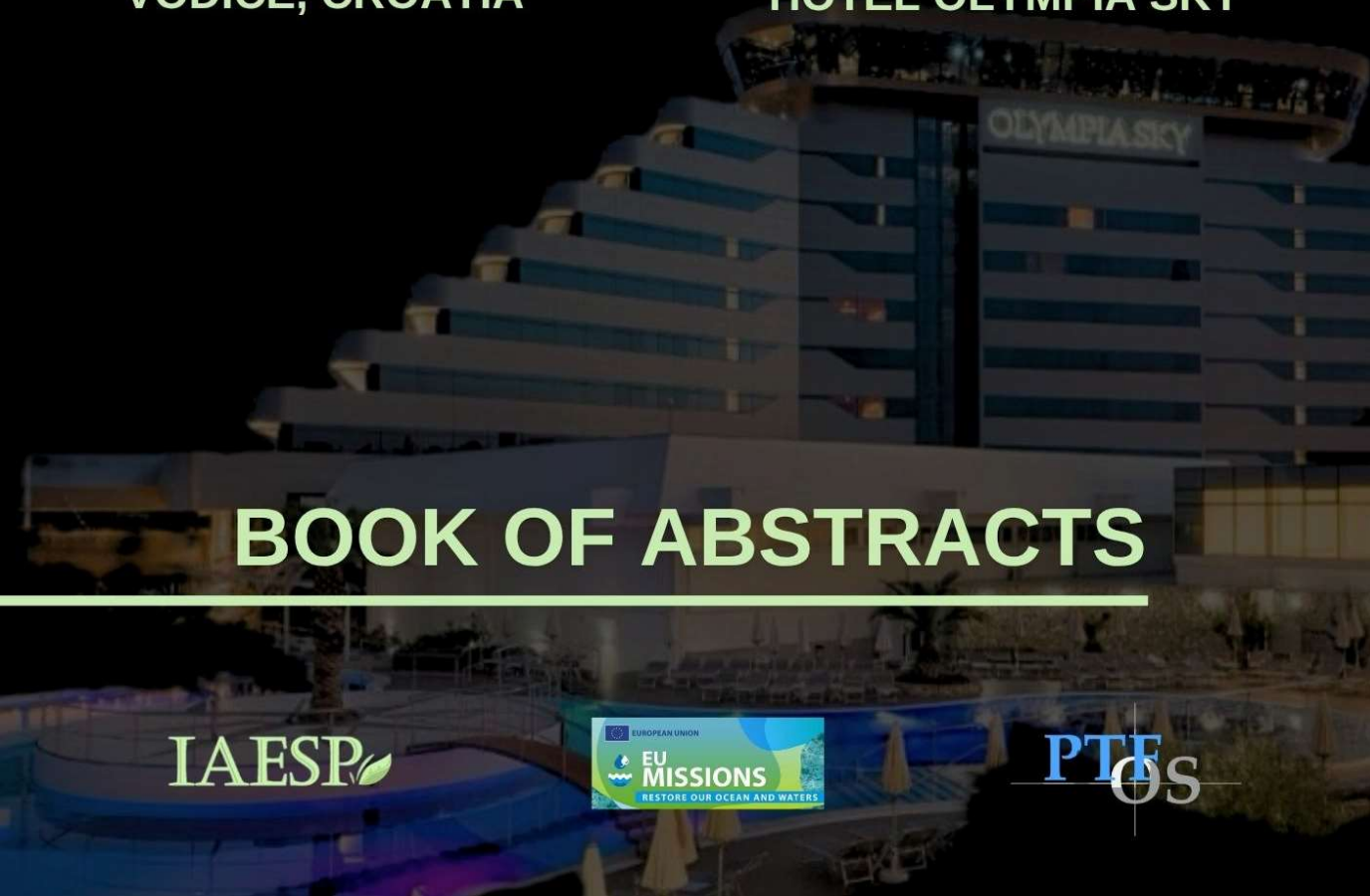

BOOK OF ABSTRACTS

IAESP

EUROPEAN UNION
EU MISSIONS
RESTORE OUR OCEAN AND WATERS

PTFOs

4. Europska GREEN konferencija

GREEN 2026

26. — 29. svibnja

VODICE, HRVARSKA

HOTEL OLYMPIA SKY

KNJIGA SAŽETAKA

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BOOK OF ABSTRACTS **4th European GREEN Conference**
KNJIGA SAŽETAKA ***4. Europska GREEN konferencija***

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PLENARY LECTURES
PLENARNA PREDAVANJA

Shaping Europe's sustainable future: Cohesion policy, strategic investments, and citizen engagement in the Green and Digital Transition

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[2] University of Liège, Faculty of Law, Political Science and Criminology / Faculty of Social Sciences (CEDEM), Bâtiment 31 – Boîte 45, Quartier Agora, 3, Place des Orateurs, Liège, Belgium

Abstract
This plenary lecture addresses a central question at the heart of contemporary European governance: to what extent can individuals shape the direction of European Union policies and investments? By examining Cohesion Policy as one of the EU's most significant financial and strategic instruments, the presentation bridges institutional analysis with the often-underexplored dimension of individual agency. Drawing on the 2021–2027 cohesion policy framework, the lecture will analyse how targeted investments are mobilised to advance the green and digital transitions while reinforcing climate, policy, and socio-economic resilience. Particular focus will be placed on key areas where these dynamics are most visible and impactful, including affordable housing and island regions. At the same time, the lecture will critically engage with the proposed Multiannual Financial Framework for 2028–2034, highlighting emerging priorities, structural shifts in EU budgetary governance, and the growing importance of strategic flexibility. In this forward-looking perspective, special attention will be given to the role of individuals – policy experts, diplomats, and engaged national, regional and local stakeholders – in influencing policy design, negotiating priorities, and shaping investment outcomes. By combining analytical depth with a reflective and forward-looking approach, the lecture argues that Europe's sustainable transformation is not only a matter of financial capacity and institutional design, but also of informed, strategic, and persistent individual engagement within complex governance systems.

Keywords: cohesion policy, green and digital transition, sustainable and strategic investments, individual agency

Oblikovanje održive budućnosti Europe: kohezijska politika, strateška ulaganja i uključivanje građana u zelenu i digitalnu tranziciju

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Sažetak
Ovo plenarno predavanje bavi se jednim od ključnih pitanja suvremenog europskog upravljanja: u kojoj mjeri pojedinci mogu utjecati na oblikovanje politika i ulaganja Europske unije? Promatrajući kohezijsku politiku kao jedan od najvažnijih financijskih i strateških instrumenata EU-a, izlaganje povezuje institucionalnu analizu s često zanemarenom dimenzijom individualnog djelovanja. U kontekstu programskog razdoblja 2021.–2027., predavanje analizira kako se ciljanim ulaganjima potiču zelena i digitalna tranzicija te jača klimatska, politička i socio-ekonomska otpornost. Poseban naglasak stavljen je na područja u kojima su ti procesi najvidljiviji i najutjecajniji, poput priuštivog stanovanja i otočnih regija. Istodobno, predavanje kritički razmatra prijedlog višegodišnjeg financijskog okvira za razdoblje 2028.–2034., s posebnim osvrtom na nove prioritete, promjene u upravljanju proračunom EU-a i rastuću važnost strateške fleksibilnosti. U tom kontekstu, naglašava se uloga pojedinaca – stručnjaka, diplomata te nacionalnih, regionalnih i lokalnih dionika – u oblikovanju politika, pregovaranju prioriteta i usmjeravanju ulaganja. Kombinirajući analitičku dubinu i refleksivan pristup, predavanje zaključuje kako održiva transformacija Europe ne ovisi isključivo o financijskim resursima i institucionalnom okviru, već i o informiranom, strateškom i kontinuiranom djelovanju pojedinaca unutar složenih sustava upravljanja.

Ključne riječi: kohezijska politika, zelena i digitalna tranzicija, održiva i strateška ulaganja, individualno djelovanje

Impact of Climate Change on Viticulture and Winemaking in the Republic of Croatia

Anita PICHLER

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Abstract

Climate change is one of the most significant global challenges affecting viticulture and winemaking systems, altering the ecological, biological, and technological conditions of grape and wine production. Rising average daily temperatures, reduced water availability, more frequent extreme climatic events, and changes in precipitation patterns and insolation are causing significant shifts in grapevine phenology. An earlier onset of vegetation, accelerated development of phenophases, and earlier and more intensive sugar accumulation in grapes have been observed. These processes are often not accompanied by proportional development of organic acids and aroma precursors, leading to disturbances in technological maturity and to compositional changes in grapes that influence wine style and quality. Biochemical changes associated with heat and water stress, as well as UV radiation, result in changes in the concentration and composition of phenolic compounds, terpenes, and methoxypyrazines, thereby altering the aroma profile and style of wine. Increased alcohol content, reduced acid content, and changes in aromatic and phenolic compounds are increasingly common in viticultural and winemaking regions worldwide. At the same time, warmer grape-growing conditions promote the spread of diseases and pests and increase the need for sustainable and complex approaches to vineyard management. Current research focuses on investigating the adaptive mechanisms of grapevine and developing effective strategies for coping with climatic stress. These include the selection of more tolerant varieties and clones, improvements in training systems, the application of precise irrigation and shading strategies, enhancement of physical and chemical soil properties, and the development of enological approaches that mitigate undesirable changes in grape composition. Innovative enological practices, such as targeted modulation of fermentation processes, the use of yeast and bacterial strains with specific metabolic properties, and the application of adapted processing techniques, enable the mitigation of climate-induced changes in wine composition and style. An interdisciplinary approach integrating grapevine physiology, agronomic practices, enological processes, climatology, and principles of sustainable management is essential for understanding and mitigating climate impacts and for developing effective adaptation measures. The application of this knowledge in practice is essential for ensuring the long-term sustainability of grape and wine quality and for strengthening the resilience of viticulture and winemaking systems to future climatic challenges.

Keywords: climate change, viticulture, Croatia, grapevine phenology, grape composition, wine quality, climate adaptation, sustainable vineyard management

Utjecaj klimatskih promjena na vinogradarstvo i vinarstvo u Republici Hrvatskoj

Anita PICHLER

Sažetak

Klimatske promjene predstavljaju jedan od najvažnijih globalnih izazova koji utječu na sustave vinogradarstva i vinarstva, mijenjajući ekološke, biološke i tehnološke uvjete proizvodnje grožđa i vina. Porast prosječnih dnevnih temperatura, smanjena dostupnost vode, učestalije ekstremne klimatske pojave te promjene u obrascima oborina i insolacije uzrokuju značajne promjene u fenologiji vinove loze. Uočeni su raniji početak vegetacije, ubrzan razvoj fenofaza te ranije i intenzivnije nakupljanje šećera u grožđu. Ovi procesi često nisu praćeni proporcionalnim razvojem organskih kiselina i aromatskih prekursora, što dovodi do poremećaja tehnološke zrelosti te promjena u sastavu grožđa koje utječu na stil i kvalitetu vina. Biokemijske promjene povezane s toplinskim i vodnim stresom, kao i UV zračenjem, dovode do promjena u koncentraciji i sastavu fenolnih spojeva, terpena i metoksipirazina, čime se mijenjaju aromatski profil i stil vina. Povećani udio alkohola, smanjeni sadržaj kiselina te promjene u aromatičnim i fenolnim spojevima, sve su češće prisutne u vinogradarsko-vinarskim regijama svijeta. Istodobno, topliji uvjeti uzgoja vinove loze potiču širenje bolesti i štetnika te povećavaju potrebu za održivim i složenim pristupima upravljanju vinogradima. Suvremena istraživanja usmjerena su na istraživanja adaptacijskih mehanizama vinove loze te razvoj učinkovitih strategija za suočavanje s klimatskim stresom. One uključuju odabir tolerantnijih sorata i klonova, unaprjeđenje uzgojnih oblika, primjenu preciznih strategija navodnjavanja i zasjenjivanja, poboljšanje fizikalnih i kemijskih svojstava tla te razvoj enoloških pristupa koji ublažavaju neželjene promjene u sastavu grožđa. Inovativne enološke prakse, poput ciljane modulacije fermentacijskih procesa, primjene sojeva kvasaca i bakterija sa specifičnim metaboličkim svojstvima te prilagođenih tehnoloških postupaka omogućuju ublažavanje promjena u sastavu i stilu vina uzrokovanih klimatskim promjenama. Interdisciplinarni pristup koji integrira fiziologiju vinove loze, agronomske prakse, enološke procese, klimatologiju i principe održivog upravljanja ključan je za razumijevanje i ublažavanje utjecaja klimatskih promjena te razvoj učinkovitih mjera prilagodbe. Primjena ovih spoznaja u praksi ključna je za osiguravanje dugoročne održivosti kvalitete grožđa i vina te za jačanje otpornosti vinogradarsko-vinarskih sustava na buduće klimatske izazove.

Ključne riječi: klimatske promjene, vinogradarstvo, Hrvatska; fenologija vinove loze, sastav grožđa, kvaliteta vina, prilagodba klimatskim promjenama, održivo upravljanje vinogradima

Sustainable Management and Environmental Protection on the Istrian Y Motorway

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Abstract
This paper presents an integrated approach to environmental protection in the planning, construction, management, and maintenance of the Istrian Y motorway system. The presentation focuses on implementing sustainable construction principles through innovative materials, including "green concrete" with a reduced CO_2 footprint, and optimizing construction processes to minimize environmental impact. Particular attention is given to the sustainable management of rest areas and traffic infrastructure, including the introduction of EV charging stations and energy-efficient solutions related to lighting, traffic management, and tunnel ventilation systems. In the field of water and soil protection, emphasis is placed on drainage and treatment systems for stormwater and roadway runoff, the protection of water sources in the Učka Tunnel area, and the responsible disposal and reuse of excess construction materials generated during construction and maintenance activities. The presentation also addresses measures to reduce noise and mitigate traffic-related environmental impacts through both technical barriers and nature-based solutions. A significant segment is dedicated to biodiversity conservation through the implementation of wildlife protection measures. The Istrian Y is presented as an example of modern transport infrastructure that combines technical excellence with environmentally responsible management, contributing to long-term sustainability and alignment with European green policies.

Keywords: sustainable infrastructure, environmental protection, green construction

Održivo upravljanje i zaštita okoliša na Istarskom ipsilonu

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Sažetak
Rad prikazuje integrirani pristup zaštiti okoliša u planiranju, izgradnji, upravljanju i održavanju sustava autocesta Istarskog ipsilona. Fokus izlaganja usmjeren je na primjenu načela održive gradnje kroz korištenje inovativnih materijala, uključujući „zelene betone“ sa smanjenim CO_2 otiskom, te optimizaciju građevinskih procesa radi smanjenja utjecaja na okoliš. Posebna pažnja posvećena je održivom upravljanju odmorištima i prometnom infrastrukturom, uključujući uvođenje punionica za električna vozila i energetski učinkovitih rješenja povezanih s rasvjetom, upravljanjem prometom i sustavima ventilacije tunela. U području zaštite voda i tla naglasak je stavljen na sustave odvodnje i pročišćavanja oborinskih i kolničkih voda, zaštitu izvora vode na području tunela Učka te odgovorno zbrinjavanje i ponovnu uporabu viška građevinskog materijala nastalog tijekom izgradnje i održavanja. Izlaganje također obuhvaća mjere smanjenja buke i ublažavanja okolišnih utjecaja prometa primjenom tehničkih barijera i rješenja temeljenih na prirodi. Značajan dio posvećen je očuvanju bioraznolikosti kroz provedbu mjera zaštite divljači. Istarski ipsilon predstavlja se kao primjer moderne prometne infrastrukture koja povezuje tehničku izvrsnost s okolišno odgovornim upravljanjem te doprinosi dugoročnoj održivosti i usklađenosti s europskim zelenim politikama.

Ključne riječi: održiva infrastruktura, zaštita okoliša, zelena gradnja

INVITED LECTURES
POZVANA PREDAVANJA

Valorization of Food Plant Waste and By-Products Using Sustainable Technologies in Functional Food Development

Marija BADANJAK SABOLOVIĆ, Suzana RIMAC BRNČIĆ, Mladen BRNČIĆ

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Abstract
The global food system is currently undergoing a structural transformation, shifting from a linear model to a circular bioeconomy to address the systematic failure of contemporary agri-food models. The agro-food industry generates tremendous amounts of food waste and by-products, approximately 1.3 billion tons per year, contributing to environmental degradation, resource depletion, and economic losses. Approximately 50 % of this waste is generated from fruit and vegetable processing. Valorization of these materials, such as fruit and vegetable peels, seeds, husks, pomaces, through sustainable technologies offers a promising pathway to transform waste into high–value functional foods enriched with different bioactive compounds (polyphenols, dietary fibres, micronutrients, proteins). In functional food development, these valorized by-products can serve as natural fortifiers. This approach aligns with circular economy principles, reducing landfill burdens while enhancing food security and nutritional outcomes. Through the collaboration of the food industry and the academic community in introducing new sustainable technologies (e.g., high-pressure processing, pulsed electric field, ultrasound-assisted and supercritical fluid extraction, or innovative drying methods) is possible to reduce the amount of waste and by-products while simultaneously utilizing them for food production. Future research should focus on optimizing these processes and exploring consumer acceptance of products derived from food waste.

Keywords: food waste, functional food, innovative technologies

Acknowledgements: This paper has been funded by the European Union (NextGenerationEU) under the National Recovery and Resilience Plan 2021-2026 (NRRP), through the UNIZG FFTB institutional project " Application of Non-Thermal Technologies and Artificial Intelligence for Enhancing Food Product Quality and Waste Valorisation - SUSTAINIQ", approved by the Ministry of Science, Education and Youth of the Republic of Croatia (component C3.2, source 581).

Green chemistry approaches to the sustainable synthesis of pyridine compounds

Valentina BUŠIĆ

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Abstract

Pyridine compounds are an important class of nitrogen-containing heterocyclic molecules widely present in natural products, pharmaceuticals, and biologically active substances. Their structural versatility and rich reactivity make pyridine derivatives highly significant in organic and medicinal chemistry. Particularly important are derivatives of vitamins B6 and B3, which contain a pyridine ring as the central structural motif. Vitamins B6 and B3 are essential water-soluble compounds involved in numerous metabolic processes. Vitamin B6 includes pyridoxine, pyridoxal, and pyridoxamine, whose active coenzyme forms participate in more than 140 enzymatic reactions, including amino acid metabolism and neurotransmitter biosynthesis. Vitamin B3 occurs as nicotinic acid and nicotinamide, precursors of NAD and NADP, key cofactors in cellular redox processes and energy metabolism. Due to the presence of reactive functional groups, pyridoxine and nicotinamide allow structural modifications that enable the synthesis of derivatives with potential biological activity. In line with the principles of green chemistry, this work investigates quaternization reactions on the pyridine nucleus of pyridoxal oxime, nicotinamide, and pyridinium aldoximes using both conventional and, including microwave-assisted synthesis, ultrasound-assisted synthesis, and mechanosynthesis. Hazardous volatile solvents were replaced with low-temperature deep eutectic solvents, representing a more environmentally friendly alternative. The obtained pyridinium quaternary salts showed promising antifungal activity, while pyridoxal oxime derivatives demonstrated potential as antidotes for organophosphorus poisoning. This research was funded by the European Union – NextGenerationEU (581-UNIOS-92).

Keywords: pyridine derivatives, green chemistry, quaternization reactions, deep eutectic solvents

Pristupi zelene kemije u održivoj sintezi piridinskih spojeva

Valentina BUŠIĆ

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Sažetak

Piridinski spojevi predstavljaju važnu klasu heterocikličkih molekula koje sadrže dušik, a široko su prisutni u prirodnim, farmaceutskim i biološki aktivnim tvarima. Njihova strukturna svestranost i bogata reaktivnost čine derivate piridina vrlo značajnima u organskoj i medicinskoj kemiji. Posebno su važni derivati vitamina B6 i B3, koji sadrže piridinski prsten kao središnji strukturni motiv. Vitamini B6 i B3 esencijalni su spojevi topljivi u vodi, uključeni u brojne metaboličke procese. Vitamin B6 obuhvaća piridoksin, piridoksal i piridoksamin, čiji aktivni koenzimski oblici sudjeluju u više od 140 enzimskih reakcija, uključujući metabolizam aminokiselina i biosintezu neurotransmitera. Vitamin B3 javlja se kao nikotinska kiselina i nikotinamid, prekursori NAD-a i NADP-a, ključnih kofaktora u staničnim redoks procesima i energetskom metabolizmu. Zbog prisutnosti reaktivnih funkcijskih skupina, piridoksin i nikotinamid omogućuju strukturne modifikacije koje dopuštaju sintezu derivata s potencijalnom biološkom aktivnošću. U skladu s principima zelene kemije, u ovom radu istražene su reakcije kvaternizacije na piridinskoj jezgri piridoksal-oksima, nikotinamida i piridinijevih aldoksima koristeći konvencionalne i zelene metode, uključujući sintezu uz pomoć mikrovalova, ultrazvuka i mehanosintezu. Opasna hlapljiva otapala zamijenjena su niskotemperaturnim eutektičkim otapalima, što predstavlja ekološki prihvatljiviju alternativu. Dobivene piridinijeve kvaternarne soli pokazale su obećavajuću antifungalnu aktivnost, dok su derivati piridoksal oksima pokazali potencijal kao antidoti u trovanju organofosfornim spojevima. Ovo istraživanje financirala je Europska unija – NextGenerationEU (581-UNIOS-92).

Ključne riječi: piridinski spojevi, zelena kemija, reakcije kvaternizacije, niskotemperaturna eutektička otapala

The impact of fossil fuel geopolitics on national security and the (international) legal challenges

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Abstract

The past few decades have been characterized by an intensification of the global transition toward renewable energy sources, driven by the imperative of climate sustainability and technological advancements. Although the normative framework and public policies at the turn of the 21st century proclaimed "green energy" as a strategic developmental direction, contemporary geopolitical processes indicate a resurgence in the dominance of fossil fuels. This paper analyzes the cleavage between ecological objectives and the energy reality in which oil and gas remain pivotal factors of national security and economic stability. The research seeks to demonstrate that the global energy architecture remains primarily determined by the control over the exploitation and distribution of conventional resources, which subsequently leads to geopolitical confrontations, conflicts, and wars. Consequently, energy systems—and the global economy itself—remain dependent on traditional energy sources. Therefore, the objective of this research is to illustrate that, notwithstanding the factual advantages of green energy, contemporary energy geopolitics remains centered on state policies aimed at securing dominance over regions of fossil fuel extraction and distribution. Thus, such energy remains intrinsically linked to the protection of national security—with a particular emphasis in this paper on the Republic of Croatia—as well as to global economic development and its ramifications. In this context, energy geopolitics leads to the instrumentalization of energy, resulting in the derogation of fundamental norms of public international law, thereby jeopardizing global stability and the international legal order.

Keywords: fossil fuels, energy geopolitics, legal challenges, national security

Suverenitet i energetska ovisnost: Utjecaj geopolitike fosilnih goriva na nacionalnu sigurnost i (međunarodne) pravne izazove

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Sažetak

Posljednja desetljeća obilježena su intenziviranjem globalnog prijelaza na obnovljive izvore energije, potaknutog imperativom klimatske održivosti i tehnološkim napretkom. Iako je normativni okvir i javna politika na prijelazu u 21. stoljeće proklamirala "zelenu energiju" kao strateški pravac razvoja, suvremeni geopolitički procesi ukazuju na ponovno vraćanje dominacije fosilnih goriva. Ovaj rad analizira podjelu između ekoloških ciljeva i energetske realnosti u kojoj nafta i plin (fosilna goriva) ostaju ključni čimbenici nacionalne sigurnosti i ekonomske stabilnosti. Istraživanje nastoji dokazati da globalna energetska arhitektura ostaje primarno determinirana kontrolom eksploatacije i distribucije konvencionalnih resursa, a što dovodi do geopolitičkih konfrontacija, sukoba i ratova. Time takva energija kao i samo globalno gospodarstvo ostaje i dalje ovisno o tradicionalnim izvorima energije. Stoga, cilj ovog rada i istraživanja je prikazati da bez obzira na činjenične realitete prednosti zelene energije, energetska geopolitika današnjeg vremena je i dalje usmjerena na politike država za ovladavanjem područjima iz koje se crpi i distribuira energija dobivena iz fosilnih goriva, čime je takva energija i dalje povezana kako sa zaštitom nacionalne sigurnosti država, a ovom radu s posebnim naglaskom na Republiku Hrvatsku, tako i s globalnim ekonomskim razvojem i posljedicama. Pri tome energetske geopolitike dovode do instrumentalizacije energije što rezultira derogacijom temeljnih normi međunarodnog javnog prava, čime se ugrožava globalna stabilnost i pravni poredak.

Ključne riječi: fosilna goriva, energetska geopolitika, pravni izazovi, nacionalna sigurnost

Climate change, security risks, and Civil protection system responses in the Republic of Croatia and the EU

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Abstract
Climate change represents one of the most complex challenges of our time, transforming traditional security paradigms into direct threats to societal stability. This paper explores the correlation between extreme climate events and security risks, with a particular focus on the operational efficiency of civil protection systems. Using a multidisciplinary approach, it analyzes the evolution of risks—ranging from catastrophic floods and wildfires to threats against critical infrastructure—and how these processes necessitate a redefinition of national and supranational response strategies. The first part of the paper focuses on the Republic of Croatia, analyzing its vulnerability as a Mediterranean country and the adaptation of national legislation to European directives. The second part examines European Union mechanisms, such as the Union Civil Protection Mechanism (UCPM) and the rescEU system, which serve as the foundation for collective security and solidarity. The research aims to evaluate the extent to which the integration of the Green Deal and digital early-warning technologies contributes to system resilience. In conclusion, the paper proposes models to enhance cross-sectoral cooperation and strengthen local capacities, emphasizing the need for synergy between scientific knowledge and operational action to minimize damage and protect human lives amid changing climatic conditions.

Keywords: climate change, security risks, civil protection, Republic of Croatia, European Union

Klimatske promjene, sigurnosni rizici te odgovori sustava civilne zaštite u Republici Hrvatskoj i EU

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Sažezak
Klimatske promjene predstavljaju jedan od najsloženijih izazova današnjice, transformirajući tradicionalne sigurnosne paradigme u izravne prijetnje stabilnosti društva. Ovaj rad istražuje korelaciju između ekstremnih klimatskih događaja i sigurnosnih rizika, s posebnim naglaskom na operativnu učinkovitost sustava civilne zaštite. Multidisciplinarnim pristupom analizira se evolucija rizika, od katastrofalnih poplava i šumskih požara do ugroze kritične infrastrukture, te kako ti procesi zahtijevaju redefiniranje nacionalnih i nadnacionalnih strategija odgovora. U prvom dijelu rada fokus je na Republici Hrvatskoj, analizirajući njezinu ranjivost kao mediteranske zemlje i prilagodbu nacionalnog zakonodavstva europskim direktivama. Drugi dio rada razmatra mehanizme Europske unije, poput Mehanizma unije za civilnu zaštitu (UCPM) i rescEU sustava, koji služe kao temelj kolektivne sigurnosti i solidarnosti. Cilj istraživanja je evaluirati u kojoj mjeri integracija Zelenog plana i digitalnih tehnologija za rano upozoravanje doprinosi otpornosti sustava. Zaključno, rad predlaže modele za unapređenje međusektorske suradnje i jačanje lokalnih kapaciteta, ističući nužnost sinergije znanstvenih spoznaja i operativnog djelovanja u svrhu minimiziranja šteta i zaštite ljudskih života u promjenjivim klimatskim uvjetima.

Ključne riječi: klimatske promjene, sigurnosni rizici, civilna zaštita, Republika Hrvatska, Europska unija

Valorization of the geoheritage of Medvednica Nature Park in the context of the establishment of a UNESCO World Geopark

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Abstract
The geological history of Medvednica dates back more than 300 million years, which defines it as a specific lithofacies mosaic and a "geological window" of the Pannonian Basin. Although the entire area is protected as a nature park and part of the Natura 2000 ecological network, with an annual attendance of almost a million visitors, the geological heritage of the mountain remains in the shadow of dominant recreational facilities. The research conducted in the first quarter of 2026 aimed to determine the level of information about geoheritage among visitors and to analyze attitudes towards the nomination and proclamation of Medvednica as a UNESCO Global Geopark. The results of the empirical research indicate a significant disparity between the high level of declarative support for the initiative and the low level of knowledge of specific geological phenomena. The analysis of information sources confirmed the dominance of formal education (34.8%) as the primary channel for acquiring knowledge, while the existing field interpretation infrastructure (26.1%) does not meet contemporary needs and trends. The finding that most respondents do not know the precise definition of a geopark indicates that their support primarily relies on trust in the institutional authority of UNESCO. The paper concludes that for the successful implementation of the geopark model, while respecting the standards of the Natura 2000 network, it is necessary to redefine the interpretation system through innovative approaches. By applying a participatory model of cooperation with stakeholders, geodiversity would become an active resource of the green transition, directly integrating geological heritage with regional identity and sustainable development goals.

Keywords: geodiversity, Medvednica, UNESCO World Geopark, regional identity, sustainable development

Valorizacija geobaštine Parka prirode Medvednica u kontekstu uspostave UNESCO-vog svjetskog geoparka

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Sažetak

Geološka povijest Medvednice seže više od 300 milijuna godina u prošlost, što je definira kao specifičan litofacijesni mozaik i „geološki prozor“ Panonskog bazena. Iako je cijelo područje zaštićeno kao park prirode i dio ekološke mreže Natura 2000, uz godišnju posjećenost od gotovo milijun posjetitelja, geološka baština planine i dalje ostaje u sjeni dominantnih rekreativnih sadržaja. Istraživanje provedeno u prvom kvartalu 2026. godine imalo je za cilj utvrditi razinu informiranosti posjetitelja o geobaštini te analizirati stavove o nominaciji i proglašenju Medvednice UNESCO-vim svjetskim geoparkom.Rezultati empirijskog istraživanja ukazuju na značajan nesrazmjer između visokog stupnja deklarativne podrške inicijativi i niskog poznavanja specifičnih geoloških fenomena. Analiza izvora informiranja potvrdila je dominaciju formalnog obrazovanja (34,8 %) kao primarnog kanala stjecanja znanja, dok postojeća terenska interpretacijska infrastruktura (26,1 %) ne zadovoljava suvremene potrebe i trendove. Spoznaja da većina ispitanika ne poznaje preciznu definiciju geoparka ukazuje na to da se njihova podrška primarno oslanja na povjerenje u institucionalni autoritet UNESCO-a. Rad zaključuje kako je za uspješnu implementaciju modela geoparka, uz uvažavanje standarda mreže Natura 2000, nužno redefinirati sustav interpretacije kroz inovativne pristupe. Primjenom participativnog modela suradnje s dionicima, georaznolikost bi postala aktivan resurs zelene tranzicije, čime se geološka baština izravno integrira s regionalnim identitetom i ciljevima održivog razvoja.

Ključne riječi: georaznolikost, Medvednica, UNESCO-ov svjetski geopark, regionalni identitet, održivi razvoj

Microplastics in Agroecosystems: A New Challenge for Sustainable Soil Management

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Abstract

Microplastic (MP) contamination has become an increasingly visible component of modern environmental pollution. As the use of plastic materials expanded in agriculture, fragments of these materials gradually entered soil systems and began to accumulate. Today, microplastics can be found not only in oceans and rivers, but also in agricultural soils, where they represent a growing challenge for soil health and sustainable food production. In agricultural landscapes, microplastics originate mainly from the degradation of plastic mulching films, while additional inputs occur through irrigation water and the application of sewage sludge. Once in the soil, these particles may alter soil structure, influence microbial communities and nutrient dynamics, and potentially affect plant development and the safety of the food chain. The presence of microplastics in soil highlights the limitations of the traditional linear economic model of "take–make–dispose". To address this issue, agriculture must move toward a circular bioeconomy that emphasizes resource efficiency, responsible waste management, and sustainable soil practices. Systematic soil monitoring, balanced fertilization based on soil analysis, and the use of precision agriculture tools provide a scientific foundation for maintaining soil quality and reducing environmental pressures. At the same time, innovation plays a crucial role. The development and use of biodegradable polymers, such as PLA and PHA, represent promising alternatives to conventional plastic materials and may help reduce the long-term accumulation of plastic residues in soils. By integrating improved soil management, innovative materials and circular economy principles, agriculture can contribute to healthier soils, more resilient agroecosystems and a more sustainable future.

Keywords: microplastic pollution, agroecosystems, circular bioeconomy, sustainable agriculture

Mikroplastika u agroekosustavima: Novi izazov za održivo upravljanje tlom

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Sažetak

Onečišćenje mikroplastikom (MP) postaje sve vidljivija komponenta suvremenog onečišćenja okoliša. Širenjem primjene plastičnih materijala u poljoprivredi, njihovi fragmenti postupno ulaze u pedosustave i akumuliraju se u tlu. Danas se mikroplastika ne nalazi samo u morima i rijekama, već i u poljoprivrednim tlima, gdje predstavlja rastući izazov za očuvanje plodnosti tla i održivost proizvodnje hrane. U poljoprivrednim sustavima mikroplastika prvenstveno potječe od degradacije plastičnih malč-folija, dok dodatni unos u tlo nastaje putem vode za navodnjavanje te primjenom kanalizacijskog mulja. Nakon ulaska u tlo, te čestice mogu mijenjati fizikalna svojstva tla, utjecati na strukturu i aktivnost mikrobnih zajednica te poremetiti dinamiku hraniva. Posljedično, takve promjene mogu utjecati na rast i razvoj biljaka te potencijalno na sigurnost hranidbenog lanca. Prisutnost mikroplastike u tlu istodobno ukazuje na ograničenja tradicionalnog linearnog gospodarskog modela „uzmi–proizvedi–odbaci“. Suočavanje s tim izazovom zahtijeva prijelaz prema načelima kružne bioekonomije u upravljanju tlom i poljoprivrednim resursima. U tom kontekstu, sustavno praćenje stanja tla predstavlja temelj za donošenje održivih agrotehničkih odluka. Redovite kemijske i fizikalne analize tla, gnojidba temeljena na analizi i opskrbljenosti tla hranivima, praćenje mineralnih oblika dušika u sustavima precizne poljoprivrede te procjena teksture tla, sadržaja organske tvari i biološke aktivnosti ključni su elementi održivog gospodarenja tlom. Istodobno, važnu ulogu imaju inovativna rješenja temeljena na ekosustavnim pristupima. Razvoj i primjena biorazgradivih polimera, poput PLA i PHA, predstavljaju obećavajuću alternativu konvencionalnim plastičnim materijalima te mogu pridonijeti smanjenju dugoročne akumulacije plastičnih ostataka u tlu. Integracijom održivog gospodarenja tlom, inovativnih materijala i načela kružne bioekonomije moguće je doprinijeti očuvanju plodnosti tla, povećanju otpornosti agroekosustava i razvoju održivog poljoprivrednog sustava.

Ključne riječi: onečišćenje mikroplastikom, agroekosustavi, cirkularna bioekonomija, održiva poljoprivreda

Updating the mining and geological study of varaždin county: Institutional challenges, resource reserves, and demand projections

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Abstract
Mineral resources, as natural aggregates of minerals and/or compounds, play a key role in the economic development of Varaždin County. Their value is primarily reflected in their potential for exploitation and application in various industrial sectors, including the petroleum, chemical, glass, ceramic, cement, and construction industries. While energy resources such as geothermal waters, oil, and natural gas are considered strategic resources, solid mineral raw materials—such as construction sand and gravel, dimension stone, and brick clay—are often marginalized, despite being equally important for the construction sector and overall regional development. Mining activities in Varaždin County are carried out within a complex regulatory framework which, in addition to mining legislation, also includes regulations related to environmental and nature protection. The aim of the research is to analyze the regulatory and management framework of mining activities in Varaždin County, with particular emphasis on administrative and procedural challenges. The objective of the research is to examine the possibilities and limitations of mineral resource exploitation, and to develop recommendations for improving the efficiency of mining activities, integrating sustainable practices, and balancing economic needs with environmental protection. The research results show that the expansion of existing exploitation fields within planned areas, in accordance with the conditions prescribed by spatial planning documentation, may be requested provided that at least 70% of the mineral reserves defined in the valid permit have been extracted, and that progressive (phased) rehabilitation of the exploitation field is being implemented or has been completed in accordance with mining regulations, State Inspectorate requirements, environmental and nature protection legislation, and other applicable acts.

Keywords: mineral resources, mining activities, regulatory framework, spatial planning, environmental protection, Varaždin County

Revizija rudarsko-geološke studije varaždinske županije: institucionalni izazovi, rezerve i projekcije potreba

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Sažetak
Mineralne sirovine, kao prirodni agregati minerala i/ili spojeva, imaju ključnu ulogu u gospodarskom razvoju Varaždinske županije. Njihova vrijednost očituje se kroz mogućnost eksploatacije i primjene u različitim industrijskim djelatnostima, uključujući naftnu, kemijsku, staklarsku, keramičku, cementnu i građevinsku industriju. Dok se energetski resursi poput geotermalnih voda, nafte i prirodnog plina ističu kao strateški resursi, čvrste mineralne sirovine: građevni pijesak i šljunak, tehničko-građevni kamen, ciglarska glina – često su marginalizirane, iako su jednako važne za građevinski sektor i ukupni regionalni razvoj. Rudarska djelatnost u Varaždinskoj županiji odvija se u okviru složenog regulatornog okvira koji, uz rudarsko zakonodavstvo, obuhvaća i propise iz područja zaštite okoliša i prirode. Svrha istraživanja je analiza regulatornog i upravljačkog okvira rudarske djelatnosti u Varaždinskoj županiji s posebnim naglaskom na administrativne i proceduralne izazove. Cilj istraživanja je ispitati mogućnosti i ograničenja iskorištavanja mineralnih resursa, te razviti preporuke za unaprjeđenje učinkovitosti rudarske djelatnosti, integraciju održivih praksi i uravnoteženje gospodarskih potreba s očuvanjem okoliša. Rezultati istraživanja pokazuju da proširenja postojećih eksploatacijskih polja unutar planiranih područja, u skladu s uvjetima propisanim u prostorno-planskoj dokumentaciji, moguće je zatražiti pod uvjetom da je na postojećem eksploatacijskom polju otkopano najmanje 70 % eksploatacijskih rezervi utvrđenih važećim rješenjem te da se provodi ili je provedena sukcesivna (fazna) sanacija na eksploatacijskom polju sukladno propisima iz područja rudarstva, državnog inspektorata, zaštite okoliša i prirode te ishođenim aktima.

Ključne riječi: mineralni resursi, rudarska djelatnost, regulatorni okvir, prostorno planiranje, zaštita okoliša, Varaždinska županija

PRESENTATIONS
PRIOPĆENJA

CLIMATE CHANGE
KLIMATSKE PROMJENE

Conservation strategies for an Endangered freshwater fish under a warming climate: the case of *Padogobius nigricans* (Canestrini, 1867) in the Tiber River Basin (Italy)

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Abstract
Biological invasions and global warming are major threats to freshwater fish. In the case of *Padogobius nigricans*, a species endemic to Central Italy, the application of climate models trained with historical fish and environmental observational data produced future scenarios for habitat suitability. These scenarios predict a narrowing distribution of this species, limited to the eastern mountainous Tiber River Basin, where it is currently absent. Climate change will compound the impacts caused by the introduction of *Padogobius bonelli*, an invasive species responsible for local extinctions of *P. nigricans* through competitive exclusion mechanisms. This research aimed to formulate and test, according to an adaptive approach, a management strategy to enhance the persistence of the Endangered *P. nigricans*. Key actions, implemented starting from 2024 in 25 watercourses of the Tiber River Basin as part of the European Project LIFE19-IPE/IT/000015 IMAGINE, include: i) the removal of three unnecessary weirs to enhance river connectivity, considering that gobies show limited dispersal ability and can be hindered in their upstream migration by obstacles, and ii) relocating *P. nigricans* from 10 source populations (for a total of 2500 adults per year) to 15 selected sites with suitable environmental conditions and devoid of alien species. These efforts have resulted in new self-sustaining populations at 14 of the restocked sites, providing evidence for the effectiveness of the measures adopted to mitigate endemic fish vulnerability in Mediterranean freshwater ecosystems.

Keywords: freshwater fish, invasive species, climate change, Mediterranean rivers, biodiversity conservation

The Neretva Delta at a Crossroads: Climate Risks and Anthropogenic Pressures – Implications for Agricultural Production

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Abstract
The Neretva Delta represents a complex and highly sensitive agro-ecological system in which the effects of climate change and anthropogenic pressures are manifested through changes in the hydrological regime and salinization processes. Sea level rise, reduced freshwater inflow from the Neretva and Trebišnjica river basins, and intensive use of water resources disrupt the balance between surface and groundwater, with direct consequences for soil quality and the sustainability of agricultural production. This paper is based on the results of water body assessments and the Characterisation Study of the Neretva Delta pilot area in Bosnia and Herzegovina, developed within the MoWaCLIM project. An interdisciplinary approach was applied, including the assessment of ecological status and potential of surface waters, analysis of physicochemical water quality parameters, and evaluation of agricultural practices, with a particular focus on the sensitivity of dominant crops to irrigation water salinity. Preliminary results indicate spatial variability of salinization and identify areas of increased risk, particularly under conditions of reduced river flow, intensive use of water resources, and projected climate change scenarios (RCP 2.6–8.5). A high dependence on irrigation and a limited application of data-driven management practices were observed. The results highlight the need for the development of integrated, data-driven approaches to water and agricultural management, supported by digital tools to enhance the resilience of agricultural production to climate and development pressures.

Keywords: salinization, coastal agroecosystems, climate change impacts, water resources management, decision support systems

Delta Neretve na prekretnici: klimatski rizici i antropogeni pritisci – implikacije za poljoprivrednu proizvodnju

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Sažetak

Delta Neretve predstavlja složen i visoko osjetljiv poljoprivredno-ekološki sustav u kojem se učinci klimatskih promjena i antropogenih pritisaka očituju kroz promjene hidrološkog režima i procese zaslanjenja. Porast razine mora, smanjen dotok vode iz sliva Neretve i Trebišnjice te intenzivno korištenje vodnih resursa narušavaju ravnotežu između površinskih i podzemnih voda, s izravnim posljedicama na kakvoću tla i održivost poljoprivredne proizvodnje. Rad se temelji na rezultatima istraživanja vodnih tijela i Studije karakterizacije pilot područja delte Neretve u Bosni i Hercegovini izrađene u okviru projekta MoWaCLIM. Primijenjen je interdisciplinarni pristup koji uključuje procjenu ekološkog stanja i potencijala površinskih voda, analizu fizikalno-kemijskih pokazatelja kakvoće vode te analizu poljoprivrednih praksi, uz procjenu osjetljivosti dominantnih kultura na zaslanjenost vode za navodnjavanje. Preliminarni rezultati ukazuju na prostornu varijabilnost zaslanjenja i identificiraju područja povećanog rizika, osobito u uvjetima smanjenog riječnog protoka, intenzivnog korištenja vodnih resursa te projiciranih klimatskih promjena prema različitim scenarijima (RCP 2.6–8.5). Uočena je visoka ovisnost o navodnjavanju te ograničena primjena upravljanja temeljenog na podacima. Dobiveni rezultati potvrđuju potrebu za razvojem integriranih, na podacima utemeljenih pristupa upravljanju vodnim resursima i poljoprivredom, uz primjenu digitalnih alata u svrhu jačanja otpornosti poljoprivredne proizvodnje na klimatske i razvojne pritiske.

Ključne riječi: zaslanjenje, obalni agroekosustavi, utjecaji klimatskih promjena, upravljanje vodnim resursima, sustavi za potporu odlučivanju

Resources, resilience and circularity of today's aquaculture

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Abstract
In order to sustainably meet the growing demand for aquatic products, it is necessary to recognize the strong connection that exists within and between fisheries, aquaculture, and agricultural systems. Climate change is now considered a risk to global food production and a major threat to the quality and quantity of production. In aquaculture, most of the recent literature indicates that some changes in climate, such as rising temperatures, changing precipitation patterns, and increased frequency of some extreme events are now evident on water resources. Despite numerous publications, the available literature reviews have not shown that it has been sufficiently researched how the sustainability of the aquaculture sector could be affected by the projected climate changes. Numerous reports have emerged showing that climate change effects on aquaculture may vary depending on geographical areas, economy, climatic zones, production systems, and cultured species. The effects of climate change on aquaculture have been addressed; however, there has been a tendency to research the negative effects of climate change on aquaculture, while positive effects, which are very important for adaptation strategies, receive much less attention. A broader study of both the negative and positive sides of climate change will promote producers' preparedness and help minimize the risks to their production. The paper discusses the effects of climate change on aquaculture production and the sustainability implications, highlighting how each specific element of climate change will impact the sector. It also presents some mitigation and adaptation options that may have broader application, as well as challenges for successful adaptation.

Keywords: climate change mitigation, sustainability, aquaculture technologies

Analysis of the success rate of rehabilitation of windbreaks in state forests in the Medvednica Nature Park

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Abstract
Due to its proximity to the capital, Medvednica receives significant public attention. Alongside ecological and socio-ecological roles, forests provide important social functions, including tourism, recreation, health, and aesthetic value. Public interest within Medvednica Nature Park is particularly focused on forest management, especially biological restoration, which includes tree removal. Sustainable forest management is essential to maintain ecosystem stability and to respond to ongoing natural processes and changes. Over the past 12 years, Medvednica's forests have been affected by several major and minor storms, which have significantly altered the landscape, disrupted stand structure and stability, and required adjustments to management plans. Hrvatske šume Ltd., responsible for managing state forests, has invested considerable effort in windthrow recovery through three phases: urgent infrastructure interventions, timber removal and forest order establishment, and biological restoration. This paper aims to present the implemented restoration measures as an example of good practice under climate extremes. It highlights the volume of salvaged timber and emphasizes the importance of continuous management for forest stability, climate change mitigation, and strengthening public understanding and trust.

Keywords: sustainable forest management, Nature Park Medvednica, windthrows, forest restoration, public engagement

Analiza uspješnosti sanacija vjetroizvala u državnim šumama na području Parka prirode Medvednica

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Sažetak

Medvednica, zbog blizine glavnog grada, ima velik značaj za građane. Osim ekoloških i ekološko-socijalnih uloga, posebno dolaze do izražaja njezine socijalne funkcije poput turizma, rekreacije, zdravlja i estetike. Unutar Parka prirode velika se pažnja posvećuje gospodarenju šumama, osobito biološkoj obnovi koja uključuje i uklanjanje stabala. Održivo gospodarenje jedini je način očuvanja stabilnosti šumskih ekosustava, uz razumijevanje prirodnih procesa i promjena. Tijekom posljednjih 12 godina šume Medvednice pogođene su brojnim olujama koje su narušile njihovu strukturu i stabilnost te utjecale na planove gospodarenja. Hrvatske šume d.o.o. uložile su znatne napore u sanaciju vjetroizvala kroz tri faze: hitne intervencije, uklanjanje i zbrinjavanje drvne mase te biološku obnovu. Svrha rada je prikazati provedene sanacije kao primjer dobre prakse u uvjetima klimatskih ekstrema. Cilj je analizirati količine sanirane drvne mase i naglasiti važnost kontinuiranog gospodarenja za stabilnost šuma. Također se razmatra utjecaj vjetroizvala na planove gospodarenja i krajobraz te potreba za informiranjem javnosti radi jačanja povjerenja u šumarsku struku.

Ključne riječi: održivo gospodarenje šumama, Park prirode Medvednica, vjetroizvale, obnova šuma, javnost

Impact of climate change on food safety: risks and implications

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Abstract
Climate change represents one of the most significant global challenges of the modern era, with particularly pronounced effects on food safety. The aim of this review was to identify the key food safety risks associated with climate change and to analyze their implications for the food supply chain and human health. The study was conducted as a review article based on an analysis of scientific literature published over the past ten years and indexed in the databases PubMed, Scopus, and Web of Science. Changes in temperature patterns, disruptions to the hydrological cycle, and the increasing frequency of extreme weather events have emerged as major drivers of food safety risks. These factors adversely affect primary agricultural production, food quality and availability, as well as the stability and resilience of food supply chains. Climate change has been associated with an increased occurrence of microbiological, chemical, and physical hazards, including foodborne pathogens whose distribution, survival, and seasonal dynamics are influenced by changing environmental conditions. Warmer temperatures and increased humidity create favorable conditions for mycotoxin contamination, while elevated concentrations of heavy metals, pesticide residues, antibiotics, and other veterinary medicinal products have also been reported. Furthermore, climate change compromises the safety and availability of water resources and disrupts storage conditions and cold-chain systems during extreme weather events, leading to increased food spoilage and food waste. The reviewed evidence highlights substantial health, nutritional, and socioeconomic consequences for populations worldwide. Addressing the challenges posed by climate change requires timely, coordinated, and integrated strategies aimed at safeguarding food safety, strengthening food system resilience, and protecting public health.

Keywords: food safety, climate change, food hazards, risks, implications

Utjecaj klimatskih promjena na sigurnost hrane: rizici i implikacije

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Sažetak

Klimatske promjene predstavljaju jedan od najznačajnijih globalnih izazova suvremenog doba, s osobito izraženim utjecajem na sigurnost hrane. Cilj ovog preglednog rada bio je identificirati ključne rizike za sigurnost hrane povezane s klimatskim promjenama te analizirati njihove implikacije na prehrambeni lanac i zdravlje ljudi. Rad je izrađen kao pregledni članak temeljen na analizi znanstvene literature objavljene tijekom posljednjih deset godina i indeksirane u bazama podataka PubMed, Scopus i Web of Science. Promjene temperaturnih obrazaca, poremećaji hidrološkog ciklusa te sve učestalija pojava ekstremnih vremenskih događaja prepoznati su kao glavni pokretači rizika za sigurnost hrane. Navedeni čimbenici nepovoljno utječu na primarnu poljoprivrednu proizvodnju, kvalitetu i dostupnost hrane te stabilnost i otpornost prehrambenih lanaca opskrbe. Klimatske promjene povezane su s povećanom pojavom mikrobioloških, kemijskih i fizikalnih opasnosti, uključujući patogene koji se prenose hranom, a čija su rasprostranjenost, preživljavanje i sezonska dinamika pod utjecajem promijenjenih okolišnih uvjeta. Više temperature i povećana vlažnost zraka stvaraju povoljne uvjete za kontaminaciju mikotoksinima, dok su zabilježene i povećane koncentracije teških metala, ostataka pesticida, antibiotika i drugih veterinarsko-medicinskih proizvoda. Nadalje, klimatske promjene ugrožavaju sigurnost i dostupnost vodnih resursa te narušavaju uvjete skladištenja i funkcioniranje hladnog lanca tijekom ekstremnih vremenskih događaja, što dovodi do povećanog kvarenja hrane i nastanka otpada od hrane. Pregledana literatura ukazuje na značajne zdravstvene, nutritivne i socioekonomske posljedice za stanovništvo diljem svijeta. Suočavanje s izazovima koje donose klimatske promjene zahtijeva pravodobne, koordinirane i integrirane mjere usmjerene na očuvanje sigurnosti hrane, jačanje otpornosti prehrambenih sustava i zaštitu javnog zdravlja.

Ključne riječi: sigurnost hrane, klimatske promjene, opasnosti u hrani, rizici, implikacije

Aligning EU Funding with Climate Resilience: Evidence from CAP Implementation in Croatia

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Abstract
The Common Agricultural Policy (CAP) is a central instrument of EU agricultural funding and plays a key role in stabilising farm income. At the same time, increasing climate variability requires stronger alignment between financial support and the development of adaptive capacity. This paper examines the relationship between CAP funding and climate resilience in Croatian agriculture using secondary data from the Croatian Bureau of Statistics, FADN and Eurostat for the period 2014–2020, testing the hypothesis that CAP allocations primarily stabilise income while exhibiting limited association with structural transformation relevant for resilience. The results indicate a continued decline in the number of farms, only modest consolidation, and a persistently high share of direct payments in farm income (approximately 70–80%). These patterns confirm the stabilisation function of CAP, but also suggest limited capacity to stimulate investment in adaptive capacity. The findings point to a structural gap between income stabilisation and climate resilience outcomes, particularly in the design and uptake of CAP measures. Investment and project-based instruments have the potential to translate financial support into concrete adaptation outcomes. More broadly, policy frameworks primarily oriented towards income stabilisation may underperform in fostering long-term adaptive capacity under increasing climate uncertainty.

Keywords: CAP, climate resilience, structural change, projects, Croatia

Usklađenost EU financiranja s klimatskom otpornošću: empirijski dokazi iz provedbe ZPP-a u Hrvatskoj

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Sažetak

Zajednička poljoprivredna politika (ZPP) predstavlja ključni instrument financiranja poljoprivrede u Europskoj uniji te ima važnu ulogu u stabilizaciji dohotka poljoprivrednih gospodarstava. Istodobno, rastuća klimatska varijabilnost zahtijeva snažnije usklađivanje financijske potpore s razvojem adaptivnog kapaciteta. Ovaj rad analizira odnos između ZPP-a i klimatske otpornosti u hrvatskoj poljoprivredi na temelju sekundarnih podataka (DZS, FADN, Eurostat) za razdoblje 2014.–2020., testirajući hipotezu da alokacija sredstava ZPP-a primarno stabilizira dohodak uz ograničenu povezanost sa strukturnom transformacijom. Rezultati pokazuju kontinuirani pad broja gospodarstava, spor proces konsolidacije te visok i stabilan udio izravnih plaćanja u dohotku (približno 70 – 80 %). Takvi obrasci potvrđuju stabilizacijsku funkciju ZPP-a, ali istodobno upućuju na ograničenu sposobnost poticanja ulaganja u adaptivni kapacitet. Dobiveni nalazi ukazuju na strukturni jaz između stabilizacije dohotka i klimatske otpornosti, osobito u dizajnu i provedbi mjera ZPP-a. Investicijski i projektno orijentirani instrumenti imaju potencijal pretvoriti financijsku potporu u konkretne učinke prilagodbe. U širem smislu, politike usmjerene na stabilizaciju dohotka mogu podbacivati u razvoju dugoročne otpornosti u uvjetima klimatske neizvjesnosti.

Ključne riječi: ZPP, klimatska otpornost, strukturne promjene, projekti; Hrvatska

Climate proofing

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Abstract
The Climate Change and Ozone Layer Protection Act (OG 67/2025) introduced the obligation of climate proofing. This process involves integrating climate change mitigation and adaptation measures into the planning and development of infrastructure projects, allowing investors to demonstrate the resilience and sustainability of a project to qualify for EU funding. It is conducted in accordance with the Technical guidance on the proofing of infrastructure to climate change in the period 2021–2027 (2021/C 373/01). Its goal is to ensure the long-term sustainability and functionality of infrastructure amidst a changing climate, thereby protecting investments and communities from future climate challenges. The process consists of two key pillars, each featuring two assessment phases (screening and detailed analysis). Mitigating climate change (Pillar 1) involves decarbonisation, energy efficiency, energy savings, and deploying renewable forms of energy. It involves taking action to reduce GHG emissions or increase GHG sequestration and is guided by EU policy on emission reduction targets for 2030 and 2050. Through the second pillar – climate change adaptation/resilience – climate risks such as more intense floods, cloudbursts, droughts, heatwaves, wildfires, storms, landslides, hurricanes, and others are identified, and the infrastructure's resilience to these risks is verified throughout its lifespan. By conducting detailed vulnerability and risk assessments, specific protective measures are defined. This ensures that infrastructure remains safe in the long term and fully compliant with modern standards, while continuously strengthening capacities and raising public awareness of climate challenges.

Keywords: climate change, mitigation, adaptation, climate proofing

Klimatsko potvrđivanje

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Sažetak
Zakonom o klimatskim promjenama i zaštiti ozonskog sloja (NN 67/2025) uvedena je obaveza provedbe klimatskog potvrđivanja. To je proces uključivanja mjera ublažavanja klimatskih promjena i prilagodbe klimatskim promjenama u planiranje i razvoj infrastrukturnih projekta čime investitori dokazuju otpornost i održivost projekta za ostvarivanje prava na financiranje iz EU fondova. Provodi se prema Tehničkim smjernicama za pripremu infrastrukture za klimatske promjene u razdoblju 2021.–2027. (2021/C 373/01). Ima za cilj osigurati dugoročnu održivost i funkcionalnost infrastruktura usred promjenjive klime, čime se štite ulaganja i zajednice od budućih klimatskih izazova. Proces se sastoji od dva ključna stupa s dvije faze procjene: pregleda i detaljne analize. Ublažavanje klimatskih promjena (prvi stup) uključuje dekarbonizaciju, energetsku učinkovitost, uštedu energije i korištenje obnovljivih oblika energije. To uključuje poduzimanje mjera za smanjenje emisija stakleničkih plinova ili povećanje sekvestracije stakleničkih plinova te se vodi politikom EU o ciljevima smanjenja emisija za 2030. i 2050. godinu. Kroz drugi stup - prilagodba/otpornost na klimatske promjene, identificiraju se klimatski rizici kao što su intenzivnije poplave, prolomi oblaka, suše, toplinski valovi, šumski požari, oluje te odroni tla, uragani i dr., i provjerava se otpornost infrastrukture na njih tijekom njezina životnog vijeka. Provođenjem detaljnih procjena osjetljivosti i rizika, definiraju se konkretne zaštitne mjere. Time se jamči da je infrastruktura dugoročno sigurna te potpuno usklađena s modernim standardima, uz kontinuirano jačanje kapaciteta i podizanje javne svijesti o klimatskim izazovima.

Ključne riječi: klimatske promjene, ublažavanje, prilagodba, klimatsko potvrđivanje

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COMPUTER SCIENCE IN ENVIRONMENTAL PROTECTION
RAČUNALNE ZNANOSTI U ZAŠTITI OKOLOŠA

AI-Based Microzonation of nitrate vulnerability in an alluvial Aaquifer: The DIMRAN approach (Croatia)

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Abstract

Long-term nitrate contamination remains one of the most pressing groundwater quality challenges in shallow alluvial aquifers influenced by intensive agriculture. The Varaždin aquifer (NW Croatia), a strategic drinking water resource, has recorded persistent nitrate exceedances, resulting in the closure of one of three major wellfields. Although extensive monitoring datasets exist, spatially integrated and predictive vulnerability assessments remain limited. The DIMRAN project (Digital Intelligence for Microzonation of Nitrate Vulnerability) aims to develop a robust methodology for high-resolution microzonation by integrating hydrogeological knowledge with artificial intelligence (AI). The approach combines long-term datasets of nitrate concentrations in groundwater, surface water and springs with precipitation records and geological parameters. Machine learning (ML) and deep learning (DL) algorithms (e.g., Random Forest, XGBoost, LSTM) are applied to capture nonlinear relationships between climatic drivers, recharge dynamics, and nitrate transport. Unlike conventional index-based methods, the framework enables dynamic, data-driven delineation of vulnerability microzones reflecting intrinsic aquifer characteristics and temporal variability linked to extreme events. The outcome is a transferable digital tool supporting mitigation planning, adaptive groundwater management, and early warning of nitrate contamination under climate change conditions.

Keywords: nitrate, groundwater vulnerability, machine learning, alluvial aquifer, microzonation

Acknowledgement: The research is funded by the EU – NextGenerationEU, through the project "Development of a Methodology for Microzonation of Nitrate Vulnerability Using Artificial Intelligence and Multiple Data Sources (DIMRAN)", NPOO GFV-IP-006/2025.

Primjena UI u mikrozoniranju ranjivosti na nitrate u aluvijalnom vodonosniku: DIMRAN pristup (Hrvatska)

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Sažetak

Dugotrajno onečišćenje nitratima ostaje jedan od najozbiljnijih izazova kakvoće podzemnih voda u plitkim aluvijalnim vodonosnicima pod utjecajem intenzivne poljoprivrede. Varaždinski vodonosnik (sjeverozapadna Hrvatska), kao strateški resurs za opskrbu pitkom vodom, bilježi trajna prekoračenja koncentracija nitrata, što je dovelo do zatvaranja jednog od tri glavna vodocrpilišta. Iako postoje opsežni skupovi podataka monitoringa, prostorno integrirane i prediktivne procjene ranjivosti i dalje su ograničene. Projekt DIMRAN (Digitalna inteligencija za mikrozoniranje ranjivosti na nitrate) ima za cilj razvoj robusne metodologije za visokorezolucijsko mikrozoniranje integriranjem hidrogeoloških spoznaja i umjetne inteligencije (UI). Pristup objedinjuje dugogodišnje nizove podataka o koncentracijama nitrata u podzemnim, površinskim i izvorskim vodama s podacima o oborinama i geološkim parametrima. Algoritmi strojnog (ML) i dubokog učenja (DL) (npr. Random Forest, XGBoost, LSTM) primjenjuju se za opis nelinearnih odnosa između klimatskih čimbenika, dinamike prihranjivanja i pronosa nitrata. Za razliku od konvencionalnih indeksnih metoda, predloženi okvir omogućuje dinamičko, podatkovno vođeno razgraničenje mikrozona ranjivosti koje odražavaju intrinzična svojstva vodonosnika i vremensku varijabilnost povezanu s ekstremnim događajima. Rezultat je prenosiv digitalni alat za planiranje mjera ublažavanja, prilagodljivo upravljanje podzemnim vodama i rano upozoravanje na onečišćenje nitratima u uvjetima klimatskih promjena.

Ključne riječi: nitrati, ranjivost podzemnih voda, strojno učenje, aluvijalni vodonosnik, mikrozoniranje

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CULTURE, ART AND SUSTAINABILITY
UMJETNOST, KULTURA I ODRŽIVOST

Industrial Heritage and Urban Identity: The Case of Pécs Mining Sites

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Abstract
The identity of Pécs is closely linked to mining, which shaped the region's economic and social development for nearly two centuries. Following the cessation of mining, a large number of former industrial areas lost their function, while the collective memory associated with them gradually faded. This research investigates how these sites can be reinterpreted through contemporary architectural tools in order to function as both spaces of memory and community. It focuses on the relationship between the preservation of physical heritage and the ongoing formation of urban identity. As part of the study, an architectural design experiment is developed, presenting possible approaches to the adaptive reuse of industrial heritage. The concept is illustrated through my research project, which addresses the redevelopment of the István III mine site. The proposal redefines the area by transforming the former mining tower into a mining pantheon, commemorating workers, educators, and victims of the industry. Rather than proposing fixed solutions, the study outlines a conceptual framework in which abandoned industrial sites can become active elements of urban memory, contributing to the reinterpretation of local communities and identities.

Keywords: architecture, industrial heritage, collective memory, mining, revitalisation

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ECOLOGICAL AGRICULTURE AND FOOD PRODUCTION
EKOLOŠKA POLJOPRIVREDA I PROIZVODNJA HRANE

Multianalytical characterisation of Cabernet Sauvignon wines from organic and conventional production

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Abstract
Conventional and organic wine production differ primarily in their approach to grapevine cultivation and technological interventions during vinification. Conventional production allows broader use of mineral fertilisers, pesticides, and oenological agents to achieve product stability and consistency. In contrast, organic production relies on limited use of synthetic agents, greater dependence on natural processes, and environmental protection, which can result in greater variability in the composition and sensory properties of wine. In this study, two Cabernet Sauvignon wines produced in Osijek-Baranja County, Croatia, within the same climate but under different cultivation systems – conventional and organic vineyards – were analysed. To determine the aroma profile, a gas chromatograph with a mass detector (GC/MS) was used. Individual phenolic compounds were determined using high-performance liquid chromatography (HPLC), while the total phenolic content and antioxidant activity were measured using spectrophotometric methods. The results showed that the same aroma and phenolic compounds were detected in both wines, but at different concentrations. Fruity aroma was the most abundant in both wines, but was more pronounced in the organic wine, accounting for 70.5% of the total aroma. Compounds contributing to the floral aroma were more prominent in the conventional than in the organic wine. Total phenolic content and antioxidant activity were similar, but conventional wine contained more anthocyanins, and organic wine contained more flavonoids.

Keywords: conventional, organic, Cabernet Sauvignon, aroma profile, phenolic composition

Apple and citrus fibers as carriers for polyphenols of chokeberry juice

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Abstract
During the production of fruit juices, a considerable amount of by-product remains; this is also the case with apples and citrus fruits. Fibers are often isolated from these by-products and can be further used in the formulation of bioactive food additives (BFA). The aim of this study was to use apple fibers and citrus fibers as carriers for the encapsulation of polyphenols from chokeberry juice. Fiber microparticles were obtained by complexation of 10% of fibers with chokeberry juice. After complexation, stable powders were obtained by freeze-drying and evaluated for total polyphenols, proanthocyanidins, individual polyphenols concentrations, and antioxidant activity. Results showed that both fibers contained a small portion of bioactive compounds from the initial source; that is, citrus fibers contained hesperidin and naringin, while apple fibers contained phloretin, chlorogenic acid, quercetin-3-rutinoside, quercetin-3-galactoside, and quercetin-3-glucoside. Generally, citrus fibers microparticles had higher concentrations of anthocyanins, chlorogenic and neochlorogenic acids, quercetin-3-rutinoside, and quercetin-3-vicianoside, while apple fibers microparticles contained higher concentrations of quercetin-3-galactoside and quercetin-3-glucoside. Citrus fibers also had higher total polyphenols and proanthocyanidins contents, as well as antioxidant activity by ABTS, DPPH, and FRAP methods. Screening of IR spectra of fibers and corresponding microparticles revealed changes in fibers structures due to the adsorption of polyphenols.

Keywords: apple fibers, citrus fibers, polyphenols of chokeberry juice

Acknowledgement: This research was conducted as part of the IP-2025-02-3588 project financed by the Croatian Science Foundation.

Chokeberry pomace: a source of polyphenols for the preparation of bioactive food ingredients based on pumpkin and pea protein matrices

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Abstract

Chokeberry pomace is a valuable by-product in the fruit industry, as it contains high amounts of bioactive compounds. Therefore, it can be used for their extraction and subsequent application in the formulation of bioactive food additives (BFI). Nowadays, due to global climate change, the importance of sustainability is increasingly recognised. Consequently, we utilised chokeberry pomace extracts (CPE) for complexation with two types of protein matrices, pumpkin (50% of proteins) and pea (85% of proteins) as encapsulation carriers for the preparation of BFI. The resulting BFI were compared by calculating adsorption capacities, i.e. the affinity of the selected protein matrices for adsorption of polyphenols from CPE. Adsorption capacities (AC) were determined for total polyphenols, proanthocyanidins, and anthocyanins. Generally, the pea protein matrix had a higher affinity towards CPE polyphenols. The ACs for the pea protein matrix were 41.3%, 59.2%, and 73.6%, while the values for the pumpkin protein matrix were lower, 39.1%, 54.6%, and 70.1%, respectively. The difference in ACs between the protein carriers is not only the result of different protein composition and structure, but also due to the protein content in the matrices. IR screening was also conducted to assess changes in protein structure resulting from the adsorption of CPE polyphenols. This type of preparation presents a green tool for the formulation of BFI, with significant application potential, as these BFI can be used as additives in various foods to enrich them with valuable compounds (both proteins and polyphenols), improve nutritional value, increase stability, and modify the colour of products.

Keywords: chokeberry pomace, pumpkin proteins, pea proteins, bioactive food ingredients

Acknowledgement: This research was conducted as part of the project „From food industry by-products to new functional products (NUS-PRO-FUN, 581-UNIOS-94)" funded by the National Recovery and Resilience Plan (funded by the European Union, NextGenerationEU).

Effect of the aqueous extract of mastic tree (*Pistacia lentiscus* L.) on the germination and early growth of beggarticks (*Bidens subalternans* DC.)

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Abstract

Weeds represent a significant challenge in agriculture as they can affect crop yield and competitive relationships within agroecosystems, particularly in the case of invasive species, which encourages the development of environmentally friendly control management. Among such approaches, allelopathy stands out as it is based on the action of natural plant compounds, i.e., allelochemicals, capable of inhibiting seed germination as well as plant growth and development of other plants. The aim of this study was to investigate the allelopathic effect of an aqueous extract of mastic tree (*Pistacia lentiscus* L.) on germination and early growth stages of the invasive species beggar-ticks (*Bidens subalternans* D.C.). The research was conducted in two phases under outdoor conditions—germination and early growth. In the germination phase, the degree of inhibition increased with increasing extract concentration, while the 30% concentration completely prevented seed germination. In the second phase, a negative effect on the development of young plants was observed; at lower concentrations, the effect was weaker, whereas at the 30% concentration, wilting and subsequent decay of some young plants occurred. The obtained results confirm the significant allelopathic potential of the mastic tree and indicate the possibility of its application in weed control within organic production. However, before practical application, further research is required on larger areas and under different climatic conditions, including assessment of selectivity toward other species and analysis of long-term impacts on the environment and biodiversity.

Keywords: invasive species, beggar-ticks, mastic tree, allelopathy, biodiversity

Utjecaj vodenog ekstrakta tršlje (*Pistacia lentiscus* L.) na klijanje i rani rast blago izmjeničnog dvozuba (*Bides subalternans* D.C.)

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Sažetak

Korovi predstavljaju značajan izazov u poljoprivredi jer mogu utjecati na prinos i kompeticijske odnose u agroekosustavima, osobito kada je riječ o invazivnim vrstama, što potiče razvoj okolišno prihvatljivih metoda njihova suzbijanja. Među takvim pristupima ističe se alelopatija koja se temelji na djelovanju prirodnih biljnih spojeva, odnosno alelokemikalija, sposobnih inhibirati klijanje te rast i razvoj drugih biljaka. Cilj ovog istraživanja bio je istražiti alelopatski učinak vodenog ekstrakta tršlje (*Pistacia lentiscus L.*) na klijanje te početne faze rasta invazivne vrste blago izmjenični dvozub (*Bidens subalternans D.C.*). Istraživanje je provedeno u dvije faze u vanjskim uvjetima – klijanje i početni rast. U istraživanju utjecaja na klijanje stupanj inhibicije klijanja povećavao se s povećanjem s koncentracije ekstrakta, dok je koncentracija od 30 % u potpunosti spriječila klijanje sjemena. U drugoj fazi utvrđen je negativan utjecaj na razvoj mladih biljaka, koji je pri nižim koncentracijama bio slabiji, dok je pri koncentraciji od 30 % došlo do venuća , a zatim propadanja dijela mladih biljaka. Dobiveni rezultati potvrđuju značajan alelopatski potencijal tršlje i ukazuju na mogućnost njezine primjene kod suzbijanja korova u ekološkoj proizvodnji, no prije praktične primjene nužna su dodatna istraživanja na većim površinama i u različitim klimatskim uvjetima, procjena selektivnosti prema drugim vrstama te analiza dugoročnog utjecaja na okoliš i bioraznolikost.

Ključne riječi: invazivne vrste, blago izmjenični dvozub, tršlja, alelopatija, bioraznolikost

The effects of climate change on fruit production

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Abstract
Recently, climate change has increasingly impacted fruit crop cultivation through more frequent heat and drought, causing stress and complicating production. Research conducted at the experimental sites of the Croatian Agency for Agriculture and Food confirms a significant impact of climate on growth, yield, and physiological characteristics of fruit and olives. Rising temperatures lead to earlier flowering and fruit ripening, reduced fruit quality, and the emergence of new diseases and pests. Studies on apple varieties have shown that traditional varieties exhibit greater tolerance to sunburn and have better nutritional value, including higher contents of total phenols and hydroxycinnamic acids, compared to commercial varieties and scab-resistant varieties. High daily temperatures reduce photosynthetic activity and sugar synthesis in fruits, resulting in smaller size, poorer coloration, and lower market value. In combination with water deficiency, high temperatures also negatively affect plum fruit quality, as reflected in reduced firmness and darkening of the fruit flesh. Measurements of photosynthetic activity using the SPAD-502 device in olive varieties have shown that local, autochthonous varieties exhibit higher relative chlorophyll content (SPAD values) under water deficit conditions and greater resistance to drought stress compared to introduced, less vigorous varieties.

Keywords: climate change, fruit crops, heat stress, drought stress, photosynthetic activity

Utjecaj klimatskih promjena na uzgoj voća

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Sažetak

Posljednjih godina klimatske promjene sve snažnije utječu na uzgoj voćnih kultura, osobito kroz učestalije visoke temperature i sušna razdoblja. Takvi uvjeti uzrokuju toplinski i sušni stres, otežavaju proizvodnju i zahtijevaju dodatne agrotehničke mjere. Istraživanja provedena na pokušalištima Hrvatske agencije za poljoprivredu i hranu potvrđuju značajan utjecaj klime na rast, prinos i fiziološke karakteristike voća i maslina. Porast prosječnih dnevnih temperatura dovodi do ranije cvatnje i dozrijevanja plodova, smanjenje kvalitete plodova te pojavi novih bolesti i štetnika. Istraživanjima na sortama jabuka utvrđeno je da tradicionalne sorte pokazuju veću toleranciju na sunčane ožegotine te imaju bolje nutritivne vrijednosti, uključujući veći sadržaj ukupnih fenola i hidroksicimetnih kiselina, u odnosu na komercijalne sorte i sorte otporne na fuzikladij. Visoke dnevne temperature smanjuju fotosintetsku aktivnost i sintezu šećera u plodovima, što se očituje smanjenjem dimenzija ploda, slabijim obojenjem te nižom tržišnom vrijednošću plodova. U kombinaciji s nedostatkom vode, visoke temperature negativno utječu i na kvalitetu plodova šljive, što se očituje smanjenom tvrdoćom ploda i potamnjenjem mesa unutar ploda. Mjerenjem fotosintetske aktivnosti uređajem SPAD-502 kod sorti maslina utvrđeno je da domaće, autohtone sorte pokazuju veći relativni sadržaj klorofila (SPAD vrijednost) u uvjetima nedostatka vode i otpornost na sušni stres u odnosu na introducirane sorte slabije bujnosti.

Ključne riječi: klimatske promjene, voćne kulture, toplinski stres, sušni stres, fotosintetska aktivnost

ECOLOGY AND SOCIETY
EKOLOGIJA I DRUŠTVO

Encouraging employee engagement in sustainability: Practices and strategic directions in APIS IT

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Abstract
Sustainable development represents one of the key challenges and strategic priorities of contemporary organizations. In this context, encouraging employees to adopt sustainable practices becomes an important factor in achieving successful and responsible business operations. This paper focuses on presenting practical experiences and activities implemented by APIS IT in promoting sustainable employee behavior, as well as outlining planned initiatives defined within the strategic framework for the upcoming period. The paper provides an overview of measures implemented to date, including employee education, the development of a sustainability-oriented organizational culture, and the implementation of internal projects aimed at increasing employee engagement. Attention is given to the role of management and the integration of sustainability principles into business processes and everyday work practices. Furthermore, the paper examines planned activities aimed at further raising employee awareness and systematically strengthening their involvement in sustainability initiatives. In conclusion, the paper highlights the importance of a continuous and strategically aligned approach to the development of sustainable practices, emphasizing that organizational culture and active employee participation play a crucial role in achieving long-term business sustainability.

Keywords: sustainability, employees, organizational culture, strategy, APIS IT

Poticanje uključenosti zaposlenika u održivost: prakse i strateški smjerovi u APIS IT

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Sažetak

U suvremenom poslovnom okruženju održivost postaje ključan element dugoročne konkurentnosti organizacija. Ovaj rad bavi se poticanjem zaposlenika na usvajanje održivih praksi unutar radnog okruženja, s posebnim naglaskom na iskustva tvrtke APIS IT. Cilj rada je prikazati dosadašnje aktivnosti i inicijative usmjerene na razvoj održivog ponašanja zaposlenika, kao i planirane korake definirane strateškim smjernicama za nadolazeće razdoblje. Rad analizira konkretne mjere koje su implementirane, uključujući edukacijske programe, razvoj organizacijske kulture usmjerene na održivost te interne projekte koji potiču aktivno sudjelovanje zaposlenika. Poseban naglasak stavlja se na ulogu vodstva i važnost integracije održivosti u svakodnevne poslovne procese. Nadalje, prikazuju se planirane aktivnosti koje imaju za cilj dodatno unaprijediti svijest zaposlenika i njihovu uključenost u održive prakse. Zaključno, rad ističe da kontinuirani razvoj i strateško planiranje aktivnosti u području održivosti doprinose jačanju organizacijske kulture i dugoročno održivom poslovanju.

Ključne riječi: održivost, zaposlenici, organizacijska kultura, strategija, APIS IT

ENVIRONMENT AND SECURITY RISKS
OKOLIŠ I SIGURNOSNI RIZICI

Climate change and water supply systems: Strengthening critical Infrastructure and societal resilience

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Abstract
Global environmental and systemic stressors are increasingly undermining the resilience of critical infrastructure systems, with water supply networks being particularly exposed. Extreme weather events, prolonged droughts, floods, and the growing interdependence of infrastructure systems directly affect the reliability, safety, and continuity of water provision, with cascading impacts on other essential sectors such as energy, healthcare, and urban functionality. Under these conditions, strengthening the resilience and operational readiness of critical infrastructure has become a key security and societal priority. Civil-military cooperation makes a significant contribution to enhancing the resilience and security of critical infrastructure, while coordinated action between civilian authorities, infrastructure operators, and military structures improves preparedness, the effectiveness of rapid response, and recovery capacity in complex emergencies affecting essential services. Key components of this approach include integrated risk assessment, early warning systems, redundancy in water supply systems, and business continuity planning. Coordinated crisis management, logistical support, and operational interoperability between civilian and military actors further strengthen resilience in situations of partial or complete infrastructure disruption. Strengthening intersectoral coordination between water utilities, civil protection systems, environmental institutions, and defence structures is essential, as it enables faster information exchange, more effective decision-making, and aligned operational response under crisis conditions. Effective resilience is based on well-developed cooperation mechanisms, shared operational frameworks, and continuously strengthened interoperability among all relevant stakeholders, with civil-military cooperation representing an important component of an integrated approach to the protection and stability of critical infrastructure systems.

Keywords: resilience, critical infrastructure, infrastructure security, water supply systems

Klimatske promjene i vodoopskrbni sustavi: jačanje kritične infrastrukture i društvene otpornosti

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Sažetak

Sigurna i pouzdana vodoopskrba predstavlja temeljni element sustava kritične infrastrukture te ključni preduvjet stabilnog funkcioniranja suvremenog društva. U okviru upravljanja krizama, posebno mjesto zauzima zdravstveno-ispravna voda za ljudsku potrošnju i sigurni, na krizne situacije otporni, vodoopskrbnih sustavi, s obzirom na njihov status kritične infrastrukture čiji prekid može imati neposredne i kaskadne posljedice na javno zdravlje, gospodarske aktivnosti i društvenu stabilnost. U uvjetima sve učestalijih i intenzivnijih prirodnih opasnosti, poput poplava, suša i toplinskih valova, kao i novih prijetnji uključujući tehničke kvarove i kibernetičke napade, otpornost vodoopskrbnih sustava postaje strateški prioritet. Među ključnim ranjivostima vodoopskrbne infrastrukture ističu se zastarjela oprema, visoka međuzavisnost s energetskim i informacijskim sustavima te operativni rizici tijekom kriznih situacija. U ovom radu prikazane su mogućnosti jačanja otpornosti vodoopskrbnih sustava kroz integrirano planiranje kriznog upravljanja, procjene rizika i uvođenja redundantnih rješenja radi osiguravanja kontinuiteta opskrbe. Za otpornost sustava ključna je i uloga upravljanja, institucionalne koordinacije te učinkovite komunikacije s javnošću, koja doprinosi održavanju povjerenja i učinkovitom odgovoru tijekom poremećaja. Jačanje otpornosti vodoopskrbnih sustava predstavlja ne samo tehnički izazov, već i društvenu nužnost u suvremenom sustavu upravljanja krizama.

Ključne riječi: otpornost, kritična infrastruktura, sigurnost infrastrukture, vodoopskrba

Blue-Green Infrastructure as a tool for urban groundwater resilience: Insights from the Varaždin aquifer (Croatia)

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Abstract
Urbanization and climate change are altering recharge patterns and groundwater quality in many European alluvial aquifers. The Varaždin aquifer (NW Croatia), a key drinking water resource hydraulically connected to the Drava River and hydropower reservoirs, represents a highly vulnerable system exposed to agricultural pressures and urban stormwater impacts. Recent analyses within the Interreg Project "MAURICE" integrated groundwater flow modelling, particle tracking, nitrate monitoring, and precipitation trend analysis to assess aquifer sensitivity. Results show that recharge areas delineated by backward MODPATH simulations overlap with intensive agricultural zones, explaining nitrate concentrations locally exceeding 50 mg/L. At the same time, increasing precipitation intensity leads to higher peak runoff, sewer overload, and reduced effective infiltration in urban areas. This study evaluates blue-green infrastructure (BGI) measures – green roofs, permeable pavements, rain gardens, and rooftop rainwater harvesting – as tools to restore recharge dynamics and reduce hydraulic stress on drainage systems. Scenario analyses indicate that partial in-situ infiltration and temporary storage of runoff can reduce peak discharge, enhance distributed recharge, and support contaminant dilution. The Varaždin case demonstrates how integrating urban hydrogeology and environmental engineering supports groundwater resilience under climate change.

Keywords: urban hydrogeology, blue-green infrastructure, groundwater resilience, nitrate, sponge city

Acknowledgement: This work was carried out within the Interreg Central Europe project CE0100184 „Management of urban water resources in Central Europe facing climate change MAURICE".

Plavo-zelena infrastruktura kao alat za otpornost podzemnih voda u urbanim područjima: primjer varaždinskog vodonosnika (Hrvatska)

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Sažetak
Urbanizacija i klimatske promjene mijenjaju obrasce prihranjivanja i kakvoću podzemnih voda u mnogim europskim aluvijalnim vodonosnicima. Varaždinski vodonosnik, ključni resurs za opskrbu pitkom vodom hidraulički povezan s rijekom Dravom i akumulacijama hidroelektrana, predstavlja vrlo ranjiv sustav izložen poljoprivrednim pritiscima i utjecajima urbanog upravljanja oborinskim vodama. Nedavne analize u okviru Interreg projekta "MAURICE" integrirale su modeliranje toka podzemnih voda, praćenje čestica, monitoring nitrata i analizu trendova oborina s ciljem procjene osjetljivosti vodonosnika. Rezultati pokazuju da se zone prihranjivanja određene metodom povratnog praćenja (MODPATH) preklapaju s intenzivnim poljoprivrednim područjima, što objašnjava lokalno zabilježene koncentracije nitrata veće od 50 mg/L. Istodobno, porast intenziteta oborina dovodi do većih vršnih otjecanja, preopterećenja kanalizacijskog sustava i smanjenja učinkovite infiltracije u urbanim područjima. U radu se procjenjuje potencijal mjera plavo-zelene infrastrukture (BGI) – zeleni krovovi, propusne površine, kišni vrtovi i prikupljanje oborinske vode s krovova – kao alata za obnovu prirodnijih procesa prihranjivanja i smanjenje hidrauličkog opterećenja sustava odvodnje. Analize scenarija pokazuju da djelomična infiltracija na mjestu nastanka i privremeno zadržavanje otjecanja mogu smanjiti vršne protoke, povećati raspodijeljeno prihranjivanje te doprinijeti razrjeđivanju onečišćivala. Primjer Varaždina pokazuje kako integracija urbane hidrogeologije i inženjerstva okoliša doprinosi otpornosti podzemnih voda u uvjetima klimatskih promjena.

Ključne riječi: urbana hidrogeologija, plavo-zelena infrastruktura, otpornost podzemnih voda, nitrati, „sponge city"

Zahvala: Ovaj rad je izrađen u sklopu Interreg Central Europe projekta CE0100184 „Management of Urban Water Resources in Central Europe Facing Climate Change – MAURICE".

Electromagnetic Wave Propagation in Plant-Based Materials

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Abstract
This study presents a comprehensive electromagnetic analysis of plant materials in the frequency range from 0.1 to 10 GHz. The dielectric properties of representative plant groups, including agricultural crops, leaves, fruits, and woody tissues, were modeled based on literature data and calibrated using available experimental measurements at discrete frequencies. The frequency-dependent complex permittivity was used to derive key electromagnetic parameters, including attenuation coefficient, reflection coefficient (S11), transmission coefficient (S21), and absorption. A homogeneous slab model under normal incidence was applied to evaluate wave propagation through plant materials with thicknesses of 50 mm and 250 mm. Additionally, the influence of porosity was investigated using the Maxwell–Garnett effective medium model, considering air inclusions of 10% and 30%. The results demonstrate that plant materials with higher water content exhibit significantly higher dielectric losses and absorption, particularly at higher frequencies. The attenuation coefficient increases with frequency, leading to reduced transmission and enhanced absorption. Porosity reduces the effective permittivity and consequently decreases electromagnetic losses. The proposed semi-empirical modeling approach provides a physically consistent framework for estimating electromagnetic behavior of plant materials over a broad frequency range, even in the absence of continuous experimental data.

Keywords: electromagnetic properties, plant materials, dielectric permittivity, S parameters, attenuation, microwave frequencies

ENVIRONMENTAL ENGINEERING
INŽENJERSTVO OKOLIŠA

Ecological and geochemical research of landfills (EkoGeoKem)

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Abstract
Landfills are a significant source of pollutant emissions that adversely affect all environmental compartments, with heavy metals being of particular concern due to their persistence, bioaccumulation, and toxicity. In Croatia, systematic data on landfill emissions are lacking, and ecological studies of landfills are rare. The institutional project EkoGeoKem (2025–2029) aims to investigate the concentrations and spatial distribution of heavy metals at eight landfills in northern Croatia, link geochemical data with floristic composition and vegetation cover to assess metal transfer to plant species, evaluate phytoremediation potential, and propose guidelines for ecological remediation and restoration. The research will employ an interdisciplinary approach, including field sampling (soil, water, plants, and sediment), flora and vegetation inventory, laboratory analyses, and statistical data processing. The project will result in scientific publications and one doctoral dissertation. The results will be integrated into higher education curricula, while the professional component includes the development of a digital manual for ecological landfill restoration. The project represents a rare combination of geochemical and ecological landfill assessment and will strengthen research capacity while supporting integrated environmental protection and sustainable management of degraded areas where such solutions are lacking.

Keywords: heavy metals, landfills, phytoremediation, spatial distribution, ecological restoration

Acknowledgement: The project is funded by the European Union (NextGenerationEU).

Ekološka i geokemijska istraživanja odlagališta otpada (EkoGeoKem)

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Sažetak
Odlagališta otpada predstavljaju značajan izvor emisija različitih onečišćivala koja nepovoljno utječu na sve sastavnice okoliša, pri čemu posebnu zabrinutost izazivaju teški metali zbog svoje postojanosti, bioakumulacije i toksičnosti. U Republici Hrvatskoj nedostaju sustavni podaci o njihovim emisijama s odlagališta, a ekološka istraživanja odlagališta su vrlo rijetka. Institucionalni projekt EkoGeoKem (2025. – 2029.) ima za cilj istražiti koncentracije i prostornu distribuciju teških metala na osam odlagališta u sjevernoj Hrvatskoj, povezati geokemijske podatke s floističkim sastavom i vegetacijskim pokrovom radi procjene prijenosa metala na biljni svijet, ispitati potencijal fitoremedijacije te predložiti smjernice za ekološku sanaciju i obnovu. Istraživanje se temelji na interdisciplinarnom pristupu koji uključuje terensko uzorkovanje (tla, vode, biljaka i sedimenta), inventarizaciju flore i vegetacije, laboratorijske analize te statističku obradu podataka. Projekt će rezultirati znanstvenim publikacijama i izradom jedne doktorske disertacije, dok će s obrazovnog aspekta rezultati biti integrirani u visokoškolski kurikulum. Stručna komponenta projekta bit će zaokružena izradom digitalnog priručnika o ekološkoj obnovi odlagališta otpada. Projekt predstavlja rijetku kombinaciju geokemijske i ekološke evaluacije odlagališta te će ojačati istraživačke kapacitete i dati doprinos razvoju integriranog pristupa zaštiti okoliša i održivom upravljanju degradiranim prostorima gdje takva rješenja nedostaju.

Ključne riječi: teški metali, odlagališta otpada, fitoremedijacija, prostorna distribucija, ekološka obnova

Acknowledgement: Projekt je financiran sredstvima Europske unije (NextGenerationEU).

SWOT analysis of the potential of solid mineral resources in Varaždin County, Croatia

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Abstract
This research aimed to conduct a SWOT analysis of the potential of solid mineral raw materials in Varaždin County, with a focus on reserves, demand, and future challenges, to ensure sustainable and responsible exploitation and to improve strategic planning in a regional context by analyzing the current situation and identifying strengths, weaknesses, opportunities, and threats. Data collected from exploitation reports, construction activity statistics (number of building permits, areas of new construction sites, value of works), and financial indicators (fees) show that construction sand and gravel, as well as dimension stone, have significant exploitable reserves, with an estimated lifetime of 62 years for construction sand and gravel and increasing reserves of dimension stone, alongside stable or increasing annual extraction levels. Brick clay maintains stable production, while industrial carbonate mineral raw materials show a decline in exploitation and sensitivity to interruptions in processing. The current needs of the County are largely met by local production, with no need for imports, and the fiscal contribution from exploitation is continuously increasing. The SWOT matrix identifies key strengths (reserves, location), weaknesses (statistics, processing), opportunities (construction cycle, regulations), and threats (cyclicality, environmental issues). Opportunities include the continuation of the construction cycle, improved statistical monitoring, and increased value added through processing, while threats arise from macroeconomic shocks, regulatory requirements, and climate change. The results of the research show that Varaždin County relies on a strong resource base and logistical advantages; however, the decline in industrial processing of carbonate raw materials requires sustainable spatial management, improved statistical monitoring, stronger regulations, and circular resource management models to ensure long-term resource security and the preservation of space for future generations.

Keywords: Varaždin County, solid mineral raw materials, SWOT analysis, sustainable resource management, mineral resource exploitation

SWOT analiza potencijala čvrstih mineralnih sirovina Varaždinske županije

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Sažetak

Cilj ovog istraživanja bio je provesti SWOT analizu potencijala čvrstih mineralnih sirovina Varaždinske županije, s naglaskom na rezerve, potražnju i buduće izazove, kako bi se osigurala održiva i odgovorna eksploatacija te unaprijedilo strateško planiranje u regionalnom kontekstu, analizirajući trenutačno stanje te identificirajući snage, slabosti, prilike i prijetnje. Podaci prikupljeni iz eksploatacijskih izvješća, statistika građevinske aktivnosti (broj dozvola, površine novih gradilišta, vrijednost radova) i financijskih pokazatelja (naknade) pokazuju da građevni pijesak i šljunak, te tehničko-građevni kamen imaju značajne eksploatacijske rezerve, s procijenjenim trajanjem od 62 godine za građevni pijesak i šljunak i rastućim rezervama tehničko-građevnog kamena, uz stabilnu ili rastuću godišnju eksploataciju. Ciglarska glina održava stabilnu proizvodnju, dok industrijske karbonatne mineralne sirovine pokazuju smanjenje eksploatacije i osjetljivost na zastoje u preradi. Trenutačne potrebe Županije uglavnom su pokrivene lokalnom proizvodnjom, bez potrebe za uvozom, a fiskalni doprinos eksploatacije kontinuirano raste. SWOT matrica otkriva ključne snage (rezerve, lokacija), slabosti (statistike, prerada), prilike (građevinski ciklus, regulative) i prijetnje (cikličnost, ekologija). Prilike uključuju nastavak građevinskog ciklusa, poboljšanje statističkog praćenja i povećanje dodane vrijednosti preradom, dok prijetnje proizlaze iz makroekonomskih šokova, regulatornih zahtjeva i klimatskih promjena. Rezultati istraživanja pokazuju da se Varaždinska županija oslanja na snažnu resursnu osnovu i logističke prednosti, no smanjenje industrijske prerade karbonatnih sirovina zahtijeva održivo upravljanje prostorom uz statističko praćenje i jače regulative te kružne modele gospodarenja za dugoročnu sigurnost resursa i očuvanje prostora za buduće generacije.

Ključne riječi: Varaždinska županija, čvrste mineralne sirovine, SWOT analiza, održivo upravljanje resursima, eksploatacija mineralnih sirovina

ENVIRONMENTAL IMPACT ASSESSMENT
PROCJENE UTJECAJA NA OKOLIŠ

Genotoxic potential of ibuprofen tested on *Allium cepa* L.

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Abstract

Non-steroidal anti-inflammatory drug ibuprofen (IBU), due to its high use, is frequently detected in aquatic ecosystems. The aim of this study was to test the genotoxicity of IBU using the *Allium* test, a well-established bioassay widely applied in environmental monitoring. Onions' roots were exposed to IBU (concentration range: 1-100 mg/L; n=10 bulbs *per* concentration) or to distilled water (control) for 72 h in a control environment (dark, 20 °C, 75 % humidity). Following exposure, the roots' length and fresh weight, as well as frequency of chromosomal aberrations (CAs) in meristem cells of root tips, were evaluated. The frequency of CAs was estimated on approximately 100 divisions *per* slide. For statistical analysis, one-way ANOVA followed by Dunnett's test ($p<0.05$) was used. IBU at higher concentrations (50 and 100 mg/L) decreased the roots' length and fresh weight. Even at the lowest applied concentration (1 mg/L), IBU increased the frequency of CAs. Among CAs, the most frequent were C-mitosis, anaphase bridges and sticky chromosomes, indicating aneugenic (affecting mitotic spindle) as well as clastogenic (affecting DNA) effects of IBU in eukaryotic cells. Although CAs were recorded following exposure to IBU at a concentration 1 mg/L, due to its accumulation in the environment, the presence of IBU in the environment should be taken with precaution.

Keywords: pharmaceuticals, *Allium* test, genotoxicity, aneugenic, clastogenic

Acknowledgement: Financial support: NextGenerationEU; project PlantPharmaTox

Monitoring of anionic and nonionic surfactant Concentrations in chemical industry wastewater for environmental protection purposes

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Abstract

Surfactants are surface-active substances that play a key role in the chemical industry, particularly in the production of household detergents. Due to their ability to reduce the surface tension of water, they enable the effective removal of grease and dirt; however, their release into wastewater may pose a risk to aquatic organisms and the environment. Therefore, systematic monitoring of their concentrations is important for assessing environmental impact and the efficiency of treatment systems. The aim of this study was to determine the concentrations of anionic and nonionic surfactants in wastewater from the chemical industry over a ten-day period, depending on different production cycles (powder and liquid laundry detergents, dishwashing detergents, and fabric softeners). The analyses were performed using the potentiometric titration method. The results showed that the concentrations of anionic surfactants ranged from 0.00 to 8.32 mg/L, while nonionic surfactants ranged from 0.24 to 7.37 mg/L. The highest values of anionic surfactants were recorded after the production of powder detergents, whereas nonionic surfactants predominated in samples collected after dishwashing detergent production. All measured values were below the legally permitted limit of 10 mg/L, confirming the satisfactory efficiency of the existing wastewater treatment system, while indicating the need for further improvement of wastewater treatment technologies.

Keywords: surfactants, wastewater, chemical industry, potentiometric titration, environmental protection

Praćenje koncentracija anionskih i neionskih tenzida u otpadnim vodama kemijske industrije u svrhu zaštite okoliša

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Sažetak

Tenzidi su površinski aktivne tvari koje imaju ključnu ulogu u kemijskoj industriji, osobito u proizvodnji deterdženata za kućanstvo. Zbog svoje sposobnosti smanjenja površinske napetosti vode omogućuju učinkovito uklanjanje masti i nečistoća, no njihovo dospijeće u otpadne vode može predstavljati rizik za vodene organizme i okoliš. Stoga je sustavno praćenje njihovih koncentracija važno za procjenu ekološkog opterećenja i učinkovitosti sustava pročišćavanja. Cilj rada bio je odrediti koncentracije anionskih i neionskih tenzida u otpadnim vodama kemijske industrije tijekom deset dana, ovisno o različitim proizvodnim ciklusima (praškasti i tekući deterdženti za rublje, deterdženti za pranje posuđa te omekšivači). Analize su provedene metodom potenciometrijske titracije. Rezultati su pokazali da su koncentracije anionskih tenzida iznosile od 0,00 do 8,32 mg/L, a neionskih od 0,24 do 7,37 mg/L. Najviše vrijednosti anionskih tenzida zabilježene su nakon proizvodnje praškastih deterdženata, dok su neionski tenzidi dominirali u uzorcima nakon proizvodnje deterdženata za posuđe. Sve izmjerene vrijednosti bile su ispod zakonski dopuštene granice od 10 mg/L, što potvrđuje zadovoljavajuću učinkovitost postojećeg sustava pročišćavanja, uz potrebu daljnjeg unaprjeđenja tehnologija obrade otpadnih voda.

Ključne riječi: tenzidi, otpadne vode, kemijska industrija, potenciometrijska titracija, zaštita okoliša

ENVIRONMENTAL MONITORING
MONITORING OKOLIŠA

Garments with Integrated NIR Information as a Medium for Environmental Monitoring

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Abstract
This paper presents a novel approach to environmental monitoring through the integration of hidden information into clothing products. By embedding text within a design solution applied to shirts, where the text is visible exclusively in the near-infrared (NIR) spectrum, the proposed concept enables the discreet inclusion of data relevant to environmental analysis and urban exteriors. In the visible spectrum (VIS), only the aesthetic design applied to the shirts is perceived. “Twin” dyes that are used were adapted for sublimation printing on textiles and enable the realization of graphic and textual elements that are invisible to the human eye but detectable in the NIR spectrum, making them suitable for applications in monitoring environments equipped with infrared camera systems. The duality of the dyes is analyzed using spectroscopic methods on digital forensic devices. The design solution employs visually complex motifs that create regions of varying optical absorption, allowing effective concealment of information and its reliable detection. The results demonstrate that textile surfaces can serve as unobtrusive carriers of information for environmental and urban monitoring systems. This approach opens possibilities for the integration of design, materials and sensing technologies, enabling everyday garments to contribute to distributed environmental monitoring systems without compromising their visual aesthetics.

Keywords: environmental monitoring, near-infrared spectrum (NIR), textile design, sublimation printing, twin dyes

Odjevni predmeti s integriranom NIR informacijom kao medij za monitoring okoliša

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Sažetak

Ovaj rad predstavlja novi pristup monitoringu okoliša kroz integraciju skrivenih informacija u odjevne proizvode. Ugradnjom teksta unutar dizajnerskog rješenja primijenjenog na majicama, pri čemu je tekst vidljiv isključivo u blisko-infracrvenom (NIR) dijelu spektra, predloženi koncept omogućuje diskretno uključivanje podataka relevantnih za analizu okoliša i urbanih eksterijera. U vidljivom dijelu spektra (VIS) percipira se isključivo estetski dizajn apliciran na majice. Korišteni blizanci bojila prilagođeni su sublimacijskom tisku na tekstilu te omogućuju realizaciju grafičkih i tekstualnih elemenata koji su nevidljivi ljudskom oku, ali detektabilni u NIR spektru, što ih čini pogodnima za primjene u monitoringu prostora opremljenih sustavima s infracrvenim kamerama. Dualnost boja analizirana je spektroskopskim metodama na uređajima za digitalnu forenziku. Dizajnersko rješenje koristi vizualno kompleksne motive koji stvaraju područja različite optičke apsorpcije, čime se omogućuje učinkovito skrivanje informacija i njihova pouzdana detekcija. Rezultati pokazuju da tekstilne površine mogu služiti kao nenametljivi nositelji informacija za sustave monitoringa okoliša i urbanih prostora. Ovaj pristup otvara mogućnosti integracije dizajna, materijala i senzorskih tehnologija, omogućujući da svakodnevni odjevni predmeti doprinose distribuiranim sustavima praćenja okoliša bez narušavanja njihove vizualne estetike.

Ključne riječi: monitoring okoliša, blisko-infracrvei spektar (NIR), tekstilni dizajn, sublimacijski tisak, blizanci bojila

Monitoring air quality in the extended stay classroom

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Abstract
The Parma Declaration on Environment and Health from 2010 is based on a fundamental goal – to protect children's health from health risks arising from inappropriate environmental conditions, such as inadequate air quality that children breathe. The National Development Strategy of the Republic of Croatia until 2030 states that students spend more than one-fifth of their hours in a year in schools. The Croatian academic and research network has launched the AERO project – a system for managing smart sensors that monitors the most important parameters of air quality in classrooms, such as relative humidity levels, temperature, and CO_2. The Juraj Dobrila Primary School from Rovinj has joined the project and installed sensors in the Extended Stay classroom. Measurements are carried out automatically, are visible on the sensor board, and are stored in a database. November 12, 2025, was randomly selected from the database, and measurements show that exceedances of the CO_2 level above the recommended 1000 ppm occurred between 3 PM and 5 PM. Considering that ventilation is used in the classroom as a natural method of regulating CO_2 concentration, we can conclude that it is necessary to continue monitoring with sensors, while during the disputed time interval, it is essential to enhance ventilation.

Keywords: air quality, classroom microclimate, Parma Declaration on Environment and Health

Water, Life, and eDNA: Innovative Tools for Ecosystem Assessment

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Abstract
Environmental conditions strongly influence the survival, distribution, and resilience of living organisms, particularly in sensitive freshwater ecosystems exposed to climate change, habitat degradation, invasive species, and human activities. Fishponds and wetlands represent valuable biodiversity hotspots, but their ecological balance increasingly depends on sustainable management and continuous environmental monitoring. Understanding how environmental changes affect aquatic life requires innovative scientific approaches capable of detecting even subtle ecosystem disturbances. This project highlights the importance of modern analytical methods in studying complex interactions between biodiversity, water quality, and ecosystem health. Advanced techniques such as environmental DNA (eDNA) analysis enable the detection of endangered, invasive, and cryptic species directly from water samples without disturbing habitats. In parallel, water quality monitoring using real-time sensors and standardized chemical analyses provides essential information on ecosystem conditions, including nutrient levels, dissolved oxygen, pH, and climate-related stressors. Additional tools such as satellite tracking, digital biodiversity mapping, and integrated data platforms further improve ecosystem assessment and management. By combining ecological research with innovative technologies, the project contributes to a deeper understanding of environmental impacts on life and supports the development of sustainable, climate-resilient management practices.

Keywords: biodiversity, eDNA, freshwater ecosystems, climate resilience

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Voda, život i eDNA: inovativni alati za procjenu ekosustava

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Sažetak
Okolišni uvjeti snažno utječu na preživljavanje, rasprostranjenost i otpornost živih organizama, osobito u osjetljivim slatkovodnim ekosustavima izloženima klimatskim promjenama, degradaciji staništa, invazivnim vrstama i ljudskim aktivnostima. Ribnjaci i močvarna područja predstavljaju vrijedna žarišta bioraznolikosti, no njihova ekološka ravnoteža sve više ovisi o održivom upravljanju i kontinuiranom praćenju okoliša. Razumijevanje utjecaja okolišnih promjena na vodeni svijet zahtijeva inovativne znanstvene pristupe sposobne prepoznati i suptilne poremećaje u ekosustavu. Ovaj projekt naglašava važnost suvremenih analitičkih metoda u proučavanju složenih međudjelovanja između bioraznolikosti, kvalitete vode i zdravlja ekosustava. Napredne tehnike, poput analize okolišne DNA (eDNA), omogućuju otkrivanje ugroženih, invazivnih i kriptičnih vrsta izravno iz uzoraka vode bez narušavanja staništa. Istodobno, praćenje kvalitete vode pomoću senzora u stvarnom vremenu i standardiziranih kemijskih analiza pruža ključne informacije o stanju ekosustava, uključujući razine hranjivih tvari, koncentraciju otopljenog kisika, pH vrijednost i stresore povezane s klimatskim promjenama. Dodatni alati, poput satelitskog praćenja, digitalnog kartiranja bioraznolikosti i integriranih podatkovnih platformi, dodatno unaprjeđuju procjenu i upravljanje ekosustavima. Povezivanjem ekoloških istraživanja s inovativnim tehnologijama, projekt pridonosi dubljem razumijevanju utjecaja okoliša na živi svijet te podupire razvoj održivih i klimatski otpornih praksi upravljanja.

Ključne riječi: bioraznolikost, okolišna DNA (eDNA), slatkovodni ekosustavi, klimatska otpornost

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Analysis of groundwater from the well-field Vinogradi

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Abstract
This study analysed the quality of groundwater at the Vinogradi well-field, the main source of drinking water for the City of Osijek and the surrounding settlements. Continuous monitoring of groundwater quality parameters is important for the timely detection of possible changes caused by natural processes or anthropogenic impacts. Systematic monitoring enables the preservation of water safety for human consumption, as well as the security and stability of the water supply system. During one hydrological year, physical-chemical, chemical, and microbiological parameters of water from 18 exploitation wells, which were used alternately, were monitored. The analysed parameters included pH value, temperature, electrical conductivity, concentrations of iron, manganese, nitrates, nitrites, and chlorides, as well as microbiological indicators: total colony count at 22 °C and 36 °C, *Escherichia coli*, enterococci, and *Clostridium perfringens*. The results showed that the water was generally neutral to slightly alkaline, with seasonal variations in dissolved oxygen concentration and conductivity. Elevated concentrations of iron and manganese were recorded in certain wells, while nitrate and nitrite concentrations were generally low, with occasional deviations associated with agricultural activities and seasonal influences. Microbiological analyses did not detect the presence of *Escherichia coli*, enterococci, or *Clostridium perfringens*, confirming the good microbiological quality of the groundwater. Regular water quality monitoring is essential for ensuring a safe water supply and the timely identification of potential sources of contamination.

Keywords: well-field Vinogradi, groundwater analysis, hydrological year

Analiza podzemne vode s vodocrpilišta Vinogradi

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Sažetak

U ovom radu analizirana je kvaliteta podzemne vode vodocrpilišta Vinogradi, glavnog izvora pitke vode za Grad Osijek i okolna naselja. Kontinuirano praćenje parametara kakvoće podzemne vode važno je radi pravovremenog otkrivanja mogućih promjena uzrokovanih prirodnim procesima ili antropogenim utjecajima. Sustavni monitoring omogućuje očuvanje zdravstvene ispravnosti vode za ljudsku potrošnju te sigurnost i stabilnost vodoopskrbnog sustava. Tijekom jedne hidrološke godine provedeno je praćenje fizikalno-kemijskih, kemijskih i mikrobioloških parametara vode iz 18 eksploatacijskih bunara koji su se koristili naizmjenično. Analizirani su pH vrijednost, temperatura, električna vodljivost, koncentracije željeza, mangana, nitrata, nitrita i klorida te mikrobiološki pokazatelji: ukupan broj kolonija pri 22 °C i 36 °C, *Escherichia coli*, enterokoki i *Clostridium perfringens*. Rezultati su pokazali da je voda uglavnom neutralna do blago alkalna, uz sezonske promjene koncentracije otopljenog kisika i vodljivosti. Povišene koncentracije željeza i mangana zabilježene su u pojedinim bunarima, dok su koncentracije nitrata i nitrita uglavnom bile niske, uz povremena odstupanja povezana s poljoprivrednim aktivnostima i sezonskim utjecajima. Mikrobiološke analize nisu pokazale prisutnost bakterije *Escherichia coli*, enterokoka ni *Clostridium perfringens*, što potvrđuje dobru mikrobiološku kvalitetu podzemne vode. Redovito praćenje kvalitete vode ključno je za sigurnu vodoopskrbu i pravovremeno prepoznavanje mogućih izvora onečišćenja.

Ključne riječi: crpilište Vinogradi, analiza vode, hidrološka godina

The impact of air pollution on the incidence of cancer in the area of Tuzla Canton

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Abstract
This paper examines the impact of air pollution on human health, with particular emphasis on the relationship between long-term exposure to polluted air and the increasing incidence of malignant diseases in Tuzla Canton. Air quality data for the period 2022–2023 were analyzed using official environmental reports. The monitored pollutants included sulfur dioxide (SO_2), nitrogen oxides (NOx), carbon monoxide (CO), ozone (O_3), and suspended particulate matter (PM_{10} and $PM_{2.5}$). Results showed frequent exceedances of legal limit values, especially during winter months. The main sources of pollution were heavy industry, thermal power plant emissions, road traffic, and household heating systems using coal, wood, and low-quality fuels. Municipalities with higher exposure to pollution recorded an increased incidence of lung cancer, bronchial cancer, and other respiratory carcinomas. The findings indicate a significant association between prolonged exposure to polluted air and elevated cancer risk. The study emphasizes the need for continuous environmental monitoring, stricter emission control, cleaner energy solutions, and stronger preventive public health measures in Tuzla Canton.

Keywords: air pollution, carcinomas, Tuzla Canton, industry, traffic, public health

Utjecaj zagađenja zraka na učestalost pojave karcinoma na području Tuzlanskog kantona

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Sažetak

Ovaj rad analizira utjecaj zagađenja zraka na zdravlje ljudi, s posebnim naglaskom na povezanost dugotrajne izloženosti zagađenom zraku i porasta učestalosti malignih oboljenja na području Tuzlanskog kantona. Podaci o kvaliteti zraka za period 2022.–2023. godine analizirani su korištenjem službenih izvještaja nadležnih institucija. Praćene su koncentracije sumpor-dioksida (SO_2), dušikovih oksida (NOx), ugljen-monoksida (CO), ozona (O_3) te lebdećih čestica (PM_{10} i $PM_{2.5}$). Rezultati su pokazali česta prekoračenja dozvoljenih graničnih vrijednosti, naročito tokom zimskih mjeseci. Glavni izvori zagađenja bili su teška industrija, emisije termoelektrane, cestovni promet te individualna ložišta na ugalj, drvo i nekvalitetna goriva. U općinama s većom izloženošću zagađenju zabilježena je povećana učestalost raka pluća, bronhijalnog karcinoma i drugih karcinoma respiratornog sustava. Dobiveni rezultati ukazuju na značajnu povezanost između dugotrajne izloženosti zagađenom zraku i povećanog rizika od karcinoma. Rad naglašava potrebu za kontinuiranim monitoringom, strožom kontrolom emisija, primjenom čistijih energetskih rješenja i jačanjem preventivnih mjera javnog zdravstva u Tuzlanskom kantonu.

Ključne riječi: zagađenje zraka, karcinomi, Tuzlanski kanton, industrija, promet, javno zdravstvo

Invasion of the northern pike, Esox lucius, in the protected wetlands of the River Neretva Estuary (Bosnia and Herzegovina, Croatia)

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Abstract
The invasion of northern pike, Esox lucius, in the River Neretva catchment (Bosnia and Herzegovina and Croatia) is described, with particular emphasis on the recent establishment of a population in the protected wetlands of Hutovo blato, an area rich in native and endemic fish species. The first record and establishment of northern pike in the region was reported from the Prološko blato wetlands (Croatia) around 2010. Subsequent dispersal through the Vrljika, Matica and Trebižat rivers appears to have enabled the species to reach the main course of the Neretva River and the protected Hutovo blato wetlands. During 2025 and 2026, 149 specimens were collected and examined for total length, body weight and stomach contents. Measured specimens ranged from 10 to 89 cm in length. The dominant prey items were two endemic fish species, the Neretva roach, Rutilus basak, and the Neretva nase, Chondrostoma knerii. However, a substantial proportion of the diet also consisted of introduced invasive species, including pumpkinseed, Lepomis gibbosus, and gibel carp, Carassius gibelio. The establishment of a viable northern pike population represents a major threat to the protected Hutovo blato wetland, which is an important habitat for numerous native and endemic fish species.

Keywords: biological invasion, Esox Lucius, Hutovo blato, Neretva River, endemic fishes, diet analysis

Invazija štuke (*Esox lucius*) u zaštićena močvarna područja estuarija rijeke Neretve (Bosna i Hercegovina, Hrvatska)

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Sažetak

U radu je opisana invazija štuke (*Esox lucius*) u slivu rijeke Neretve (Bosna i Hercegovina i Hrvatska), s posebnim naglaskom na nedavno uspostavljanje populacije u zaštićenim močvarama Hutova blata, području bogatom autohtonim i endemskim vrstama riba. Prvi nalaz i uspostava štuke u slivu Neretve zabilježeni su u močvarama Prološkog blata (Hrvatska) oko 2010. godine. Naknadno širenje rijekama Vrljikom, Maticom i Trebižatom vjerojatno je omogućilo dolazak vrste u glavni tok rijeke Neretve te u zaštićeno područje Hutova blata. Tijekom 2025. i 2026. godine prikupljeno je i analizirano 149 jedinki, pri čemu su određivani ukupna duljina, tjelesna masa i sadržaj želuca. Duljina analiziranih jedinki kretala se od 10 do 89 cm. Dominantni plijen činile su dvije endemske vrste riba: neretvanska plotica (Rutilus basak) i podustva (Chondrostoma knerii). Međutim, značajan udio u prehrani činile su i unesene invazivne vrste, uključujući sunčanicu (*Lepomis gibbosus*) i babuška (*Carassius gibelio*). Uspostavljanje održive populacije štuke predstavlja ozbiljnu prijetnju zaštićenom močvarnom području Hutova blata, koje je važno stanište brojnih autohtonih i endemskih vrsta riba.

Ključne riječi: biološka invazija, štuka, *Esox lucius*, Hutovo blato, rijeka Neretva, endemske ribe, analiza prehrane

Impact of environmental stressors on the occurrence of Vairimorpha ceranae in honey bee colonies across differing habitats

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Abstract
Microsporidia of the genus *Vairimorpha* are major pathogens contributing to global honeybee declines, with *Vairimorpha ceranae* now dominant worldwide. This parasite is linked to shortened lifespan, weakened immunity, and reduced colony performance. While biotic and abiotic stressors influencing nosematosis have been widely studied, the influence of environmental context—particularly urbanization, agricultural activity, and habitat microclimate—remains insufficiently understood. In March 2024, we sampled winter bee carcasses from 82 colonies across four habitat types in eastern Slovakia: urban, rural intravillage, rural extravillage, and forest. Samples were examined microscopically (Pohl, 2005) and analysed by duplex PCR targeting *Vairimorpha apis* and *V. ceranae*. Habitat characteristics included proximity to industry, traffic intensity, agricultural practices, and microclimatic features. Microscopy detected Vairimorpha spores in 50% of colonies, and PCR confirmed *V. ceranae* in all positive samples. Prevalence was highest in urban colonies (81.8%) and rural intravillage sites (74%). Rural extravillage colonies showed much lower positivity (18.2%), and all forest colonies tested negative. The results suggest synergistic impacts of urbanization, industrial pollution, traffic-related vibrations, and reduced forage quality. The study demonstrates strong habitat-dependent differences in *V. ceranae* prevalence, identifying urban and intravillage environments as high-risk. Forest habitats appear most favourable for colony health. Findings highlight the need to further investigate underexplored abiotic stressors, including traffic-induced vibrations, in shaping microsporidian infection dynamics.

Keywords: *Vairimorpha ceranae*, honeybees, environmental stressors, duplex PCR, nosematosis

Results of phytobenthos research in the Vučica, Marjanac and Lukavac watercourses prior to regulation works

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Abstract
Research on phytobenthos was conducted as part of the project "Monitoring the impact of flood-protection system construction in the settlements of Bokšić Lug and Bokšić on the status of surface water bodies (watercourses Vučica, Marjanac and Lukavac)" funded by Croatian Waters. This study presents the results of phytobenthos research conducted prior to the start of construction activities. Sampling was performed in May 2025 at four sites: Lukavac 1 and Lukavac 2 (located downstream and upstream of the planned reconstruction section, respectively), Marjanac (at the location designated for retention area construction) and Vučica (downstream of the planned dam site). A total of 68 diatom taxa were identified, with Bacillariophyceae as the dominant group. At the Lukavac 1 and Lukavac 2 sites, the community was dominated by *Achnanthidium minutissimum* and *Planothidium frequentissimum*, indicating eutrophic conditions associated with elevated nutrient availability. The phytobenthic assemblage at the Marjanac site, characterized by the dominance of *Navicula cryptocephala* and taxa of the genus *Nitzschia*, suggests slow-flowing or stagnant conditions influenced by anthropogenic pressures and increased organic matter load. In contrast, the occurrence of taxa from the genera *Adlafia*, *Gomphonema*, and *Diploneis* at the Vučica site reflects more stable environmental conditions, with low to moderate nutrient concentrations. According to the Trophic Diatom Index (TID_{HR}) and the Ecological Quality Ratio (EQR), the ecological potential of the Lukavac 1 and Lukavac 2 sites was classified as moderate. The Marjanac site showed moderate ecological status, whereas the Vučica site was assessed as having good ecological status.

Keywords: phytobenthos algae, trophic index, ecological assessment

Rezultati istraživanja fitobentosa vodotoka Vučica, Marjanac i Lukavac prije zahvata regulacije vodotoka

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Sažetak

Istraživanje fitobentosa provedeno je u sklopu projekta „Monitoring utjecaja zahvata uređenja sustava zaštite od poplava naselja Bokšić Lug i Bokšić na stanje površinskih vodnih tijela (za vodotoke Vučica, Marjanac i Lukavac)“ financiranog od strane Hrvatskih voda. U ovom radu su prikazani rezultati istraživanja fitobentosa prije početka izvođenja radova na predmetnom području. Uzorkovanje je provedeno u svibnju 2025. godine na četiri postaje: Lukavac 1 i Lukavac 2 (nizvodno i uzvodno od dijela vodotoka na kojem se planira rekonstrukcija), Marjanac (dionica na kojoj se planira izgradnja retencijskog prostora) i Vučica (nizvodno od mjesta izgradnje ustave). Ukupno je utvrđeno 68 svojti dijatomeja, a najzastupljenije su bile svojte iz razreda Bacillariophyceae. Vrste *Achnanthidium minutisssimum* i *Planothidium frequentissimum* bile su najzastupljenije na postajama Lukavac 1 i Lukavac 2, što ukazuje na eutrofne uvjete s povišenim koncentracijama hranjivih tvari. Sastav zajednice na postaji Marjanac, gdje su prevladavale *Navicula cryptocephala* i vrste roda *Nitzschia*, karakterističan je za stajaće ili sporotekuće vode pod antropogenim utjecajem, s povećanim udjelom organskih tvari. Dobra zastupljenost vrsta rodova *Adlafia*, *Gomphonema* i *Diploneis* na postaji Vučica ukazuje na stabilne ekološke uvjete, s niskim do umjerenim sadržajem hranjivih tvari. Na temelju trofičkog indeksa dijatomeja (TID_{HR}) i omjera ekološke kakvoće (OEK) procijenjeni ekološki potencijal istraživanih lokaliteta Lukavac 1 i Lukavac 2 je umjeren. Ekološko stanje lokaliteta Marjanac je umjereno, dok je za lokalitet Vučica utvrđeno dobro ekološko stanje.

Ključne riječi: fitobentos, trofički indeks dijatomeja, ekološko stanje/potencijal

Real-Time Monitoring of Micropollutants Using Electrochemical Sensor-Based Technology: A Case Study of Pomorie Lake, Bulgaria

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Abstract
Coastal lagoons are highly dynamic ecosystems exposed to multiple anthropogenic pressures, including agricultural runoff, urban discharge, and seasonal tourism. This study presents an innovative approach for micropollutant monitoring based on electrochemical sensors developed within the iMERMAID project and applied in Pomorie Lake (Bulgaria). The approach was validated to assess its feasibility and potential for improving the understanding of pollution sources and dynamics. Screen-printed sensors with various modified carbon electrodes were used for the detection of pharmaceutical and agrochemical contaminants, including paracetamol (APAP) and tebuconazole, and were validated against standard instrumental analyses. The results showed consistent qualitative agreement between the methods. Following rainfall events, increased organic load was observed, indicating combined effects of diffuse runoff and wastewater-related inputs. Tebuconazole was detected at in-lake monitoring points, while paracetamol was identified primarily at locations associated with wastewater transport and treatment, highlighting both agricultural and urban sources of pollution. The study demonstrates the capability of integrated sensor–laboratory approaches to capture pollution dynamics in a timely manner compared to conventional monitoring practices. The findings support the application of such systems for data-driven water quality management and suggest the need for measures to control runoff inflows into the lagoon.

Keywords: electrochemical sensors, micropollutants, CECs, coastal lagoon monitoring

ENVIRONMENTAL REGULATIONS AND LAWS
OKOLIŠNO PRAVO I ZAKONSKA REGULATIVA

The Dark Side of Green Business: Misleading Sustainability Claims and Legal Liability

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Abstract
Sustainability has, in recent years, become one of the key market and regulatory concepts within the European Union. Alongside the development of the ESG industry and green finance, the issue of misleading sustainability claims in market communication has also been growing. An increasing number of products and services are presented as "green," "sustainable," or "climate neutral," without a solid basis in objective and verifiable criteria. Such claims now represent not only a marketing issue but also a significant regulatory, legal, and reputational risk. The European Union has been developing a stricter regulatory framework aimed at improving ESG reporting transparency, protecting consumers, and preventing unfair commercial practices. Particular attention is given to the phenomenon of greenwashing as a form of market deception in which sustainability is falsely presented to gain competitive advantage. This includes the use of unverified claims, selective disclosure of information, misleading ESG labels, and the creation of an illusion of sustainability through marketing strategies. Certain sectors are especially exposed, including finance, automotive, fashion, energy, and tourism, as evidenced by numerous international regulatory and judicial cases. Such practices may lead to regulatory investigations, substantial financial penalties, loss of investor confidence, and serious reputational damage. Issues of responsibility increasingly extend to corporate boards, compliance professionals, marketing departments, and lawyers and business advisors involved in ESG communication and reporting. Sustainability is therefore no longer viewed as a matter of marketing or reputation, but as a significant area of legal and financial risk.

Keywords: sustainability, greenwashing, ESG regulation, legal risk

Tamna strana zelenog biznisa: Obmanjujuće tvrdnje o održivosti i pravna odgovornost

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Sažetak
Održivost je posljednjih godina postala jedno od ključnih tržišnih i regulatornih pitanja unutar Europske unije. Uz razvoj ESG industrije i zelenog financiranja raste i problem obmanjujućih tvrdnji o održivosti u tržišnoj komunikaciji. Sve više proizvoda i usluga prikazuje se kao „zeleno“, „održivo“ ili „klimatski neutralno“, bez stvarnog uporišta u provjerljivim kriterijima. Takve tvrdnje predstavljaju ozbiljan regulatorni, pravni i reputacijski rizik. Europska unija razvija stroži regulatorni okvir usmjeren na transparentnost ESG izvještavanja, zaštitu potrošača i sprječavanje nepoštene poslovne prakse. U fokusu je fenomen zelenog zavaravanja kao oblika tržišne obmane kojim se lažno prikazuje održivost radi ostvarivanja tržišne prednosti. Posebna pažnja posvećuje se korištenju neprovjerljivih tvrdnji, selektivnom prikazivanju podataka, manipulativnim ESG oznakama i stvaranju privida održivosti kroz marketinške kampanje. Posebno su izloženi sektori financija, automobilske industrije, mode, energetike i turizma, što potvrđuju brojni primjeri iz međunarodne regulatorne i sudske prakse. Takvo poslovanje može rezultirati regulatornim istragama, visokim novčanim kaznama, gubitkom povjerenja investitora i ozbiljnom reputacijskom štetom. Pitanje odgovornosti sve više obuhvaća članove uprava, compliance stručnjake, marketinške odjele, ali i odvjetnike te poslovne savjetnike uključene u ESG komunikaciju i izvještavanje. Zaključno, održivost se više ne promatra kao pitanje marketinga, već kao područje značajnog pravnog i financijskog rizika.

Ključne riječi: održivost, greenwashing, ESG regulacija, pravni rizik

FORESTRY AND URBAN FORESTRY
ŠUMARSTVO I URBANO ŠUMARSTVO

Active conservation of urban and peri-urban forest ecosystems in Zagreb

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Abstract
Urban and peri-urban forests in Zagreb are exposed to significant pressures from urbanization, including intensive public use, habitat fragmentation, illegal waste disposal, and the loss of forest areas. Parts of these forests are protected and included in the Natura 2000 ecological network. Sustainable forest management is implemented through forest management plans aligned with conservation management objectives, ensuring adaptation to nature protection goals. These forests provide essential ecosystem services to local residents, such as recreation, air purification, and soil erosion control. The aim of this paper is to present EU Green Deal and national legislative frameworks through concrete active conservation measures implemented by Hrvatske šume d.o.o. in the urban and peri-urban forests of Zagreb, with the goal of preserving biodiversity and maintaining habitat naturalness. A historical overview of sustainable forest management principles since the 18th century is also included. One of the key educational measures is the program "Forest in the School, School in the Forest," which emphasizes the importance of forests and sustainable forest management among school-age children. The conclusion highlights that effective conservation of forest ecosystems requires cooperation among all stakeholders and consistent implementation of legal frameworks to ensure their preservation for future generations.

Keywords: conservation measures, EU Green Deal, urban and peri-urban forests, forest ecosystem, education

Aktivne mjere očuvanja šumskih ekosustava u urbanim i periurbanim područjima Grada Zagreba

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Sažetak

Na području Grada Zagreba urbane i periurbane šume izložene su snažnim pritiscima urbanizacije, od pritiska javnosti do fragmentacije staništa, ilegalnog odlaganja otpada te gubitak šumskih površina. Dio tih šuma zaštićen je i uključen u ekološku mrežu Natura 2000. Održivo gospodarenje provodi se putem šumskogospodarskih planova koji su usklađeni s planovima upravljanja, čime se osigurava prilagodba ciljevima zaštite prirode. Ove šume imaju veliku vrijednost za stanovnike jer pružaju općekorisne funkcije poput rekreacije, pročišćivanja zraka i zaštite tla od erozije. Cilj rada je prikazati europski zeleni plan i nacionalne zakonske okvire kroz direktne aktivne mjere očuvanja šumskih ekosustava koje provode Hrvatske šume d.o.o. u urbanim i periurbanim šumama Grada Zagreba s ciljem očuvanja bioraznolikosti i prirodnosti staništa, uz povijesni pregled razvoja tih načela od 18. stoljeća. Jedna od ključnih mjera edukacije javnosti je Škola u šumi, šuma u školi kao neophodna edukacija djece školske dobi o važnosti šuma i uloge održivog gospodarenja šumama i šumarskoj struci. Zaključak je da čuvanje šumskih ekosustava zahtijeva suradnju svih dionika i dosljednu primjenu zakonskih regulativa kako bi se prirodna staništa sačuvala za buduće generacije.

Ključne riječi: mjere očuvanja, europski zeleni plan, urbane i periurbane šume, šumski ekosustav, edukacija

GREEN ARCHITECTURE AND CONSTRUCTION
ZELENA ARHITEKTURA I GRADNJA

Integrating IAQ Risk Potential Assessment into Ventilation Strategy Selection and Control in Educational Buildings

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Abstract
The increasing airtightness of buildings driven by decarbonisation has intensified the challenge of maintaining healthy indoor air quality (IAQ) while limiting energy use, yet ventilation system choices are often made without assessing location-specific IAQ risk potential. This study proposes a framework that integrates IAQ risk potential assessment, based on combined outdoor and indoor monitoring, into both early-stage ventilation strategy selection and the subsequent operation of natural ventilation systems. The approach extends prior work on IAQ risk potential identification, towards decision support for educational buildings in both new construction and retrofit scenarios. Long-term classroom living-lab measurements of CO_2, $PM_{2.5}$, PM_{10}, VOCs, temperature, and relative humidity were analysed alongside outdoor data to assess pollutant patterns and seasonal variability. Results show limited CO_2 exceedances, while particulate matter frequently exceeds WHO guideline values, particularly during the heating season. VOC levels mainly reflect occupancy and indoor sources. The framework introduces a risk-informed layer that supports ventilation strategy selection and adaptive operation, including limiting window opening under high outdoor pollution. CO_2 and VOCs indicate occupancy-driven demand, while particulate matter reflects outdoor-related IAQ risk. The findings show that integrating IAQ risk potential into design and operation supports more robust, health-oriented, and context-sensitive ventilation strategies in educational buildings.

Keywords: healthy buildings, IAQ risk potential, particulate matter, ventilation strategy selection, data-driven decision-making

Adaptive reuse and heritage integration in the architectural design competition of Penc School

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Abstract
This paper presents a design-based research project examining adaptive reuse and integrated heritage protection within the framework of a Hungarian national architectural design competition for the Penc School. Conducted as part of the International Integrated Heritage Protection Research Team, the study emphasizes the integration of academic design thinking and university-based architectural methodologies into a real-world competition context. The competition focused on the expansion of an existing educational complex through a combination of demolition, preservation, and new construction, including the integration of the historic Evva Castle, currently functioning as part of the school. The design brief required the addition of nine new classrooms while preserving the architectural and historical values of the site. The research explores how adaptive reuse strategies and heritage-sensitive approaches can inform contemporary architectural design under competitive conditions. It highlights the role of architectural competitions as experimental platforms where academic knowledge and professional practice intersect. The case study demonstrates how the incorporation of academic perspectives can support a balanced approach to preservation, functionality, and spatial coherence, contributing to more sustainable and context-responsive architectural solutions.

Keywords: sustainability, adaptive reuse, heritage revitalization, green architecture, rehabilitation

Evaluating academic design strategies for urban revitalization: The Balokány District, Pécs

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Abstract
The Balokány District of Pécs is located between the historical city centre and a postindustrial heritage building complex. The area represents a defining asset for the city, characterized by centuries-old heritage and valuable green and blue spaces. Recent transformations have contributed to the development of a significant cultural urban fabric as part of the European Capital of Culture programme in 2010. Despite large-scale urban regeneration, parts of the Balokány Grove remain spatially and functionally disconnected from the developing urban context. During an academic semester, architecture students at the University of Pécs developed design proposals focusing on the revitalization of the Balokány Grove and the adaptive reuse of the former open-air bath house in the area. The task was to create a recreational and community space while preserving the protected buildings and their historical significance. This study evaluates the students' design approaches and sustainable strategies for creating inclusive building environments and integrating the outdated and vulnerable urban tissue into contemporary urban life, while protecting and enhancing the value of green urban areas. The analyses identify the design drivers and strategic elements used to respond to the fragmented urban area.

Keywords: architecture, revitalization, heritage, adaptive reuse

Simulation-based evaluation of daylighting performance and illuminance levels in school buildings under semi-arid (BSk) and temperate (Csa) climate conditions

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Abstract
Adequate daylighting in educational buildings is critical for student performance, visual comfort, and energy efficiency, with studies demonstrating that optimized daylight utilization can reduce artificial lighting energy consumption by up to 66% in school classrooms. However, the design and evaluation of daylighting systems require climate-sensitive approaches, particularly in regions with divergent solar radiation conditions. This study presents a simulation-based evaluation of daylighting performance and illuminance distribution in typical school buildings located in two distinct climate zones: the semi-arid BSk climate, representative of the Kurdistan Region of Iraq, and the temperate Csa (hot-summer Mediterranean) climate. Using validated computational simulation tools, key daylighting metrics — including Useful Daylight Illuminance (UDI, threshold: 100–2,000 lux), Daylight Factor (DF, minimum target: 2%), and Annual Sun Exposure (ASE) — are assessed across representative classroom configurations with a window-to-wall ratio (WWR) of 20–40%. The results identify critical differences in daylight availability, glare risk, and thermal-visual trade-offs between the two climate contexts. Findings contribute to the development of climate-responsive daylighting design guidelines and inform multi-criteria optimization frameworks aimed at achieving an estimated 30–50% reduction in energy demand for artificial lighting.

Keywords: daylighting simulation, illuminance performance, climate-responsive design, school buildings, BSk and Csa climate zones

Impact of mixing sequence on alkali-activated mortar characteristics

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Abstract
Locally sourced materials from brick manufacturing plants in northern Croatia were used to produce alkali-activated mortars. Four mortar mixtures with identical compositions were prepared. While most previous studies have focused on binders produced with liquid alkaline activators cooled to ambient temperature, this research investigated the influence of mixing sequence and curing regime on mechanical properties and fire resistance. To evaluate fire performance, mortar specimens were exposed to 600 °C and then left to cool naturally. Flexural and compressive strength, as well as mass, were measured to determine residual values after heating. Visual examination of specimen cross-sections before and after heating was conducted to support the results. For two mortars with superior fire resistance, FT-IR and FE-SEM-EDS analyses were performed for further interpretation. Thermal properties, including thermal conductivity and specific heat capacity, were determined for the mortar that showed favorable performance and simple preparation. Results indicate that the performance of alkali-activated binders based on ground fired brick depends not only on chemical composition but also significantly on mixing procedure and activation conditions. Proper mixing protocols improve microstructure, strength, and thermal resistance, with premixing the alkaline powder with dry components followed by liquid addition proving to be the most effective approach.

Keywords: alkali-activated mortar, mixing sequence, fire resistance, mechanical properties, thermal properties

Construction materials and residues – introducing Croatian geothermal drilling -radon/thoron gas issues

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Abstract

EU Member States are responsible for the safety, environmental, and energy requirements applicable to buildings and other civil engineering constructions. Mineral materials that belong to the group of Naturally Occurring Radioactive Material (NORM) residues, from mining and other industries, are under the “reuse” waste management policy, increasingly utilized in the manufacturing of building materials. Within the EU, these materials are falling under the dual regulation of radiological safety standards Euratom Basic Safety Standards (Directive 2013/59/Euratom), which sets requirements for NORM in building materials and is to be integrated into the new Construction Products Regulation (EU) No 2024/3119 (CPR). It will be essential to add this information to a Digital Product Passport (DPP). DPP will be mandatory starting in 2026, serving as a basis for ensuring traceability, transparency, and access to essential information throughout the product's lifecycle, including data on the composition, origin, carbon footprint, and reuse or recycling potential of each material, reducing the environmental impact of the built environment. As Croatia has no such integrated standards, this paper provides basic lessons learned during the reconstruction campaign of public educational and health buildings after the Zagreb and Petrinja earthquakes, for which reconstruction permits the Radon protection Plan to be a legal obligation due to the National Recovery and Resilience Plan 2021-2026. financially supported by the European Bank for Reconstruction and Development. As in many public buildings, following the EU Green Deal Plan, green energy is to be utilized. This paper covers the novelty research on possible NORM residues from geothermal heating sources, such as for the new National Children's Hospital facility in Zagreb.

Keywords: residue, radon, exposure to NORM, construction materials

Reinterpreting Zsolnay architectural ceramics: Development of a modular Façade System

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Abstract
The research originates from the design of a community pavilion for the 2023 centenary of the University of Pécs, raising the question of how Zsolnay ceramics can become an innovative material in contemporary architecture beyond its current, predominantly restorative use. Since 2025, the work has continued the EKÖP–KDP scholarship at the Zsolnay Factory, aiming to develop a contemporary architectural ceramic façade element. The study focuses on the material properties and manufacturing possibilities of pyrogranite, alongside the analysis of international examples of contemporary ceramic architecture. As a result, a modular façade system concept, titled "Zsolnay Modular," is proposed, consisting of freely combinable pyrogranite elements. The presentation introduces a fabricated prototype of one possible component of the system: a ceramic shading element that explores both the structural and plastic potential of the material. Sustainability is a key aspect of the research: the designed modules are intended to function as load-bearing elements and are partly produced using handcrafted techniques. The overall aim is to reinterpret Pécs's ceramic heritage innovatively and to strengthen the role of Zsolnay architectural ceramics in 21st-century architecture.

Keywords: architecture, sustainability, modularity, Zsolnay ceramics

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GREEN BIOTECHNOLOGY
ZELENA BIOTEHNOLOGIJA

Sheep wool-derived hydroponic substrates: Effects on radish yield and quality

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Abstract
Climate change, declining efficiency in field food production, and the environmental burden of synthetic fertilizers highlight the urgent need for sustainable agricultural solutions. Simultaneously, significant volumes of biowaste, such as sheep wool and other plant/animal by-products, remain underutilized, contributing to landfill growth and resource loss. This study addresses these interconnected challenges by developing functional agromaterials derived from comprehensively characterized streams of sheep wool, an abundant yet underexploited resource. Advanced spectrometric and spectroscopic analyses were employed to determine essential nutrients and identify potential contaminants, including heavy metals and organic pollutants. Based on these findings, tailored hydroponic substrates were formulated for the radish seedling stage and evaluated against conventional substrates (peat, rock wool, and recycled rock wool). Plant performance was assessed using fresh and dry biomass and elemental composition. The results demonstrate that processed wool-based substrates can match or exceed commercial alternatives in hydroponic efficiency while ensuring safety and nutrient availability. This approach integrates circular bioeconomy principles with precision nutrient management, supporting climate-resilient, resource-efficient agricultural systems.

Keywords: biowaste valorization, circular bioeconomy, nutrient recycling, sustainable agriculture

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GREEN CHEMISTRY AND CHEMICAL ENGINEERING

ZELENA KEMIJA I KEMIJSKO INŽENJERSTVO

Valorisation of waste quince peel using natural deep eutectic solvents

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Abstract

The valorization of waste generated from processing fruits and vegetables represents a sustainable approach to producing value-added products. This study focuses on valorizing quince (*Cydonia oblonga*) waste bark. To ensure environmentally friendly extraction of bioactive compounds, green solvents such as natural eutectic solvents were employed. Specifically, the study examined the use of five natural eutectic solvents with water contents of 40% and 80% (v/v) for extracting compounds from quince bark. The results were compared to those obtained using a conventional extraction method involving acidified ethanol. The total polyphenol content in the quince extract was measured using differential pulse voltammetry, an electrochemical technique. This extract was analyzed to identify and quantify one of the most abundant polyphenolic compounds in quince. For the electrochemical measurements, a carbon electrode coated with carbon nanoparticles served as the working electrode, with carbon as the auxiliary electrode and silver/silver chloride as the reference electrode.

Keywords: quince bark extract, eutectic solvents, differential pulse voltammetry

Valorizacija otpadne kore dunje primjenom prirodnih niskotemperaturnih eutektičkih otapala

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Sažetak

Valorizacija otpada nastalog preradom voća i povrća predstavlja održiv način dobivanja proizvoda s dodanom vrijednosti. Ovaj rad obuhvaća valorizaciju otpadne kore dunje (*Cydonia oblonga*). Kako bi ekstrakcija bioaktivnih spojeva bila ekološki prihvatljiva, korištena su zelena otapala poput prirodnih niskotemperaturnih eutektičkih otapala. U ovom radu ispitana je mogućnost primjene pet prirodnih eutektičkih otapala s udjelima vode od 40 % i 80 % (v/v) u ekstrakciji otpadne kore dunje. Rezultati su uspoređeni s konvencionalnom ekstrakcijom u zakiseljenom etanolu. Elektrokemijskom tehnikom diferencijalne pulsne voltametrije određen je ukupan sadržaj polifenola u ekstraktu dunje. Ekstrakt je obogaćen određenom koncentracijom najzastupljenijih polifenolnih spojeva u dunji radi identifikacije i kvantifikacije polifenola u realnom uzorku. Korištena je ugljikova elektroda s nanosom ugljikovih nanočestica kao radna elektroda, ugljik kao pomoćna elektroda i srebro/srebro klorid kao referentna elektroda.

Ključne riječi: ekstrakt kore dunje, eutektička otapala, diferencijalna pulsna voltametrija

Visible-light-driven CO_2 conversion over Ceria-Zirconia-based photocatalysts

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Abstract

Ceria-zirconia-based oxides are benchmark redox catalysts, driven by the Ce^{3+}/Ce^{4+} couple and their exceptional oxygen storage capacity. Here, we utilize configurational entropy to design rare-earth high-entropy ceria-zirconia oxides and directly compare them with ordered and partially ordered counterparts. Controlled sol-gel synthesis and redox-driven transformations yield solid solution, pyrochlore, κ-phase, and partially oxidized structures. Entropy-stabilized materials exhibit lattice distortion, high defect tolerance, and a dense population of redox-active sites. High-entropy pyrochlore-derived phases, in particular, show abundant oxygen vacancies, surface hydroxyls, and stabilized mixed-valence Ce/Pr species, enabling efficient charge separation under visible light. Despite having band gaps over 3 eV, disorder-induced electronic states extend absorption into the visible region. Density functional theory confirms enhanced CO_2 adsorption on high-entropy surfaces. Photocatalytic CO_2 hydrogenation highlights pyrochlore-fluorite dual-phase and partially oxidized pyrochlore catalysts as top performers, achieving CO_2 conversions up to 24.15% with unique selectivity toward formaldehyde, demonstrating a powerful entropy-driven route to sustainable CO_2 valorization.

Keywords: photocatalytic CO_2 hydrogenation, high-entropy oxides, visible light reduction

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Synthesis of 2,3-disubstituted quinazolin-4(3*H*)-ones – a green chemistry approach

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Abstract
Quinazolinones are a prominent class of heterocyclic compounds known for their significant biological activity. Due to their huge biological potential, they have been studied for decades, both their synthesis and their application in different areas. As the most prominent evidence of their pharmacological potential is the fact, that quinazolinone core is incorporated in many marketed drugs, such as Albaconazole, Cloroqualone, Nolatrexed, Raltitrexed, etc. Thus, a large amount of synthetic work has been performed in order to investigate the synthesis and subsequent biological activity of different quinazolinone derivatives. In order to decrease the environmental impact of these processes, the green chemistry concept if often applied. This research was focused on the synthesis of 2,3-disupstituted-quinazolinones where mechanochemical synthesis was applied in all synthetic steps. First, 2-mercapto-3-substituted-quinazolinones were synthesized by a known reaction of anthranilic acid and different isothiocyanates. Then, the alkylation of –SH group was performed, leading to the formation of desired esters, which in reaction with hydrazine hydrate let to the formation of hydazides. Hydrazides were reacted with different isothiocyanates to yield thisoemicarbazides, which were cyclized to 1,3,4-oxadiazoles or 1,3,4-thiadiazoles using different reagents. Mechanochemistry was shown to be very effective in all of these synthetic steps, working in solvent-free conditions, with minimum postsynthetic demands and in short times.

Keywords: quinazolinone, 1,3,4-thiadiazoles, 1,3,4-oxadiazoles, mechanochemistry

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Sinteza 2,3-disupstituiranih kinazolin-4(3*H*)-ona – koncept zelene kemije

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Sažetak

Kinazolinoni su heterociklički spojevi s vrlo izraženom biološkom aktivnoću. Upravo zbog svog biološkog potencijala, predmetom su brojnih istraživanja koja uključuju, kako njihovu sintezu, tako i ispitivanje njihove potencijalne primjene. Evidentan dokaz njihovog farmakološkog potencijala je i činjenica da su strukturna sastavnica brojnih komercijalnih lijekova, Albakonazola, Klorokvalona, Nolatrekseda, Raltitrekseda, itd. Stoga se njihova sinteza vrlo intenzivno istražuje, te naknadno ispituje biološka aktivnost. Upravo u ovom segmentu, koji je značajan s ekološke strane, se nastoji primijeniti što više procesa koji su u skladu s principima zelene kemije. Ovo istraživanje uključuje mehanokemijsku sintezu 2,3-disupstituiranih-kinazolinona prema spomenutim principima. 2-Merkapto-3-supstituirani-kinazolinoni su pripravljeni iz derivata antranilne kisleine te odgovarajućih izotiocijanata. Alkiliranjem –SH skupine su dobiveni odgovarajući esteri, koji su naknadno u reakciji s hidrazin hidratom prevedeni u hidrazide. Hidrazidi u reakciji s izotiocijanatima daju tiosemikarbazide, koji su dalje ciklizirani u 1,3,4-oksadiazole i 1,3,4-tiadiazole pomoću različitih reagenasa. Svi produkti su dobiveni mehanokemsijkim putem što se pokazalo kao vrlo učinkovit pristup. Sve reakcije su provedene u *solvent-free* uvjetima, uz minimalnu naknadnu obradu reakcijske smjese, te u kratkom vremenu.

Ključne riječi: kinazolinoni, 1,3,4-tiadiazoli, 1,3,4-oksadiazoli, mehanokemija

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Hydrogen bonding, thermal decomposition and catalytic performance of centrosymmetric imidazolium hydrogen squarate structure

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Abstract

The centrosymmetric form of the organic compound imidazolium hydrogen squarate ($[C_3H_5N_2]^+[C_4O_4H]^-$) is investigated in this paper with respect to intermolecular hydrogen bonding, thermal decomposition mechanism and catalytic behavior. The analysis was performed using several experimental techniques, including TGA and DSC, together with computational methods such as Hirshfeld surface (HS), RDG method and QTAIM. The catalytic properties of $[C_3H_5N_2]^+[C_4O_4H]^-$ were investigated in the reaction of butyl acetate production. Valuable kinetic (rate constant, activation energy, pre-exponential factor) and thermodynamic parameters (enthalpy, entropy, Gibbs free energy) were determined. All theoretical calculations were carried out by means of DFT/B3LYP/6-311++G(2d,2p). HS, QTAIM, and RDG approaches, revealed the presence of electrostatic hydrogen interactions (O···H) between the imidazolium ring and $[C_4O_4H]^-$ anion. These interactions influence the chemical bond distances in $[C_3H_5N_2]^+[C_4O_4H]^-$, resulting in C–C and C–O bonds with partially double-bond character. The O···H interactions contribute to the thermal stability of the compound up to 290°C. TGA and DSC profiles of $[C_3H_5N_2]^+[C_4O_4H]^-$ showed a total mass loss of 76.3% in the temperature range of 295–880°C, leaving solid carbon as a final residue. The experimentally measured mass loss closely matched the theoretically calculated value, consistent with the proposed thermal decomposition mechanism.

Keywords: hydrogen bonding, thermal decomposition, theoretical analysis, esterification, reaction kinetics

GREEN ECONOMY
ZELENA EKONOMIJA

Greening public procurement in the defence sector: A comparative analysis before and after the introduction of mandatory environmental criteria in Croatia

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Abstract
The paper analyzes the application of green criteria in the public procurement procedures of the Ministry of Defence of the Republic of Croatia during 2024 and 2025, i.e., before and after the introduction of mandatory Green Public Procurement. The research has aimed to examine the extent to which the regulatory change has led to measurable changes in the contracting authority's purchasing practices and to assess the role of managerial efforts in the process of going green. The analysis was conducted using the mixed-method scientific approach. Qualitative methods were applied to analyze the relevant scientific and regulatory papers. In addition, quantitative methods, including descriptive statistics and before-and-after analysis, were used to analyze publicly available documentation from the Electronic Public Procurement Bulletin Board of the Republic of Croatia. Procurement procedures were coded according to the presence of environmental criteria, to investigate the number and value share of procedures with green criteria in the two observed years. The results show that in 2024, no procedures met green criteria, whereas in 2025, a few did. Such findings point to a direct effect of the introduction of mandatory environmental criteria, but also suggest their selective implementation. Additionally, recommendations on more efficient sustainability management have been provided.

Keywords: circular economy; managing sustainability; defence sector; green public procurement

Ozelenjavanje javne nabave u obrambenom sektoru: komparativna analiza prije i nakon uvođenja obveznih ekoloških kriterija u Hrvatskoj

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Sažetak

Rad analizira primjenu zelenih kriterija u postupcima javne nabave Ministarstva obrane Republike Hrvatske tijekom 2024. i 2025. godine, tj. prije i nakon uvođenja obvezne Zelene javne nabave. Cilj istraživanja bio je ispitati u kojoj je mjeri regulatorna promjena dovela do mjerljivih promjena u realiziranim nabavama naručitelja te procijeniti ulogu upravljačkih napora u procesu prelaska na zelenu nabavu. Istraživanje je provedeno korištenjem mješovitog metodološkog okvira. Za analizu relevantnih znanstvenih i regulatornih radova primijenjene su kvalitativne metode. U nastavku, kvantitativne metode, uključujući deskriptivnu statistiku i analizu prije i poslije, korištene su za analizu javno dostupne dokumentacije s Elektroničkog oglasnika javne nabave Republike Hrvatske. Postupci nabave kodirani su prema prisutnosti ekoloških kriterija kako bi se istražio broj i vrijednosni udio postupaka sa zelenim kriterijima u dvije promatrane godine. Rezultati pokazuju da u 2024. godini nijedan postupak nije zadovoljavao zelene kriterije, dok ih je u 2025. godini nekoliko zadovoljavalo. Takvi nalazi ukazuju na izravan učinak uvođenja obveznih ekoloških kriterija, ali i sugeriraju njihovu selektivnu provedbu. Temeljem rezultata istraživanja dane su preporuke za učinkovitije upravljanje održivošću.

Ključne riječi: kružno gospodarstvo, upravljanje održivošću, obrambeni sektor, zelena javna nabava

GREEN EDUCATION
ZELENO OBRAZOVANJE

Scientific publication trends in green education: A bibliometric analysis

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Abstract
This paper aims to examine the term “green education” by conducting a bibliometric analysis based on a search conducted in two databases, Scopus (n = 187) and Web of Science (n = 120), yielding 307 records in total. After duplicate removal, 210 records remained and were included in the final analysis. The findings indicate that green education is still expanding as annual growth rate of nearly 13%. With 598 authors contributing to 210 documents, there's a clear indication of a highly collaborative environment with 3,26 co-authors per document. The collection is primarily composed of articles (108), conference and proceedings papers (52) and books (38), indicating a focus on original research and conference presentations. An average of nearly 6 citations per document is a moderate level of impact. The findings also showed that China, Italy, USA and UK are the most productive countries on green education. The co-occurrence network displays a moderately dense structure, indicating a significant interconnectedness among the identified keywords. It clearly reveals a core-periphery structure dominated by two highly central and large nodes: green education and sustainable development.

Keywords: bibliometric analysis, green education, sustainable development.

Vegetation and ecological characteristics of the Mediterranean wetland Hutovo blato

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Abstract
Hutovo blato is a rare type of lake ecosystem on a limestone base formed by the influence of the fluvial dynamics of the Neretva River and the maritime climate. The high biodiversity, high rate of endemism, and the role of the wetland as a vital ornithological hub classify this area as a priority habitat within the broader framework of international protection of the European sub-Mediterranean. Research was conducted on the lakes Jamica, Londža, Škrka, Krupa, Matica Svitavska, Jelim, and Deran in the period from 2020 to 2025. The vegetation research conducted identified 17 plant communities classified into seven orders, four orders, and three classes: *Lemnetea*, *Potametea pectinati,* and *Phragmito australis-Magnocaricetea elatae*. Lake Škrka shows a higher affinity for salinity and dissolved substances than other locations, as well as a correlation with the presence of the species *Stuckenia pectinata*. Samples from Deran in seasons 3 and 4 were grouped specifically based on nitrogen content, which is highly correlated with *Hydrocharis morsus ranae*. Species of the genus *Potamogeton* and *Ranunculus aquatilis* positively correlate with phosphates from water and sediment.

Keywords: Hutovo blato, associations, ecosystem

Vegetacijske i ekološke značajke mediteranske močvare Hutovo blato

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Sažetak

Hutovo blato predstavlja rijedak tip jezerskog ekosustava na karbonatnoj podlozi, nastao utjecajem fluvijalne dinamike Neretve i maritimne klime. Velika bioraznolikost, visoka stopa endemizma te uloga močvare kao vitalnog ornitološkog čvorišta klasificiraju ovo područje kao prioritetno stanište unutar šireg okvira međunarodne zaštite europskog submediterana. Istraživanja su rađena na jezerima Jamica, Londža, Škrka, Krupa, Matica Svitavska, Jelim i Deran u period od 2020. do 2025. Provedenim vegetacijskim istraživanjima utvrđeno je 17 biljnih zajednica svrstanih u sedam sveza, četiri reda i tri razreda: *Lemnetea*, *Potametea pectinati* i *Phragmito australis-Magnocaricetea elatae.* Jezero Škrka pokazuje veći afinitet prema salinitetu i otopljenim tvarima za razliku od drugih lokacija kao i korelaciju s prisutnošću vrste *Stuckenia pectinata.* Uzorci s Derana u sezoni 3 i 4 grupirali su se specifično na temelju sadržaja dušika koji je u visokoj korelaciji s *Hydrocharis morsus ranae.*Vrste roda *Potamogeton* i *Ranunculus aquatilis* pozitivno koreliraju s fosfatima iz vode i sedimenta.

Ključne riječi: Hutovo blato, biljne zajednice, ekosustav

Non-native plants in the *Populetalia albae* Braun-Blanq. ex Tchou. 1948 communities along the Neretva River in Bosnia and Herzegovina

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Abstract
Non-native species are known to have significant effects on native species at local scales in many countries. The spread of non-native plants into native communities is a global issue and has been shown to result in major disruptions to communities, changes in ecological functioning, and species extinctions. In disturbed habitats, the key determinant of diversity is dominance by competitive invasive species regardless of their native or non-native origin. This study aimed to assess the contribution of nonnative species within the communities of the *Populetalia albae* order along the Neretva River. The investigation is focused in the area south of the city of Mostar (Bosnia and Herzegovina), including several localities in the Neretva River delta. Changes in the floristic composition and an increasing number of non-native species in these communities clearly indicate a strong influence of anthropogenic factors. The most frequent non-native species were *Artemisia annua*, *Ambrosia artemisiifolia*, *Xanthium strumarium*, *Broussonetia papyrifera*, *Rudbeckia hirta,* and *Ailanthus altissima.*

Keywords: the *riparian* plant *communities*, invasive species, disturbed habitats, NE Mediterranean

Alohtone biljke u zajednicama *Populetalia albae* Braun-Blanq ex Tchou 1948 duž rijeke Neretve u Bosni i Hercegovini

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Sažetak
Poznato je da alohtone biljne vrste imaju značajan utjecaj na autohtone vrste na lokalnoj razini u mnogim zemljama. Širenje alohtonih biljaka u autohtone zajednice globalni je problem i pokazalo se da rezultira velikim poremećajima u zajednicama, promjenama u ekološkom funkcioniranju i izumiranjem vrsta. U poremećenim staništima ključna odrednica raznolikosti je dominacija konkurentnih invazivnih vrsta bez obzira na njihovo autohtono ili alohtono podrijetlo. Cilj ovog istraživanja bio je procijeniti doprinos alohtonih vrsta unutar zajednica reda Populetalia albae uz rijeku Neretvu. Istraživanje je usmjereno na područje južno od grada Mostara (Bosna i Hercegovina), uključujući nekoliko lokaliteta u delti rijeke Neretve. Promjene u floističkom sastavu i sve veći broj alohtonih vrsta u tim zajednicama jasno ukazuju na snažan utjecaj antropogenih čimbenika. Najčešće alohtone vrste bile su *Artemisia annua, Ambrosia artemisiifolia, Xanthium strumarium, Broussonetia papyrifera, Rudbeckia hirta i Ailanthus altissima.*

Ključne riječi: priobalne biljne zajednice, invazivne vrste, poremećena staništa, sjeveroistočni Mediteran

Representation of content and learning outcomes related to the concept of forces in nature in the syllabi of Science and Science Methodology Courses

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Abstract
"Primary school as a whole-day school - a balanced, fair, efficient and sustainable education system" is an experimental programme in primary schools in the Republic of Croatia since 2023, which introduced a new subject Science in classroom teaching. The Science curriculum contains educational outcomes that previously did not appear in the subject Nature and Society, raising the question of their representation in the education of students in teacher education programmes. Therefore, this research analyses the representation of content and learning outcomes related to the concept of forces in nature in syllabi of science and science methodology courses at seven teacher education institutions. Through a qualitative analysis of the syllabi, the learning outcomes and content related to the aforementioned concepts are identified and analysed, with special attention given to their alignment with the educational outcomes of the Science Curriculum for grades 1–4 of primary school. The research provides insight into the representation of fundamental science concepts related to forces in initial teacher education programmes and the degree of their alignment with the curriculum expectations of primary school science education.

Keywords: whole-day school, science curriculum, forces in nature, learning outcomes, SINTEZA

Acknowledgement: This paper serves as a starting point for considering the need to align the content of science courses in teacher education study programmes and has been carried out within the framework of the institutional research project "Synergy of Technology and Science: STEM Education and Intelligent Methods – SINTEZA" (code 581-UNIOS-50) under the National Recovery and Resilience Plan of the Republic of Croatia, funded by the European Union – Next Generation EU.

Zastupljenost sadržaja i ishoda učenja povezanih s konceptom sila u prirodi u silabusima kolegija iz područja prirodoslovlja i metodike prirodoslovnih predmeta

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Sažetak

„Osnovna škola kao cjelodnevna škola: Uravnotežen, pravedan, učinkovit i održiv sustav odgoja i obrazovanja“ eksperimentalni je program u osnovnim školama u Republici Hrvatskoj od 2023. godine, a u okviru kojeg je uveden u razrednu nastavu novi predmet Prirodoslovlje. Kurikulum nastavnog predmeta Prirodoslovlje sadrži odgojno-obrazovne ishode koji se ranije nisu pojavljivali u nastavnom predmetu Priroda i društvo, što otvara pitanje njihove zastupljenosti u obrazovanju studenata na učiteljskim studijima. Stoga se u ovome istraživanju analizira zastupljenost sadržaja i ishoda učenja povezanih s konceptom sila u prirodi u silabusima kolegija iz prirodoslovlja i metodike prirodoslovnih predmeta na sedam učiteljskih studija. Kvalitativnom analizom silabusa identificiraju se i analiziraju ishodi učenja, kao i sadržaji vezani uz navedene koncepte, a posebna se pozornost posvećuje njihovoj usklađenosti s odgojno-obrazovnim ishodima Kurikuluma nastavnog predmeta Prirodoslovlje za 1.–4. razred osnovne škole. Istraživanje daje uvid u zastupljenost temeljnih prirodoznanstvenih koncepata povezanih sa silama u programima inicijalnog obrazovanja učitelja te u stupanj njihove podudarnosti s kurikulumskim očekivanjima osnovnoškolskog prirodoslovnog obrazovanja.

Ključne riječi: cjelodnevna škola, kurikulum prirodoslovlja, sile u prirodi, ishodi učenja, SINTEZA

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GREEN TECHNOLOGIES
ZELENE TEHNOLOGIJE

Integration of Ultrasound Pretreatment and Artificial Intelligence for Optimising Bioactive Compound Retention in Dried Apple

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Abstract

The integration of non-thermal technologies with artificial intelligence potentially can enable advanced optimisation of food processing systems. This study investigates ultrasound pretreatment combined with various AI-based modelling to improve the retention of bioactive compounds in dried apple slices. Ultrasound was applied using both bath and probe systems at amplitudes of 30% to 90% and treatment times of 30 min to 60 min. Experimental results showed a significant effect of ultrasound on total phenolic content, with the highest value (227.75 mg GAE/L) achieved using an ultrasonic bath at 30% amplitude for 60 min. Chlorophyll retention was higher at lower amplitudes, while carotenoids showed a slight increase at higher amplitudes, indicating compound-specific responses. ANOVA confirmed that treatment type and amplitude significantly affected phenolic content ($p = 0.016$). AI models (Random Forest) demonstrated strong predictive performance for phenolic content ($R^2 = 0.93$, RMSE = 6.8 mg GAE/L), enabling accurate prediction of process outcomes. PCA analysis explained over 80% of the total variance. A clear clustering of samples by ultrasound treatment type is observed, with probe-treated samples showing higher phenolic release and bath-treated samples showing better pigment preservation. The integration of ultrasound pretreatment with AI modelling provides an effective approach to multi-objective optimisation of drying processes, supporting the development of intelligent, adaptive food processing systems.

Keywords: ultrasound pretreatment, artificial intelligence, drying, apple, optimization

Microstructural effects on optical performance of a sustainable TiO_2-based toner in digital packaging printing

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Abstract
In light of the increasing demand for sustainable solutions in the packaging industry, this study evaluates the applicability of a white toner based on titanium dioxide (TiO_2) particles. In contrast to conventional mineral and polymer-based systems adapted for Inkjet technology, the research focuses on a material whose properties enable the simultaneous achievement of high optical efficiency and reduced environmental impact. The high refractive index of TiO_2 enables the desired optical properties to be achieved at minimal layer thicknesses, thereby reducing material consumption. In addition, the absence of migration and compatibility with recycling processes indicates its potential within the context of the circular economy and packaging safety. The scientific contribution of this paper lies in the systematic analysis of the relationship between toner microstructure and its functional properties. The correlation between particle-size distribution in the micrometer range, determined by a scanning electron microscope with an energy-dispersive X-ray detector (SEM-EDS system), and the optical performance of prints was investigated for three toners and two paperboard substrates (coated and uncoated). The results demonstrate that variations in granulometric characteristics directly influence light reflectance and print quality on black substrates, thereby quantitatively confirming the role of microstructure in optimizing white print performance. The findings further enable the definition of criteria for toner design and selection with respect to targeted optical and sustainability performance. The integration of optical measurements and morphological analysis provides deeper insight into material–substrate interactions and establishes scientifically grounded guidelines for the development and selection of sustainable printing materials in packaging applications.

Keywords: digital printing, TiO_2-based toner, sustainability, packaging products

Mikrostrukturni utjecaji na optičke performanse održivog TiO_2 tonera u ambalažnom digitalnom tisku

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Sažetak
U svjetlu rastućih zahtjeva za održivim rješenjima u ambalažnoj industriji, ovaj rad evaluira mogućnosti primjene bijelog tonera temeljenog na česticama titanijeva dioksida (TiO_2). Za razliku od konvencionalnih mineralnih i polimernih sustava prilagođenih Inkjet tehnologiji, istraživanje je usmjereno na materijal čija svojstva omogućuju istodobno postizanje visoke optičke učinkovitosti i smanjenog okolišnog opterećenja. Visok indeks loma TiO_2 omogućuje postizanje željenih optičkih svojstava pri minimalnim debljinama nanosa, čime se smanjuje potrošnja materijala. Dodatno, odsutnost migracije i kompatibilnost s procesima recikliranja potvrđuju njegov potencijal u kontekstu kružnog gospodarstva i sigurnosti ambalažnih materijala. Znanstveni doprinos rada temelji se na sustavnoj analizi odnosa između mikrostrukture tonera i njegovih funkcionalnih svojstava. Povezanost između distribucije veličine čestica u mikrometarskom području, određene skenirajućim elektronskim mikroskopom s energodisperzivnim detektorom rendgenskih zraka (SEM-EDS sustav), i optičkih performansi otiska ispitana je na trima tonerima i dvjema kartonskim podlogama (premazanoj i nepremazanoj). Rezultati pokazuju da varijacije u granulometrijskim karakteristikama izravno utječu na refleksiju svjetlosti i kvalitetu ispisa na crnim podlogama, čime se kvantitativno potvrđuje uloga mikrostrukture u optimizaciji bijelog ispisa. Dobiveni rezultati omogućuju definiranje kriterija za dizajn i odabir tonera s obzirom na ciljane optičke i održive performanse. Integracija optičkih mjerenja i morfološke analize omogućuje dublje razumijevanje interakcije materijala i podloge te uspostavlja znanstveno utemeljene smjernice za razvoj i izbor održivih tiskarskih materijala u ambalažnim primjenama.

Ključne riječi: digitalni tisak, toner na bazi TiO_2, održivost, ambalažni proizvodi

Optimization of innovative, safe, and eco-friendly extraction of golden samphire pigments

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Abstract

Golden samphire is one of the most common Mediterranean edible halophytes, well known for its richness in various bioactives. This study aimed to investigate ultrasound-assisted extraction (UAE, at amplitudes of 30, 50, and 70%), microwave-assisted extraction (MAE, at power levels of 300, 500, and 700 W), and accelerated solvent extraction (ASE, at temperatures of 70, 100, and 130 °C), to improve the recovery of pigments (carotenoids and chlorophylls) from golden samphire. The target compounds were determined by spectrophotometry and chromatography. It can be concluded that ASE proved to be the superior extraction method for chlorophylls, with pigment yields more than twice as high compared to the other methods. Increasing temperature significantly enhanced the extraction of chlorophyll a (14.4 µg/mL) and chlorophyll b (17.8 µg/mL), as well as increase in ultrasound amplitude and microwave power. However, regarding carotenoids, MAE at 500 W was found to be the most efficient extraction method (1.69 µg/mL). The obtained results confirm that extraction optimization is essential when isolating target compounds, representing an efficient approach for obtaining bioactive extracts with potential applications across various industries.

Keywords: *Limbarda crithmoides* (L.) Dumort.; carotenoids; chlorophyll; extraction; optimisation

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Book of Abstracts I *Knjiga sažetaka*
Presentations I *Priopćenja*

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Tailoring PBS/PHBV biopolymer blends for sustainable food packaging

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Abstract
The excessive production and accumulation of synthetic plastics have driven the development of biodegradable polymers as sustainable alternatives. However, the properties of biopolymers often require modification to enable their use in various applications, such as biodegradable food packaging, which has led to the development of biopolymer blends. Blends of poly(butylene succinate) (PBS) and poly(3-hydroxybutyrate-*co*-3-hydroxyvalerate) (PHBV) have shown adequate mechanical properties due to the high ductility of PBS, which can be compensate for the inherent brittleness of PHBV at mass fractions of up to 20 wt.%. Since these two polymers have been shown to be immiscible, their properties and miscibility can be improved using various additives, such as the chain extender Joncryl ADR. Joncryl ADR 4468 is an epoxy-functional chain extender commonly used to improve the compatibility of immiscible polymer blends through reactions with terminal groups of polymer chains. Such interactions can enhance interfacial adhesion, improve processability, and contribute to improved mechanical and barrier performance of the resulting materials. In this research, PBS/PHBV blends with ratios of 80/20, 85/15, and 90/10 were prepared and analysed. Differential scanning calorimetry (DSC) confirmed the immiscibility of the polymers, whereas tensile testing showed the most favourable elongation at break for the blend with an 85/15 ratio. Furthermore, this blend exhibited the lowest oxygen transmission rate (OTR) and water vapour transmission rate (WVTR) among the investigated blends. Based on these results, the PBS/PHBV blend with a ratio of 85/15 was selected for further modification, incorporating Joncryl ADR at concentrations of 1, 3, and 5 wt.% to improve blend compatibility while maintaining favourable mechanical properties and potentially reducing gas permeability, which is a key requirement for food packaging materials. The resulting blends were further analysed through DSC, thermogravimetric analysis (TGA), tensile testing, OTR, WVTR, and scanning electron microscopy (SEM). The obtained results highlight the potential of Joncryl-modified PBS/PHBV blends for developing sustainable food packaging materials.

Keywords: biodegradability, poly(butylene succinate) (PBS); poly(3-hydroxybutyrate-*co*-3-hydroxyvalerate) (PHBV); Joncryl ADR 4468, biopolymer blends

3D-Printed Functional Foods from Cornelian Cherry: Impact of Cultivars and Hydrocolloids on Bioactive Properties

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Abstract
Cornelian cherry (*Cornus mas* L.) is a traditional fruit species that remains insufficiently explored despite its strong bioactive potential. Interest in the development of new functional foods from cornelian cherry cannot overlook 3D printing (3DP) as a sustainable technology, as it enables innovative formulation, and the creation of customized products with enhanced nutritional value and reduced environmental impact. This study investigates the potential of cornelian cherry as a raw material for the development of functional foods using 3DP. Three cultivars (Schönbrunner Gourmet Dirndl, Kasenlaker, and Panchevar) were combined with different hydrocolloids (wheat starch, guar gum and gum arabic) to produce 3D-printed snacks. The samples were evaluated for the content of bioactive compounds and antioxidant capacity. The results indicated that cultivars richer in bioactive compounds exhibited higher antioxidant activity. Hydrocolloids significantly influenced the stability of bioactive compounds, with gum arabic showing a slightly more favorable effect in preserving certain compounds. Although some reduction in anthocyanin stability was observed during 3DP, cornelian cherry demonstrated strong potential for the development of innovative functional products. In conclusion, cornelian cherry has strong potential for the development of functional products via 3DP due to its high content of bioactive compounds and antioxidant capacity.

Keywords: Cornelian cherry, 3D food printing, functional foods, bioactive compounds, antioxidant activity

GREEN TRANSPORT
ZELENI TRANSPORT

Scenarios for increasing electric vehicle adoption and their impact on the existing electric grid

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Abstract
At the moment, with gas prices rising sharply, there is also a possibility of restrictions on the use of internal combustion vehicles in Europe. Transport in modern times is crucial to the community; people can get to work, buy groceries, fulfill obligations, etc. One option is to increase transport with sustainable vehicles and alternative fuels. We conducted research on different scenarios of transitioning to electric, hybrid, and plug-in hybrid vehicles in the H2RES energy system modeling software. Because of the faster transition than the adoption of electrical energy systems, we are considering bidirectional energy flow, vehicle-to-grid. Different scenarios were used depending on different levels of renewable resources and the number of vehicles.

Keywords: green transportation, electric vehicles, vehicle-to-grid

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Reduction of the collection route length for ordinary letter mail through the integration of parcel lockers and mailboxes

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Abstract
Although only about 4% of all ordinary letter-mail items are collected via postal mailboxes, this still amounts to approximately four million such items. However, the number of postal mailboxes has been decreasing each year, primarily due to declining usage, which in turn reduces accessibility and further diminishes the attractiveness of the service. In parallel, parcel lockers have been emerging within the postal network, with their popularity, coverage, and application steadily increasing. The central idea of this study stems from integrating the parcel locker network with the postal mailbox network by extending the functionality of parcel lockers. Such integration would reduce the number of collection points within the postal network and, consequently, the total route length, leading to lower energy consumption, reduced traffic congestion (particularly in urban areas), and decreased emissions of harmful pollutants. At the same time, postal service providers would reduce operational costs and establish a network better aligned with user needs. This issue is particularly relevant for universal postal service providers (in the Republic of Croatia, this is Hrvatska pošta d.d.), both within Croatia and globally. The paper proposes potential redesigns of parcel lockers and the postal mailbox network. Special emphasis is placed on the specific characteristics of urban and rural contexts, where different selection criteria must be applied. By enabling parcel lockers to assume the function of accepting ordinary letter-mail items, a certain number of postal mailboxes could be removed without compromising service quality—indeed, potentially improving it, as parcel lockers are typically located in more accessible locations than many existing postal mailboxes.

Keywords: parcel locker, mailbox, mail, optimisation

Smanjenje puta ophodnje prikupa običnih pismovnih pošiljaka integracijom paketomata i poštanskih sandučića

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Sažetak
Iako se putem poštanskih sandučića prikupi tek oko 4% ukupnih običnih pismovnih pošiljaka još uvijek se radi o oko 4 miliona takvih pošiljaka. No, broj poštanskih sandučića svake se godine smanjuje prvenstveno zbog sve manje upotrebe što dovodi do smanjenja dostupnosti te dodatnom smanjenju atraktivnosti usluge. Paralelno, u poštanskoj mreži se pojavljuju paketomati čija je popularnost, rasprostranjenost i primjena sve veća. Temeljna ideja rada proizlazi iz integracije mreže paketomata i mreže poštanskih sandučića proširenjem funkcionalnosti paketomata. Time bi se smanjio broj ophodnih točaka poštanske mreže, a onda i ukupna duljina puta što posljedično dovodi do smanjenje potrošnje energije, prometnih zagušenja (pogotovo u gradovima), smanjenja emisije štetnih tvari i sl. Istovremeno, davatelj poštanskih usluga smanjuje operativne troškove i uspostavlja mrežu prilagođeniju korisnicima. Pri tome je ovaj problem primjenjiv samo za davatelje univerzalne poštanske usluge (u Republici Hrvatskoj je to Hrvatska pošta d.d.) kako u Republici Hrvatskoj, ali i svugdje u svijetu. U radu se navode prijedlozi mogućih redizajna paketomata te mreže poštanskih sandučića. Posebno se ističu specifičnosti situacija u urbanim područjima i u ruralnim (potrebna je prilagodba kriterija odabira). Kako bi paketomati preuzimali funkcionalnost prijma običnih pismovnih pošiljaka određeni broj poštanskih sandučića bi se mogao ukinuti, a da se kvaliteta usluge ne smanji, naprotiv (paketomati su obično na dostupnijim lokacijama od mnogih postojećih poštanskih sandučića).

Ključne riječi: paketomat, poštanski sandučić, obična pismovna pošiljka, optimizacija

MANAGEMENT OF NATURAL PROTECTED AREAS
UPRAVLJANJE ZAŠTIČENIM PODRUČJIMA PRIRODE

Freshwater fish communities and management of protected areas: a case study from a Natura 2000 site in Northeastern Italy

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Abstract
Protected areas have a central role in conservation management, especially for freshwater fish which are heavily threatened nowadays, and anthropogenic impact can affect these areas, threatening the most delicate species. In this study, we analyzed the fish community within the Chiarò di Cialla Creek (Northeast Italy), included in the Special Area of Conservation (SAC IT3320041). Electrofishing activities were performed within the SAC during 2023-2024, while hydrological characterization was led. Main impacts were recorded and the Riverine Functionality Index (IFF) was used to asses the watercourse functionality. Our results highlight that the investigated creek is a biodiversity hotspot, hosting several species of community interest (*Barbus plebejus*, *Lampetra zanandreai*, *Cobitis bilineata*, *Protochondrostoma genei*, *Telestes muticellus*, and the crayfish *Austropotamobius pallipes*). Among the impacts, riverbank vegetation cutting, wastewater discharge spots and intensive agriculture were observed, with consequences on the riverine functionality, which appear compromised especially in the downstream watercourse stretches. However, proper management can help in biodiversity conservation and our results represent a pivotal source of information. In particular, the cutted vegetation (branches often leaved within the riverbed) can represent a refuge (when properly managed), providing shading and a shelter zones from predators for small specimens.

Keywords: fish community, riverine ecosystems, Natura 2000 network, management, anthropogenic impacts

Interaction of protected piscivorous species with aquaculture and fisheries

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Abstract
The management of protected piscivorous (fish-eating) organisms, such as birds and marine mammals, presents a complex ecological issue involving the blance of the protection of predators, and the sustainable management of farmed aquatic organisms and/or wild fish stocks. These predators can cause significant damage to fish farms either directly or indirectly. Direct damage occurs when they kill and eat, or seriously injure aquatic organisms, or when they damage fishing gears. Indirect damage is highly variable and includes non-lethal injuries to fish, chronic stress and susceptibility to diseases, reduced growth, lower feed conversion efficiency, and transmission of pathogens such as bacteria, viruses, and parasites. Economic losses caused by piscivorous predators are strongly affecting production profitability, and breeders and fishermen apply various protection measures, but in a large number of cases they have not proven to be effective. Although protected fish-eating birds, especially cormorants, cause damage to various fish farms and wild fish populations, this problem is most evident in carp ponds included in the Natura 2000 ecological network. The recognition of this problem by the legislative bodies led to the adoption of regulations related to the allocation of state aid for damage caused by protected predators in carp ponds. On the other hand, in marine fisheries, damage caused by protected marine mammals (dolphins) is recognized, and regulations regarding State aid for damage caused by protected marine mammals (dolphins) have been adopted. In this review, possible protection measures for farmed aquatic organisms and wild fish stocks are discussed, as well as the impact of protected aquatic organisms on biodiversity.

Keywords: predation damages, cormorants, dolphins, nature conservation, biodiversity

Investment in the environmental protection and energy efficiency fund in the implementation of priority invasive alien species (IAS) population control projects

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Abstract
Invasive Alien Species (IAS) are often accidentally or deliberately introduced into the habitat. Apart from native species and habitats, IAS can also have a direct impact on human health. They have a detrimental effect on biodiversity and related ecosystem services, causing deleterious economic impacts in the introduced area. To reduce the negative impacts IAS have on biodiversity and to meet strategic goals and legislative obligations at the national and EU level, the Ministry of Environmental Protection and Green Transition (MEPGT), in cooperation with the Environmental Protection and Energy Efficiency Fund (EPEEF), is implementing a project contributing to the control of priority IAS populations in Croatia in certain areas. The threat level to certain strictly protected species and areas in the ecological network by IAS and the necessary urgency of action were factored in. To this end, EPEEF launched public calls providing funds for priority IAS population control projects to reduce their impact on native species and habitats. Besides population control, ecosystem restoration was carried out in some locations as a measure supporting the prevention of recolonisation following eradication activities. Through the implementation of these pilot projects, risks and economic viability of priority IAS population control and ecosystem restoration measures are evaluated, and their effectiveness is monitored.

Keywords: alien invasive species, IAS, IAS eradication, ecosystem restoration

Ulaganje Fonda za zaštitu okoliša i energetsku učinkovitost u provedbu projekata kontrole populacije prioritetnih stranih invazivnih vrsta IAS

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Sažetak
Strane invazivne vrste (*Invasive Alien Species*, IAS) su često slučajno ili namjerno unesene u stanište. Osim na zavičajne vrste i staništa, IAS mogu imati i izravan utjecaj na ljudsko zdravlje. Negativno utječu na bioraznolikost i povezane usluge ekosustava, pričinjavaju ekonomsku štetu na području na koje su unesene. Kako bi se smanjili negativni učinci koje IAS imaju na bioraznolikost te ispunili strateški ciljevi i zakonodavne obveze na nacionalnoj i EU razini, Ministarstvo zaštite okoliša i zelene tranzicije (MZOZT) u suradnji sa Fondom za zaštitu okoliša i energetsku učinkovitost (FZOEU) provode projekt koji doprinosi kontroli populacija prioritetnih IAS u RH na određenim područjima. Uzeta je u obzir razina ugroženosti pojedinih strogo zaštićenih vrsta te područja ekološke mreže od strane IAS te neophodna hitnost djelovanja. S tim ciljem, FZOEU je objavio javne pozive i osigurao sredstva za projekte kontrole populacija prioritetnih IAS kako bi se umanjio njihov utjecaj na autohtone vrste i staništa. Uz kontrolu populacija na nekim lokacijama provodila se i obnova ekosustava kao mjera za potporu sprječavanju ponovne invazije nakon aktivnosti iskorjenjivanja. Istovremeno se kroz provedbu ovih pilot projekata vrednuju rizici i isplativost mjera kontrole populacija prioritetnih IAS i obnove ekosustava te prati njihova učinkovitost.

Ključne riječi: strane invazivne vrste, IAS, uklanjanje IAS, obnova ekosustava

RENEWABLE ENERGY
OBNOVLJIVI IZVORI ENERGIJE

Integration potential of thin films in the Croatian renewable energy systems

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Abstract
Croatia is undergoing an accelerated energy transition, with solar photovoltaic (PV) capacity exceeding 1.3 GW and wind power reaching 1.28 GW. However, to improve the qualitative aspect of the national energy portfolio, broader integration of thin-film technologies is essential. This transformation requires increased funding for nanotechnologies that bridge applied research and industrial scale-up, such as chemical deposition (e.g., roll-to-roll colloidal methods) and physical deposition (e.g., additive manufacturing like spark plasma deposition). While the market currently relies on silicon-based PVs and geared wind turbines, emerging thin-film PVs offer vital alternatives for specialized applications and even for solar collectors. The deposition advancements enable new PV thin films characterized by lightweight and flexibility, and reduce costs associated with materials and lifecycle. Furthermore, permanent magnets surface-treated with amorphous metal films provide a robust solution for direct-drive gearless wind turbines. The deposition advancements enable new permanent magnets characterized by corrosion-resistant surface coatings, enhancing lifecycle considerations while reducing costs associated with transport, installation and maintenance. Therefore, greater utilization of thin-film technologies in both PV and wind energy sectors will boost system sustainability and minimize environmental footprints. This strategic shift directly supports Croatia's 2030 decarbonization targets and long-term energy independence.

Keywords: spark plasma thin film deposition; sol-gel spin coating; thin-film photovoltaics; permanent magnets for wind turbines; renewable energy conversion

SUSTAINABLE TOURISM
ODRŽIVI TURIZAM

Zero Waste as a Sustainable Development Model in Fine Dining Restaurants

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Abstract
The zero-waste concept is becoming an increasingly important model of sustainable business practice in the fine dining sector, where high gastronomic quality is increasingly associated with environmental responsibility and efficient resource management. The aim of this paper is to analyse the application of zero-waste principles in haute cuisine restaurants and to explore their impact on business sustainability, food waste reduction, and customer perception. The paper discusses strategies such as the use of local and seasonal ingredients, whole-ingredient utilisation (nose-to-tail and root-to-stem approaches), composting, procurement optimisation, and the creative transformation of food leftovers into new gastronomic products. Special emphasis is placed on the role of chefs and staff education in the implementation of sustainable practices. Previous research indicates that the zero-waste concept can help reduce operational costs, strengthen restaurant identity, and increase consumer awareness of sustainable gastronomy. In conclusion, the zero-waste approach represents an important direction in the development of modern fine dining by integrating gastronomic innovation with the principles of sustainable development and the circular economy.

Keywords: zero waste, fine dining, sustainable gastronomy, food waste, circular economy

Zero-waste kao model održivog razvoja u fine dining restoranima

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Sažetak
Koncept *zero-waste* postaje sve značajniji model održivog poslovanja u sektoru *fine dininga*, gdje se visoka gastronomska kvaliteta sve češće povezuje s ekološkom odgovornošću i racionalnim upravljanjem resursima. Cilj ovog rada je analizirati primjenu principa *zero-waste* pristupa u restoranima visoke gastronomije te istražiti njihov utjecaj na održivost poslovanja, smanjenje otpada od hrane i percepciju gostiju. U radu se razmatraju strategije poput korištenja lokalnih i sezonskih namirnica, cjelovite iskoristivosti sirovina (*nose-to-tail* i *root-to-stem* pristup), kompostiranja, optimizacije nabave i kreativne transformacije ostataka hrane u nove gastronomske proizvode. Poseban naglasak stavljen je na ulogu chefova i edukacije osoblja u implementaciji održivih praksi. Rezultati dosadašnjih istraživanja ukazuju da *zero-waste* koncept može doprinijeti smanjenju troškova poslovanja, jačanju identiteta restorana i povećanju svijesti potrošača o održivoj gastronomiji. Zaključno, *zero-waste* pristup predstavlja važan smjer razvoja suvremenog *fine dininga* te integrira gastronomske inovacije s načelima održivog razvoja i kružnog gospodarstva.

Ključne riječi: *zero-waste*, *fine dining*, održiva gastronomija, otpad od hrane, kružno gospodarstvo

WASTE MANAGEMENT
GOSPODARENJE OTPADOM

Impacts of biowaste prevention measures in public institutions: Quantitative analysis (2023–2025)

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Abstract
Based on the EU and Croatian legislative framework, including Directives (EU) 2018/851 and (EU) 2018/850, and the Waste Management Act, this paper analyses the effectiveness of biowaste prevention measures implemented by the Environmental Protection and Energy Efficiency Fund in public institutions across Croatia during 2023–2025. The analysis is based on aggregated data regarding input–output flows of biowaste processed in devices of varying capacity, alongside number of users, sectoral distribution, and financial investments. Biowaste includes food and kitchen waste generated by public institutions' activities, where the treatment output is not marketed but used at the place of origin. Efficiency is assessed by applying a reduction factor, the degree of biowaste mass reduction, and relative efficiency per user. Results demonstrate high treatment efficiency, with a significant reduction in biowaste mass and a stable decreasing trend in waste quantities over the observed period. Despite high operational efficiency at the individual user level, the findings highlight the need for a more systematic approach to measure implementation. Specifically, expanding user coverage is identified as a key determinant of overall impact. This is crucial for achieving substantial reductions in total biowaste at the national level, in line with the principles of the circular economy.

Keywords: biowaste, food waste, waste prevention, waste management, circular economy

Učinci mjera sprječavanja nastanka biootpada u javnim ustanovama: kvantitativna analiza (2023.-2025.)

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Sažetak
Utemeljen u zakonodavnom okviru Europske unije i Republike Hrvatske, uključujući Direktivu (EU) 2018/851, Direktivu (EU) 2018/850 te Zakon o gospodarenju otpadom, rad analizira učinkovitost mjera sprječavanja nastanka biootpada koje je proveo Fond za zaštitu okoliša i energetsku učinkovitost u javnim ustanovama na području Republike Hrvatske u razdoblju 2023.–2025. Analiza se temelji na agregiranim podacima o ulaznim i izlaznim tokovima biootpada u uređajima različitog kapaciteta, broju korisnika, sektorskoj raspodjeli i financijskim ulaganjima. Biootpad uključuje otpad od hrane te kuhinjski otpad nastao u djelatnosti javnih ustanova, pri čemu se produkt obrade ne stavlja na tržište, već koristi na mjestu nastanka. Učinkovitost je procijenjena primjenom redukcijskog faktora, stupnja smanjenja mase biootpada i relativne učinkovitosti po korisniku. Rezultati ukazuju na visoku učinkovitost obrade, uz značajno smanjenje mase biootpada i stabilan trend smanjenja količina biootpada kroz promatrano razdoblje. Unatoč visokoj operativnoj učinkovitosti na razini pojedinačnih korisnika, rezultati ukazuju na potrebu sustavnijeg pristupa implementaciji mjera. Posebno se ističe proširenje obuhvata korisnika kao ključna determinanta ukupnog učinka, kako bi se u skladu s načelima kružnog gospodarstva ostvario značajniji doprinos smanjenju ukupnih količina biootpada na nacionalnoj razini.

Ključne riječi: biootpad, otpad od hrane, prevencija otpada, gospodarenje otpadom, kružno gospodarstvo

From waste tires to functional carbon materials: Effect of chemical activation and pyrolysis conditions on structure and properties

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Abstract
The increasing accumulation of end-of-life tires (ELTs) represents a significant environmental challenge, necessitating the development of sustainable strategies for their valorization into high-value materials. In this study, ELT was converted into functional carbon materials through a combined approach involving chemical pretreatment, activation with KOH and $ZnCl_2$ and controlled pyrolysis at different temperatures. The structural evolution of the obtained materials was systematically investigated using UV–Vis, Raman and XRD, complemented by porosimetry (BET) analysis. BET analysis indicated a strong influence of the activating agent, with $ZnCl_2$-activated samples exhibiting higher specific surface areas (above 500 m^2/g) compared to KOH-activated materials (around 310 m^2/g). Raman spectroscopy demonstrated the presence of characteristic D- and G-bands, indicating the formation of sp^2-hybridized carbon with a significant degree of structural disorder. The relatively high I_D/I_G ratio suggests a defect-rich structure composed of small graphitic domains. XRD patterns showed broad 002 and 100 reflections, confirming a predominantly disordered, turbostratic carbon structure. The results demonstrate that both the nature of the activating agent and the pyrolysis temperature play a key role in tailoring material properties, yielding defect-engineered carbons suitable for adsorption, catalysis and environmental applications.

Keywords: waste tire valorization, activated carbon materials, chemical activation, pyrolysis, turbostratic carbon

Impact of fast fashion on textile waste: Citizens' perceptions, sustainable practices, and comparative analysis with global trends

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Abstract

In modern society, textile waste is an increasingly prominent environmental problem that directly affects climate change and the sustainability of natural resources. Growing production and consumption within the framework of fast fashion contribute to the creation of huge amounts of waste, much of which ends up in landfills or is incinerated, leading to air, soil, and water pollution and increased greenhouse gas emissions. This paper is based on research into the global and national consequences of inefficient textile waste disposal, with particular emphasis on fast fashion and the situation in the Republic of Croatia. It analyses the amount of waste generated by the textile industry, how it is managed, and which sustainable practices are present globally and applicable in the Croatian context. The paper employs several scientific methods: analysis, synthesis, induction, deduction, generalization, proof, and survey. The aim is to demonstrate how textile waste represents a modern threat, while also offering concrete proposals for reducing negative impacts – through changes in consumer habits, education, legislative measures, and the implementation of sustainable models of textile production and disposal. As part of the research, a survey was conducted in the Republic of Croatia, including citizens of different age groups, to examine their attitudes, habits, and level of awareness regarding the impact of fast fashion on the environment. The survey results were statistically processed, and the data obtained were presented and compared with practices from other countries. The conclusions from the statistical analysis generally show a significant connection between awareness and concern for environmental protection, which is associated with more positive attitudes towards sustainability, but behavior largely remains within previous patterns. It should be emphasized that the Republic of Croatia lags in effective textile waste management, and it is necessary to develop measures to reduce it, including education and separate collection systems.

Keywords: textile waste, fast fashion, sustainability, public perception

Utjecaj brze mode na tekstilni otpad: Percepcije građana, održive prakse i komparativna analiza s globalnim trendovima

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Sažetak

U suvremenom društvu tekstilni otpad predstavlja sve izraženiji ekološki problem koji izravno utječe na klimatske promjene i održivost prirodnih resursa. Rastuća proizvodnja i potrošnja u okviru brze mode pridonose stvaranju ogromnih količina otpada, od čega veliki dio završava na odlagalištima ili se spaljuje, što dovodi do zagađenja zraka, tla i voda te povećane emisije stakleničkih plinova. Tema ovog rada temelji se na istraživanju globalnih i nacionalnih posljedica ne učinkovitog zbrinjavanja tekstilnog otpada, s posebnim naglaskom na „brzu modu“ i stanje u Republici Hrvatskoj. Analizirano je koliko otpada generira tekstilna industrija, kako se njime upravlja te koje su održive prakse prisutne u svijetu s primjenom u hrvatskom kontekstu. Rad koristi više znanstvenih metoda: analizu, sintezu, indukciju, dedukciju, generalizaciju, dokazivanje i anketiranje. Cilj rada je prikazati kako tekstilni otpad predstavlja modernu ugrozu, ali i ponuditi konkretne prijedloge za smanjenje negativnih utjecaja, kroz promjenu potrošačkih navika, edukaciju, zakonodavne mjere i implementaciju održivih modela tekstilne proizvodnje i zbrinjavanja. U okviru rada provedeno je anketno istraživanje na području RH koje je uključilo građane različitih dobnih skupina, kako bi se ispitali njihovi stavovi, navike i razina svijesti o utjecaju brze mode na okoliš. Rezultati istraživanja su statistički obrađeni, a dobiveni podaci prikazani su i komparirani s praksama iz drugih zemalja. Zaključci iz statističke analize generalno pokazuju značajnu povezanost svijesti i zabrinutosti prema očuvanju okoliša, što je povezano s pozitivnijim stavovima o održivosti no ipak ostaje sve u sustavu ponašanja dosadašnjih obrazaca. Pri tome valja naglasiti da Republika Hrvatska zaostaje u učinkovitom gospodarenju tekstilnim otpadom te je potrebno razviti mjere za njegovo smanjenje, uključujući edukaciju i sustave odvojenog prikupljanja.

Ključne riječi: tekstilni, otpad, brza moda, održivost, percepcija javnosti

WATER AND WASTEWATER TREATMENTS
PRERADA I PROČIŠĆAVANJE VODA

Iron-modified sunflower seed husk biochar for arsenate removal: Adsorption mechanism and surface characterisation

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Abstract
This study focuses on arsenate (As(V)) adsorption onto iron-modified biochar derived from sunflower seed husks (FeSUN). Adsorption mechanisms and physicochemical characteristics of novel biochar were revealed through comprehensive characterisation (BET, FESEM-EDX, pH_{pzc}, FTIR, XRD and XPS). FeSUN exhibited a heterogeneous, porous structure, while structural analysis revealed an amorphous carbon framework with embedded crystalline iron oxides. BET analysis, before and after As(V) adsorption, showed a reduction in specific surface area and pore volume which indicated partial pore blocking, suggesting effective retention of As(V) within the biochar matrix. Elemental analysis confirmed successful As(V) uptake, accompanied by changes in Fe and O content, pointing to the involvement of Fe - based active sites. The fact that FeSUN had low pH_{pzc} (2.1) and predominantly negatively charged surface, but, despite that, showed high As(V) removal efficiency, indicated that adsorption was not primarily governed by electrostatic attraction. Instead, inner-sphere complexation might be the dominant adsorption mechanism. FTIR and XPS analyses confirmed strong surface complexation, including Fe-O-As bond formation and shifts in Fe and O binding energies, indicating inner-sphere complexation via ligand exchange with surface hydroxyl groups. Overall, FeSUN demonstrated strong affinity and promising potential for arsenic removal from water systems.

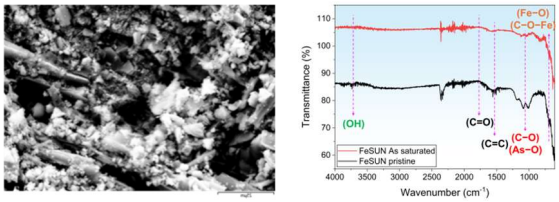

Figure 1. (left) SEM micrographs of As(V) saturated FeSUN and (right) FTIR spectrums for FeSUN before and after adsorption

Keywords: green remediation, biochar physicochemical characteristics, groundwater treatment

Selection of A/O/A process configuration with endogenous denitrification for efficient C, N and P removal

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Abstract
In the anaerobic/oxic/anoxic (A/O/A) process with endogenous denitrification (ED), the anaerobic phase provides intracellular carbon storage for denitrification and phosphorus uptake, the oxic phase phosphorus uptake, nitrification and denitrification, and the anoxic phase endogenous denitrification. The A/O/A process configurations with endogenous denitrification were investigated: (i) A/O/A 2 h/3 h/3 h, at DO (dissolved oxygen) ≥ 2 mg/L and DO ~ 1 mg/L, at C/N 4 and 6, (ii) A/O/A 2 h/2 h/4 h, at DO ≥ 2 mg/L, at C/N 4 and 6. Each configuration was investigated during 30 days, at 30±2 mg NH_4-N/L in the influent and 3.0±0.2 g MLSS/L (Mixed Liquor Suspended Solids). Sodium acetate was used as a carbon source. The A/O/A process with endogenous denitrification in the 2h/3h/3h regime at DO ~ 1 mg/L is the most favorable of those investigated, and resulted in COD (chemical oxygen demand) removal efficiency of 92.7%, 100% NH_4-N removal, 98.8% total N removal and 83.3% P removal.

Keywords: process configuration, anaerobic/oxic/anoxic, nutrient removal

A multivariate statistical approach for process monitoring and parameter interdependency in textile wastewater treatment

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Abstract
This study explores how multivariate statistical methods can be used to better understand and monitor textile wastewater treatment. Textile wastewater is difficult to manage because its composition changes frequently and it often contains organic pollutants, salts and surfactants. The research was carried out using wastewater samples collected over one year from an industrial treatment plant connected to a textile facility. Several important water quality parameters were monitored, including chemical oxygen demand (COD), turbidity, chlorides, sulphates, nitrogen compounds, phosphates, phenols, and detergents. Pearson correlation analysis and multiple linear regression were used to examine how these parameters are related and whether some of them could help estimate organic load more quickly. The results show that statistical analysis can provide useful insight into the behavior of textile wastewater and support more effective process monitoring. This approach may help operators detect changes in wastewater quality earlier, improve treatment performance and manage industrial wastewater more sustainably.

Keywords: textile wastewater, Pearson correlation, multiple linear regression, process monitoring

Modification of lignocellulosic materials for wastewater treatment applications

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Abstract

Natural materials and by-products of the food industry, particularly lignocellulosic materials such as wood, straw, seeds, and various agricultural residues, have become the focus of contemporary research in the fields of adsorption processes and circular economy. Owing to their abundance, low cost, and renewable nature, these materials exhibit considerable potential for application in wastewater treatment processes. This paper presents the possibilities for modifying lignocellulosic materials with the aim of enhancing their adsorption properties and improving the efficiency of pollutant removal from wastewater. Although natural lignocellulosic materials offer numerous advantages, their pronounced hydrophilicity imposes certain limitations, including swelling, biodegradation, and reduced mechanical stability and durability during application. Modification of natural materials represents a key approach in modern engineering and industry, as it enables the alteration of their physical, chemical, and biological properties, thereby overcoming inherent drawbacks such as low mechanical strength and moisture sensitivity. Various modification methods aimed at improving the functional characteristics of lignocellulosic materials are reviewed, together with their applications in wastewater treatment and purification processes. The results of previous studies demonstrate that modified lignocellulosic materials exhibit enhanced adsorption performance and represent an environmentally friendly and sustainable alternative to conventional synthetic adsorbents. These materials show significant potential for the development of highly efficient wastewater treatment systems while simultaneously contributing to environmental protection and more efficient resource utilization.

Keywords: lignocellulosic materials, modification, food industry by-products, sustainable materials

Modificirani lignocelulozni materijali i njihova primjena u pročišćavanju otpadnih voda

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Sažetak

Prirodni materijali i nusproizvodi prehrambene industrije, posebice lignocelulozni materijali poput drva, slame, sjemenki i različitog poljoprivrednog otpada, predstavljaju važan fokus suvremenih istraživanja u području adsorpcijskih procesa i kružnog gospodarstva. Zbog svoje dostupnosti, niske cijene i obnovljivog karaktera, ovi materijali imaju značajan potencijal za primjenu u procesima pročišćavanja otpadnih voda. U ovom radu prikazane su mogućnosti modifikacije lignocelulozних materijala s ciljem poboljšanja njihovih adsorpcijskih svojstava i učinkovitosti uklanjanja onečišćivala iz otpadnih voda. Iako prirodni lignocelulozni materijali posjeduju brojne prednosti, njihova izražena hidrofilnost uzrokuje određena ograničenja, poput bubrenja, biološke razgradnje te smanjene mehaničke stabilnosti i trajnosti tijekom primjene. Modifikacija prirodnih materijala predstavlja ključan pristup u suvremenom inženjerstvu i industriji jer omogućuje promjenu njihovih fizikalnih, kemijskih i bioloških svojstava te prevladavanje inherentnih nedostataka, kao što su niska mehanička čvrstoća i osjetljivost na vlagu. U radu će biti prikazane različite metode modifikacije kojima se poboljšavaju funkcionalna svojstva lignocelulozних materijala, kao i njihova primjena u procesima obrade i pročišćavanja otpadnih voda. Rezultati dosadašnjih istraživanja potvrđuju da modificirani lignocelulozni materijali ostvaruju poboljšane adsorpcijske performanse te predstavljaju ekološki prihvatljivu i održivu alternativu konvencionalnim sintetskim adsorbensima. Navedeni materijali pokazuju značajan potencijal u razvoju visokoučinkovitih sustava za pročišćavanje otpadnih voda, uz istodoban doprinos zaštiti okoliša i učinkovitijem iskorištavanju resursa.

Ključne riječi: lignocelulozni materijali, modifikacija, nusproizvodi prehrambene industrije, održivi materijali

Multiscale visualisation of sewage sludge status in Serbia using artificial intelligence: Supporting circular economy and net-zero targets

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Abstract
Effective management of sewage sludge (SS) from wastewater treatment is crucial for environmental sustainability, biodiversity, and public health. Within the European Union, around 8.7 million tons of dry SS are generated annually and directed toward various valorisation pathways. In contrast, in Serbia, sewage sludge is still largely deposited in unsanitary landfills, which contributes to environmental degradation and greenhouse gas emissions. The paper proposes alternative concept in bioresource and wastewater management using integrated approach to SS valorization through biochar production, leveraging machine learning (ML) and artificial intelligence (AI) for process optimisation. Given that eutrophication-driven by excessive phosphorus (P) levels in water bodies-remains a widespread environmental issue, an innovative solution is needed to both mitigate P pollution and recover P as a valuable resource. Pyrolysis of SS into biochar offers a dual advantage: reducing disposal costs while creating an efficient filtration medium for phosphorus adsorption from wastewater. The resulting P-enriched biochar can subsequently be repurposed as a soil amendment. A key innovation of the concept presented in the paper is the use of AI-driven methods to enhance biochar production and performance. ML models will be employed to predict biochar yield and specific surface area, optimising adsorption capacity and ensuring the most effective feedstock selection. By integrating AI with environmental engineering, the concept enables an efficient and scalable approach to nutrient recovery from wastewater. Beyond technical advancements, new concepts will promote sustainable waste management practices in Serbia by demonstrating a cost-effective and eco-friendly circular economy approach.

Keywords: biochar production optimisation, machine learning, circular economy

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WATER MANAGEMENT
UPRAVLJANJE VODAMA

Application of the CWatM water balance model in the upper Sava pilot area

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Abstract
The "Danube Water Balance" project, implemented under the Interreg Danube Region Programme 2021–2027, aims to develop a harmonized approach to water balance modelling in transboundary river basins. Hrvatske vode and the Agencija Republike Slovenije za okolje apply the CWatM in the Upper Sava sub-basin upstream of Zagreb. Within the Upper Sava pilot area (12.319 km²), the water cycle is simulated at a daily time step, enabling the assessment of water availability and use. The model was calibrated and validated using hydrological station data from Croatia and Slovenia, with Kling–Gupta Efficiency (KGE) values ranging from 0.73 to 0.95, indicating very good agreement between observed and simulated data. Harmonization of methodologies across the Danube region represents a key step toward more reliable water resource management. Climate change is already affecting the hydrological cycle, particularly through reduced snow cover in alpine areas (such as Kranjska Gora) and mountainous regions (such as Medvednica), leading to altered runoff regimes (higher winter and lower spring flows), and indirectly impacting tourism by shortening the winter ski season. Consequently, the risk of extreme events, such as droughts and floods, is increasing, along with the need for advanced modelling as a tool for adaptation.

Keywords: CWatM, water balance, climate change, Upper Sava

Primjena modela vodne bilance CWatM u pilotnom području gornje Save

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Sažetak

Projekt „Dunavska vodna bilanca", u okviru programa Interreg Danube Region Programme 2021–2027, usmjeren je na razvoj zajedničkog pristupa modeliranju vodne bilance u prekograničnim riječnim slivovima. Hrvatske vode i Agencija Republike Slovenije za okolje primjenjuju model CWatM u podslivu Gornje Save uzvodno od Zagreba. Na pilot-području Gornje Save (12.319 km²) vodni ciklus simulira se u dnevnoj rezoluciji, uz procjenu dostupnosti i korištenja vodnih resursa. Model je kalibriran i validiran pomoću mjerenja s vodomjernih postaja u Hrvatskoj i Sloveniji, pri čemu vrijednosti KGE pokazatelja (0,73–0,95) ukazuju na vrlo dobro podudaranje modeliranih i izmjerenih podataka. Usklađivanje metodologija u dunavskoj regiji ključan je korak prema pouzdanijem upravljanju vodnim resursima. Klimatske promjene već utječu na vodni ciklus, osobito kroz smanjenje snježnog pokrivača u alpskim područjima (poput Kranjske Gore) i brdskim područjima (poput Medvednice), što dovodi do promjena režima otjecanja (povećani zimski i smanjeni proljetni protoci), a neizravno utječe i na turizam skraćivanjem zimske skijaške sezone. Posljedično raste rizik od ekstremnih događaja, poput suša i poplava, ali i potreba za naprednim modeliranjem kao alatom za prilagodbu.

Ključne riječi: CWatM, vodna bilanca, klimatske promjene, gornja Sava

Microplastics in drinking water: Findings from the Croatian karst pilot site within the Microdrink project

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Abstract
Project MicroDrink, implemented under the Interreg Danube Region Programme, is a transnational initiative designed to translate emerging EU legislation on microplastics monitoring in drinking water into practice. Throughout the project lifetime, 11 institutions from 8 countries applied a harmonized sampling and analysis approach, gathered and shared knowledge, and strengthened stakeholder capacity for microplastics monitoring in the Danube Region. Microplastics are polymer particles between 5 mm and 1 µm, increasingly recognized as contaminants of emerging concern, with potential environmental and public health implications. Despite growing evidence in surface and drinking water, data on their presence in groundwater remain scarce. To address this, a harmonized approach following methodology in Commission Delegated Decision 2024/1441, based on large-volume sampling (1000 L) using cascade filtration and 20 µm filters, was implemented at 9 pilots representing karst, intergranular, and surface water resources. Samples were analyzed using FTIR and Raman spectroscopy. In Croatia, sampling was conducted at Kupica spring, a typical karst aquifer. Detected particles were predominantly polyethylene and polypropylene in the 20 – 100 µm size category. Beyond occurrence data, MicroDrink generates insights into sampling logistics and existing sampling gaps, together with equipment types, availability and performance, and contamination control, supporting stakeholders' decision making and readiness for integration of microplastics monitoring into drinking water management.

Keywords: microplastics, drinking water, karst aquifer, Danube River Basin, harmonized approach

Mikroplastika u vodi za piće: rezultati istraživanja u okviru projekta MicroDrink na hrvatskoj krškoj pilot lokaciji

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Sažetak

Projekt MicroDrink, koji se provodi u okviru programa Interreg Danube Region, predstavlja transnacionalnu inicijativu usmjerenu na primjenu nove europske regulative o praćenju mikroplastike u vodi za piće u praksi. Tijekom trajanja projekta, 11 institucija iz 8 zemalja primjenjuje usklađen pristup uzorkovanju i analizi, prikuplja i razmjenjuje znanja te jača kapacitete dionika za praćenje mikroplastike u dunavskoj regiji. Mikroplastika, definirana kao čestice polimera veličine od 5 mm do 1 µm, sve češće se prepoznaje kao onečišćivalo s potencijalnim utjecajem na okoliš i zdravlje ljudi. Unatoč sve većem broju istraživanja u površinskim vodama i vodi za piće, podaci o prisutnosti mikroplastike u podzemnim vodama i dalje su vrlo ograničeni. Kako bi se taj nedostatak podataka smanjio, primijenjen je usklađen pristup u skladu s metodologijom iz Delegirane odluke Komisije 2024/1441, koji se temelji na uzorkovanju velikih volumena vode (1000 L) uz korištenje kaskadne filtracije i filtera od 20 µm. Uzorkovanje je provedeno na 9 pilot lokacija koje obuhvaćaju krške, međuzrnske i površinske vodne resurse, a uzorci su analizirani FTIR i Raman spektroskopijom. U Hrvatskoj je uzorkovanje provedeno na izvoru Kupice, koji predstavlja tipičan krški vodonosnik. Detektirane čestice pretežno su bile polietilen i polipropilen u rasponu veličina od 20 do 100 µm. Osim podataka o pojavnosti, projekt MicroDrink pruža uvid u logističke aspekte uzorkovanja te postojeće nedostatke u sustavu uzorkovanja, kao i u vrste opreme, njihovu dostupnost i učinkovitost te kontrolu onečišćenja, čime se podupire donošenje odluka i spremnost dionika za uvođenje praćenja mikroplastike u sustave upravljanja vodom za piće.

Ključne riječi: mikroplastika, voda za piće, krški vodonosnik, slijev rijeke Dunav, usklađeni pristup

SpongeCity Project - Dealing with the consequences of climate change in urban areas

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Abstract
Policies at the European, national, and regional-local levels, through strategies and implementing legislation, determine the framework for dealing with climate change, and international cooperation through European projects provides a very good environment for developing acceptable solutions. The EU Interreg project SpongeCity, in which Koprivničke vode participates, aims to innovate practical solutions for managing the water microcycle in the urban environment in the context of the harmful effects of climate change. It is conceptually based on natural hydrological processes and green-blue infrastructure. Compared to the usual practice of high-budget technical solutions for large-volume grey infrastructure, the basic idea is simple - to reduce the share of impervious surfaces and increase the retention capacity and (semi)permeable urban surfaces, with solutions such as: rain gardens, engineered green areas, green walls and roofs, retention channels and ponds, terraces, permeable surfaces and underground tanks for later use of water or management of infiltration into the underground. The benefits of such solutions are multiple: mitigating the consequences of heavy rainfall, increasing the precipitation infiltration balance, protecting water and other infrastructure and other facilities and buildings, preventing the emergence of urban heat islands, creating a greener and more pleasant living space, as well as financial savings through significantly lower investment and rehabilitation costs caused by urban flash floods.

Keywords: climate change, urban harmful consequences, SpongeCity concept

SpongeCity projekt - Suočavanje s posljedicama klimatskih promjena u urbanom prostoru

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Sažetak
Politike na europskoj, nacionalnoj i regionalno–lokalnoj razini, kroz strategije i provedbeno zakonodavstvo, određuju okvire suočavanja sa klimatskim promjenama, a međunarodna suradnja kroz europske projekte daje vrlo dobro okruženje za razvijanje prihvatljivih rješenja. EU Interreg projekt SpongeCity, u kojem sudjeluju Koprivničke vode, ima za cilj inovirati praktična rješenja upravljanja mikrociklusom vode u urbanoj sredini u kontekstu štetnih posljedica klimatskih promjena. Konceptualno se temelji na prirodnim hidrološkim procesima i zeleno – plavoj infrastrukturi. U odnosu na uobičajenu praksu visokobudžetnih tehničkih rješenja sive infrastrukture velikih volumena, osnovna ideja je jednostavna - smanjiti udio nepropusnih površina a povećati retencijski kapacitet i (polu)propusne urbane površine, rješenjima kao što su: kišni vrtovi, inženjerski dizajnirane zelene površine, zeleni zidovi i krovovi, retencijski kanali i jezerca, taracane, propusne površine i podzemni spremnici za kasniju upotrebu vode ili upravljanju infiltraciju u podzemlje. Dobrobiti takvih rješenja su višestruke: ublažavanje šetnih posljedica za vrijeme intenzivnih oborina, povećanje oborinske infiltracijske bilance, zaštita vodne i druge infrastrukture i drugih objekata i građevina, sprječavanje nastanka urbanih toplinskih otoka, zeleniji i ugodniji životni prostor, kao i financijska ušteda kroz značajno niže investicijske i sanacijske troškove uzrokovane štetama urbanih bujičnih poplava.

Ključne riječi: klimatske promjene, urbane štetne posljedice, SpongeCity koncept

STUDENT GREEN LAB
STUDENTSKI GREEN LAB

Removal of amoxicillin from aqueous solutions using $MgCl_2 \cdot 6H_2O$-activated buckwheat hull biochar

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Abstract
Pharmaceutical residues that persist in aquatic environments, even at very low concentrations, are of growing concern due to their long-term environmental effects and potential risks to human health. In this study, biochar derived from buckwheat hulls and chemically activated with $MgCl_2 \cdot 6H_2O$ was evaluated as a biosorbent for the removal of amoxicillin (AMX) from model solutions and synthetic wastewater. Batch experiments examined the effects of key parameters, including biosorbent concentration (2–12 g dm^{-3}), contact time (5–360 min), initial AMX concentration (5–25 mg dm^{-3}), and pH (2–12). The results showed that increasing the biosorbent concentration improved both AMX removal efficiency and biosorption capacity. Higher initial AMX concentrations enhanced AMX removal efficiency due to a stronger mass transfer driving force, while lower concentrations reduced removal efficiency. AMX removal was less effective in synthetic wastewater than in model solutions, due to the coexistence of wastewater constituents. Equilibrium data were well described by the Freundlich and Langmuir isotherm models, while adsorption kinetics followed a pseudo-second-order model. The findings demonstrate that $MgCl_2 \cdot 6H_2O$-activated buckwheat hull biochar is a promising and sustainable material for efficient AMX removal from aqueous systems.

Keywords: biosorbent, amoxicillin, buckwheat biochar, wastewater

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Nutritional and physiological determinants of equine welfare: The role of ration structure, feed categories, and body condition in the preservation of health and functional capacity

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Abstract
This paper examines feeding as a fundamental precondition of equine health, body condition, work capacity, and overall welfare, proceeding from the distinctive features of the horse's digestive system as a monogastric herbivore with a simple stomach and hindgut fermentation. The purpose of the paper was to determine how the selection, quality, quantity, and distribution of feedstuffs, as well as water provision, affect the preservation of welfare and the prevention of digestive and metabolic disorders. Methodologically, the paper was based on an analytical review of professional and scholarly literature in horse breeding, animal science, nutrition, and animal welfare, together with a comparative discussion of equine physiological specificities, the nutritional requirements of different categories of horses—including pregnant mares, lactating mares, young stock, stallions, and sport horses—and the effects of roughage and concentrate feeds. The analysis showed that pasture and high-quality hay constitute the basis of stable digestion, proper intestinal microflora, and satiety, whereas concentrate feeds should be added according to the animal's age, physiological status, workload, and body condition. Sudden dietary changes, deficiency or excess of crude fiber, moldy or contaminated feed, excessive starch intake, and inadequate pasture may contribute to colic, laminitis, diarrhea, constipation, poisoning, and reduced functional capacity. In conclusion, equine welfare requires individually adjusted, balanced, and hygienically appropriate feeding, continuous access to clean water, the gradual introduction of new feeds, regular assessment of body condition, and precise adaptation of rations to the actual needs of each animal in breeding and continuous daily care.

Keywords: equine feeding, equine welfare, roughage feeds, body condition, digestive and metabolic disorders

STUDENT GREEN LAB I *STUDENTSKI GREEN LAB*
Poster presentation I *Postersko priopćenje*

Nutritivno-fiziološke determinante dobrobiti konja: uloga strukture obroka, krmnih kategorija i tjelesne kondicije u očuvanju zdravlja i funkcionalne sposobnosti

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Sažetak
Rad razmatra hranidbu kao temeljnu pretpostavku zdravlja, tjelesne kondicije, radne sposobnosti i ukupne dobrobiti konja polazeći od posebnosti probavnoga sustava monogastričnoga biljojeda s jednostavnim želudcem i fermentacijom u stražnjem dijelu probavnoga trakta. Svrha je bila utvrditi kako odabir, kakvoća, količina i raspored krmiva te opskrba vodom utječu na očuvanje dobrobiti i prevenciju probavnih i metaboličkih poremećaja. Metodologija je stoga zasnovana na analitičkome pregledu stručne i znanstvene literature iz konjogojstva, zootehnike, hranidbe i dobrobiti životinja, uz komparativnu razradbu fizioloških posebnosti konja, nutritivnih potreba različitih kategorija grla, uključujući gravidne kobile, kobile u laktaciji, pomladak, pastuhe i sportske konje, te učinaka voluminoznih i krepkih krmiva. Analiza je pokazala da paša i kvalitetno sijeno čine osnovu stabilne probave, pravilne crijevne mikroflore i sitosti, dok se krepka krmiva trebaju dodavati prema dobi, fiziološkomu stanju, radnom opterećenju i kondiciji grla. Nagle promjene obroka, manjak ili višak sirovih vlakana, pljesniva ili onečišćena hrana, prekomjeran unos škroba i neadekvatna paša mogu pridonijeti kolikama, laminitisu, proljevima, opstipacijama, trovanjima i smanjenoj funkcionalnoj sposobnosti. Zaključuje se da dobrobit konja zahtijeva individualno uravnoteženu i higijensku hranidbu, stalnu dostupnost čiste vode, postupno uvođenje novih krmiva, redovitu procjenu tjelesne kondicije te preciznu prilagodbu obroka stvarnim potrebama svakoga grla u uzgoju i kontinuiranoj svakodnevnoj skrbi.

Ključne riječi: hranidba konja, dobrobit konja, voluminozna krmiva, tjelesna kondicija, probavni i metabolički poremećaji

Adsorption of CO and CO_2 gases on 2D indium

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Abstract
Indiene is a two-dimensional material composed of a single atomic layer of indium, which has attracted increasing interest due to its unique electronic properties and potential applications in nanoelectronics and gas sensing. The study focuses on the theoretical analysis of the interaction between indene and carbon monoxide (CO) and carbon dioxide (CO_2) molecules using density functional theory, implemented through the Quantum ESPRESSO software package. The results show that freestanding planar indiene in a hexagonal structure exhibits metallic behavior, as confirmed by the analysis of the electronic band structure and density of states, dominated by hybridized p orbitals around the Fermi level. The central part of the study includes geometric optimization and analysis of the electronic properties of indiene during the adsorption of CO and CO_2 molecules at different high-symmetry sites, considering both horizontal and vertical molecular configurations. It was found that gas adsorption induces structural changes, which in certain cases lead to local distortion of the indiene monolayer. Although the interactions are relatively weak, the adsorption of CO and CO_2 molecules results in changes in the electronic structure of the system, indicating the sensitivity of indiene to the presence of adsorbed molecules. Low adsorption energies suggest the reversibility of the process, which is desirable for gas sensor applications, with the possibility of further enhancement of properties through functionalization or external influences.

Keywords: indiene, density functional theory, sensor

Adsorpcija plinova CO i CO_2 na 2D indiju

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Sažetak
Indijen je dvodimenzionalni materijal sastavljen od jednog atomskog sloja indija, koji zbog svojih jedinstvenih elektronskih svojstava privlači sve veći interes za primjene u nanoelektronici i senzorici plinova. Fokus istraživanja je na teorijskoj analizi interakcije indijena s molekulama ugljikovog monoksida (CO) i ugljikovog dioksida (CO_2) primjenom teorije funkcionala gustoće, pomoću programskog paketa Quantum ESPRESSO. Rezultati pokazuju da se samostalni planarni indijen u heksagonalnoj strukturi ponaša kao metal, što je potvrđeno analizom elektronske strukture vrpci i gustoće elektronskih stanja, kojom dominiraju hibridizirane p orbitale oko Fermijeve energije. Središnji dio rada obuhvaća geometrijsku optimizaciju i analizu elektronskih svojstava indijena pri adsorpciji molekula CO i CO_2 na različitim visokosimetričnim položajima uz variranje horizontalnih i vertikalnih konfiguracija molekula. Utvrđeno je da adsorpcija plinova uzrokuje strukturne promjene, koje u određenim slučajevima dovode do lokalnog izobličenja jednosloja indijena. Iako su interakcije relativno slabe, adsorpcija molekula CO i CO_2 dovodi do promjena u elektronskoj strukturi sustava, što ukazuje na osjetljivost indijena na prisutnost adsorbiranih molekula. Niske energije adsorpcije upućuju na reverzibilnost procesa, što je poželjno za primjenu u senzorima plinova, uz mogućnost daljnjeg poboljšanja svojstava kroz funkcionalizaciju ili primjenu vanjskih utjecaja.

Ključne riječi: indijen, teorija funkcionala gustoće, senzor

Urban Dual: A new standard of sustainable and inclusive student housing in Zagreb

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Abstract
The *Urban Dual* project presents an innovative model of student accommodation in Zagreb that integrates affordability, sustainability, and an international orientation. The concept is based on a dual structure of supply, a "lower budget" wing with shared rooms and a "premium" wing with private rooms and en suite bathrooms, complemented by shared spaces that encourage social interaction and community, including kitchens, lounges, study rooms, and a gym. A strong emphasis is placed on environmentally sustainable solutions, including the use of solar panels, rooftop gardens, and hydroponic cultivation, contributing to the reduction of the ecological footprint and raising awareness of sustainable practices among students. Digitized management systems, 24/7 security, and integrated support for international students further enhance the user experience. As part of the project, a PESTLE analysis was conducted to identify external market and regulatory factors, with comparative insights from the international PBSA sector. In addition, primary quantitative research was carried out among 51 international Erasmus students in Croatia, showing that 72.5% prefer more affordable accommodation with shared spaces, while 56.9% express a preference for private rooms. Urban Dual differentiates itself through sustainability, a "community" concept, and adaptability to different financial capabilities, aiming to set a new standard in student housing.

Keywords: student housing, sustainability, international students, community, conceptual model

Urban Dual: Novi standard održivog i inkluzivnog studentskog smještaja u Zagrebu

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Sažetak
Projekt Urban Dual predstavlja inovativni model studentskog smještaja u Zagrebu koji integrira pristupačnost, održivost i internacionalnu orijentaciju. Koncept se temelji na dualnoj strukturi ponude, „lower budget“ krilu s dijeljenim sobama i „premium“ krilu s privatnim sobama i kupaonicama uz zajedničke prostore koji potiču društvenu interakciju i zajednicu (kuhinje, dnevni boravci, učionice, teretana). Poseban naglasak stavljen je na ekološki održiva rješenja, uključujući korištenje solarnih panela, krovnih vrtova i hidroponskog uzgoja, čime se doprinosi smanjenju ekološkog otiska i edukaciji studenata o održivim praksama. Digitalizirani sustavi upravljanja, 24/7 sigurnost i integrirana podrška stranim studentima dodatno unapređuju korisničko iskustvo. U sklopu projekta provedena je PESTLE analiza s ciljem razumijevanja vanjskih tržišnih i regulatornih čimbenika, uz komparativne uvide iz međunarodnog PBSA sektora. Također, provedeno je primarno kvantitativno istraživanje među 51 međunarodnim Erasmus studentom u Hrvatskoj, koje pokazuje da 72,5 % ispitanika preferira pristupačniji smještaj s dijeljenim prostorima, dok 56,9 % istovremeno izražava interes za privatne sobe. Urban Dual se diferencira kroz spoj održivosti, „community“ koncepta i prilagodbe različitim financijskim mogućnostima studenata, s ciljem postavljanja novog standarda studentskog smještaja.

Ključne riječi: studentski smještaj, održivost, međunarodni studenti, community koncept, dualni model

Dynamics of ground-level ozone and nitrogen oxides in relation to meteorological parameters in continental and coastal Croatia

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Abstract
Understanding the dynamics of ground-level ozone and nitrogen oxides is important for assessing air quality. This study analyzes the influence of meteorological parameters on variations in the concentrations of these pollutants using the example of Osijek (continental climate) and Rijeka (coastal area). The analysis included data collected from 2019 to 2023. Statistical data processing identified patterns in daily changes and the spatial distribution of pollution, depending on the flow of air masses. The research showed significant differences in the two observed areas. In Osijek, stable continental dynamics prevail, with a high correlation between ozone and temperature, and elevated nitrogen oxide levels are associated with traffic. In Rijeka, a more complex situation was recorded due to coastal circulation and orography. The results indicate frequent photochemical titration of ozone near emission sources, and the highest ozone concentrations on the coast are associated with the transport of air masses from the sea. Another role of wind speed was also determined: in the plain, it favors dispersion, and along the coast, it contributes to the transfer of secondary pollutants. The findings confirm that the geographical location and meteorological regimes significantly modify the atmospheric response to precursor emissions.

Keywords: ground-level ozone, nitrogen oxides, air quality, continental Croatia, coastal Croatia

Acknowledgments: This research was funded by the European Union-NextGenerationEU. Project "Advanced Interdisciplinary Approaches to Environmental Chemistry: From Materials to Sustainable Solutions for Pollution" (Grant number: 581-UNIOS-101).

Glucosinolate profiles of *Erysimum cheiri* and the endemic *Erysimum croaticum*

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Abstract
Glucosinolates (GSLs) are sulfur-containing specialized metabolites characteristic of the Brassicaceae family. Their occurrence in plant species adapted to unique ecological habitats highlights the importance of exploring local biodiversity as a source of natural compounds. The genus *Erysimum* L. is one of the largest within the Brassicaceae family, comprising approximately 267 species, many of which have a long history of medicinal use. In this study, the GSL profiles of different plant parts of *E. croaticum* and *E. cheiri* were investigated using LC-MS/MS analysis of desulfoglucosinolates. *E. croaticum* is a Croatian endemic species whose GSL profile has not yet been systematically characterized. 4-(Methylsulfinyl)but-3-enyl GSL (glucoraphenin), 4-(methylsulfanyl)but-3-enyl GSL were identified as the major GSLs, while glucotropaeolin, and 4-methoxyglucobrassicin were detected in traces. A similar qualitative profile was observed across all analyzed plant organs, indicating a consistent distribution of the major GSLs within the plant. In contrast, *E. cheiri* was characterized mainly by 3-(methylsulfinyl)propyl GSL (glucoiberin) and 3-(methylsulfanyl)propyl GSL (glucoibervirin). These results reveal the genus's chemical diversity and underscore the value of studying endemic and locally adapted plant species for environmental sustainability.

Keywords: glucosinolates, *Erysimum croaticum*, *Erysimum cheiri*, endemic plants

Acknowledgement: This research was funded by the project GREEN4MED (IP-UNIST-26) granted by the European Union -"NextGenerationEU".

Glucosinolate profiles of *Cardamine bulbifera* at different developmental stages

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Abstract
The genus *Cardamine* belongs to the Brassicaceae family and represents a phytochemically interesting group within the tribe Cardamineae, known for pronounced glucosinolate (GSL) diversity. GSLs are specialized metabolites involved in plant defense and plant-environment interactions, while their degradation products may exhibit various biological activities. In this study, the GSL profiles of *C. bulbifera*, collected at different developmental stages (April and June) were investigated using LC-MS/MS analysis of desulfoglucosinolates. Gluconapin was identified as the predominant methionine-derived GSL across all analyzed plant organs and developmental stages. Several additional aliphatic GSLs were detected mainly in trace amounts, including glucoraphanin, glucohesperin, glucohirsutin, and glucoarabin, together with minor indole GSLs such as glucobrassicin and 4-methoxyglucobrassicin. The overall GSL profile remained qualitatively stable despite sampling at different developmental stages, suggesting a regulated and conserved metabolic composition. These findings contribute to the phytochemical characterization of wild Brassicaceae taxa and support further ecological and bioactivity-oriented research on natural plant compounds.

Keywords: glucosinolates, *Cardamine bulbifera*, *Cardamine hirsute*, LC-MS/MS

Acknowledgement: This research was funded by the project GREEN4MED (IP-UNIST-26) granted by the European Union -"NextGenerationEU".

Sustainable management of nautical and diving tourism on Premuda Island

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Abstract
This paper analyses the sustainability of tourism development on Premuda Island, with a particular focus on balancing environmental conservation with the development of nautical and diving tourism. Premuda is characterised by a preserved coastal landscape, attractive underwater sites and valuable marine habitats, while at the same time facing strong seasonality, limited water supply, insufficient communal infrastructure and a small permanent population. The analysis is based on tourism sustainability indicators, data on tourist arrivals and overnight stays, accommodation capacity, environmental pressures, stakeholder insights and a comparison with selected examples of good practice from small island destinations. The results indicate that Premuda does not experience mass tourism in absolute terms. However, due to the limited and isolated island space and the small number of permanent residents, the destination's carrying capacity remains limited, particularly during periods of seasonal concentration of tourism activity. Attention should be given to improved monitoring of anchoring and diving activities, especially in areas with Posidonia oceanica meadows and sensitive underwater sites. The paper proposes targeted management measures, including anchoring regulation, the introduction of eco-moorings, visitor control at diving sites and systematic monitoring of sustainability indicators. The case of Premuda points to the need to develop tourism in accordance with the characteristics of the island space and the local community, based on tradition, authenticity, sustainability principles and low-impact tourism.

Keywords: sustainable tourism, small islands, nautical tourism, diving tourism, carrying capacity

Održivo upravljanje nautičkim i ronilačkim turizmom na otoku Premudi

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Sažetak
Ovaj rad analizira održivost turističkog razvoja otoka Premude s posebnim naglaskom na ravnotežu između očuvanja okoliša te razvoja nautičkog i ronilačkog turizma. Premuda se odlikuje očuvanim obalnim krajobrazom, atraktivnim podmorskim lokalitetima i vrijednim morskim staništima, ali se istodobno suočava s izraženom sezonalnošću, ograničenom vodoopskrbom, nedostatnom komunalnom infrastrukturom i malim brojem stalnih stanovnika. Analiza se temelji na pokazateljima održivosti turizma, podacima o turističkim dolascima i noćenjima, smještajnim kapacitetima, okolišnim pritiscima, uvidima dionika te usporedbi s odabranim primjerima dobre prakse malih otočnih destinacija. Rezultati upućuju na to da Premuda ne bilježi masovni turizam u apsolutnom smislu. Međutim, zbog ograničenog i izoliranog otočnog prostora te malog broja stalnih stanovnika, nosivi kapacitet destinacije ostaje limitiran, osobito u razdobljima sezonske koncentracije turističke aktivnosti. Posebnu pozornost potrebno je usmjeriti na bolje praćenje sidrenja i ronilačkih aktivnosti, osobito u područjima livada vrste Posidonia oceanica i osjetljivih podmorskih lokaliteta. Rad predlaže ciljane mjere upravljanja, uključujući regulaciju sidrenja, uvođenje eko-vezova, kontrolu posjeta ronilačkim lokalitetima i sustavno praćenje pokazatelja održivosti. Primjer Premude upućuje na potrebu razvoja turizma u skladu s datostima otočnog prostora i lokalne zajednice, temeljenog na tradiciji, autentičnosti, načelima održivosti i niskog utjecaja.

Ključne riječi: održivi turizam, mali otoci, nautički turizam, ronilački turizam, nosivi kapacitet

Structural diversity of uncommon glucosinolates in *Arabis* Species

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Abstract
Plants of the genus *Arabis* represent an underexplored yet chemically diverse group of species with significant potential as a source of bioactive secondary metabolites relevant to sustainable agriculture and environmentally friendly plant protection. Among these, glucosinolates (GSLs) play a key role as natural defense compounds, whose hydrolysis products are known to exhibit diverse activities, including antiproliferative, antimicrobial, and pesticidal properties. In this study, GSLs were identified and quantified in *Arabis alpina*, *Arabis hirsuta*, and *Pseudoturritis turrita* (syn. *A. turrita*) using LC-MS/MS analysis of their desulfo forms. *A. alpina* was dominated by methionine-derived aliphatic GSLs, including progoitrin (C3), and less common long-chain C7–C9 GSLs, while *P. turrita* contained C8–C10 GSLs, primarily 9-(methylsulfonyl)nonyl GSL. In *A. hirsuta*, the major compounds were phenylalanine- and/or tyrosine-derived aromatic GSLs, including 4-hydroxyphenethyl GSL (glucosinalbin), and the structurally uncommon (*R*)-2-hydroxy-2-(4-hydroxyphenyl)ethyl GSL and (*R*)-2-hydroxy-2-(4-methoxyphenyl)ethyl GSL, whose structural specificity is associated with distinct metabolic transformations in herbivores, suggesting different biological outcomes. Selected major GSLs were isolated by preparative chromatographic fractionation for structural confirmation using spectroscopic techniques. These findings highlight the significance of *Arabis* species as a source of structurally diverse GSLs with potential relevance for sustainable plant protection.

Keywords: glucosinolates, *Arabis alpina*, *Arabis hirsuta*, *Pseudoturritis turrita*, LC-MS/MS

Acknowledgement: This research was funded by the project GREEN4MED (IP-UNIST-26) granted by the European Union -"NextGenerationEU".

Environmental impact of concrete production and a sustainable future

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Abstract
Concrete production is one of the most important industrial activities in modern society due to its extensive use in construction and infrastructure development. However, it also has a significant environmental impact, particularly through carbon dioxide emissions, high energy consumption, and the exploitation of natural resources. The largest share of the negative impact originates from cement production, the key component of concrete, during which substantial amounts of CO_2 are released through chemical reactions and the combustion of fossil fuels. In addition to greenhouse gas emissions, concrete production contributes to landscape degradation through the extraction of sand and gravel, while also increasing industrial waste generation and water consumption. Nevertheless, modern research and technological advances provide opportunities to reduce these negative effects through the use of recycled materials, alternative binders, and more energy-efficient production processes. Special attention is being given to the development of "green concrete," which enables the reduction of the carbon footprint without compromising the mechanical properties and durability of the material. This paper aims to analyze the main environmental challenges associated with concrete production and to present sustainable approaches and innovations that can contribute to reducing the impact of the construction industry on the environment while supporting the achievement of sustainable development goals.

Keywords: concrete, CO_2 emissions, sustainable construction, environmental protection

Utjecaj proizvodnje betona na okoliš i održivu budućnost

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Sažetak

Građevinski sektor u Hrvatskoj i Europskoj uniji posljednjih godina prolazi kroz snažnu transformaciju koju obilježava ekspanzivni rast **i** tehnološke promjene**.** Prema podacima Hrvatske obrtničke komore, broj građevinskih obrta je u nekoliko godina porastao za više od 60 %, te čini više od 7 % BDP-a, dok se na razini EU trenutno, nakon razdoblja stagnacije, bilježi ponovni uzlet i ast proizvodnje od oko 1,5 %. Proizvodnja betona predstavlja jednu od najvažnijih industrijskih aktivnosti suvremenog društva zbog svoje široke primjene u građevinarstvu i infrastrukturi. Međutim, istovremeno ima značajan utjecaj na okoliš, posebno kroz emisije ugljikova dioksida, veliku potrošnju energije i iskorištavanje prirodnih resursa. Najveći udio negativnog utjecaja dolazi iz proizvodnje cementa, ključne sastavnice betona, tijekom koje se oslobađaju velike količine CO_2 uslijed kemijskih procesa i sagorijevanja fosilnih goriva. Osim emisija stakleničkih plinova, proizvodnja betona doprinosi degradaciji krajolika eksploatacijom pijeska i šljunka te povećava količine industrijskog otpada i potrošnju vode. Unatoč tome, suvremena istraživanja i tehnološki razvoj nude mogućnosti za smanjenje negativnih posljedica kroz primjenu recikliranih materijala, alternativnih veziva i energetski učinkovitijih proizvodnih procesa. Posebna se pažnja posvećuje razvoju „zelenog betona“ koji omogućuje smanjenje ugljičnog otiska bez narušavanja mehaničkih svojstava i trajnosti materijala. Cilj ovog rada je analizirati glavne ekološke izazove povezane s proizvodnjom betona te prikazati održive pristupe i inovacije koje mogu doprinijeti smanjenju utjecaja građevinske industrije na okoliš i ostvarivanju ciljeva održivog razvoja.

Ključne riječi: beton, cement, emisije CO_2, održiva gradnja, zaštita okoliša

A Green Living Room as a model for the green transformation of public space

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Abstract
Student life on the New Campus of the University of Zadar is marked by a lack of quality green areas for relaxation, studying, and social activities. Existing open spaces are primarily intended for traffic and parking and do not meet the needs of campus users. The aim of this paper is to examine students' needs and propose a model for activating public space through the establishment of a multifunctional mobile green area called the Green Living Room. The research methodology is based on a quantitative approach using a survey questionnaire conducted on a sample of 70 students from the New Campus of the University of Zadar. The collected data will be analyzed using descriptive statistical methods to determine patterns of space usage, satisfaction with the current conditions, and priorities for future spatial improvements. Based on the results, the project proposes the design of a 200 m² area equipped with seating elements, work surfaces, and urban greenery in mobile wooden planters. The space would be intended for students, pupils, and the general public, and adapted for hosting social, educational, and recreational outdoor activities. Expected outcomes include increased functionality and attractiveness of the space, encouragement of social interaction, stress reduction, and improvement of users' mental health. The project also contributes to strengthening urban biodiversity and mitigating the urban heat island effect in Zadar.

Keywords: student life, public space, green infrastructure, mobile green area, Zadar

Green Living Room kao model zelene transformacije javnog prostora

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* student

Sažetak
Studentski život na Novom kampusu Sveučilišta u Zadru obilježen je nedostatkom kvalitetnih zelenih površina za boravak, učenje i društvene aktivnosti. Postojeći otvoreni prostori primarno su namijenjeni prometu i parkiranju te ne odgovaraju potrebama korisnika kampusa. Cilj rada je ispitati potrebe studenata i predložiti model aktivacije javnog prostora kroz uspostavu multifunkcionalne mobilne zelene površine Green Living Room. Metodologija istraživanja temelji se na kvantitativnom pristupu putem anketnog upitnika provedenog na uzorku od 70 studenata Novog kampusa Sveučilišta u Zadru. Prikupljeni podaci analizirat će se metodama deskriptivne statistike radi utvrđivanja navika korištenja prostora, zadovoljstva postojećim stanjem te prioriteta budućeg uređenja. Na temelju rezultata predlaže se uređenje prostora površine 200 m² s elementima za sjedenje, radnim površinama i urbanim zelenilom u mobilnim drvenim posudama. Prostor bi bio namijenjen studentima, učenicima i široj javnosti te prilagođen održavanju društvenih, edukativnih i rekreativnih aktivnosti na otvorenom. Očekivani rezultati uključuju povećanje funkcionalnosti i atraktivnosti prostora, poticanje socijalne interakcije, smanjenje stresa te poboljšanje mentalnog zdravlja korisnika. Projekt dodatno pridonosi jačanju urbane bioraznolikosti i ublažavanju efekta urbanog toplinskog otoka u Zadru.

Ključne riječi: studentski život, javni prostor, zelena infrastruktura, mobilna zelena površina, Zadar

GREEN PROJECTS ZONE
ZONA GREEN PROJEKATA

Project title: Global changes and the ecosystem of the southern Adriatic: effects on zooplankton populations with a focus on the species *Calanus helgolandicus*

Project Acronym: AdZooPro

Visual:

Funding Programme: NextGenerationEU

Project Duration: 01/10/2025 – 30/09/2029

Total Budget: 61.810,69 EUR

Project Leader: Marijana HURE

Project summary:
The aim of the project is to provide insight into long-term changes in the zooplankton communities of the Adriatic Sea and to define their response to rapidly increasing environmental changes. The project will consolidate historical data on plankton communities in the South Adriatic over the past 20 years. In addition, field trips will collect samples from Veliko Jezero on Mljet Island, providing insight into the current state of plankton in the system. The target species, the calanoid copepod *Calanus helgolandicus*, will provide information on biomass dynamics, population relationships, and physiological responses of copepods to stress conditions, such as increased temperature, in the environment. The project is expected to provide valuable data on the secondary production of the Adriatic Sea and its long-term dynamics, as well as on the response of zooplankton to rapid changes in the marine environment.

Coordinator and partners:
[1] University of Dubrovnik, Institute for Marine and Coastal Research. Kneza Damjana Jude 12, Dubrovnik, Croatia
[2] Stacione Zooplogica Anton Dohrn, V. Francesco Caracciolo, Napoli, Italy

Key results/activities
- Establishment of a new research team and successful coordination between members
- Determine the long-term trend of secondary production, abundance and composition of Adriatic zooplankton and determine the influence of abiotic and biotic parameters on the dynamics of their populations
- Determine the dynamics of density, biomass and genetic structure of *C. helgolandicus* populations in the southern Adriatic and the Veliko Jezero on Mljet

Project website:
www.imp-du.com

Contacts:
Marijana HURE, Institute for Marine and Coastal Research, University of Dubrovnik, Kneza Damjana Jude 12, Dubrovnik, Croatia, marijana.hure@undu.hr

Naziv projekta: Globalne promjene i ekosustav južnog Jadrana: učinci na zooplanktonske populacije s fokusom na vrstu *Calanus helgolandicus*

Akronim projekta: AdZooPro

Vizual:

Program financiranja: NextGenerationEu

Trajanje projekta: 01.10.2025. – 30.09.2029.

Ukupni budžet: 61.810.69 EUR

Voditelj projekta: Marijana HURE

Sažetak projekta:
Cilj projekta je dati uvid u dugoročne promjene zooplanktonskih zajednica Jadranskog mora te definirati njihovu reakciju na brzorastuće promjene u okolišu. Projektom će se objediniti povijesni podaci planktonskih zajednica južnojadranske kotline u detaljnim vertikalnim slojevima (od površine do 1200 m dubine) u zadnjih 20 godina. Dodatno, terenskim izlascima sakupit će se uzorci iz Velikog jezera na Mljetu, koji će nam dati uvid u trenutno stanje planktona ova dva sustava. Uz podatke o gustoćama i vertikalnoj raspodjeli planktonskih populacija, preko ciljane vrste (kalanoidni kopepod *Calanus helgolandicus*) dobiti će se informacije o dinamici biomase, populacijskim odnosima i fiziološkim reakcijama kopepoda na stresne uvjete (povećanje temperature) u okolišu. Projektom se očekuju dobiti vrijedni podaci o sekundarnoj produkciji Jadranskog mora i njenoj dugoročnoj dinamici, kao i o odgovoru zoopanktona na ubrzane promjene morskog okoliša, što se u konačnici odražava i na slijedeću razinu hranidbenog lanca kao što je riblji stok.

Koordinator i partneri:
[1] Institut za more i priobalje, Sveučilište u Dubrovniku, Kneza Damjana Jude 12, Dubrovnik, Hrvatska
[2] Stacione Zooplogica Anton Dohrn, V. Francesco Caracciolo, Napoli, Italija

Ključni rezultati / aktivnosti:
• Uspostava novog istraživačkog tima i uspješna koordinacija između članova
• Odrediti dugoročni trend sekundarne produkcije, brojnosti i sastava zooplanktona Jadrana te determinirati utjecaj abiotičkih i biotičkih parametara na dinamiku njihovih populacija
• Odrediti dinamiku gustoće, biomase i genetičku strukturu populacija vrste *C. helgolandicus* u južnom Jadranu i Velikom jezeru na Mljetu

Mrežna stranica projekta:
www.imp-du.com

Kontakti:
Marijana HURE, Institut za more i priobalje, Sveučilište u Dubrovniku, Kneza Damjana Jude 12, Dubrovnik, Hrvatska, marijana.hure@unidu.hr

Project title: Bioindicators and anthropogenic pressures in aquatic systems of the Mura-Drava-Danube Biosphere Reserve

Project Acronym: AQUA-BIOPRESS

Visual:

Funding Programme: Funded by European Union NextGenerationEU

Project Duration: 01/10/2025 – 30/09/2029

Total Budget: 143.000,00 EUR

Project Leader: Tanja ŽUNA PFEIFFER

Project summary:
The aim of the project is to investigate the influence of environmental and anthropogenic factors on the structure and dynamics of planktonic and periphytic communities in freshwater ecosystems of the Mura-Drava-Danube Biosphere Reserve. The diversity of these communities in different water bodies will be examined using standard identification methods and modern molecular analyses. Field research, to be conducted during one vegetation season from April to October, will analyse changes in nutrient dynamics, carbon and nitrogen sources, the impact of organic matter input from land, and the presence of polluting compounds in natural aquatic ecosystems. Experimental research will be conducted under controlled conditions and will enable assessment of the effects of anthropogenic pollutants on organisms in targeted biotic communities. The project results will contribute to a better understanding of ecological changes in freshwater ecosystems, biodiversity conservation, and the long-term and efficient management of natural resources.

Coordinator and partners:
[1] Department of Biology, Josip Juraj Strossmayer University of Osijek, Ulica cara Hadrijana 8/A, Osijek, Croatia
[2] Institute for Nature Conservation of the Polish Academy, Department of Freshwater Biology, Slawkowska 17, Krakow, Poland

Key results/activities:
- Strengthen the professional team by introducing new methods and an interdisciplinary approach to the research subject.
- Study the impact of environmental factors on the biotic communities of aquatic ecosystems.
- Investigate the presence of anthropogenic pollutants in aquatic ecosystems and, through *ex situ* and *in situ* experiments, examine their impact on planktonic and periphytic communities.
- Create a database of plankton and periphyton communities, as well as environmental factors and anthropogenic pollutants.

Impact:
The project results will contribute to biodiversity conservation and a better understanding of ecological changes in freshwater ecosystems, enabling long-term, effective, and sustainable management of the world's first transboundary biosphere reserve, which spans five countries and is protected by UNESCO.

Project website:
https://npoo.biologija.unios.hr/aqua-biopress/homepage/

Contacts:
[1] Tanja ŽUNA PFEIFFER, Department of Biology, Josip Juraj Strossmayer University of Osijek, Croatia, tzuna@biologija.unios.hr
[2] Filip STEVIĆ, Department of Biology, Josip Juraj Strossmayer University of Osijek, Croatia, fstevic@biologija.unios.hr
[3] Anita GALIR, Department of Biology, Josip Juraj Strossmayer University of Osijek, Croatia, agalir@biologija.unios.hr
[4] Dubravka ŠPOLJARIĆ MARONIĆ, Department of Biology, Josip Juraj Strossmayer University of Osijek, Croatia, dspoljaric@biologija.unios.hr

Naziv projekta: Bioindikatori i antropogeni pritisci u vodenim sustavima Rezervata biosfere Mura-Drava-Dunav

Akronim projekta: AQUA-BIOPRESS

Vizual:

Program financiranja: Europska unija – NextGenerationEU

Trajanje projekta: 01.10.2025.-30.09.2029.

Ukupni budžet: 143.000.00 EUR

Voditelj projekta: Tanja ŽUNA PFEIFFER

Sažetak projekta:
Cilj projekta je istražiti utjecaj okolišnih i antropogenih čimbenika na strukturu i dinamiku razvoja planktonskih i obraštajnih zajednica u slatkovodnim ekosustavima Rezervata biosfere Mura-Drava-Dunav. Raznolikost ovih zajednica u različitim vodnim tijelima ispitat će se primjenom standardnih metoda determinacije i suvremenih molekularnih analiza. Terenskim istraživanjima koja će se provoditi tijekom jedne vegetacijske sezone odnosno od travnja do listopada, analizirat će se promjene u hranidbenim odnosima, izvori ugljika i dušika, utjecaj unosa organske tvari s kopna te prisutnost onečišćujućih spojeva u prirodnim vodenim ekosustavima. Eksperimentalna istraživanja će se provoditi u kontroliranim uvjetima i omogućit će procjenu učinaka antropogenih onečišćivača na organizme u ciljanim biotičkim zajednicama. Rezultati projekta će doprinijeti boljem razumijevanju ekoloških promjena u slatkovodnim ekosustavima, očuvanju bioraznolikosti te dugoročnom i učinkovitom upravljanju prirodnim resursima.

Koordinator i partneri:
[1] Odjel za biologiju, Sveučilište Josipa Jurja Strossmayera u Osijeku, Ulica cara Hadrijana 8/A, Osijek, Hrvatska
[2] Institut za zaštitu prirode poljske akademije, Odjel za slatkovodnu biologiju, Slawkowska 17, Krakow, Poljska

Ključni rezultati / aktivnosti:
• Osnažiti stručni tim uvođenjem novih metoda i interdisciplinarnog pristupa u predmetnom istraživanju
• Proučiti utjecaj okolišnih čimbenika na biotičke zajednice vodenih ekosustava.
• Istražiti prisutnost antropogenih onečišćujućih tvari u vodenim ekosustavima te, kroz *ex situ* i *in situ* eksperimente ispitati njihov utjecaj na planktonske i obraštajne zajednice.
• Izraditi bazu podataka o planktonskim i obraštajnim zajednicama te okolišnim čimbenicima i antropogenim onečišćivačima

Utjecaj:
Rezultati projekta će doprinijeti očuvanju bioraznolikosti i boljem razumijevanju ekoloških promjena u slatkovodnim ekosustavima te omogućiti dugoročno i učinkovito održivo upravljanje prvim svjetskim prekograničnim rezervatom biosfere koji se proteže na području pet država i pod zaštitom je UNESCO-a.

Mrežna stranica projekta:
https://npoo.biologija.unios.hr/aqua-biopress/

Kontakti:
[1] Tanja ŽUNA PFEIFFER, Odjel za biologiju, Sveučilište Josipa Jurja Strossmayera u Osijeku, Hrvatska, tzuna@biologija.unios.hr
[2] Filip STEVIĆ, Odjel za biologiju, Sveučilište Josipa Jurja Strossmayera u Osijeku, Hrvatska, fstevic@biologija.unios.hr
[3] Anita GALIR, Odjel za biologiju, Sveučilište Josipa Jurja Strossmayera u Osijeku, Hrvatska, agalir@biologija.unios.hr
[4] Dubravka ŠPOLJARIĆ MARONIĆ, Odjel za biologiju, Sveučilište Josipa Jurja Strossmayera u Osijeku, Hrvatska, dspoljaric@biologija.unios.hr

Project title: Improving coastal areas' resilience to climate change impacts and setting up guidelines for sustainable beach stabilization and management

Project Acronym: ClimBeach

Visual:

Funding Programme: Interreg IPA VI-A IPA CBC Croatia–Bosnia and Herzegovina–Montenegro

Project Duration: 01/09/2024 – 31/08/2027

Total Budget: 1.785.195,60 EUR

Project Leader: Veljko SRZIĆ

Project summary:
Coastal areas within the programme region are among the most renowned tourist destinations in the world and play a key role in the economic development of the participating countries. Effective management of beaches, which are increasingly exposed to risks such as erosion and flooding, requires systematic monitoring of sea dynamics, as such data enable timely responses to extreme events and contribute to the long-term stability and preservation of coastal areas. This analysis, conducted within the ClimBeach project, covers all twelve pilot locations. Publicly available data were analyzed to generate location-specific insights and to develop approaches for effective coastal monitoring and management planning. As part of the analysis, beaches at all pilot sites were also classified according to wave energy and sediment volume. The goal of the ClimBeach project is to develop a unified, multi-physical and multi-technical solution to mitigate the negative impacts of climate change on coastal areas, while increasing beach resilience to erosion and flooding. The

developed solutions are designed to be applied and adaptable to other pilot locations, both within and beyond the programme area.

Coordinator and partners:
[1] University of Split, Faculty of Civil Engineering, Architecture and Geodesy, Split, Croatia
[2] University of Mostar, Faculty of Civil Engineering, Architecture and Geodesy, Trg hrvatskih velikana 1, Mostar, Bosnia and Herzegovina
[3] Regional Development Agency of Dubrovnik-Neretva County (DUNEA), Ulica branitelja 41, Dubrovnik, Croatia
[4] Municipality of Neum, Kralja Tomislava 1, Neum, Bosnia and Herzegovina
[5] Public Enterprise for Coastal Zone Management of Montenegro, Budva, Montenegro

Key Results / Activities:
- Establishment and implementation of a pilot project for a combined system for monitoring atmosphere, oceanography, and beach volumetry
- Development of the BeachCloud tool to enhance beach resilience to climate change impacts
- Development of a strategy and action plan for beach areas to prevent coastal erosion and flooding caused by climate change

Impact:
Management approaches, including integrated coastal zone management and ecosystem-based adaptation, incorporate these measures into long-term planning and development strategies.

Collaboration opportunities:
Opportunities for collaboration on this project include networking with relevant partners. Project partners have selected target groups of various levels and interests whose professional scope aligns with the project results, which can improve the quality and efficiency of implementation.

Project website:
https://interreg-hr-ba-me.eu/project/project-library/climbeach/

Social media:
https://www.facebook.com/InterregHRBAME/
https://www.linkedin.com/company/interreg-ipa-hr-ba-me/
https://x.com/hrbame

Contacts:
Maja PRSKALO, University of Mostar, Faculty of Civil Engineering, Architecture and Geodesy, Trg hrvatskih velikana 1, Bosnia and Hercegovina, maja.prskalo@fgag.sum.ba

Naziv projekta: Podizanje razine otpornosti obalnih područja na utjecaj klimatskih promjena i uspostava smjernica za održivo upravljanje i stabilizaciju plaža

Akronim projekta: ClimBeach

Vizual:

Program financiranja: Interreg IPA VI A IPA CBC Hrvatska-Bosna i Hercegovina-Crna Gora

Trajanje projekta: 01.09.2024.-31.08.2027.

Ukupni budžet: 1.785.195,60 EUR

Voditelj projekta: Veljko SRZIĆ

Sažetak projekta:
Obalna područja unutar programskog prostora ubrajaju se među najpoznatija svjetska turistička odredišta te imaju ključnu ulogu u gospodarskom razvoju uključenih zemalja. Učinkovito upravljanje plažama koje su sve više izložene rizicima erozije i poplavama, zahtjeva sustavno praćenje dinamike mora, budući da takvi podaci omogućuju pravodobno reagiranje na ekstremne događaje i dugoročno doprinose stabilnosti i očuvanju obalnog prostora. Ova analiza, provedena u okviru projekta ClimBeach, obuhvaća svih dvanaest pilot lokacija. Na njima su analizirani javno dostupni podaci kako bi se dobili uvidi specifični za svaku lokaciju te razvili pristupi za učinkovito praćenje i planiranje upravljanja obalom. U sklopu analize izvršena je i klasifikacija plaža prema energiji valova i količini sedimenta na svim pilot lokacijama. Cilj projekta ClimBeach je razviti jedinstveno, multifizičko i multitehničko rješenje za ublažavanje negativnih utjecaja klimatskih promjena na obalna područja, uz povećanje otpornosti plaža na eroziju i poplave. Razvijena rješenja osmišljena su tako da budu primjenjiva i prilagodljiva drugim pilot-lokacijama, kako unutar tako i izvan programskog područja.

Koordinator i partneri:
[1] Fakultet građevinarstva, arhitekture i geodezije, Sveučilište u Splitu, Matice hrvatske 15, Split, Hrvatska
[2] Fakultet građevinarstva, arhitekture i geodezije, Sveučilište u Mostaru, Trg hrvatskih velikana br 1, Mostar, Bosna i Hercegovina
[3] Regionalna razvojna agencija Dubrovačko neretvanske županje, DUNEA, Ulica branitelja 41, Dubrovnik, Hrvatska
[4] Općina Neum, Kralja Tomislava 1, Neum, Bosna i Hercegovina
[5] Javno poduzeće za upravljanje morskim dobrom Crne Gore, Popa Jola Zeca bb, Budva, Crna Gora

Ključni rezultati / aktivnosti:
•Uspostavljanje i implementacija pilot-projekta kombiniranog sustava za praćenje atmosfere, oceanografije i volumetrije plaža
• Razvoj alata BeachCloud za povećanje otpornosti plaža na utjecaje uzrokovane klimatskim promjenama
• Razvoj strategije i akcijskog plana za područja plaža za spriječavanje erozije i poplava obale uzrokovanih klimatskim promjenama

Utjecaj:
Upravljački pristupi, uključujući integralno upravljanje obalnim područjem i prilagodbu temeljenu na ekosustavu integriraju ove mjere u dugoročne strategije planiranja i razvoja.

Mogućnosti suradnje:
Mogućnost suradnje na ovom projektu uključuje povezivanje s relevantnim partnerima, s tim da su projektni partneri odabrali ciljnu skupinu različitih razina i interesa čiji profesionalni opseg odgovara rezultatima projekta, što može unaprijediti kvalitetu i učinkovitost provedbe.

Mrežna stranica projekta:
https://interreg-hr-ba-me.eu/project/project-library/climbeach/

Društvene mreže:
https://www.facebook.com/InterregHRBAME/
https://www.linkedin.com/company/interreg-ipa-hr-ba-me/
https://x.com/hrbame

Kontakti:
Maja PRSKALO, Sveučilište u Mostaru, Fakultet građevinarstva, arhitekture i geodezije, Trg hrvatskih velikana br 1, Mostar, Bosna i Hercegovina, maja.prskalo@fgag.sum.ba

Project title: Promoting shared stewardship for Mediterranean Coasts

Project Acronym: COASTRUST

Visual:

Funding Programme: Interreg Euro-MED

Project Duration: 01/01/2024 - 30/09/2026

Total Budget: 2.420.503,00 EUR

Project Leader: Zaimis FOKION

Project summary:
The Mediterranean basin is one of the most important hotspots of biodiversity in the world in terms of the richness of species and ecosystems. Human activities and overexploitation of natural resources are resulting in ecosystem degradation and species loss at an alarming rate, requiring a coordinated transnational approach. The COASTRUST project applies environmental management in coastal areas exposed to the influence of anthropogenic pressures and results in the establishment of multi-stakeholder management mechanisms with the aim of improved management of natural resources on land and sea. The project will develop a coastal management strategy and a series of activities for each target area according to its specificities, needs and environmental goals.

Coordinator and partners:
[1] Region of Western Greece, New National Road Patron-Athinon 32, Patras, Greece,
[2] DUNEA - Regional Development Agency Dubrovnik - Neretva County, Ulica branitelja Dubrovnika 41, Dubrovnik, Croatia
[3] Roma Tre University - Department of Architecture, LARGO GIOVANNI BATTISTA MARZI 10, Rome, Italy
[4] Andalusian Federation of Towns and Provinces, Avenida San Francisco Javier 22, Sevilla, Spain

[5] Institute for Nature Conservation in Albania, Rruga "Islam Alla", pallati IVEA, Kati I pare, Tirana, Albania
[6] Office of The Prime Minister of Herzegovina - Neretva Canton Government, Stjepana Radića 3, Mostar, Bosnia and Herzegovina
[7] Sustainable Development Foundation, Via Garigliano 61, Rome, Italy
[8] SUBMON, Ortigosa 14, Barcelona, Spain
[9] Nature Trust Malta, Wied Għollieqa Environment Centre, Malta University 1, Msida, Malta

Key results/activities:

- Capacity building of partners on coast stewardship to share best practices and an array of possible pilot interventions.
- Establishment of a common methodology for implementing coastal stewardship in the project target areas, and as a basis for mapping resources, needs and stakeholders in pilot areas and the collaborative development of the local Strategies.
- Establishment of one local action group (LAG) in the target area, involving the identified stakeholders, who will develop the strategies aiming to enhance the management of natural resources in which public/private interests interfere and the restoration of degraded areas on land and sea. Coastal stewardship will be the priority tool to address such challenges.
- Several stewardship agreements will be subscribed to within the strategies and will be related to the development of priority actions.
- Partners will exchange the lessons learned and compare the results achieved in the implementation of the pilot action in the target areas to draw conclusions and release the project methodology 2.0.

Project website:
https://coastrust.interreg-euro-med.eu/

Social media:
https://www.instagram.com/coastrust_euromed/
https://www.facebook.com/people/Coastrust/61558479554695/?locale=vi_VN#

Contacts:
Kristina CRNJAC, Herzegovina-Neretva Canton Government, Stjepana Radića, Mostar, Bosnia and Herzegovina, kristinac@vlada-hnz-k.ba

Naziv projekta: Promicanje zajedničkog upravljanja mediteranskim obalama

Akronim projekta: COASTRUST

Vizual:

Program financiranja: Interreg Euro-MED

Trajanje projekta: 01.01.2024. – 30.09.2026.

Ukupni budžet: 2.420.503,00 EUR

Voditelj projekta: Zaimis FOKION

Sažetak projekta:
Mediteranski bazen jedno je od najvažnijih žarišta bioraznolikosti u svijetu u smislu bogatstva vrsta i ekosustava. Ljudske aktivnosti i prekomjerno iskorištavanje prirodnih resursa rezultiraju degradacijom ekosustava i gubitkom vrsta alarmantnom brzinom, što zahtijeva koordinirani transnacionalni pristup. Projekt COASTRUST primjenjuje upravljanje okolišem u obalnim područjima koja su izložena utjecaju antropogenih pritisaka s ciljem uspostavljanja mehanizama upravljanja s više dionika i poboljšanog upravljanja prirodnim resursima na kopnu i moru. Projekt će razviti strategiju upravljanja obalnim područjem i niz aktivnosti za svako ciljano područje u skladu s njegovim specifičnostima, potrebama i ciljevima zaštite okoliša.

Koordinator i partneri:
[1] Regija Zapadne Grčke, New National Road Patron-Athinon 32, Patras, Grčka, vodeći partner i partneri:
[2] DUNEA – Razvojna agencija Dubrovačko.-nertvanske županije, Ulica branitelja Dubrovnika 41, Dubrovnik, Hrvatska
[3] Roma Tre Sveučilište – Odjel za arhitekturu, LARGO GIOVANNI BATTISTA MARZI 10, Rim, Italija

[4] Federacija gradova i pokrajina Andaluzije, Avenida San Francisco Javier 22, Sevilla, Španjolska

[5] Institut za zaštitu prirode u Albaniji, Rruga "Islam Alla", pallati IVEA, Kati I pare, Tirana, Albanija
[6]Ured predsjednika Vlade Hercegovačko-neretvanske županije/kantona, Stjepana Radića 3, Mostar, Bosna i Hercegovina
[7] Zaklada za održivi razvoj, Via Garigliano 61, Rim, Italija
[8] SUBMON, Ortigosa 14, Barcelona, Španjolska
[9] Zaklada za prirodu Malta, Wied Ghollieqa Environment Centre, Malta University 1, Msida, Malta

Ključni rezultati / aktivnosti:

- Izgradnja kapaciteta partnera za upravljanje obalom radi razmjene najboljih praksi i niza mogućih pilot intervencija.
- Uspostavljanje zajedničke metodologije za provedbu upravljanja obalom u ciljanim područjima projekta kao osnove za mapiranje resursa, potreba i dionika u pilot područjima i zajednički razvoj lokalnih strategija.
- Osnivanje jedne lokalne akcijske skupine (LAG) u ciljanom području, koja uključuje identificirane dionike, a koja će razviti strategije s ciljem poboljšanja upravljanja prirodnim resursima u kojima se isprepleću javni/privatni interesi i obnove degradiranih područja na kopnu i moru. Upravljanje obalom bit će prioritetni alat za rješavanje takvih izazova.
- U sklopu strategija bit će potpisan niz sporazuma o upravljanju koji će biti povezani s razvojem prioritetnih akcija.
- Partneri će razmijeniti naučene lekcije i usporediti rezultate postignute u provedbi pilot akcija u ciljanim područjima kako bi izvukli zaključke i izradili projektnu metodologiju 2.0.

Mrežna stranica projekta:
https://coastrust.interreg-euro-med.eu/

Društvene mreže:
https://www.instagram.com/coastrust_euromed/
https://www.facebook.com/people/Coastrust/61558479554695/?locale=vi_VN#

Kontakti:
Kristina CRNJAC, Vlada Hercegovačko-neretvanske županije/kantona, Stjepana Radića 3, Mostar, Bosnia and Herzegovina, kristinac@vlada-hnz-k.ba

Project title: Development of a harmonized water balance modelling system for the Danube River Basin

Project Acronym: Danube Water Balance

Visual:

Funding Programme: Interreg Danube Region Programme

Project Duration: 01/01/2024 - 30/06/2026

Total Budget: 2.999.983,00 EUR

Project Leader: Norbert CSATÁRI

Project summary:
The extreme and trend-like climate change impacts cause significant water balance issues in the Danube River Basin (DRB), already posing major challenges also for the environment, the economy and the whole society. Water management in the DRB is characterized by scattered data availability and various national calculation methods, ultimately leading to country-scale or sub-regional mosaics about the water balance. A jointly developed data management and a water balance model is needed to cope with the transnational water quantity challenges of the basin. The Danube Water Balance project aims to overcome this situation and contribute to sustainable, integrated transnational water management in the DRB. The overall objective of the project is to develop a harmonized water balance modelling system in the DRB.

Coordinator and partners:
[1] General Directorate of Water Management, Márvány utca 1/D., Budapest, Hungary
[2c]Budapest University of Technology and Economics, Műegyetem rakpart, Budapest, Hungary
[3] Vienna University of Technology, Karlsplatz 13, Wien, Austria
[4] International Institute for Applied Systems Analysis, Schlossplatz 1, 2361 Laxenburg, Austria
[5] Brno University of Technology, Antonínská 548/1, Brno, Czechoslovakia
[6] Slovak University of Technology in Bratislava, Radlinského 11, Bratislava
[7] Slovenian Environment Agency, Vojkova 1b, Ljubljana, Slovenia

[8] Croatian waters, Ulica grada Vukovara 220, Zagreb, Croatia
[9] Institute for Water Management, Milosa Obilica 51, Bijeljina, Bosnia and Herzegovina
[10] University of Sarajevo, Obala Kulina bana 7/II, Sarajevo, Bosnia and Herzegovina
[11] Faculty of Agriculture, University of Novi Sad, Trg D. Obradovića 8, Novi Sad, Serbia
[12] Jaroslav Černi Water Institute, Jaroslava Černog 80, Belgrade, Serbia
[13] Public Water Management Company „Srbijavode“, Bulevar umetnosti 2a, Belgrade, Serbia
[14] National Institute of Hydrology and Water Management, sos. Bucuresti- Ploiesti 97 E, Bucarest, Romania
[15] National Administration Romanian Waters, Strada Ion Campineanu 11, Bucharest, Romania
[16] National Meteorological Administration, Ploiești St. 97, Bucharest, Romania
[17] Executive Agency "Exploration and Maintenance of the Danube River, Slavyanska 6, Ruse, Bulgaria
[18] National Institute of Meteorology and Hydrology, Tsarigradsko Shose Blvd 66, Sofia, Bulgaria
[19] Bulgarian Water Association, Hristo Smirnenski Boulevard 1, Sofia, Bulgaria
[21] Center for Strategic Environmental Studies ECOS, sos Hincesti 58, Chisinau, Moldova

Key results/activities:

- Improved data management for present and future water balance calculations. This will consist of (i) a data repository for all input and output data of the model, (ii) a set of tools supporting input data collection, validation, conversion and result visualization and interpretation and (iii) a new data management strategy providing a sound basis for data-related activities of future water balance and water management modelling. Both the data repository and the tools will be open access, therefore the list of beneficiaries extends from water experts using the developed model through experts from other water-related fields to decision makers willing to understand the main characteristics of the DRB as a hydrological system.
- Elaborated water balance scenarios for 4 selected transboundary sub-basins, namely Morava (CZ, SK & AT), Tisa (HU, SK, RO, RS & UA), Upper Sava (SI & HR), and Drina (RS & BA). This key action within the project will be the cornerstone of future cooperation by providing a good exercise for our international experts to test and enhance the Danube River Basin Water Balance model (DRBWBM) and the established common data repository.
- Improved stakeholder insight into transboundary water balance methodology: strong emphasis will be put on sectoral stakeholder involvement and capacity building in the project. Besides the essential technical modelling steps, it is planned that several training sessions will be carried out and an expert hub will be established that will consist of modelling experts, water managers, and other professionals from water-related sectors.

Impact:
Sustainable, integrated, transnational water and sediment management in the Danube River Basin, ensuring good quality and quantity of water and sediment balance. The Danube Water Balance project aims to improve the effectiveness of the joint, transboundary and cross-sectoral water management in the Danube River Basin (DRB) to cope with water quantity issues. The project will deliver a basin-wide water balance model for surface and groundwater, tested in transboundary sub-basins, along with the application of climate scenarios. It will foster improving data management and capacity building by preparing a common training material and establishing an expert hub.

Project website:
https://interreg-danube.eu/projects/danube-water-balance

QR codes

Contacts:
[1] Daria ČUPIĆ, Croatian waters, Ulica grada Vukovara, Zagreb, Croatia, daria.cupic@voda.hr
[2] Alena VLAŠIĆ, Croatian waters, Ulica grada Vukovara, Zagreb, Croatia, alena.vlasic@voda.hr

Naziv projekta: Razvoj i harmonizacija sustava modeliranja vodne bilance na slivu rijeke Dunav

Akronim projekta: Danube Water Balance

Vizual:

Program financiranja: Interreg Danube Region Programme

Trajanje projekta: 01.01.2024. – 30.06.2026.

Ukupni budžet: 2.999.983,00 EUR

Voditelj projekta: Norbert CSATÁRI

Sažetak projekta:
Ekstremni i dugoročni učinci klimatskih promjena uzrokuju značajne poremećaje vodne bilance u slivu rijeke Dunav, što već danas predstavlja velik izazov za okoliš, gospodarstvo i društvo u cjelini. Upravljanje vodnim resursima u dunavskom slivu obilježeno je raspršenom dostupnošću podataka i primjenom različitih nacionalnih metodologija izračuna, što rezultira fragmentiranim prikazima vodne bilance na nacionalnoj i subregionalnoj razini. Za učinkovito suočavanje s transnacionalnim izazovima upravljanja količinama voda u slivu potrebno je uspostaviti zajednički sustav upravljanja podacima i razviti usklađeni model vodne bilance. Projekt Danube Water Balance ima za cilj prevladati postojeće nedostatke te doprinijeti održivom i integriranom transnacionalnom upravljanju vodama u slivu rijeke Dunav. Opći cilj projekta je razvoj usklađenog sustava modeliranja vodne bilance na području cijelog dunavskog sliva.

Koordinator i partneri:
[1] General Directorate of Water Management, Márvány utca 1/D., Budapest, Hungary
[2c] Budapest University of Technology and Economics, Műegyetem rakpart, Budapest, Hungary
[3] Vienna University of Technology, Karlsplatz 13, Wien, Austria

[4] International Institute for Applied Systems Analysis, Schlossplatz 1, 2361 Laxenburg, Austria
[5] Brno University of Technology, Antonínská 548/1, Brno, Czechoslovakia
[6] Slovak University of Technology in Bratislava, Radlinského 11, Bratislava
[7] Slovenian Environment Agency, Vojkova 1b, Ljubljana, Slovenia
[8] Croatian waters, Ulica grada Vukovara 220, Zagreb, Croatia
[9] Institute for Water Management, Milosa Obilica 51, Bijeljina, Bosnia and Herzegovina
[10] University of Sarajevo, Obala Kulina bana 7/II, Sarajevo, Bosnia and Herzegovina
[11] Faculty of Agriculture, University of Novi Sad, Trg D. Obradovića 8, Novi Sad, Serbia
[12] Jaroslav Černi Water Institute, Jaroslava Černog 80, Belgrade, Serbia
[13] Public Water Management Company „Srbijavode“, Bulevar umetnosti 2a, Belgrade, Serbia
[14] National Institute of Hydrology and Water Management, Sos. Bucuresti- Ploiesti 97 E, Bucarest, Romania
[15] National Administration Romanian Waters, Strada Ion Campineanu 11, Bucharest, Romania
[16] National Meteorological Administration, Ploiești St. 97, Bucharest, Romania
[17] Executive Agency "Exploration and Maintenance of the Danube River, Slavyanska 6, Ruse, Bulgaria
[18] National Institute of Meteorology and Hydrology, Tsarigradsko Shose Blvd 66, Sofia, Bulgaria
[19] Bulgarian Water Association, Hristo Smirnenski Boulevard 1, Sofia, Bulgaria
[21] Center for Strategic Environmental Studies ECOS, Sos Hincesti 58, Chisinau, Moldova

Ključni rezultati / aktivnosti:

• Unaprjeđenje upravljanja podacima za sadašnje i buduće procjene vodne bilance uspostavom otvoreno dostupnog repozitorija podataka, alata za obradu i vizualizaciju podataka te nove strategije upravljanja podacima za buduće aktivnosti modeliranja.
• Izrada scenarija vodne bilance za četiri prekogranična podsliva (Morava, Tisa, Gornja Sava i Drina) radi testiranja i daljnjeg unaprjeđenja Modela vodne bilance sliva rijeke Dunav te jačanja transnacionalne suradnje.
• Povećanje znanja i kapaciteta dionika u području prekogranične procjene vodne bilance kroz edukacijske aktivnosti, uključivanje dionika i uspostavu stručne mreže koja okuplja modelare, upravitelje vodama i stručnjake iz sektora povezanih s vodama.

Utjecaj:

Održivo, integrirano i transnacionalno upravljanje vodama i sedimentom u slivu rijeke Dunav ključno je za osiguranje dobre kvalitete i dostatnih količina voda te održavanje ravnoteže sedimenta. Projekt Danube Water Balance usmjeren je na unaprjeđenje učinkovitosti zajedničkog, prekograničnog i međusektorskog upravljanja vodama u slivu rijeke Dunav radi suočavanja s izazovima vezanim uz količine voda. U okviru projekta razvit će se model vodne bilance za površinske i podzemne vode na razini cijelog sliva, koji će biti testiran u odabranim prekograničnim podslivovima uz primjenu klimatskih scenarija. Projekt će također doprinijeti

unaprjeđenju upravljanja podacima i jačanju kapaciteta kroz izradu zajedničkih edukacijskih materijala i uspostavu stručne mreže.

Mrežna stranica projekta:
https://interreg-danube.eu/projects/danube-water-balance

QR kodovi

Kontakti:
[1] Daria ČUPIĆ, Hrvatske vode, Ulica grada Vukovara, Zagreb, Hrvatska, daria.cupic@voda.hr
[2] Alena VLAŠIĆ, Hrvatske vode, Ulica grada Vukovara, Zagreb, Hrvatska, alena.vlasic@voda.hr

Project title: Availability of Public Services and Green Spaces for Vulnerable Groups

Project Acronym: DORAS

Visual:

Funding Programme: European Social Fund (Operational Programme Efficient Human Resources 2014–2020)

Project Duration: 24/12/2021 – 24/06/2023

Total Budget: 58.910,00 EUR

Project Leader: Silvija ŠILJEG

Project summary:
The DORAS project focused on analyzing the spatial and social accessibility of key public services and green spaces for vulnerable groups in the settlement of Zadar. The project aimed to determine the extent to which residents have equal access to services of general interest, such as healthcare and educational facilities, public transportation, administrative services, as well as parks and other green spaces that significantly contribute to the quality of life and public health. The purpose of the project was to develop multi-criteria GIS accessibility models for public services and green spaces for vulnerable groups in the local community of Zadar, with the goal of promoting equal opportunities and non-discrimination. The research combined GIS-based spatial analysis methods, statistical indicators, and survey research among vulnerable groups. The project results revealed spatial inequalities in access to public services and green spaces, particularly in the peripheral parts of the city. The project provided recommendations for spatial planning and public policies aimed at enhancing spatial cohesion, sustainable development, and improving quality of life. In this way, DORAS contributed to a better understanding of the relationship between space, service accessibility, and social justice, and offered useful guidelines for local decision-makers.

Coordinator and partners:
[1] Croatian Geographical Society, Zadar, Ul. dr. Franje Tuđmana 24i, Zadar, Croatia
[2] University of Zadar, Mihovila Pavlinovića 1, Zadar, Croatia

Key results/activities:
• Development of an urban green cadastre database for the City of Zadar; development of a GIS database of transport infrastructure; development of accessibility models; identification of the optimal location for the provision of facilities and infrastructure within green spaces for persons with disabilities; inventory of required amenities within green spaces; conducting public opinion surveys; data collection through aerial surveying; development of a WebGIS application; preparation of a handbook; and organization of workshops.

Impact:
The project has had a significant scientific, professional, and social impact by establishing an urban green cadastre and a GIS database of transport infrastructure for the City of Zadar. Accessibility models identified spatial inequalities and optimal locations for facilities adapted to persons with disabilities. The WebGIS application, handbook, and workshops enabled public access to results and knowledge transfer. Overall, the project has contributed to inclusive and sustainable urban planning, improved accessibility of green spaces, and enhanced quality of life and social equity in the local community.

Collaboration opportunities:
Collaboration opportunities are open to public institutions, civil society organizations, and research institutions for data sharing, joint analyses, and the application of project results.

Project website:
https://www.hgd-zadar.hr/doras/

Social media:
Facebook: https://www.facebook.com/hgdzadar
Instagram: https://www.instagram.com/hgdzadar
LinkedIn: https://www.linkedin.com/company/hgdzadar

Contacts:
Silvija ŠILJEG, University of Zadar, Trg kneza Višeslava 9, Zadar, Croatia, ssiljeg@unizd.hr

Naziv projekta: Dostupnost javnih usluga i zelenih površina za ranjive skupine

Akronim projekta:DORAS

Vizual:

Program financiranja: Europski socijalni fond, Učinkoviti ljudski potencijali 2014.-2020.

Trajanje projekta: 24.12.2021. – 24.06.2023.

Ukupni budžet: 58.910,00 EUR

Voditelj projekta: Silvija ŠILJEG

Sažetak projekta:
Projekt DORAS bavio se analizom prostorne i društvene dostupnosti ključnih javnih sadržaja i zelenih površina za ranjive skupine u naselju Zadar. Cilj projekta bio je utvrditi u kojoj mjeri stanovnici imaju jednak pristup uslugama od općeg interesa, poput zdravstvenih i obrazovnih ustanova, javnog prijevoza, administrativnih usluga te parkova i drugih zelenih površina, koje značajno pridonose kvaliteti života i zdravlju stanovništva. Svrha projekta bila je izrada višekriterijskih GIS modela dostupnosti do javnih servisa i zelenih površina za ranjive skupine u lokalnoj zajednici Zadra radi postizanja jednakih mogućnosti i nediskriminacije. Istraživanje je kombiniralo metode prostorne analize u GIS-u, statističke pokazatelje i anketna istraživanja među ranjivim skupinama, a rezultati projekta pokazali su prostorne nejednakosti u dostupnosti javnih usluga i zelenih površina, osobito u perifernim dijelovima grada. Projekt je ponudio preporuke za prostorno planiranje i javne politike usmjerene na povećanje prostorne kohezije, održivi razvoj i podizanje kvalitete života. DORAS je tako pridonio boljem razumijevanju povezanosti prostora, dostupnosti usluga i društvene pravednosti te pružio korisne smjernice za donositelje odluka na lokalnoj razini.

Koordinator i partneri:
[1] Hrvatsko geografsko društvo Zadar, Ul. dr. Franje Tuđmana 24i, Zadar, Hrvatska
[2] Sveučilište u Zadru, Mihovila Pavlinovića 1, Zadar, Hrvatska

Ključni rezultati / aktivnosti:
• Izrada baze urbanog zelenog katastra za grad Zadar, izrada GIS baze podataka prometne infrastrukture, izrada modela dostupnosti, predlaganje optimalne lokacije za uređenje sadržaja i infrastrukture unutar zelenih površina za osobe s invaliditetom, evidentiranje potrebnih sadržaja unutar zelenih površina, provođenje ispitivanja javnog mnijenja, prikupljanje podataka snimanjem iz zraka, izrada WebGIS aplikacije, izrada priručnika, provedba radionica.

Utjecaj:
Projekt je ostvario značajan znanstveni, stručni i društveni utjecaj uspostavom urbanog zelenog katastra i GIS baze podataka prometne infrastrukture za Grad Zadar. Modeli dostupnosti identificirali su prostorne nejednakosti i optimalne lokacije za sadržaje prilagođene osobama s invaliditetom. WebGIS aplikacija, priručnik i radionice omogućili su javni pristup rezultatima i prijenos znanja. Projekt je pridonio uključivom i održivom urbanom planiranju, poboljšao dostupnost zelenih površina te unaprijedio kvalitetu života i društvenu jednakost u lokalnoj zajednici.

Mogućnosti suradnje:
Moguća je suradnja s javnim institucijama, organizacijama civilnog društva i istraživačkim organizacijama na razmjeni podataka, zajedničkim analizama i primjeni rezultata projekta.

Mrežna stranica projekta:
https://www.hgd-zadar.hr/doras/

Društvene mreže:
Facebook: https://www.facebook.com/hgdzadar
Instagram: https://www.instagram.com/hgdzadar
LinkedIn: https://www.linkedin.com/company/hgdzadar

Kontakti:
Silvija ŠILJEG, Sveučilište u Zadru, Trg kneza Višeslava 9, Zadar, Hrvatska, ssiljeg@unizd.hr

Project title: Environmentally friendly methods for the synthesis and extraction of organic compounds with potential biological activity

Project Acronym: EMSEO

Visual:

Funding Programme: NextGenerationEU

Project Duration: 01/10/2025 – 30/09/2029

Total Budget: 113.820,00 €

Project Leader: Valentina BUŠIĆ

Project summary:
This project focuses on developing sustainable methods for organic synthesis and extraction to reduce the environmental impact of chemical processes while improving energy and process efficiency. The research will involve microwave- and ultrasound-assisted synthesis and extraction, mechanochemical approaches, and the use of deep eutectic solvents as green alternatives to conventional methods. These techniques enable lower solvent consumption, milder reaction conditions, and shorter processing times. Pyridine, quinazolinone, and coumarin derivatives will be synthesised and characterised by NMR, IR, and MS spectroscopy, while polyphenolic compounds in plant extracts will be quantified. Their antioxidant and antifungal activities, as well as electrochemical properties, will be evaluated. In addition, the project will investigate food industry by-products as eco-friendly catalysts, promoting sustainable chemistry and circular economy principles.

Coordinator:
Josip Juraj Strossmayer University of Osijek, Faculty of Food Technology Osijek, Franje Kuhača 18, Croatia

Key results/activities:

- To optimize environmentally friendly synthesis methods (of pyridine, quinazolinone, and coumarin derivatives) and extraction processes by selecting the most suitable reaction parameters (catalyst, pH, solvent, temperature, or reaction time) to achieve significant cost reduction, increased product purity, and improved yields.
- To investigate the possibilities for preparing organic compounds according to the principles of green chemistry, with priority given to reactions activated by microwave and ultrasonic irradiation, as well as mechanochemical synthesis.
- To investigate the efficiency of low-temperature eutectic solvents as alternative media for the synthesis and extraction of organic compounds.
- To examine the effectiveness of alternative catalysts, such as ash derived from food industry by-products, in various organic reactions.
- To extract natural organic compounds from plant material and quantify the bioactive components present in the extracts.

Impact:

The project will significantly contribute to the development of sustainable and environmentally friendly approaches in organic synthesis and extraction by applying green chemistry principles. A reduction in the use of toxic solvents, energy consumption, and waste generation is expected, along with increased reaction efficiency and product yields. The developed methods and synthesised bioactive compounds will have potential applications in the pharmaceutical, food, and chemical industries. Furthermore, the project will strengthen scientific excellence through publications in internationally recognised journals, the promotion of open science, and the involvement of young researchers and students in contemporary interdisciplinary research.

Project website:

https://www.ptfos.unios.hr/EMSEO/

QR code

Contacts:

Valentina BUŠIĆ, Josip Juraj Strossmayer University of Osijek, Faculty of Food Technology Osijek, Franje Kuhača 18, Croatia; vbusic@ptfos.hr

Naziv projekta: Ekološki prihvatljive metode sinteze i ekstrakcije organskih spojeva s potencijalnom biološkom aktivnošću

Akronim projekta: EMSEO

Vizual:

Program financiranja: NextGenerationEU

Trajanje projekta: 01. 10. 2025. – 30. 09. 2029.

Ukupni budžet: 113.820,00 €

Voditelj projekta: Valentin BUŠIĆ

Sažetak projekta:
Ovaj projekt usmjeren je na razvoj održivih metoda organske sinteze i ekstrakcije s ciljem smanjenja utjecaja kemijskih procesa na okoliš te povećanja energetske i procesne učinkovitosti. Istraživanje će obuhvatiti sintezu i ekstrakciju potpomognutu mikrovalovima i ultrazvukom, mehanokemijske pristupe te primjenu dubokih eutektičkih otapala kao zelenih alternativa konvencionalnim metodama. Ovi postupci omogućuju manju potrošnju otapala, blaže reakcijske uvjete i kraće vrijeme obrade. Sintetizirani derivati piridina, kinazolinona i kumarina bit će okarakterizirani NMR, IR i MS spektroskopijom, dok će se u biljnim ekstraktima kvantificirati polifenolni spojevi. Također će se ispitati njihova antioksidativna i antifungalna svojstva te elektrokemijska svojstva. Dodatno, projekt će istražiti nusproizvode prehrambene industrije kao ekološki prihvatljive katalizatore, promičući načela održive kemije i kružnog gospodarstva.

Koordinator i partneri:
Sveučilište Josipa Jurja Strossmayera u Osijeku, Prehrambeno-tehnološki fakultet Osijek, Franje Kuhača 18, Osijek, Hrvatska

Ključni rezultati / aktivnosti:

- Optimizirati ekološki prihvatljive metode sinteze derivata piridina, kinazolinona i kumarina te procese ekstrakcije odabirom najprikladnijih reakcijskih parametara (katalizator, pH, otapalo, temperatura, vrijeme reakcije) radi značajnog smanjenja troškova, povećanja čistoće produkata i poboljšanja prinosa.
- Istražiti mogućnosti priprave organskih spojeva prema načelima „zelene" kemije, s naglaskom na reakcije aktivirane mikrovalnim i ultrazvučnim zračenjem te mehanokemijsku sintezu.
- Istražiti učinkovitost niskotemperaturnih eutektnih otapala kao alternativnih medija za sintezu i ekstrakciju organskih spojeva.
- Ispitati učinkovitost alternativnih katalizatora, poput pepela dobivenog iz nusproizvoda prehrambene industrije, u različitim organskim reakcijama.
- Provesti ekstrakciju prirodnih organskih spojeva iz biljnog materijala i kvantificirati bioaktivne komponente prisutne u ekstraktima.

Utjecaj:

Projekt će značajno doprinijeti razvoju održivih i ekološki prihvatljivih pristupa u organskoj sintezi i ekstrakciji primjenom načela zelene kemije. Očekuje se smanjenje uporabe toksičnih otapala, potrošnje energije i količine otpada, uz povećanje učinkovitosti i prinosa reakcija. Razvijene metode i pripravljeni bioaktivni spojevi imat će potencijalnu primjenu u farmaceutskoj, prehrambenoj i kemijskoj industriji. Projekt će dodatno ojačati znanstvenu izvrsnost objavom rezultata u međunarodno priznatim časopisima, promicanjem otvorene znanosti te uključivanjem mladih istraživača i studenata u suvremena interdisciplinarna istraživanja.

Mrežna stranica projekta:

https://www.ptfos.unios.hr/EMSEO/

QR kod

Kontakti:

Valentina BUŠIĆ, Sveučilište Josipa Jurja Strossmayera u Osijeku, Prehrambeno-tehnološki fakultet Osijek, Franje Kuhača 18, Croatia; vbusic@ptfos.hr

Project title: Mediterranean plants as part of the "Green Deal": bioactive metabolites and their potential

Project Acronym: GREEN4MED

Visual:

Funding Programme: NPOO, NextGenerationEU

Project Duration: 01/10/2025 – 30/09/2029

Total Budget: 238.050,00 EUR

Project Leader: Ivana GENERALIĆ MEKINIĆ

Project summary:
The subject of the project is unexplored or insufficiently investigated Mediterranean wild edible plant species that have developed a range of morphological, physiological, and biochemical adaptive mechanisms, enabling them to survive and grow under unfavorable and extreme habitat conditions. These include environments characterized by high salinity (halophytes), water scarcity (xerophytes), and high temperatures (thermotolerant species). Due to these abiotic factors, these plants produce and accumulate high levels of various bioactive compounds, primarily secondary plant metabolites, as a form of defense. The project aims to investigate their phytochemical composition (including phenolic compounds, carotenoids, sulfur compounds, and terpenes) and their biological activity (antioxidant, antimicrobial, and enzyme-inhibitory activities). Special attention will be given to the use and optimization of *green* extraction techniques. Selected isolates will be subjected to encapsulation methods in order to preserve stability and enhance the bioactivity of the isolated active phytometabolites.

Coordinator and partners:
University of Split, Faculty of Chemistry and Technology, Ruđera Boškovića 35, HR-21000 Split, Croatia

Key results/activities:
- Selection of coastal plant species from the Dalmatian region
- Optimization of green extraction techniques for the isolation of targeted bioactive metabolites
- Chemical characterization of the samples and evaluation of their biological activity
- Optimization of different encapsulation techniques to preserve or enhance the stability, bioavailability, and bioactivity of the target analytes

Project website:
https://green4med.ktf-split.hr/hr/

Social media:
@green4med (IG)

Contacts:
Ivana GENERALIĆ MEKINIĆ, University of Split, Faculty of Chemistry and Technology, Ruđera Boškovića 35, Split, Croatia; gene@ktf-split.hr

Naziv projekta: Mediteranske biljke kao dio „Zelenog plana“: bioaktivni metaboliti i njihov potencijal

Akronim projekta: GREEN4MED

Vizual:

Program financiranja: NPOO, NextGenerationEU

Trajanje projekta: 01. 10. 2025. – 30. 09. 2029.

Ukupni budžet: 238.050,00 EUR

Voditelj projekta: Ivana GENERALIĆ MEKINIĆ

Sažetak projekta:
Predmet projekta su neistražene ili nedovoljno istražene mediteranske samonikle jestive biljne vrste koje su razvile niz morfoloških, fizioloških i biokemijskih adaptivnih mehanizama koji im omogućuju preživljavanje i rast u nepovoljnim i ekstremnim stanišnim uvjetima. To uključuje uvjete visokog saliniteta (halofiti), oskudice vode (kserofiti) i izloženosti visokim temperaturama (termotolerantne vrste). Zbog navedenih abiotičkih čimbenika ove biljke kao vid obrane proizvode i akumuliraju visoke razine različitih bioaktivnih spojeva, prvenstveno sekundarnih biljnih metabolita. Cilj projekta je istražiti njihov fitokemijski sastav (uključujući fenolne spojeve, karotenoide, sumporne spojeve i terpene) te njihovu biološku aktivnost (antioksidativno, antimikrobno i enzimsko-inhibitorno djelovanje). Posebna pozornost posvetit će se primjeni i optimizaciji zelenih ekstrakcijskih tehnika, a odabrani izolati podvrgnut će se metodama enkapsulacije kako bi se očuvala stabilnost i poboljšala bioaktivnost izoliranih aktivnih fitometabolita.

Koordinator i partneri:
Sveučilište u Splitu, Kemijsko-tehnološki fakultet, Ruđera Boškovića 35, Split, Croatia

Ključni rezultati / aktivnosti:

• Odabir priobalnih biljnih vrsta s područja Dalmacije
• Optimizacija *zelenih* ekstrakcijskih tehnika za izolaciju ciljanih bioaktivnih metabolita
• Kemijska karakterizacija uzoraka i testiranje njihove biološke aktivnosti
• Optimizacija različitih tehnika inkapsulacije u svrhu očuvanja ili poboljšanja stabilnosti, bioraspoloživosti i bioaktivnosti ciljanih analita

Mrežna stranica projekta:

https://green4med.ktf-split.hr/hr/

Društvene mreže:

@green4med (IG)

Kontakti:

Ivana GENERALIĆ MEKINIĆ, Sveučilište u Splitu, Kemijsko-tehnološki fakultet, Ruđera Boškovića 35, Split, Croatia; gene@ktf-split.hr

Project title: Monitoring interaction between the ground and surface water to improve the sustainable agricultural resilience to climate changes impact in coastal systems

Project Acronym: MoWaCLIM

Visual:

Interreg Co-funded by the European Union
IPA Croatia - Bosnia and Herzegovina – Montenegro
MoWaCLIM

Funding Programme: Interreg VI-A IPA Programme Croatia – Bosnia and Herzegovina – Montenegro 2021–2027

Project Duration: 01/09/2024 – 31/08/2027

Total Budget: 1.514.937,44 EUR

Project Leader: Veljko SRZIĆ

Project summary: The MoWaCLIM project addresses the challenges of climate change in coastal areas, with a particular focus on the impact of salinization of surface and groundwater on agricultural production. Coastal systems, such as the Neretva Valley, are increasingly affected by sea level rise, reduced freshwater inflow and intensive anthropogenic pressures, leading to alterations in the hydrological regime and reduced agricultural productivity. The project develops an integrated monitoring system covering climatic, hydrological and agronomic parameters, enabling the collection of data essential for understanding salinization processes. The established digital platform, HydroAgroCloud, enables data integration and analysis and supports informed decision-making. Based on the collected data, guidelines and action plans are developed to support the adaptation of agricultural production to climate change, with the aim of increasing system resilience and sustainability.

Coordinator and partners:
[1] Dubrovnik-Neretva Region, Pred Dvorom 1, 20 000 Dubrovnik, Croatia (Lead Parner)
[2] University of Split, Faculty of Civil Engineering, Architecture and Geodesy, Matice hrvatske 15, 21 000 Split, Croatia
[3] Croatian Agency for Agriculture and Food, Vinkovačka cesta 63c, 31 000 Osijek, Croatia
[4] Ministry of Agriculture, Forestry and Water Management of Herzegovina-Neretva Canton, Hrvatske mladeži bb, 88 000 Mostar, Bosnia and Herzegovina
[5] Public Company Nature park "Hutovo blato" ltd., Karaotok bb, 88 307 Čapljina, Bosnia and Herzegovina

Key results/activities:
• Development and implementation of a site-specific monitoring system for climatic, hydrological and agronomic parameters in the cross-border pilot area of the Neretva Delta
• Monitoring and analysis of surface–groundwater interactions and salinization processes in coastal areas
• Development of digital tools, including the HydroAgroCloud platform and the MoWaCLIM web application for end-users (farmers), enabling data integration, visualization and decision support
• Characterisation of the pilot area and development of a strategy and action plan for climate-resilient agricultural production

Impact: The MoWaCLIM project contributes to strengthening the resilience of agricultural production in coastal areas affected by climate change. By integrating monitoring data and digital tools, the project improves the capacity for evidence-based decision-making in water and agricultural management. It enhances cross-border cooperation and supports stakeholders, particularly farmers, in adapting to salinization and changing water availability. The project results provide a foundation for long-term sustainable management of water resources and agricultural systems, with potential for replication in other coastal regions.

Collaboration opportunities: The MoWaCLIM project is open to collaboration with relevant institutions, research organisations, public authorities and stakeholders in the fields of water resource management and sustainable agriculture. Opportunities include data and knowledge exchange, participation in dissemination activities, and contribution to the development and application of digital tools and climate change adaptation guidelines.

Open calls/pilot activities: Interested stakeholders can engage through participation in dissemination activities, exchange of data and experience, and the use of developed digital tools, including the HydroAgroCloud platform and the MoWaCLIM web application. Participation in pilot activities is also possible through collaboration with project partners at the local level.

Project website:
https://interreg-hr-ba-me.eu/project/project-library/mowaclim/

Social media:
• Facebook: https://www.facebook.com/p/Mowaclim-61568269925294/
• Instagram: https://www.instagram.com/mowaclim/

Contacts:
[1] Mato TOMLJANOVIĆ, Dubrovnik-Neretva Region, Pred Dvorom 1, Dubrovnik, Croatia, mato.tomljanovic@dnz.hr
[2] Veljko SRZIĆ, University of Split, Faculty of Civil Engineering, Architecture and Geodesy, Matice hrvatske 15, Split, Croatia, veljko.srzic@gradst.hr
[3] Tvrtko JELAČIĆ, Croatian Agency for Agriculture and Food, Vinkovačka cesta 63c, Osijek, Croatia, tvrtko.jelacic@hapih.hr
[4] Svjetlana STANIĆ-KOŠTROMAN, Ministry of Agriculture, Forestry and Water Management of Herzegovina-Neretva Canton, Hrvatske mladeži bb, Mostar, Bosnia and Herzegovina, kostroman-stanic.svjetlana@mpsv-hnz-k.ba
[5] Irena ROZIĆ, Public Company Nature park "Hutovo blato" ltd., Karaotok bb, Čapljina, Bosnia and Herzegovina, info@hutovo-blato.ba

Naziv projekta: Monitoring interakcija između podzemnih i površinskih voda u svrhu povećanja otpornosti održive poljoprivrede na utjecaje klimatskih promjena u obalnim područjima

Akronim projekta: MoWaCLIM

Visual:

Program financiranja: Interreg VI-A IPA Program Hrvatska – Bosna i Hercegovina – Crna Gora 2021.–2027.

Trajanje projekta: 01.09.2024. – 31.09.2027.

Ukupni budžet: 1.514.937,44 EUR

Voditelj projekta: Veljko SRZIĆ

Sažetak projekta: Projekt MoWaCLIM usmjeren je na rješavanje izazova klimatskih promjena u obalnim područjima, s posebnim naglaskom na utjecaj zaslanjenja površinskih i podzemnih voda na poljoprivrednu proizvodnju. Obalni sustavi, poput doline Neretve, suočeni su s porastom razine mora, smanjenim dotokom slatke vode te intenzivnim antropogenim pritiscima, što dovodi do narušavanja vodnog režima i smanjenja produktivnosti poljoprivrede. Projekt razvija integrirani sustav monitoringa koji obuhvaća klimatske, hidrološke i agronomske parametre te omogućuje prikupljanje podataka ključnih za razumijevanje procesa zaslanjenja. Uspostavljena digitalna platforma HydroAgroCloud omogućuje integraciju i analizu podataka te pruža podršku donošenju odluka. Na temelju prikupljenih podataka razvijaju se smjernice i akcijski planovi za prilagodbu poljoprivredne proizvodnje klimatskim promjenama, s ciljem povećanja otpornosti i održivosti sustava.

Koordinator i partneri:
[1] Dubrovačko-neretvanska županija, Pred Dvorom 1, Dubrovnik, Hrvatska
[2] Sveučilište u Splitu, Fakultet građevinarstva, arhitekture i geodezije, Matice hrvatske 15, Split, Hrvatska
[3] Hrvatska agencija za poljoprivredu i hranu, Vinkovačka cesta 63c, Osijek, Hrvatska
[4] Ministarstvo poljoprivrede, šumarstva i vodoprivrede Hercegovačko-neretvanske županije-kantona, Hrvatske mladeži bb, Mostar, Bosna i Hercegovina
[5] Javno poduzeće Park prirode "Hutovo blato" d.o.o. Čapljina, Karaotok bb, Čapljina, Bosna i Hercegovina

Ključni rezultati / aktivnosti:
• Razvoj i uspostava lokalno prilagođenog sustava monitoringa klimatskih, hidroloških i agronomskih parametara u prekograničnom pilot području delte Neretve
• Monitoring i analiza interakcija površinskih i podzemnih voda te procesa zaslanjenja u obalnim područjima
• Razvoj digitalnih alata, uključujući platformu HydroAgroCloud i MoWaCLIM web aplikaciju za krajnje korisnike (poljoprivredne proizvođače), za integraciju, vizualizaciju i potporu odlučivanju
• Karakterizacija pilot područja te izrada strategije i akcijskog plana za klimatski otpornu poljoprivrednu proizvodnju

Utjecaj: Projekt MoWaCLIM doprinosi jačanju otpornosti poljoprivredne proizvodnje u obalnim područjima pogođenim klimatskim promjenama. Integracijom podataka monitoringa i digitalnih alata unapređuje se kapacitet za donošenje odluka temeljenih na podacima u upravljanju vodnim resursima i poljoprivredom. Projekt jača prekograničnu suradnju te pruža podršku dionicima, osobito poljoprivrednim proizvođačima, u prilagodbi zaslanjenju i promjenama dostupnosti vode. Rezultati projekta predstavljaju osnovu za dugoročno održivo upravljanje vodnim i poljoprivrednim sustavima, uz mogućnost primjene u drugim obalnim područjima.

Mogućnosti suradnje: Projekt MoWaCLIM otvoren je za suradnju s relevantnim institucijama, istraživačkim organizacijama, javnim tijelima i drugim dionicima u području upravljanja vodnim resursima i održive poljoprivrede. Mogućnosti suradnje uključuju razmjenu podataka i znanja, sudjelovanje u diseminacijskim aktivnostima te doprinos razvoju i primjeni digitalnih alata i smjernica za prilagodbu klimatskim promjenama.

Otvoreni pozivi / pilot aktivnosti: zainteresirani dionici mogu se uključiti kroz sudjelovanje u diseminacijskim aktivnostima, razmjenu podataka i iskustava te korištenje razvijenih digitalnih alata, uključujući HydroAgroCloud platformu i MoWaCLIM web aplikaciju. Također, moguće je sudjelovanje u pilot aktivnostima kroz suradnju s projektnim partnerima na lokalnoj razini.

Mrežna stranica projekta:
https://interreg-hr-ba-me.eu/project/project-library/mowaclim/

Društvene mreže:
• Facebook: https://www.facebook.com/p/Mowaclim-61568269925294/
• Instagram: https://www.instagram.com/mowaclim/

Kontakti:
[1] Mato TOMLJANOVIĆ, Dubrovačko-neretvanska županija, Pred Dvorom 1, Dubrovnik, Hrvatska; mato.tomljanovic@dnz.hr
[2] Veljko SRZIĆ, Sveučilište u Splitu, Fakultet građevinarstva, arhitekture i geodezije, Matice hrvatske 15, Split, Hrvatska; veljko.srzic@gradst.hr
[3] Tvrtko JELAČIĆ, Hrvatska agencija za poljoprivredu i hranu, Vinkovačka cesta 63c, Osijek, Hrvatska; tvrtko.jelacic@hapih.hr
[4] Svjetlana STANIĆ-KOŠTROMAN, Ministarstvo poljoprivrede, šumarstva i vodoprivrede Hercegovačko-neretvanske županije-kantona, Hrvatske mladeži bb, Mostar, Bosna i Hercegovina; kostroman-stanic.svjetlana@mpsv-hnz-k.ba
[5] Irena ROZIĆ, Javno poduzeće Park prirode "Hutovo blato" d.o.o. Čapljina, Karaotok bb, Čapljina, Bosna i Hercegovina; info@hutovo-blato.ba

Project title: Assessing the Ecological and Economic Impact of Fish Ponds in Croatia and Hungary towards more sustainable and climate-resilient aquaculture

Project Acronym: PondSustain

Visual:

Funding Programme: Interreg VI-A Hungary-Croatia Programme 2021-2027

Project Duration: 01/04/2026 – 31/03/2028

Total Budget: 252.249,47 EUR

Project Leader: Mirna HABUDA-STANIĆ

Project summary: The project explores the ecological and economic role of fish ponds in the Croatia–Hungary border region. It focuses on biodiversity conservation, the impact of invasive species, and the effects of great cormorant *(Phalacrocorax carbo*) predation on fish populations and local livelihoods. The research applies environmental DNA (eDNA) analysis to monitor endangered species such as Tinca tinca, Carassius carassius, Umbra kramerii, and *Misgurnus fossilis*, alongside invasive species. Field observations will examine cormorant feeding behavior and its influence on fish stocks. The project also evaluates the economic consequences of predation on aquaculture, recreational fishing, and tourism through stakeholder surveys and collaboration. Expected outcomes include a comprehensive biodiversity report, scientific publications, and evidence-based recommendations for sustainable fish pond management. By integrating ecological and socio-economic perspectives, the project aims to support sustainable aquaculture practices, strengthen cross-border cooperation, and balance environmental protection with regional economic development.

Coordinator and partners:

[1] Josip Juraj Strossmayer University of Osijek, Faculty of Food Technology Osijek, Franje Kuhača 18, Osijek, Croatia
[2] Hungarian University of Agriculture and Life Sciences, Guba Sándor u. 40, Kaposvár, Hungary

Key results/activities

• Praćenje pomoću okolišne DNA (eDNA) koristit će se za procjenu bioraznolikosti vodenih ekosustava te identifikaciju ugroženih i invazivnih vrsta riba u ribnjacima i zaštićenim područjima.

• Parametri kakvoće vode, uključujući koncentraciju otopljenog kisika, hranjive tvari, pH vrijednost, mutnoću i temperaturu, pratit će se radi procjene stanja ekosustava i utjecaja klimatskih promjena.

• Utjecaj predacije velikog vranca na riblje stokove i bioraznolikost procjenjivat će se terenskim opažanjima, satelitskim praćenjem i analizom sadržaja želuca.

• Gospodarski i društveni učinci procjenjivat će se putem anketa i intervjua s dionicima kako bi se utvrdili gubici i mogućnosti suradnje u upravljanju ribnjacima.

• Analizirat će se i unaprijediti održive i klimatski otporne tehnologije uzgoja ribe s ciljem očuvanja bioraznolikosti, smanjenja negativnih utjecaja na okoliš i povećanja dugoročne gospodarske održivosti.

Impact: The project will enhance biodiversity conservation and sustainable aquaculture management in the Croatia–Hungary border region by improving knowledge of fishpond ecosystems and climate-related challenges. Through advanced monitoring, stakeholder cooperation, and the development of climate-resilient fish farming practices, the project will support evidence-based management, strengthen cross-border cooperation, promote local economic development, and contribute to long-term environmental sustainability and ecosystem resilience.

Collaboration opportunities: The project fosters long-term cross-border cooperation among research institutions, fish farmers, conservation organizations, and local authorities in Croatia and Hungary, providing a foundation for future joint research, knowledge exchange, and sustainable aquaculture and biodiversity management.

Project website: https://www.ptfos.unios.hr/PondSustain/

Social media:
https://www.instagram.com/pondsustain/
https://www.facebook.com/Pondsustain/
https://www.linkedin.com/in/interreg-pondsustain-ab5099405/

Contacts:
Mirna HABUDA-STANIĆ, Josip Juraj Strossmayer University of Osijek, Faculty of Food Technology Osijek, Franje Kuhača 18, Osijek, Croatia, habudastanic@gmail.com

Naziv projekta: Procjena ekološkog i ekonomskog utjecaja ribnjaka u Hrvatskoj i Mađarskoj s ciljem održivije i klimatski otpornije akvakulture

Akronim projekta: PondSustain

Visual:

Program financiranja: Interreg VI-A Hungary-Croatia Programme 2021-2027

Trajanje projekta: 01.04.2026. – 31.03.2028.
6
Ukupni budžet: 252.249,47 EUR

Voditelj projekta: Mirna HABUDA-STANIĆ

Sažetak projekta: Projekt istražuje ekološku i gospodarsku ulogu ribnjaka u pograničnom području Hrvatske i Mađarske. Poseban naglasak stavljen je na očuvanje bioraznolikosti, utjecaj invazivnih vrsta te učinke predacije velikog vranca (Phalacrocorax carbo) na riblje populacije i lokalno gospodarstvo. U istraživanju će se primjenjivati analiza okolišne DNA (eDNA) za praćenje ugroženih vrsta, poput linjaka (Tinca tinca), zlatnog karasa (Carassius carassius), piškura (Misgurnus fossilis) i crnke (Umbra kramerii), kao i invazivnih vrsta. Terenska istraživanja obuhvatit će promatranje hranidbenog ponašanja velikog vranca i procjenu njegova utjecaja na riblje stokove. Projekt će također analizirati gospodarske posljedice predacije na akvakulturu, sportsko-ribolovni turizam i rekreacijski ribolov putem anketa i suradnje s relevantnim dionicima. Očekivani rezultati uključuju izradu sveobuhvatnog izvješća o bioraznolikosti, objavu znanstvenih radova te izradu preporuka utemeljenih na znanstvenim dokazima za održivo upravljanje ribnjacima. Integriranjem ekoloških i socioekonomskih aspekata projekt nastoji poduprijeti razvoj održivih praksi u akvakulturi, ojačati prekograničnu suradnju te uspostaviti ravnotežu između zaštite okoliša i regionalnog gospodarskog razvoja.

Koordinator i partneri:
[1] Sveučilište Josipa Jurja Strossmayera u Osijeku, Prehrambeno-tehnološki fakultet Osijek, Franje Kuhača 18, Osijek, Hrvatska
[2] Hungarian University of Agriculture and Life Sciences, Guba Sándor u. 40, Kaposvár, Hungary

Ključni rezultati / aktivnosti:
• Razvoj i uspostava lokalno prilagođenog sustava monitoringa klimatskih, hidroloških i agronomskih parametara u prekograničnom pilot području delte Neretve
• Monitoring i analiza interakcija površinskih i podzemnih voda te procesa zaslanjenja u obalnim područjima
• Razvoj digitalnih alata, uključujući platformu HydroAgroCloud i MoWaCLIM web aplikaciju za krajnje korisnike (poljoprivredne proizvođače), za integraciju, vizualizaciju i potporu odlučivanju
• Karakterizacija pilot područja te izrada strategije i akcijskog plana za klimatski otpornu poljoprivrednu proizvodnju

Utjecaj: Projekt će unaprijediti očuvanje bioraznolikosti i održivo upravljanje akvakulturom u pograničnom području Hrvatske i Mađarske kroz bolje razumijevanje ribnjačkih ekosustava i izazova povezanih s klimatskim promjenama. Primjenom naprednih metoda praćenja, suradnjom dionika i razvojem klimatski otpornih praksi uzgoja riba, projekt će poduprijeti upravljanje temeljeno na znanstvenim spoznajama, ojačati prekograničnu suradnju, potaknuti lokalni gospodarski razvoj te doprinijeti dugoročnoj održivosti okoliša i otpornosti ekosustava.

Mogućnosti suradnje: Projekt potiče dugoročnu prekograničnu suradnju između istraživačkih institucija, uzgajivača ribe, organizacija za zaštitu prirode i lokalnih vlasti u Hrvatskoj i Mađarskoj, stvarajući temelje za buduća zajednička istraživanja, razmjenu znanja te razvoj održivih praksi upravljanja akvakulturom i bioraznolikošću.

Mrežna stranica projekta:
https://www.ptfos.unios.hr/PondSustain/

Društvene mreže:
https://www.instagram.com/pondsustain/
https://www.facebook.com/Pondsustain/
https://www.linkedin.com/in/interreg-pondsustain-ab5099405/

Contacts:
Mirna HABUDA-STANIĆ, Sveučilište Josipa Jurja Strossmayera u Osijeku, Prehrambeno-tehnološki fakultet Osijek, Franje Kuhača 18, Osijek, Hrvatska, habudastanic@gmail.com

Project title: Transforming bio-waste to innovative hydroponic solutions

Project Acronym: Was2Grow

Visual:

Funding Programme: European Union—NextGenerationEU

Project Duration: 01/06/2024 - 30/06/2026

Total Budget: 1.026.708,17 EUR

Project Leader: Gabrijel ONDRAŠEK

Project summary:
Waste management is an escalating global challenge driven by the continuous growth of landfills, despite waste streams containing valuable recyclable resources. The Was2Grow project addresses this issue by developing and experimentally validating, at laboratory scale, an innovative technology to convert industrial, agricultural, and household bio-waste into three hydroponic substrates (plug, cube, and slab) tailored to support crops across different growth stages. By transforming bio-waste into high-value cultivation media, Was2Grow advances circular bioeconomy principles and contributes to sustainable food production systems. The project aligns with EU strategic priorities in waste and energy management by reducing landfill dependency, improving waste treatment standards, and promoting resource efficiency. Ultimately, Was2Grow demonstrates how waste valorization can drive smart, green innovations that integrate environmental protection with agricultural productivity.

Coordinator and partners:
[1] University of Zagreb Faculty of Agriculture, Svetošimunska cesta 25, Zagreb, Croatia
[2] Institute for Medical Research and Occupational Health, Ksaverska cesta 2, Zagreb, Croatia
[3] INOVACIJE I RAZVOJ Ltd, Jadranski trg 1, Rijeka, Croatia
[4] FEMA Ltd, Novoselija 40, Otočac, Croatia

Key results/activities:

- Raw material mapping and comprehensive characterization (physical, chemical, microbiological, radiological)
- *In silico* design and conceptualization of hydroponic substrate prototypes
- Laboratory development and testing of plug, cube, and slab substrates
- Dissemination, technology transfer activities, and academia–industry collaboration

Impact:

Was2Grow delivers environmental and economic benefits by converting bio-waste into high-value hydroponic substrates, reducing landfill use and associated emissions. The approach enhances resource efficiency and supports circular bioeconomy practices while lowering dependence on conventional growing media. It enables more sustainable and scalable food production, particularly in controlled environments. Additionally, the technology creates opportunities for waste valorization across sectors, fostering innovation, green jobs, and alignment with EU sustainability and waste management targets.

Collaboration opportunities:

Was2Grow invites collaboration with academia, industry, and policymakers in waste management, materials, and hydroponic agriculture. Partners can support pilot-scale validation, substrate optimization, life cycle assessment, and scaling. The project targets hydroponic growers, substrate producers, and bio-waste processors, fostering integration into circular bioeconomy value chains.

Project website:

https://was2grow.agr.hr/en/

QR code

Contacts:

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Naziv projekta: Pretvorba bio-otpada u inovativna hidroponska rješenja

Akronim projekta: Was2Grow

Vizual:

Program financiranja: European Union—NextGenerationEU

Trajanje projekta: 01.06.2024. – 30.06.2026.

Ukupni budžet: 1.026.708,17 EUR

Voditelj projekta: Gabrijel ONDRAŠEK

Sažetak projekta:
Gospodarenje otpadom sve je veći globalni izazov potaknut kontinuiranim rastom odlagališta, unatoč tome što otpad sadrži vrijedne sirovine koje se mogu reciklirati. Projekt Was2Grow rješava ovaj problem razvojem i eksperimentalnom validacijom, na laboratorijskoj razini, inovativne tehnologije za pretvorbu industrijskog, poljoprivrednog i kućanskog biootpada u tri hidroponska supstrata (čep, kocka i ploča) prilagođena uzgoju usjeva u različitim fazama rasta. Pretvaranjem biootpada u visokovrijedne uzgojne medije, Was2Grow unapređuje načela kružnog bioekonomskog pristupa i doprinosi održivim sustavima proizvodnje hrane. Projekt je usklađen sa strateškim prioritetima EU-a u području gospodarenja otpadom i energijom, smanjenjem ovisnosti o odlagalištima, poboljšanjem standarda obrade otpada te poticanjem učinkovitog korištenja resursa. U konačnici, Was2Grow pokazuje kako valorizacija otpada može potaknuti pametne i zelene inovacije koje povezuju zaštitu okoliša i poljoprivrednu produktivnost.

Koordinator i partneri:
[1] Sveučilište u Zagrebu Agronomski fakultet, Svetošimunska cesta 25, Zagreb, Hrvatska
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Ključni rezultati / aktivnosti:

- Mapiranje sirovina i detaljna karakterizacija (fizikalna, kemijska, mikrobiološka, radiološka)
- *In silico* dizajn i konceptualizacija prototipova hidroponskih supstrata
- Laboratorijski razvoj i ispitivanje supstrata u obliku čepa, kocke i ploče
- Diseminacija, aktivnosti transfera tehnologije te suradnja akademske zajednice i industrije

Utjecaj:

Was2Grow pozitivno utječe na okoliš i gospodarstvo pretvaranjem biootpada u visokovrijedne hidroponske supstrate, čime se smanjuje korištenje odlagališta i povezane emisije. Takav pristup povećava učinkovitost korištenja resursa i podržava prakse kružne bioekonomije, uz smanjenje ovisnosti o konvencionalnim uzgojnim medijima, te ujedno omogućuje održiviju i skalabilnu proizvodnju hrane, osobito u kontroliranim uvjetima. Was2Grow tehnologija stvara prilike za valorizaciju otpada u različitim sektorima, potičući inovacije, zelena radna mjesta i usklađenost s ciljevima EU-a u području održivosti i gospodarenja otpadom.

Mrežna stranica projekta:

https://was2grow.agr.hr/en/

QR kod

Kontakti:

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26-29 May 2026

Vodice, CROATIA