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BOOK OF ABSTRACTS

3rd European GREEN Conference

10 - 13 June 2025
Hotel Olympia SKY
Vodice CROATIA

ISSN: 2991-5171

European Commission

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KNJIGA SAŽETAKA

3. Europska GREEN konferencija

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Vodice HRVATSKA

ISSN: 2991-5171

BOOK OF ABSTRACTS **3rd European GREEN Conference**
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Published by International Association of Environmental Scientists and Professionals (IAESP), Osijek, Croatia
Izdavač *Međunarodno udruženje znanstvenika i stručnjaka za zaštitu okoliša (MZSZO), Osijek, Hrvatska*

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Content
Sadržaj

PLENARY LECTURES
PLENARNA PREDAVANJA

INVITED LECTURES
POZVANA PREDAVANJA

PRESENTATIONS
PRIOPĆENJA

CLIMATE CHANGE
KLIMATSKE PROMJENE

CULTURE, ART AND SUSTAINABILITY
UMJETNOST, KULTURA I ODRŽIVOST

ECOLOGICAL AGRICULTURE AND FOOD PRODUCTION
EKOLOŠKA POLJOPRIVREDA I PROIZVODNJA HRANE

ECOLOGICAL MEDICINE AND BIOMEDICINE
EKOLOŠKA MEDICINA I BIOMEDICINA

ECOLOGY AND SOCIETY
EKOLOGIJA I DRUŠTVO

GREEN ARCHITECTURE AND CONSTRUCTION
ZELENA ARHITEKTURA I GRADNJA

GREEN BIOTECHNOLOGY
ZELENA BIOTEHNOLOGIJA

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ZELENA KEMIJA I KEMIJSKO INŽENJERSTVO

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UPRAVLJANJE VODAMA

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Plenary Lectures
Plenarna predavanja

The hydrological cycle under climate change pressure

Ivan GÜTTLER

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Abstract

The hydrological cycle is intensifying due to climate change, resulting in increased atmospheric water vapor and more frequent and intense precipitation events. In Europe, northern regions are getting wetter, while southern areas, including Croatia, are facing drier summers and higher drought and open fire risks. Warmer winters are causing a shift from snowfall to rainfall, reducing snowpack and altering seasonal water storage. In Croatia, this results in earlier snowmelt and changes in river regimes. The number of snowy days is expected to decrease, which will impact water supply and hydropower in the coming decades. Intense short-duration rainfall events are becoming more common, raising the threat of flash floods. Hailstorms may also become more frequent and severe due to more energetic convective storms. Water vapor, as a greenhouse gas, further amplifies atmospheric warming and hydrological extremes. These changes demand adaptive water management strategies in Croatia to ensure resilience in the face of a changing climate and rising pressures on food and energy production.

Keywords: climate change, hydrological cycle, water management

Hidrološki ciklus pod pritiskom globalnog zagrijavanja

Ivan GÜTTLER

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Sažetak

Hidrološki ciklus se intenzivira pod utjecajem klimatskih promjena zbog povećane količine vodene pare u atmosferi, što dovodi do češćih i intenzivnijih oborinskih događaja. U Europi, sjeverne regije postaju vlažnije, dok južni dijelovi, uključujući Hrvatsku, bilježe sušnija ljeta te veći rizik od suša i otvorenih požara. Toplije zime uzrokuju prijelaz sa snježnih oborina na kišu, smanjujući snježni pokrivač i mijenjajući sezonsku pohranu vode. U Hrvatskoj to dovodi do ranijeg topljenja snijega i promjena u režimu rijeka. Očekuje se smanjenje broja dana sa snijegom, što će u nadolazećim desetljećima utjecati na opskrbu vodom i hidroenergetski potencijal. Intenzivne kratkotrajne oborine postaju sve učestalije, povećavajući prijetnju od bujičnih poplava. Oluje s tučom također bi mogle postati učestalije i razornije zbog snažnijih konvektivnih procesa. Vodena para, kao staklenički plin, dodatno pojačava zagrijavanje atmosfere i hidrološke ekstreme. Ove promjene zahtijevaju prilagodljive strategije upravljanja vodama u Hrvatskoj kako bi se osigurala otpornost na promjenjivu klimu i rastuće pritiske na proizvodnju hrane i energije.

Ključne riječi: klimatske promjene, hidrološki ciklus, vodno upravljanje

Green Diet: Bridging Ecology and Metabolic Wellness

Marija HEFFER, Stipe VIDOVIĆ

Josip Juraj Strossmayer University of Osijek, Faculty of Medicine Osijek, Department of Medical Biology and Genetics, Huttlerova 4, Osijek, Croatia

Abstract

The earliest medical recommendations for healthy eating emerged in the shadow of World War II, aiming to ensure survival during times of scarcity. These guidelines primarily drove the industrial production of grains, sugar, and meat. Later recommendations, such as the food pyramid and "My Plate," shifted focus from scarcity to promoting cardiovascular and metabolic health. Given the widespread prevalence of metabolic disorders, prediabetes, and diabetes, the popular pyramid from the early 20th century and its inspired offerings of ultra-processed foods (often fat-free products) have contributed to rising obesity rates. "My Plate" has failed to gain widespread adoption, partly due to the food industry's resistance to rapid change. Advances in sequencing technology and understanding of human microbiome diversity now advocate for personalized diets tailored to individual metabolic profiles. However, the food industry is unprepared for this shift, as it would require replacing ultra-processed foods with "real food"—products directly sourced from fields to consumers. The medical practice, historically focused more on treatment than prevention, is similarly unready for this transformation. Recently, the anthropocentric view of health has been challenged by the less well-known "One Health" concept, which promotes the health of humans alongside sustainable food production that does not harm the environment. This approach emphasizes product traceability and banning items that contribute to soil degradation and deforestation. Due to significant changes in health perceptions over the past 30 years and the need to protect ecosystems, it is challenging for the average consumer to identify truly healthy products. Our study assumed that young people are aware of the connection between health and nutrition and try to select foods that meet the minimum macro-nutrient requirements set by the World Health Organization (WHO). The survey was conducted in February 2024 among first- and second-year medical students. Macronutrient intake was assessed using the European Prospective Investigation into Cancer (EPIC)-Norfolk Food Frequency Questionnaire (FFQ). The study received

ethical approval from the Medical Faculty of Osijek Ethics Committee (No: 2158-61-46-23-187). A total of 85 students participated (24 men and 61 women). The median age was 20 years (IQR: 19–21). According to the EPIC-Norfolk FFQ and WHO recommendations, 20% of participants had insufficient protein intake, while 81.2% consumed less than the recommended total fat intake. Regarding fiber intake, 12.3% consumed less than the recommended 25 grams per day. Additionally, 80% exceeded recommended carbohydrate intake, and 97.6% had an excessive intake of saturated fats. Based on our findings, young people poorly select healthy foods, which can be attributed to confusing information, financial constraints, separate living arrangements, academic stress, and the simplicity of food procurement. It is especially concerning given that these participants are future doctors who will soon provide dietary advice to patients. Even more alarming is the lack of nutrition-focused subjects in their curriculum. Addressing these curricular gaps still leaves the broader issue of public recognition of healthy foods and the necessity for clear labeling to indicate health benefits for humans and the environment. A significant scientific challenge will be establishing the link between soil health—where fruits and vegetables are grown—and the human microbiome, as well as shifting modern agriculture toward sustainability.

Keywords: nutrition, metabolic health, ultra-processed foods, personalized diets, sustainability

Zelena dijeta: Povezivanje ekologije i metaboličkog zdravlja

Marija HEFFER, Stipe VIDOVIĆ

Sveučilište Josipa Jurja Strossmayera u Osijeku, Medicinski fakultet Osijek, Katedra za medicinsku biologiju i genetiku, Huttlerova 4, Osijek, Hrvatska

Sažetak

Najranije medicinske preporuke o zdravoj prehrani nastale su u sjeni drugog svjetskog rata s ciljem da osiguraju preživljavanje u oskudici. One su bile motor industrijske proizvodnje žitarica, šećera i mesa. Kasnije kreirane preporuke, poput piramide i „My plate“, motivirane su ne više oskudicom već kardiovaskularnim i metaboličkim zdravljem. Sudeći po rasprostranjenosti metaboličkog poremećaja, predijabetesa i dijabetesa, popularna piramida s početka 20. stoljeća i njome inspirirana ponuda prerađene hrane (ultraprocesirani proizvodi s 0 % masti) samo su doprinijele porastu pretilosti. „My plate“ se nije uspio nametnuti i nije ga pratila promjena u prehrambenoj industriji koja ne trpi brze zaokrete. Zahvaljujući napretku u tehnologiji sekvenciranja i spoznajama o značenju bioraznolikosti ljudskog mikrobioma, najsuvremenije preporuke zalažu se za personalizaciju dijete s obzirom na individualne metaboličke odlike. Za ovaj najnoviji izazov industrija hrane uopće nije spremna jer bi ultraprocesiranu hranu treba zamijeniti „stvarna hrana“ koja izravnim putem dolazi s polja do potrošača. Za ovaj zaokret nije spremna niti medicinska praksa koja je do sada bila više orijentirana na liječenje nego na prevenciju. Štoviše, antropocentrični pogled na zdravlje nedavno je zamijenjen u javnosti najmanje poznatim konceptom „jednog zdravlja“ koji se zalaže ne samo za zdravlje čovjeka već i za održivu proizvodnju hrane koja ne šteti okolišu. Ovaj koncept nalaže sljedivost proizvoda i njihovo isključivanje s tržišta ako doprinose degradaciji tla, a osobito deforestaciji. Radi drastičnih promjena u shvaćanju zdravlja u zadnjih 30 godina i potrebe da se doprinese zaštiti eko sustava prosječnom potrošaču teško je procijeniti koji su proizvodi zdravi. Naša je studija pretpostavila kako su mladi osviješteni o vezi između zdravlja i prehrane i nastoje odabrati namirnice koje zadovoljavaju propisane minimalne količine makronutrijenata od strane Svjetske zdravstvene organzacije (WHO). Studija na studentima medicine prve i druge godine studija provedena je u veljači 2024. Unos makronutrijenata procijenjen je pomoću upitnika za samoprocjenu European Prospective Investigation into Cancer (EPIC)-Norfolk Food

Frequency Questionnaire (FFQ). Studija je odobrena od strane Etičkog povjerenstva Medicinskog fakulteta Osijek (No: 2158-61-46-23-187). U studiji je sudjelovalo 85 studenata (24 muškarca i 61 žena). Medijan dobi bio je 20 godina (IQR: 19 – 21). Prema EPIC-Norfolk FFQ i preporukama WHO za unos makronutrijenata, 20% sudionika imalo je nedovoljan unos proteina, dok je 81,2 % konzumiralo manje od preporučenog ukupnog unosa masti. S obzirom na unos vlakana, 12,3 % sudionika konzimiralo je manje od preporučenih 25 grama na dan. Nadalje, 80 % sudionika je unosilo ugljkohidrate iznad preporučenih vrijednosti, a 97,6 % sudionika imalo je prekomjeran unos zasićenih masti. Sudeći prema rezultatima vlastite studije – mladi loše odabiru prehrambene namirnice. Ovo je posljedica zbunjujućih informacija, materijalnih sposobnosti, odvojenog života, stresa studentskog života i jednostavnosti nabave namirnica. Zabrinjava to što se radi o studentima medicine koji će uskoro biti u prilici davati preporuke o prehrani svojim pacijentima. Još više zabrinjava nedostatak predmeta koji se tiče zdrave prehrane u kurikulumu njihova studija. I kada bi se ove kurikularne pogreške ispravile ostaje problem prepoznavanja zdravih namirnica od strane javnosti i potreba za njihovim jasnim označavanjem da su zdrave za čovjeka i okoliš. Poseban znanstveni izazov biti će utvrđivanje veze između zdravlja tla u kojemu se uzgaja voće i povrće i ljudskog mikrobioma te probrazba suvremene poljoprivrede u održivu.

Ključne riječi: prehrana, metaboličko zdravlje, ultraprerađena hrana, personalizirana prehrana, održivost

Challenges and opportunities for the Blue Economy

Andreea STRACHINESCU OLTEANU

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Abstract

If we are to take advantage of the unprecedented opportunities for the blue economy offered by rapid advances in technologies such as artificial intelligence, robotics and bioengineering, we will need to tackle challenges such as expanding our limited knowledge of what is happening and what will happen beneath the surface of the ocean to meet tough targets on decarbonisation and nature restoration whilst at the same time increasing the EU's strategic autonomy and remaining competitive in the face of fierce rivalry from traditional and emerging competitors. No EU nation can do this on its own. In response, the European Commission will shortly adopt an Ocean Pact setting out how we can work together to make the blue economy a key player in its ambition to guarantee a secure future with better living standards for EU citizens. It involves resetting its research and innovation strategy by building on Mission Ocean to focus on results and targets, shifting to a radically different and more efficient approach to knowledge and observation that embraces the principle of measure once and use for many purposes and following up the BlueInvest initiative by bringing in more private finance and exploring carbon and nature credits for blue carbon.

Keywords: blue economy, technological innovation, EU cooperation and strategic autonomy

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Invited Lectures
Pozvana predavanja

The green illusion: What generative AI really costs the planet?

Kristina AFRIĆ RAKITOVAC

Juraj Dobrila University of Pula, Faculty of Economics and Tourism "Dr. Mijo Mirković“, A. Preradovićeva 1/1, Pula, Croatia

Abstract

Generative AI is revolutionizing how we create, communicate, work and compute — but beneath its sleek, seamless output lies a complex web of environmental and social consequences. While much of the public debate focuses on the benefits of AI, the author critically reflects on what is often left out: the ecological footprint of generative AI systems, as well as the potential social risks. From mining of rare metals for hardware production, the massive water use required to cool data centres, the vast energy demands behind every prompt, the huge quantities of electronic waste, the impact on natural ecosystems— the author explores the often-neglected environmental infrastructure that fuels the illusion of a "clean" intelligence. Widespread use of generative artificial intelligence potentially carries various social risks: misinformation and deepfakes, job losses and economic inequality, discrimination, erosion of human creativity, loss of responsibility, etc. The proposed topic challenges scientists, experts, innovators, educators, policymakers, and various other relevant stakeholders to reconsider sustainability not only as an ultimate goal, but as a fundamental principle by asking the question: Can we use the transformative power of generative AI without disrupting natural systems, while preventing negative impacts on society?

Keywords: generative AI, environmental impact, social risks, sustainability, ethical responsibility

Zelena iluzija: Što generativna umjetna inteligencija doista znači za planet?

Kristina AFRIĆ RAKITOVAC

Sveučilište Jurja Dobrile u Puli, Fakultet ekonomije i turizma "Dr. Mijo Mirković", A. Preradovićeva 1/1, Pula, Hrvatska

Sažetak

Generativna umjetna inteligencija mijenja način na koji stvaramo, komuniciramo, radimo i obrađujemo podatke — no ispod njezina uglađenog i učinkovitog sučelja skriva se složen splet okolišnih i društvenih posljedica. Dok se u javnom diskursu uglavnom ističu koristi koje umjetna inteligencija donosi, autor kritički promišlja o onome što se često zanemaruje: ekološkom otisku generativnih AI sustava te njihovim potencijalnim društvenim rizicima. Od iskorištavanja rijetkih metala za proizvodnju računalne opreme, preko velike potrošnje vode potrebne za hlađenje podatkovnih centara, ogromne potrošnje energije pri svakom upitu, do velikih količina elektroničkog otpada i negativnog utjecaja na prirodne ekosustave — autor analizira često zanemarenu materijalnu infrastrukturu koja omogućuje privid „čiste“ inteligencije. Široka primjena generativne umjetne inteligencije sa sobom nosi i niz društvenih izazova: širenje dezinformacija i lažnih sadržaja, gubitak radnih mjesta i rast ekonomske nejednakosti, diskriminaciju, smanjenje ljudske kreativnosti, gubitak odgovornosti, i druge negativne učinke. Tema ovog izlaganja poziva znanstvenike, stručnjake, inovatore, odgojno-obrazovne djelatnike, donositelje odluka i sve ostale relevantne dionike da održivost sagledaju ne samo kao krajnji cilj, nego i kao temeljno načelo, uz ključno pitanje: Možemo li iskoristiti transformativnu moć generativne umjetne inteligencije, a da pritom ne narušimo prirodne sustave i spriječimo negativne posljedice za društvo?

Ključne riječi: generativna umjetna inteligencija, utjecaj na okoliš, društveni rizici, održivost, etika i odgovornost

Water-Energy relations, problems and solutions – When will it all end?

Bojan ĐURIN

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Abstract

Water and Energy are the basic elements of human life, even from the first civilizations. Food, settlements, and all other human needs are based on this. Throughout the centuries, problems with them have existed, as well as solutions. When a problem with water or energy occurred, he solved it totally or at least partially. Then a new situation arises, a new solution is found, and so on until today. Is there a solution to why new problems occur? This presentation will give insight into pursuing new solutions that seem science fiction, yet will one day come to life. The next question is the price of such solutions. Can somebody afford it? If it is affordable, is it too expensive? The doubts that arise are whether some solutions can solve the water and energy problem, but they are too costly. Will there come a time when a quality idea will not be realized due to financial or political reasons?

Keywords: water, energy, problems, solutions, costs

Odnosi između vode i energije, problemi i rješenja – kada će ovome doći kraj?

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Sažetak

Voda i energija su osnovni elementi ljudskog života, čak i od prvih civilizacija. Hrana, naselja i sve ostale ljudske potrebe temelje se na tome. Kroz stoljeća postojali su problemi s njima, kao i rješenja. Kada bi se pojavio problem s vodom ili energijom, on bi se u potpunosti ili barem djelomično riješio. Zatim bi se pojavila nova situacija, pronašlo bi se novo rješenje i tako sve do danas. Postoji li rješenje zbog čega se javljaju novi problemi? Ova prezentacija dat će uvid u traženje novih rješenja koja se čine znanstvenom fantastikom, a ipak će jednog dana zaživjeti. Sljedeće pitanje je cijena takvih rješenja. Da li si netko može to priuštiti? Ako je priuštivo, je li preskupo? Sumnje koje se javljaju su mogu li neka rješenja riješiti problem vode i energije, ali su preskupa. Hoće li doći vrijeme kada kvalitetna ideja neće biti realizirana zbog financijskih ili političkih razloga?

Keywords: voda, energija, problemi, rješenja, troškovi

Green trends in organic synthesis: Biocatalysis using by-products of the food industry

Dajana GAŠO-SOKAČ

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Abstract

Green chemistry, also known as sustainable chemistry, is an approach to the design of chemical products and processes that aims to reduce or eliminate the use and generation of hazardous substances. It was developed in response to the harmful effects of traditional chemical industry practices on the environment, with an emphasis on pollution prevention through process optimization at the design stage. In the 1990s, the U.S. Environmental Protection Agency (EPA) defined twelve principles of green chemistry. These include waste prevention, atom economy, toxicity reduction, the use of renewable raw materials, energy efficiency, and the design of safer chemicals. A key principle is the use of catalysts, which enable more selective reactions and reduce waste. Following the principles of green chemistry, modern organic synthesis focuses on the development of environmentally friendly processes that offer numerous advantages over classical methods. These “green” processes include the use of non-toxic solvents, reagents, and catalysts; performing reactions at room temperature; reducing waste generation; increasing atom economy; and applying alternative reaction conditions. Particular attention is given to the development of selective and reusable catalysts. In this context, biocatalysis based on by-products from the food industry represents a highly promising direction. Organic waste materials such as orange peel, papaya, pomegranate and banana peels, onion and peanut shells, corn leaves, sugarcane juice, and by-products of oil industry have shown significant catalytic potential. These raw materials can replace conventional, often toxic and expensive, catalysts in reactions such as the reduction of aldehydes and ketones, hydrolysis and esterification of esters, as well as condensation and multicomponent reactions. The conversion of biological waste into functional catalysts not only contributes to sustainable chemistry but also opens new possibilities for the synthesis of important intermediates, active pharmaceutical compounds, and commercially valuable substances. Green chemistry represents an interdisciplinary approach, integrating chemistry, engineering, and ecology with the goal of achieving safer, more energy-efficient, and environmentally sustainable processes—fully aligned with the principles of sustainable development.

Keywords: green chemistry, organic synthesis, food industry by-products, catalyst

Zeleni trendovi u organskoj sintezi: Biokataliza uz korištenje nusproizvoda prehrambene industrije

Dajana GAŠO-SOKAČ

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

Sažetak

Zelena kemija, poznata i kao održiva kemija, pristup je osmišljavanju kemijskih proizvoda i procesa s ciljem smanjenja ili potpunog uklanjanja upotrebe i nastanka opasnih tvari. Razvijena je kao odgovor na štetne učinke tradicionalne kemijske industrije na okoliš, s naglaskom na sprječavanje onečišćenja optimizacijom procesa već u fazi dizajna. Američka agencija za zaštitu okoliša (EPA) definirala je 1990-ih godina dvanaest načela zelene kemije. Ona uključuju sprječavanje nastanka otpada, atomsku ekonomičnost, smanjenje toksičnosti, upotrebu obnovljivih sirovina, energetsku učinkovitost i dizajn sigurnijih kemikalija. Ključno načelo je uporaba katalizatora, koji omogućuju selektivnije reakcije i smanjuju količinu otpada. U skladu s načelima zelene kemije, suvremena organska sinteza usmjerena je na razvoj okolišno prihvatljivih procesa koji imaju brojne prednosti u odnosu na klasične metode. Ti „zeleni“ procesi uključuju uporabu netoksičnih otapala, reagensa i katalizatora, provođenje reakcija na sobnoj temperaturi, smanjenje nastanka otpada, povećanje atomske učinkovitosti i primjenu alternativnih reakcijskih uvjeta. Posebna se pozornost pridaje razvoju selektivnih i višekratno upotrebljivih katalizatora. U tom kontekstu, biokataliza temeljena na nusproizvodima prehrambene industrije predstavlja iznimno obećavajući smjer. Organski otpad poput kore naranče, papaje, nara i banane, ljuski luka i kikirikija, kukuruznih listova, soka od šećerne trske te nusproizvoda industrije ulja pokazuje značajan katalitički potencijal. Ove sirovine mogu zamijeniti konvencionalne, često toksične i skupe katalizatore u reakcijama poput redukcije aldehida i ketona, hidrolize i esterifikacije te u kondenzacijskim i višekomponentnim reakcijama. Pretvorba biološkog otpada u funkcionalne katalizatore ne samo da doprinosi održivoj kemiji, već i otvara nove mogućnosti za sintezu važnih međuprodukata, aktivnih farmaceutskih spojeva i komercijalno vrijednih tvari. Zelena kemija predstavlja interdisciplinarni pristup koji objedinjuje kemiju, inženjerstvo i ekologiju s ciljem postizanja sigurnijih, energetski učinkovitijih i okolišno održivih procesa – potpuno usklađenih s načelima održivog razvoja.

Ključne riječi: zelena kemija, organska sinteza, nusproizvodi prehrambene industrije, kataliza

How safe is tuna for human consumption?

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Abstract

In recent decades, the trend of healthy food has led to an increase in fish consumption. Different species of tuna, a rich source of protein and omega-3 fatty acids, present one of the most widely consumed fish groups. According to the FAO recent statistics, during the period January–September 2024, their world trade (fresh, frozen and canned) was estimated at 3.07 million tons valued at USD 11.86 billion, representing rises of 20 % percent and 1.28 % percent compared to the same period in 2023. At the same time, mercury contamination in fish, particularly in tuna, shark, swordfish and marlin, has caused significant consumer concern. These predatory species, due to their position in the food chain, accumulate more mercury than other popular seafood items. Mercury is a metal that is found to affect the human nervous system and can affect even brain development in children. It is found naturally in the environment but also as a result of waste disposal or discharge from industrial facilities. Its accumulation in fish depends on many different factors, such as species, age, size, geographical location, water quality parameters, etc. In order to assure the safety of different food products, food safety agencies have set maximum permitted levels of mercury in food, tolerable weekly intake, as well as recommendations/guidelines for consumers. In this review, in order to understand how we can safely consume this valuable and delicate fish, an overview of mercury accumulation in different fish species, as well as the meaning of tolerable weekly intake and maximum permitted levels, is explained in detail.

Keywords: seafood safety, human health, mercury toxicity, *Thunnus* sp., tuna-like species

Education for sustainability in Norway

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Abstract
What does it mean to educate for sustainability in a Norwegian context? This keynote examines how Norwegian higher education is responding to the urgent call for environmental and social responsibility, not just through curriculum, but also through pedagogical methods, institutional culture, and real-world engagement. Drawing on practical experience from teacher education and interdisciplinary partnerships, the session reflects on how sustainability is being translated into learning strategies that involve students as active contributors, locally and globally. With a strong emphasis on relevance, inclusion, and critical reflection, education for sustainability in Norway is increasingly shaped by collaboration across sectors, cultures, and communities. This presentation provides insight into how Norwegian universities approach sustainable development in practice, without claiming to have solved all the challenges. Instead, it raises timely questions about values, leadership, and the role of higher education in shaping a more sustainable future.

Keywords: sustainability education, higher education, student engagement, pedagogical innovation, interdisciplinary learning

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Presentations
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Climate change
Klimatske promjene

Water balance modelling system in the upper Sava Region within the Interreg Project Danube Water Balance

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Abstract
Croatian Waters and the Slovenian Environment Agency (ARSO) are collaborating on the "Danube Water Balance" Interreg project, part of the Danube Transnational Programme 2021-2027. This initiative includes 20 project partners and 13 associated partners from various Danube River Basin countries, aiming to improve water balance modelling across the region by standardising methodologies, which spans Slovenia and Croatia. The pilot area of the project focuses on the Upper Sava sub-basin, which covers 53% of Slovenia's total territory and 3% of Croatia's total territory, covering an area of 12,318 km². The average discharge from the Sava River at the Jesenice na Dolenjskem gauging station is 267 m³/s over 30 years. The Upper Sava in Croatia flows from the Slovenian border to Zagreb, transitioning into the Pannonian Plain's lowlands. To model the water balance, both agencies will use the Community Water Model (CWatM), which simulates the water cycle daily and assesses water supply and demand. Before adopting CWatM, Slovenia used the mGROWA model for national water balance assessments, while Croatia analysed surface water balance over 30 years and made classification and categorisation of groundwater reserves since 1992. The goal is to standardise methodologies and harmonise the Croatian and Slovenian approaches to modelling, building on previous national experiences in water balance modelling. This international project will influence national, regional, and local policies and will certainly assist in monitoring and understanding the increasingly evident climate change.

Keywords: water balance, Interreg project, upper Sava basin, CWatM model, climate change

Sustav modeliranja vodne bilance na području gornje Save unutar Interregovog projekta Danube water balance

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Sažetak

Hrvatske vode i Slovenska agencija za okoliš (ARSO) surađuju na međunarodnom Interregovom projektu „Razvoj i harmonizacija sustava modeliranja vodne bilance na slivu rijeke Dunav - Danube water balance “, koji je dio Dunavskog transnacionalnog programa 2021.–2027. Projekt obuhvaća 20 projektnih partnera i 13 pridruženih partnera iz različitih zemalja sliva rijeke Dunav s ciljem ujednačenja i poboljšanja zajedničkog pristupa modeliranja vodne bilance u svim zemljama u slivu rijeke Dunav. Pilot područje projekta je sliv gornje Save, koje obuhvaća 53 % ukupnog teritorija Slovenije i 3 % ukupnog teritorija Hrvatske te zauzima površinu od 12.318 km². Prosječni protok rijeke Save na mjernoj postaji Jesenice na Dolenjskem iznosi 267 m³/s tijekom 30 godina. Gornja Sava u Hrvatskoj teče od slovenske granice do Zagreba, prelazeći u Panonsku nizinu. Za modeliranje vodne bilance obje agencije koristit će Community Water Model (CWatM), koji dnevno simulira vodni ciklus i procjenjuje opskrbu i potražnju za vodom. Prije primjene CWatM-a, Slovenija je koristila model mGROWA za nacionalne procjene vodne bilance, dok je Hrvatska analizirala bilancu površinskih voda kroz 30-godišnje razdoblje te od 1992. godine klasificirala i kategorizirala zalihe podzemnih voda. Cilj je standardizirati metode i uskladiti hrvatski i slovenski pristup modeliranju, oslanjajući se na prethodna nacionalna iskustva u modeliranju vodne bilance. Ovaj međunarodni projekt utjecat će na nacionalne, regionalne i lokalne politike te svakako pomoći kod praćenja i razumijevanja sve očitijih klimatskih promjena.

Ključne riječi: vodna bilanca, Interreg projekt, sliv gornje Save, CwatM model, klimatske promjene

New policy for sustainable management and use of natural resources of the Nature Park "Hutovo Blato" aimed at climate change adaptation

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Abstract
The public enterprise Nature Park Hutovo Blato is one of the most important wetland areas in Southeast Europe. The Park covers 8,000 hectares, including wetlands and aquatic areas, pastures, and other habitat types. In 1998, it was internationally recognized as an Important Bird Area (IBA), established as a special hunting ground in 2012, and has been listed as a Ramsar site since 2001. The primary activity is the protection and conservation of natural habitats and species, but revenues from economic activities and budget contributions so far have not been sufficient to meet all needs. The Park faces serious environmental challenges caused by reduced water regimes, increased salinity, and loss of biodiversity, which are further exacerbated by climate change. This paper proposes a new integrated management policy for the Park based on an ecosystem approach, participatory planning, and cooperation among local stakeholders, aimed at increasing the resilience of wetland ecosystems to hydrological stress and human pressures. The new management policy emphasizes sustainable economic activities, with key measures including the preservation of watercourses, the development of sustainable tourism, strengthening staff capacity for implementing development projects, and improving monitoring and education. This new policy represents a strategic response to the challenges of climate change and contributes to the conservation of the natural values of Hutovo Blato through an integrated approach to sustainable development and environmental protection.

Keywords: sustainable management, climate change, natural resources, Nature Park Hutovo Blato

Nova politika održivog upravljanja i korištenja prirodnih resursa Parka prirode „Hutovo blato“ u cilju prilagodbe klimatskim promjenama

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Sažetak

Javno poduzeće Park prirode Hutovo blato jedno je od najvažnijih močvarnih područja jugoistočne Europe. Obuhvat Parka od 8000 ha uključuje močvarna i vodena područja, pašnjake i druge stanišne tipove. 1998. godine je međunarodno prepoznat kao važno stanište ptica (IVBP), 2012. ustanovljeno kao posebno lovište, a od 2001. godine se nalazi na popisu Ramsarskih područja. Osnovna djelatnost je zaštita i očuvanje prirodnih staništa i vrsta, a dosadašnji prihodi od gospodarske djelatnosti i proračunski doprinos nisu bili dovoljni za sve potrebe. Park se suočava s ozbiljnim okolišnim izazovima uzrokovanim smanjenjem vodnog režima, porastom saliniteta i gubitkom biološke raznolikosti, koje dodatno pogoršavaju klimatske promjene. Ovaj rad predlaže novu integriranu politiku upravljanja Parkom, temeljenu na ekosustavnom pristupu, participativnom planiranju i suradnji lokalnih dionika, s ciljem povećanja otpornosti močvarnih ekosustava na hidrološki stres i ljudske pritiske. Nova politika upravljanja naglašava održive gospodarske aktivnosti a ključne mjere uključuju očuvanje vodnih tokova, razvoj održivog turizma, jačanje kapaciteta zaposlenika za provedbu razvojnih projekata te unapređenje monitoringa i edukacije. Ova nova politika predstavlja strateški odgovor na izazove klimatskih promjena i doprinosi očuvanju prirodnih vrijednosti Hutovog blata kroz integrirani pristup održivom razvoju i zaštiti okoliša

Ključne riječi: održivo upravljanje, klimatske promjene, prirodni resursi, Park prirode Hutovo blato

Gene count variations in aquatic algae as an evolutionary adaptation to salinity and temperature of natural habitats

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Abstract

Aquatic algae inhabit a broad spectrum of environments, from hypersaline lagoons to thermally unstable freshwater systems. This study explores how changes in gene counts—particularly gene expansions and contractions—function as evolutionary adaptations to salinity and temperature gradients in diverse algal lineages. Statistical analysis analyses revealed that these gene count variations are not random but are recurrent across unrelated taxa, indicating convergent evolutionary responses. The correlation between environmental parameters and genomic architecture supports the hypothesis that gene duplication and loss act as key mechanisms of adaptation in fluctuating or extreme habitats. This research highlights the role of genome plasticity in enabling ecological versatility and resilience in algae, offering new insights into the evolutionary-genomic interplay between organisms and their environments in a changing climate.

Keywords: gene duplication, environmental adaptation, genome plasticity

Varijacije u broju gena kod vodenih algi kao evolucijska prilagodba na salinitet i temperaturu prirodnih staništa

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Sažetak

Vodene alge nastanjuju širok spektar okoliša, od hiperslanih laguna do termalno nestabilnih slatkovodnih sustava. Ovo istraživanje proučava kako promjene u broju gena – posebno proširenja i smanjenja broja određenih gena – djeluju kao evolucijske prilagodbe na gradijente saliniteta i temperature u raznim evolucijskim linijama algi. Statističke analize pokazale su da ove varijacije u broju gena nisu nasumične, već se koreliraju među vrstama s obzirom na srodnost i stanište, što upućuje na evolucijske odgovore s ciljem prilagodbe na okoliš. Korelacija između okolišnih parametara i genomske arhitekture podupire hipotezu da su duplikacije i gubitci gena ključni mehanizmi prilagodbe na promjenjiva ili ekstremna staništa. Ovo istraživanje ističe ulogu genomske plastičnosti u omogućavanju ekološke svestranosti i otpornosti algi, nudeći novi uvid u odnos između evolucije genoma i okolišnih čimbenika u kontekstu klimatskih promjena.

Keywords: duplikacija gena, prilagodba okolišu, plastičnost genoma

The green side of the street – best practice examples

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Abstract

Considering the increasingly noticeable consequences of climate change, the implementation of "green activities" is becoming essential. These activities not only help in climate change adaptation and mitigation but also contribute to better air quality, greater biodiversity, reduced noise levels, and improved overall quality of life in urban areas. Climate change adaptation projects in urban areas of Croatia are being developed more intensively, and in the upcoming period, they will have an even greater role in sustainable development and creating social, environmental, and economic benefits. The Environmental Protection and Energy Efficiency Fund, in compliance with European and global guidelines, financially supports these projects with the aim of improving the resilience of local and regional communities and reducing the vulnerability of natural systems to the negative impacts of climate change. This consequently contributes to the development of a green and climate-neutral Croatia. In 2022, the Fund published the first public call for proposals for co-financing climate change adaptation projects under the slogan "The Green Side of the Street", followed by new public calls in 2023 and 2024. This paper presents examples of successfully implemented projects.

Keywords: climate change adaptation, strengthening the resilience of urban areas, climate change adaptation projects and measures

Zelena strana ulice – primjeri dobre prakse

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Sažetak

S obzirom na sve izraženije posljedice klimatskih promjena, provedba „zelenih aktivnosti“ postaje nužna. One ne samo da pomažu u prilagodbi i ublažavanju klimatskih promjena, već doprinose i boljoj kvaliteti zraka, većoj bioraznolikosti, smanjenju buke te općem unaprjeđenju kvalitete života u gradskim sredinama. Projekti prilagodbe klimatskim promjenama u urbanim sredinama u Republici Hrvatskoj sve se intenzivnije razvijaju i u nadolazećem će razdoblju imati još značajniji doprinos održivom razvoju, stvarajući društvene, okolišne i ekonomske koristi. Prateći europske i globalne smjernice, Fond za zaštitu okoliša i energetsku učinkovitost pruža financijsku potporu takvim projektima s ciljem jačanja otpornosti lokalnih i regionalnih zajednica te smanjenja osjetljivosti prirodnih sustava na štetne utjecaje klimatskih promjena. Time ujedno doprinosi stvaranju zelene i klimatski neutralne Hrvatske. Fond je 2022. godine raspisao prvi javni poziv za sufinanciranje projekata prilagodbe, pod sloganom „Zelena strana ulice“, a u 2023. i 2024. godini uslijedili su novi pozivi. U ovom radu predstavljaju se primjeri uspješno provedenih projekata.

Ključne riječi: prilagodba klimatskim promjenama, jačanje otpornosti urbanih sredina, projekti i mjere prilagodbe klimatskim promjenama

Leveraging climate Fintech: The role of blockchain-based carbon tokens in transforming global carbon markets

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Abstract

The development of transparent, efficient, and scalable carbon markets has become increasingly substantial in the global effort to mitigate climate change. As part of this transition, climate fintech—a subdomain of financial technology focused on environmental impact—is playing a transformative role in how carbon assets are created, verified, and exchanged. Among the most innovative instruments emerging from this space are carbon tokens, which represent digitized carbon credits or offsets, often issued and traded on blockchain platforms. By conducting a systematic review of academic papers and industry reports on climate fintech, carbon markets, and blockchain-based tokenization, this study evaluates how climate fintech, particularly through blockchain and related technologies, impacts the development, verification, and trading of carbon tokens in global carbon markets. Blockchain based carbon tokens significantly improve transparency by providing immutable records of carbon credit issuance, verification, and trading, reducing risks of fraud and double-counting. Tokenization democratizes access to carbon markets, enabling participation from smaller entities and individuals who were previously excluded due to high entry barriers. Climate fintech has the potential to drive broader participation in carbon markets, enabling small-scale renewable energy or reforestation projects in developing nations to access global funding through tokenized credits.

Keywords: climate fintech, carbon tokens, blockchain, carbon markets

Upotreba klimatske fintech tehnologije: Uloga ugljičnih tokena temeljenih na blockchainu u transformaciji globalnih tržišta ugljika

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Sažetak

Razvoj transparentnih, učinkovitih i skalabilnih tržišta ugljika postao je sve značajniji u globalnim naporima za ublažavanje klimatskih promjena. U sklopu ove tranzicije, klimatska fintech tehnologija — poddomena financijske tehnologije usmjerena na ekološki utjecaj — igra transformativnu ulogu u stvaranju, verifikaciji i razmjeni ugljične imovine. Među najinovativnijim instrumentima koji se pojavljuju su ugljični tokeni, koji predstavljaju digitalizirane ugljične kredite ili kompenzacije, često izdane i trgovane na blockchain platformama. Provođenjem sustavnog pregleda akademskih radova i industrijskih izvješća o klimatskoj fintech tehnologiji, tržištima ugljika i tokenizaciji temeljenoj na blockchainu, ova studija procjenjuje kako klimatska fintech tehnologija, posebice putem blockchaina i povezanih tehnologija, utječe na razvoj, verifikaciju i trgovanje ugljičnim tokenima na globalnim tržištima ugljika. Ugljični tokeni temeljeni na blockchainu značajno poboljšavaju transparentnost pružanjem nepromjenjivih zapisa o izdavanju, verifikaciji i trgovanju ugljičnim kreditima, smanjujući rizike od prijevara i dvostrukog računanja. Tokenizacija demokratizira pristup tržištima ugljika, omogućavajući sudjelovanje manjih subjekata i pojedinaca koji su prije bili isključeni zbog visokih ulaznih barijera. Klimatska fintech tehnologija ima potencijal potaknuti šire sudjelovanje na tržištima ugljika, omogućavajući manjim projektima obnovljive energije ili pošumljavanja u zemljama u razvoju pristup globalnom financiranju putem tokeniziranih kredita.

Ključne riječi: klimatski fintech, ugljični token, blockchain, tržište ugljika

Greening historic urban cores: Adapting to Climate change through the ActGreen project in Zagreb

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Abstract
Climate change is increasingly affecting urban environments through more frequent heatwaves, heavy rainfall, and localized flooding. Historic centers are particularly vulnerable due to their dense urban fabric, limited green spaces and aging infrastructure - conditions that also reduce residents' quality of life. Zagreb's historic core exemplifies these challenges. While the broader city benefits from a relatively rich green infrastructure network – including natural green framework, parks, tree-lined avenues, etc. – the historic core lacks sufficient green spaces, especially within urban block courtyards. This presentation focuses on the ActGreen project, a City of Zagreb initiative aimed at enhancing climate resilience and urban livability through courtyard greening and the implementation of nature-based solutions (NBS). By activating underused urban spaces, the project fosters environmental sustainability, social inclusion and climate adaptation within a heritage context. Backed by institutional support from the City of Zagreb, ActGreen not only improves local environmental conditions but also offers a replicable model for similar urban contexts across Europe. A key outcome is the development of a flexible methodology that can be adapted to diverse historic urban settings facing the pressures of climate change.

Keywords: urban resilience, green infrastructure, nature-based solution, climate change adaptation

Population density and body size of the nudibranch *Melibe viridis* in the Miletići-Rtina area (central Adriatic Sea)

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Abstract

The Indo-Pacific nudibranch *Melibe viridis* (Kelaart, 1858) has expanded its range into the Mediterranean Sea over the past 40 years and is considered a Lessepsian species. Individuals of the *M. viridis* population were observed in the Adriatic Sea at the locations Miletići, Rtina, and the study was conducted to describe habitat preferences, population characteristics, and reproductive behavior. Surveys were conducted using SCUBA equipment and strip-transects measuring 25x4 meters at depths ranging from 3 to 10 meters. Specimens were recorded primarily on rocky substrates covered with a thin layer of sediment or within *Zostera marina* seagrass beds. Measured body lengths ranged from 10 to 32 cm (mean 19.7 ± 4.3 cm), while widths ranged from 7 to 19.5 cm (mean 12.7 ± 2.66 cm). The average population density was 0.073 individuals/m², ranging from 0.04 to 0.1 individuals/m². Spawning activity was observed, confirming the presence of a reproductive, reproductively mature population in this area. Further research and findings indicate the high adaptability of this thermophilic species to various environmental conditions, consistent with global climate change patterns and warming of the Mediterranean and Adriatic Seas. Monitoring this non-indigenous species offers valuable insight into marine ecosystem interactions and the dynamics of species establishment.

Keywords: *Melibe viridis*, Adriatic Sea, Lessepsian species, habitat, reproduction

The influence of heat and drought stress on the yield of olive varieties

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Abstract
Weather conditions have had a significant impact on the growth, development, and cultivation of olives, as well as on olive oil production in recent years. This paper presents the results of the influence of weather conditions on super-high-density olive (*Olea europaea* L.) orchard cultivation planted in the experimental field of the Croatian Agency for Agriculture and Food in Kaštel Štafilić. The research included five olive cultivars: 'Arbequina IRTA-i18®', 'Arbosana-i43®', 'Koroneiki-i38®', 'Sikitita®', and 'Tosca 07®'. Monitoring of the phenological stages as well as physical and chemical analysis of olive fruits during the final growth and development stages was conducted using near-infrared spectrometry (DA NIR analysis) during the 2024 growing season. Monitoring of olive growth has shown that long-established timelines for certain olive phenological phases are shifting. which was recorded in an unusually early flowering occurring around May 1st, which is approximately 14 days earlier than average. Fruit analysis showed a correlation between the water content in the fruit and oil accumulation in the fruit's dry matter, which is the key parameter for determining the optimal harvest time. Due to a lack of precipitation during oil synthesis in the olive fruit was slowed down. In addition to the lack of rainfall during critical phenological phases, the main reason for the reduced oil synthesis was high temperatures, which often exceeded 35°C. Heat and drought stress had the strongest impact on the cv Arbequina and cv Sikitita, significantly reducing their yields, while the cv Koroneiki and local traditional cultivars were least affected.

Keywords: olive, NIR analysis, heat and drought stress

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10-13 June 2025
Hotel Olympia SKY
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Book of Abstracts / *Knjiga sažetaka*
Presentations / *Priopćenja*

Computer Science in Environmental Protection
Računalne znanosti u zaštiti okoliša

Reducing the aviation industry's environmental impact by implementing artificial intelligence solutions

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Abstract
For the purpose of environmental protection, the use of artificial intelligence in the aviation industry is focused on reducing the adverse environmental impact by optimizing operations and increasing energy efficiency. Various AI tools have been developed to help reduce the aviation's environmental footprint and achieve sustainable development goals. Examples include the Airbus Skywise platform that uses AI for predictive maintenance and optimization of operations, Honeywell Forge for route optimization, and the Lufthansa CO2-Optimized Flight Planning Tool for flight planning optimization and meteorological data analysis. The LVNL GreenPilot tool uses AI to optimize the route and altitude, while IBM Watson uses advanced analytics to predict fuel consumption and optimize the route. SITA's OptiFlight AI tool optimizes routes in real time, and GE Aviation's Digital Twin Technology predicts maintenance needs and improves engine efficiency. Other solutions include CDB Aviation's Fleet Management with AI, Boeing EcoDemonstrator for testing emissions-reducing innovations, and NATS AI for airspace optimization. This paper provides an overview of artificial intelligence solutions that help optimize aviation operations, increase energy efficiency, and improve aviation sustainability to reduce adverse emissions from the aviation industry. With the increased implementation of AI technologies in aviation, further reduction of aviation's environmental impact is expected.

Keywords: environmental impact, reduction, aviation industry, artificial intelligence, solutions

Sustainable powering of data centers using photovoltaic facade systems

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Abstract
This paper deals with the use of solar facades as an environmentally friendly solution for the energy needs of the data centers of APIS IT. Buildings with integrated photovoltaic panel systems represent an important step towards the energy transition and the reduction of greenhouse gas emissions. This paper analyzes the possibilities of collecting solar energy through solar panels built into the facade of the building with special reference to their role in supplying and powering data centers, which are known for high and continuous consumption of electricity. By increasing the capacity of the Jastrebarsko data center, there is a significant increase in the need for electricity, which further emphasizes the need for the integration of renewable energy sources. In the context of growing electricity consumption and the need for cooling in data centers, this kind of solution can significantly contribute to energy efficiency and reduce the facility's carbon footprint. The proposed project envisages the installation of high-efficiency solar panels in the vertical facade surfaces of the data center, which, in addition to the production of renewable energy, also contributes to the passive regulation of thermal energy inside the facility.

Keywords: Digitization, data center, renewable energy sources, energy efficiency, green technologies

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Presentations / *Priopćenja*

3rd European GREEN Conference
10-13 June 2025
Hotel Olympia SKY
Vodice CROATIA

Culture, Art and Sustainability
Kultura, umjetnost i održivost

Sustainable Water in Unsustainable Times: An Analysis of Historical Osijek Advertisements and Contemporary Campaigns

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Abstract

This paper explores representations of water in print advertisements from the late 19th and early 20th centuries compared to contemporary advertising practices. Using content analysis and comparative methodology, the study examines German-language newspapers printed in Osijek during the Austro-Hungarian period—often overlooked due to their use of Gothic script, which presents a research gap. The analysis draws on both anthropological and philological perspectives to uncover how language, imagery, and symbolism reflect cultural meanings and societal norms surrounding water. Historical advertisements emphasized hygiene, health, and technological advancement, reflecting local cultural and economic realities. In contrast, contemporary ads frame water within global discourses on sustainability, ecological responsibility, and consumer ethics. This shift reveals how advertising functions not only as a commercial tool but also as a cultural mirror that shapes public consciousness. By analyzing how messages about water have evolved, the paper contributes to a broader understanding of the intersection between language, culture, media, and environmental values.

Keywords: water, historical advertisements, contemporary campaigns, comparative analysis, cultural context

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Presentations / *Priopćenja*

3rd European GREEN Conference
10-13 June 2025
Hotel Olympia SKY
Vodice CROATIA

Ecological Agriculture and Food Production
Ekološka poljoprivreda i proizvodnja hrane

Biochar in viticulture: Potential for carbon sequestration and sustainable land management

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Abstract

Viticulture is a key economic activity that significantly impacts the environment, and reducing greenhouse gas emissions through the valorization of grapevine by-products represents an important step toward more sustainable practices. One of the more effective solutions for long-term carbon storage and climate change mitigation is the conversion of pruning residues into biochar. Biochar is a carbon- and mineral-rich material produced by pyrolyzing biomass in a low-oxygen environment. Unlike fresh biomass, biochar decomposes slowly in the soil, significantly reducing CO_2 emissions, while simultaneously potentially improving the physicochemical properties of the soil. The aim of this study was to examine changes in the structural properties of biochar and the concentration of elements relative to the initial biomass after the pyrolysis process. The study included twelve cultivars, six international and six Croatian indigenous varieties. Biochar was produced in laboratory conditions in a muffle furnace at a temperature of up to 400°C. The results revealed significant differences in the physicochemical properties between the initial biomass and the resulting biochar. An increase in pH value, carbon content, and the concentration of elements was observed in the biochar samples. Scanning Electron Microscopy (SEM) analysis confirmed the structural changes that occurred during pyrolysis. The resulting biochar, due to its physicochemical properties, shows significant potential for application in improving soil quality, which could have a long-term impact on the sustainability of viticultural practices.

Keywords: biochar, grapevine, cultivar, pruning residues, valorisation

Making food sustainability visible: The Eco-Score approach

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Abstract

Growing environmental concerns have increased the demand for tools that support sustainable consumer behaviour, particularly in the food sector. One such tool is the Eco-Score (ES), a front-of-pack (FOP) labelling system designed to convey the overall environmental impact of food products. Using a five-level letter grade (A to E) combined with a colour-coded scale (green to red), the Eco-Score provides a quick visual summary of a product's environmental footprint. This holistic assessment integrates multiple environmental indicators, including greenhouse gas emissions, water use, biodiversity impact, and resource depletion. Unlike conventional labels focusing on a single environmental aspect, the Eco-Score offers a more comprehensive evaluation, enabling consumers to make informed and sustainable purchasing decisions. As labelling systems like the Eco-Score gain traction, they may play a critical role in guiding consumer behaviour, incentivizing producers to adopt more sustainable practices, and supporting policy development to reduce the environmental burden of food production.

Keywords: Eco-Score (ES), environmental footprint, front-of-pack (FOP) labelling system, food sustainability

The other side of biodiversity

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Abstract:
The preservation of natural biodiversity is considered one of the most important missions and challenges faced by ecologists and conservationists. But biodiversity also exists in agricultural production, and it is biodiversity that we create and that should be treated with the same responsibility. Most animal and plant products for human consumption today are selected according to the duration of the production cycle, production price, and marketing, and not according to quality and nutritional value. The plants from the solanaceous family are the perfect example. The two main food crops with global distribution are the potato and the tomato. Other members are the nightshades, eggplants, tamarillo, and horse nettles, cultivated for their nutritional benefits. The greatest challenge in tomato production is the use of agrochemicals, particularly in pest and disease management. Injudicious use of pesticides has resulted in heavy accumulation of chemical residues, which is a threat to the production of safe tomatoes in a world where people are conscious about diet and the environment. Tomato fruits, aside from being tasty, are healthy as a source of vitamins A and C. Another important nutritional benefit is lycopene, which is a powerful antioxidant that can help prevent the development of many forms of cancer. Unfortunately, the selection of tomato varieties for mass production is based on shelf life and suitability for easy transportation, i.e., on profit, and many nutritionally valuable varieties are simply discarded because they do not meet these criteria. Manufacturers start growing potatoes based on the wide use of mineral fertilizers and means of chemical protection, which is dangerous to the environment and human health. Historically, primitive forms of cultivated potato and its wild relatives have been used in breeding programs and there is still an enormous and unimaginable potential for discovering desirable characteristics that can minimize the cultivation problem.

Keywords: agriculture, production diversification, human consumption

Blending cold-pressed vegetable oils - a new way to functional products

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Abstract

The processing of fruits such as raspberries, plums, and apricots produces a large amount of by-products in the form of seeds and pits. The valorization of these by-products has proven to be an imperative of the circular economy. Raspberry seeds, as well as plum and apricot kernels, are a source of high-quality vegetable oils. It is known that raspberry seed oil is rich in essential linoleic and linolenic acids, while apricot and plum kernel oil contain mainly oleic acid and are very stable to oxidation. To improve the nutritional value and stability of cold-pressed vegetable oils, a new trend is the blending of oils and as a result, a formulation that is rich in essential fatty acids and has good oxidation stability. Here we present a study designed to systematically evaluate blends of cold-pressed raspberry seed oil with plum and apricot kernel oils, focusing on optimizing essential fatty acid ratios to enhance oxidative stability. Measuring and reporting the fatty acid composition and balance, antioxidant capacity, and oxidative stability of cold-pressed oils and specific blends offers new comparative data and brings novelty to the field of functional oil development. The resulting blends with an optimal ratio of essential fatty acids to oleic acid exhibited good oxidative stability and antioxidant capacity. While individual oils from these sources are available on the market, their blends do not seem to be present in current commercial offerings. The formulation presents a novel approach to creating stable, nutrient-rich vegetable oil blends from fruit seed byproducts, thereby opening up opportunities for functional food and cosmetic applications.

Keywords: cold-pressed oil blends, apricot, plum, raspberry, by-products

Prevalence and mean intensity of *Anisakis* spp. parasites in two pelagic fish species from the Adriatic Sea

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Abstract

The Atlantic chub mackerel (*Scomber japonicus*) and the Atlantic horse mackerel (*Trachurus trachurus*) are pelagic fish species sharing the same habitat. Although they are not a target catch in small pelagic fisheries, they are available in fish markets and are used for human consumption. Both species are susceptible to infestation by *Anisakis* spp., parasitic nematodes whose larvae infect fish and adults parasitise marine mammals. *Anisakis* spp. pose a global public health concern due to their zoonotic potential. This study aimed to determine the prevalence and mean intensity of *Anisakis* spp. infections in these species caught in the Adriatic Sea. A total of 300 individuals of each species, captured in Adriatic fishing zone B, were examined by visual inspection of the abdominal cavity and internal organs. The prevalence of *Anisakis* spp. was 18.6% in Atlantic horse mackerel and 8.33% in Atlantic chub mackerel. The highest prevalence was found in larger horse mackerel, while the highest mean intensity of infestation was recorded in larger chub mackerel. The results highlight the need for continuous monitoring of *Anisakis* spp. in commercially important fish to ensure food safety and protect public health.

Keywords: *Anisakis* spp., prevalence, pelagic fish, food safety, Adriatic Sea

Prevalencija i srednji intenzitet parazita *Anisakis* spp. u dvije pelagične vrste riba iz Jadranskog mora

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Sažetak

Lokarda (*Scomber japonicus*) i šarun (*Trachurus trachurus*) su pelagične vrste riba koje dijele isto životno stanište. Iako nisu ciljani ulov u ribolovu male pelagične ribe, dostupne su na tržištu i koriste se u ljudskoj prehrani. Obje vrste sklone su infestaciji parazitima iz roda *Anisakis*, parazitskim oblićima čije ličinke infestiraju ribe, a odrasli stadiji parazitiraju u probavnom sustavu morskih sisavaca. *Anisakis* spp. predstavljaju globalni javnozdravstveni problem zbog svog zoonotskog potencijala. Cilj ovog istraživanja bio je utvrditi prevalenciju i srednji intenzitet infestacije parazitima Anisakis spp. kod navedenih vrsta riba. Ukupno je vizualnim pregledom trbušne šupljine i unutarnjih organa pregledano 300 jedinki svake vrste, ulovljenih u jadranskoj ribolovnoj zoni B. Prevalencija *Anisakis* spp. iznosila je 18,6 % kod šaruna i 8,33 % kod lokarde. Najviša prevalencija zabilježena je kod većih jedinki šaruna, dok je najveći srednji intenzitet infestacije utvrđen kod većih jedinki lokarde. Dobiveni rezultati ističu potrebu za kontinuiranim nadzorom prisutnosti *Anisakis* spp. u gospodarski važnim vrstama riba radi osiguranja zdravstvene ispravnosti hrane.

Ključne riječi: *Anisakis* spp., prevalencija, pelagične ribe, zdravstvena ispravnost hrane, Jadransko more

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Presentations / *Priopćenja*

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Hotel Olympia SKY
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Ecological Medicine and Biomedicine
Ekološka medicina i biomedicina

Lactone-Based Derivatives as Potential Modulators of Multidrug Resistance in K562 Cells

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Abstract

Multidrug resistance represents a major obstacle in cancer therapy, particularly in hematologic malignancies such as chronic myelogenous leukemia. The overexpression of Multidrug Resistance Protein 1 (MRP1) plays an important role in the development of chemotherapy resistance in cancer cells. In this study, we investigated the effect of three lactone-based derivatives on multidrug resistance in cancer cells. Methods: The compounds were tested on the human chronic myelogenous leukemia cell line K562 and the human fetal lung fibroblast cell line MRC-5 over 72 hours. Antiproliferative activity was assessed based on IC_{50} values, which were determined using an MTT assay. To explore potential interactions with drug resistance mechanisms, the levels of MRP1 were determined using an ELISA assay. MRC-5 cells were used as a negative control, as prior results indicated no significant cytotoxicity on these cells. Results: All three compounds significantly reduced K562 cell viability in a dose-dependent manner, with no notable effects observed in MRC-5 cells. The levels of MRP1 demonstrated an interaction between the three lactone-based derivatives and MRP1-associated pathways. Conclusion: The tested compounds have demonstrated antiproliferative effects on multidrug-resistant K562 cells, with no significant effects on MRC-5 cells. Therefore, these results indicate their potential as selective anticancer agents, possibly targeting MRP1-related mechanisms. However, further research is required to confirm their role in modulating drug resistance.

Keywords: multidrug resistance, cancer cells, K562, MRP1

The effects of drinking water contaminants on the gut microbiome

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Abstract

The gut microbiome is the sum of all microorganisms physiologically present in the human intestine. An imbalance in the relationship between these microorganisms in the intestine (dysbiosis) is considered responsible for a number of diseases and disorders, the most known of which are diarrhea, meteorism, and irritable bowel syndrome. However, in recent decades, with the development of medical science, the microbiome has become increasingly the focus of clinicians and researchers, and dysbiosis is associated with an increasing number of gastroenterological, but also endocrinological, cardiovascular, musculoskeletal, and even skin and mental diseases. Dysbiosis occurs as a result of a heterogeneous group of causes, from genetic to environmental factors such as infections, inflammation, dietary and other habits, and especially the intake of xenobiotics and toxins. One of the most common pathways of their entry into an organism is through the daily intake of drinking water. Therefore, interdisciplinary research that studies the quality of drinking water, its pollution, and its connection with the impact on the microbiome is of crucial importance. The most common contaminants of drinking water are heavy metals, chlorine, arsenic, asbestos, toxins such as pesticides and herbicides, and petroleum derivatives. This study aims to investigate the impact of drinking water contaminants on the gut microbiome, thereby examining their role in the development of diseases associated with dysbiosis, and to emphasize the importance of regular monitoring of drinking water quality.

Keywords: drinking water, water contaminants, gut microbiome

3rd European GREEN Conference
10-13 June 2025
Hotel Olympia SKY
Vodice CROATIA

Ecology and Society
Ekologija i društvo

The role of the equine industry in the green transition

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Abstarct

Pasture horse breeding influences the biodiversity of grassland ecosystems and landscape preservation; however, contemporary environmental protection challenges exert increasing pressure on other stakeholders within the equine sector. The equine industry has undergone a significant transformation, characterized by the extensive utilization of horses for various purposes. Historically, horses were predominantly used in agricultural work and transportation, whereas today their roles and significance have expanded to encompass breeding, sport, therapeutic and recreational activities, as well as the production of meat and milk. The equine sector contributes to the green transition by offering not only ecological and economic benefits but also social advantages aligned with sustainable development goals, including rural development, equine tourism, conservation of native breeds, preservation of traditions, and therapeutic applications. The sector's roles extend from supporting biodiversity conservation to producing raw materials for renewable energy sources and promoting rural vitality. In the pursuit of sustainable solutions to contemporary ecological challenges, the use of horses remains somewhat underrecognized as a green alternative. Literature introduces the concept of *five green assets*, emphasizing the ecological advantages of the equine sector compared to other agricultural industries, which include grazing, biodiversity, land use, tourism, and active equine work. Education and the appropriate application of green assets in equine management could partially address ecological demands within agriculture and contribute to the development of equine husbandry. Despite facing numerous challenges, the equine industry presents substantial opportunities for the development of environmentally friendly and sustainable futures, simultaneously supporting global environmental protection efforts and sustainable development initiatives.

Keywords: horses, equine industry, green transition, sustainability

Uloga konjičke industrije u zelenoj tranziciji

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Sažetak

Dok pašnjačko konjogojstvo utječe na bioraznolikost travnjačkih ekosustava i očuvanje krajolika, suvremeni izazovi zaštite okoliša vrše sve veći pritisak i na ostale dionike konjičkoga sektora. Konjička industrija doživjela je značajnu transformaciju koja se odlikuje širokom uporabom konja u različite svrhe. Tijekom povijesti, korištenje konja bilo je pretežito vezano uz obavljanje poljoprivrednih poslova i prijevoz, dok su danas njihova uloga i značenje prošireni na područja uzgoja, sporta, terapijskih i rekreacijskih aktivnosti te proizvodnju mesa i mlijeka. Konjički sektor doprinosi zelenoj tranziciji nudeći ne samo ekološke i ekonomske, nego i društvene koristi usklađene s ciljevima održivoga razvoja (ruralni razvoj, konjički turizam, očuvanje izvornih pasmina, tradicije, korištenje u terapiji). Njihova se uloga proteže od podrške očuvanju biološke raznolikosti pa sve do proizvodnje sirovine za obnovljive izvore energije te poticanja ruralne vitalnosti. U nastojanju pronalaska održivih rješenja za suvremena ekološka pitanja, korištenje konja ostaje pomalo zanemareno kao zeleno rješenje. U literaturi se pojavljuju pojmovi *pet zelenih dobara*, pri čemu se ističu ekološke prednosti u odnosu na ostale poljoprivredne sektore, a koja obuhvaćaju ispašu, bioraznolikost, korištenje zemljišta, turizam i aktivan rad s konjima. Obrazovanje i odgovarajuća primjena zelenih dobara u radu s konjima mogli bi djelomično odgovoriti na ekološke zahtjeve poljoprivrede te doprinijeti razvoju konjogojstva. Iako suočena s izazovima, konjička industrija otvara brojne prilike za razvoj ekološki prihvatljive i održive budućnosti istovremeno doprinoseći globalnim naporima za zaštitu okoliša i održivi razvoj.

Ključne riječi: konji, konjička industrija, zelena tranzicija, održivost

Environmental protection and energy efficiency fund investments in projects of Nongovernmental Organisations (NGO)

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Environmental Protection and Energy Efficiency Fund (EPEEF), Radnička cesta 80, Zagreb, Croatia

Abstract

Since 2013, EPEEF has been continuously inviting calls for proposals to co-finance projects in the field of environmental protection and energy efficiency (EE) implemented by nongovernmental organisations. These projects aim to contribute to the conservation, sustainable use, protection, and improvement of the environment and energy efficiency. Various project activities are co-financed in the field of environment: waste prevention and reuse, eco-drives for clearing the seabed and caves, implementing activities to raise awareness of climate change adaptation, education/training programmes about environment protection and sustainable development, and education programmes about the protection of biological and landscape diversity. For project activities in the field of EE, co-financing was provided for projects raising awareness of e-mobility, informing the public about measures regarding EE and use of RES, measures to fight energy poverty, the link between energy and climate change. The Fund also cofinances LIFE projects implemented by associations, i.e. the national component of the EU LIFE Programme for Standard Action Projects (SAPs), whose priority areas comply with the national strategies and legislation governing nature and biodiversity protection, environment protection, climate action, and the transition to clean energy. In the past, over 300 projects implemented by associations were co-financed with more than EUR 3.7m.

Keywords: NGOs, environmental protection, energy efficiency, Environmental Protection and Energy Efficiency Fund

Ulaganje Fonda za zaštitu okoliša i energetsku učinkovitost u projekte koje provode organizacije civilnog društva (udruge)

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Sažetak

Fond za zaštitu okoliša i energetsku učinkovitost kontinuirano od 2013. godine objavljuje natječaje za sufinanciranje projekata u području zaštite okoliša i energetske učinkovitosti koje provode organizacije civilnog društva (udruge).Cilj ovih projekata je doprinos očuvanju, održivom korištenju, zaštiti i unapređenju okoliša te povećanju energetske učinkovitosti. Sufinanciraju se razne projektne aktivnosti u području zaštite okoliša: sprječavanje nastanka otpada i ponovna uporaba, ekološke akcije čišćenja podmorja i speleoloških objekata, provođenje aktivnosti za podizanje svijesti o prilagodbi klimatskim promjenama, programi edukacije i obrazovanja za zaštitu okoliša i održivi razvoj, programi edukacije o zaštiti biološke i krajobrazne raznolikosti. Za projektne aktivnosti u području energetske učinkovitosti sufinancirali su se projekti podizanja svijesti o elektromobilnosti, informiranje javnosti o mjerama energetske učinkovitosti i obnovljivih izvora energije, mjerama suzbijanja energetskog siromaštva, korištenju obnovljivih izvora enegije, sprezi energetike i klimatskih promjena. Fond također sufinancira LIFE projekte koje provode udruge. Sufinancira se nacionalni dio EU projekata Programa LIFE za projekte standardnih djelovanja (SAP), čija su prioritetna područja u skladu sa nacionalnim strategijama i zakonodavstvom iz područja zaštite prirode i bioraznolikosti, zaštite okoliša, klimatskih aktivnosti i prelasku na čistu enegiju. U proteklom razdoblju sufinancirano je preko 300 projekata koje provode udruga sa više od 3,7 mil EUR.

Ključne riječi: organizacije civilnog društva, zaštita okoliša, energetska učinkovitosti, Fond za zaštitu okoliša i energetske učinkovitosti

From values to action: Exploring sustainable behaviour through participation in the ActGreen Project

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Abstract
Environmental psychology seeks to understand the dynamic relationship between people and their environment, particularly in the face of escalating environmental challenges. A major focus of the field is understanding and encouraging sustainable behavior. One promising approach is to examine individuals' value orientations – broad, enduring goals that guide behaviour and shape attitudes across contexts. Research suggests that biospheric (concern for nature), altruistic (concern for others), and egoistic (self-interest) value orientations are especially relevant in understanding environmental preferences and actions. This presentation draws on insights from the ActGreen project in Zagreb, a participatory initiative aimed at encouraging citizens to green their private urban spaces. These efforts are facilitated by the City of Zagreb, demonstrating the role of institutional backing in promoting sustainable behavior. In workshops with participants, we explored how individuals perceive their yards, their motivations for ecological improvements, and their broader hopes for a greener city. Discussions revealed how participants' goals often reflected underlying value orientations and shaped their willingness to act. By linking personal values with community-based action, this presentation offers a grounded perspective on how value orientations can help explain and encourage sustainable behavior in real-world settings.

Keywords: value orientations, sustainable behaviour, environmental psychology, urban greening, public participation

Can (preserving) rural tradition be a path to sustainability?

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Abstract
In the circumstances of the global economic and ecological crisis of modern society, as well as new risks, it is necessary to constantly consider new ways of preserving the natural and social environment. Global crises are becoming deeper and more threatening, especially to rural communities. The rural tradition was created in a harmonious, responsible, wise coexistence of man and nature, which ensured long-term survival with the scarce resources. The consequences of industrialization and urbanization are de-ruralization, the abandonment of agricultural production, the disappearance of rural values and the spread of value stereotypes about rural areas as backward and less valuable. The aim of this work is to answer the question of whether and in what way the values of rural tradition can be recognized and passed on to younger generations with the goal of sustainability. For the purposes of the study, a qualitative methodology of semi-structured interviews was used. The research involved 8 interviewees from the Zadar hinterland area, who have experience of rural life. The research provided insight into the understanding and possibilities of transferring knowledge and experiences of rural tradition to young people.

Keywords: rural tradition, sustainability, value transfer

Green Initiatives for ecosystem recovery and mental health – Research results translated into practice

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Abstract

Environmental literacy and active participation in green initiatives can play an important role in the mental health of students and staff. This research examined the relationship between environmental knowledge, attitudes, sense of responsibility, and environmentally responsible behaviors with the negative impact of environmental concerns on mental health. The research was conducted at the beginning of 2025 at the Lovran Student Dormitory, where students and staff completed a questionnaire that included four subscales: self-assessment of ecological knowledge, positive attitudes and sense of personal responsibility, negative impact of environmental concerns on mental health, and the practice of environmentally responsible behaviors. The results showed that positive attitudes and a sense of responsibility were moderately positively associated with environmentally responsible behavior and negatively with eco-anxiety. Hierarchical regression analysis revealed that these variables together predict 44% of the variance in mental health, with the most significant predictors being positive attitudes and a sense of responsibility. In conclusion, the results emphasize the importance of environmental education and active involvement, not only for environmental conservation but also for improving the emotional well-being of students. Future activities will focus on integrating education, practical engagement, and psychological support to reduce feelings of helplessness and encourage sustainable behavior.

Keywords: environmental literacy, mental health, environmental responsibility, eco-anxiety, sustainable behavior

Zelenim inicijativama do oporavka ekosustava i mentalnog zdravlja – rezultati istraživanja pretočeni u praksu

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Sažetak

Ekološka pismenost i aktivno uključivanje u zelene inicijative mogu igrati važnu ulogu u mentalnom zdravlju učenika i djelatnika. Ovo istraživanje ispitalo je povezanost između ekološkog znanja, stavova, osjećaja odgovornosti i ekološki odgovornih ponašanja s negativnim utjecajem ekoloških briga na mentalno zdravlje. Istraživanje je provedeno početkom 2025. godine u Učeničkom domu Lovran, gdje su učenici i djelatnici ispunili upitnik koji je obuhvaćao četiri podskale: samoprocjenu znanja o ekologiji, pozitivne stavove i osjećaj osobne odgovornosti, negativan utjecaj ekoloških briga na mentalno zdravlje te prakticiranje ekološki odgovornih ponašanja. Rezultati su pokazali da su pozitivni stavovi i osjećaj odgovornosti umjereno pozitivno povezani s ekološki odgovornim ponašanjem te negativno s ekološkom anksioznošću. Hijerarhijska regresijska analiza otkrila je da ove varijable zajedno predviđaju 44 % varijance mentalnog zdravlja, pri čemu su najznačajniji prediktori pozitivni stavovi i osjećaj odgovornosti. Zaključno, rezultati naglašavaju važnost ekološkog obrazovanja i aktivnog djelovanja, ne samo zbog očuvanja okoliša, već i zbog poboljšanja emocionalne dobrobiti učenika. Buduće aktivnosti usmjerit ćemo na integraciju edukacije, praktičnog angažmana i psihološke podrške kako bismo smanjili osjećaj bespomoćnosti i potaknuli održivo ponašanje.

Ključne riječi: ekološka pismenost, mentalno zdravlje, ekološka odgovornost, ekološka anksioznost, održivo ponašanje

3rd European GREEN Conference
10-13 June 2025
Hotel Olympia SKY
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Environmental Engineering
Inženjerstvo okoliša

Sizing of textile fragments released from polyester textiles during the various washing cycles

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Abstract

This study analyses the textile fragments released from polyester textiles during different washing cycles carried out according to the HRN EN ISO 6330 standard, procedure 2A. The process was carried out in tap water with the most important process parameters: ECE standard detergent mass concentration 1.25 g/L; bath ratios 1:7 (wash), 1:8 (rinse), temperature 60 °C. The released textile fragments were identified by analysing the particle size in the washing wastewater. Laser diffraction methods for measuring the size/volume distribution enabled the determination of the most important size parameters D10, D50, D90, and the values for the span, while the shape factor (k) provided an insight into the morphology of the particles. The results obtained for the individual washing cycles showed variability in the sizes and shapes of the fragments. The first cycles proved to be crucial for understanding the dynamics of fragment release during the washing process. The results obtained serve to analyse the release of fragments from textiles of different composition and structure, especially polyester, during the washing process and thus contribute to the protection of the environment from microplastic pollution. For a comprehensive identification of the fragments to assess wastewater pollution, it is necessary to combine the results obtained with other physico-chemical parameters.

Keywords: textile fragments, washing process, particle size distribution, particle size parameters

Određivanje veličine tekstilnih fragmenata otpuštenih iz poliesterskih tekstilija tijekom različitih ciklusa pranja

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Sažetak

U ovom istraživanju analizirani su fragmenti tekstila koji se oslobađaju iz poliesterskih tekstilija tijekom različitih ciklusa pranja prema normi HRN EN ISO 6330, postupak 2A. Proces je proveden u vodi uz najvažnije procesne parametre: ECE standard masena koncentracija deterdženta 1,25 g/L; omjeri kupelji 1:7 (pranje), 1:8 (ispiranje), temperatura 60 °C. Otpušteni fragmenti tekstila identificirani su analizom veličine čestica u otpadnoj vodi od pranja. Metode laserske difrakcije za mjerenje raspodjele veličina/volumen omogućile su određivanje najvažnijih parametara veličine D_{10} D_{50}, D_{90} i vrijednosti za raspon, dok je faktor oblika (k) omogućio uvid u morfologiju čestica. Rezultati dobiveni za pojedinačne cikluse pranja pokazali su varijabilnost u veličinama i oblicima fragmenata. Prvi ciklusi pokazali su se ključnima za razumijevanje dinamike otpuštanja fragmenata tijekom procesa pranja. Dobiveni rezultati služe za analizu otpuštanja fragmenata iz tekstila različitog sastava i strukture, posebice poliestera, tijekom procesa pranja i na taj način doprinose zaštiti okoliša od onečišćenja mikroplastikom. Za sveobuhvatnu identifikaciju fragmenata s ciljem procjene onečišćenja otpadnih voda potrebno je kombinirati dobivene rezultate s ostalim fizikalno-kemijskim parametrima.

Ključne riječi: fragmenti tekstila, proces pranja, parametri veličine čestica, raspodjela veličina čestica

Economic valorization of mineral resources in Varaždin County – Challenges, opportunities and sustainable development

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Abstract
The exploitation of mineral resources is crucial for the economic development of Varaždin County. Natural resources, such as technical-construction stone, construction sand and gravel, brick clay, and carbonate mineral raw materials for industrial processing, form the foundation of the region's industrial and infrastructural progress. The aim of this study is to analyze the regulatory frameworks and strategic documents governing the management of mineral resources, as well as to assess the actual situation in the field. The Spatial Plan of Varaždin County and the new Mining-Geological Study define guidelines for the exploration and exploitation of abandoned extraction sites. Using a qualitative methodology, the research includes an analysis of the regulatory framework, available resources, the state of exploitation, and the roles of key stakeholders in the sector. Special attention is given to ecological aspects, including sustainable resource use and land rehabilitation. The research findings serve as a foundation for strategic decision-making regarding the management of mineral resources in Varaždin County. The utilization of mineral resources is primarily driven by market demands, while production capacities depend on the availability of raw materials and their exploitation potential. In Varaždin County, exploitation is predominantly focused on the construction industry, contributing to the strengthening of the region's infrastructural and economic activities. The long-term sustainability of the sector requires the application of modern technological solutions and high environmental standards to minimize negative environmental impacts and preserve natural potential for future generations.

Keywords: exploitation, ecological aspects, mineral resources, spatial plan, economy

Gospodarska valorizacija mineralnih sirovina u Varaždinskoj županiji – izazovi, prilike i održivi razvoj

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Sažetak

Eksploatacija mineralnih sirovina ključna je za gospodarski razvoj Varaždinske županije. Prirodni resursi, poput tehničko-građevnog kamena, građevnog pijeska i šljunka, ciglarske gline i karbonatne mineralne sirovine za industrijsku preradbu čine temelj industrijskog i infrastrukturnog napretka regije. Cilj ovog istraživanja, rada jest analiza normativnih okvira i strateških dokumenata koji reguliraju gospodarenje mineralnim sirovinama te procjena stvarnog stanja na terenu. Prostorni plan Varaždinske županije i nova Rudarsko-geološka studija definiraju smjernice za istraživanje, eksploataciju napuštenih eksploatacijskih polja. Primjenom kvalitativne metodologije, istraživanje obuhvaća analizu regulatornog okvira, dostupnih resursa, stanje eksploatacije te uloge ključnih aktera u sektoru. Posebna pažnja posvećena je ekološkim aspektima, uključujući održivo korištenje resursa i sanaciju. Rezultati istraživanja predstavljaju temelj za donošenje strateških odluka o upravljanju mineralnim sirovinama u Varaždinskoj županiji. Iskorištavanje mineralnih resursa primarno je uvjetovano tržišnim zahtjevima, dok proizvodni kapaciteti ovise o raspoloživosti sirovina i njihovom eksploatacijskom potencijalu. Na području Varaždinske županije, eksploatacija je dominantno usmjerena na građevinsku industriju, čime se pridonosi jačanju infrastrukturnih i gospodarskih aktivnosti regije. Dugoročna održivost sektora zahtijeva primjenu suvremenih tehnoloških rješenja i visokih ekoloških standarda radi smanjenja negativnog utjecaja na okoliš te očuvanja prirodnog potencijala za buduće generacije.

Ključne riječi: eksploatacija, ekološki aspekti, mineralne sirovine, prostorni plan, gospodarstvo

3rd European GREEN Conference
10-13 June 2025
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Environmental Impact and Assessment
Procjene utjecaja na okoliš

Numerical modeling of the risk of oil platforms

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Abstract

It is an undeniable fact that accidents involving offshore drilling and production installations—whether fixed or mobile—have occurred in the past and, unfortunately, continue to occur. For many years, offshore oil installations have been governed by EU legislation, but only within the confines of territorial waters, extending up to 12 nautical miles from the shoreline. However, significant gaps were identified in the legal framework concerning major accidents occurring beyond this boundary—events that can have severe consequences for human safety, material assets, and the environment. In response, the European Commission introduced a more comprehensive legal framework in 2013 aimed at strengthening prevention, emergency response, and financial accountability related to offshore oil operations. This directive was also adopted by Romania, a country with hydrocarbon deposits in the Black Sea and licensed operators engaged in the exploitation, extraction, and eventual decommissioning of these fossil resources. In 2016, Law No. 165 was enacted, transposing Directive 2013/30 of the European Parliament into national legislation. This paper presents risk assessment programs focused on enhancing the safety of offshore platforms, with particular emphasis on environmental and water protection.

Keywords: oil offshore, offshore platform, risk assessment, numerical models

Numerical modeling of the oil rig explosion

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Abstract

The explosion of the Deepwater Horizon oil platform stands as one of the most severe accidents in offshore drilling history, resulting in the release of approximately 5 million barrels of oil into the Gulf of Mexico and the tragic loss of 11 lives. This event underscores the importance of simulation models in supporting preventive measures—especially in light of the growing strategic importance of hydrocarbon exploitation in the Black Sea region. In this paper, we present a simulation of a potential explosion scenario on a Romanian offshore oil installation. The aim is to identify and quantify the minimum set of critical data required to effectively prevent such incidents. Between 2004 and 2024, the fatality rate in the offshore oil and gas sector in U.S. waters was more than four times higher per person-hour worked than in European waters, despite many of the same companies operating in both regions. In Romania, the incidence of accidents on offshore platforms has remained low, largely due to operational strategies aligned with Life and Safety Management Authority standards. This notable disparity suggests that the core issue lies not in the nature of the business itself, but in the distinct safety cultures and regulatory frameworks in which companies operate. Past offshore accidents must be thoroughly analyzed to develop and implement improved work procedures. These lessons should play a critical role in overall risk assessments and inform risk-based decision-making processes. Risk management—especially when guided by the ALARP (As Low As Reasonably Practicable) principle—relies on sound judgment. This principle is based on the premise that most risks can be managed and mitigated, while only a small portion of residual risk must be tolerated and addressed cost-effectively. Nevertheless, this implies that a certain degree of uncontrolled risk remains and must be carefully monitored.

Keywords: oil offshore, drilling platform, risk assessment, numerical models, oil rig explosion

Water quality of the Drava and Mura Rivers along the Drava-Mura Regional Park

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Abstract

Flood areas of the Drava and Mura rivers in Croatia can be characterised as very rich in biodiversity, geological and landscape diversity. It made them the core of the Transnational Boundary Reserve Mura-Drava-Danube (TBR MDD) protected by UNESCO in 2021. Besides wetlands formed along the rivers, there are agricultural plots situated close to the river banks, which potentially can have anthropogenic impacts on the preserved area. This research of the Mura-Drava Regional Park is based on water quality monitoring, specifically data on nitrates and total phosphorus concentration obtained at 11 locations along the Drava and Mura rivers. The period of observation of 11 years (2014-2024) shows very low concentrations of both parameters. Slightly higher values have been monitored in the Drava River water upstream of the city of Osijek and in the Mura River water. We concluded that pollution caused by agricultural activities does not endanger directly Regional Park and its biological features. However, in the last several decades, climate change impacts have become more significant. They can be recognized in increasing frequencies of extreme hydrological events, an increase of air temperature, and changes in precipitation in quantity and spatial distribution. Therefore, the potential risk for the ecological balance of this valuable natural area probably lies in climate change effects, which certainly has to be explored.

Key words: climate change, wetland, water quality monitoring

Kakvoća vode rijeke Drave i mure na području Regionalnog parka Mura-Drava

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Sažetak

Poplavna područja ovih rijeka Mure i Drave u Hrvatskoj mogu se okarakterizirati kao vrlo bogata bioraznolikošću, geološkom i krajobraznom raznolikošću što ih je učinilo jezgrom Prekograničnog rezervata biosfere Mura, Drava i Dunav (TBR MDD), kojeg je UNESCO proglasio 2021, a njegova jezgra je Regionalni park Mura-Drava. Osim vlažnih područja formiranog duž riječnih tokova tu postoje i poljoprivredne površine koje često dosežu do samog riječnog toka, te je potencijalno moguć antropogeni utjecaj uslijed poljoprivrednih aktivnosti. Istraživanje Regionalnog parka Mura- Drava temeljeno na podacima o kvaliteti vode, odnosno sadržaju nitrata i ukupnog fosfora na ukupno 11 postaja na Dravi i Muri u razdoblju od 11 godina (2014.-2024.) pokazalo je rezultate s niskim vrijednostima nitrata i ukupnih fosfata na analiziranom području. Neznatno veće vrijednosti analiziranih podataka uočene na postajama na Dravi u blizini Osijeka, te na postajama rijeke Mure. Stoga zaključujemo da onečišćenja izazvana poljoprivrednim aktivnostima ne predstavljaju direktnu opasnost Regionalnom parku i njegovim biološkim značajkama. Međutim, u posljednjih nekoliko desetljeća utjecaji klimatskih promjena postaju sve izrazitiji i mogu se prepoznati u sve većoj frekvenciji ekstremnih hidroloških pojava, porastu temperature zraka, te promjenama količine i prostornog rasporeda oborina. Stoga, potencijalna opasnost za ekološku ravnotežu ovog značajnog područja vjerojatno leži u klimatskim promjenama, što je svakako potrebno dalje istraživati.

Ključne riječi: klimatske promjene, vlažna područja,monitoring kakvoće vode

Does Detail Matter? The Role of Data Granularity in Assessing the Carbon Foodprint of Cities

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Abstract

Evidence-based policymaking is essential for achieving climate justice in the face of escalating climate risks. Metrics like the carbon footprint (CF) help quantify environmental impacts; however, data availability remains a challenge, particularly in reflecting local lifestyles. This study investigates how the granularity of available data influences food-related CF assessments in cities. Using five resource scales (national, regional, city-wide, urban-size, and urban-regional), the foodprint was calculated for 18 Polish cities, resulting in five CF estimates per city and ten comparative combinations. Differences in total CF values across data resolutions were relatively small (±3.5%). However, more granular urban-regional data often led to increased estimates (by 0.001–0.003 global hectares per capita), particularly in larger cities. Notably, cities with 200–499K inhabitants showed higher CF values than national averages (+0.004 gha), while cities with over 500K exhibited the most variation at the product level—up to ±20% for poultry, cheese, fats, sugar, and potatoes. For cities below 200K population, national or regional datasets provided sufficient accuracy, suggesting that high-resolution data may not always justify the cost. These findings support better data-informed climate strategies that help prioritize resources based on local specificity truly matters.

Keywords: carbon footprint of food, data granularity, environmental indicators, environmental impact, human impact

Ecotoxicological effects of bisphenols on the aquatic plant *Lemna minor*

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Abstract

Bisphenol A and its analogs are increasingly detected in aquatic environments, yet their impacts on primary producers remain insufficiently explored. This study aimed to evaluate the effects of BPA, BPS, and BPF on the growth and photosynthetic pigments of the aquatic macrophyte *Lemna minor* in a standard OECD growth inhibition test. All tested bisphenols significantly affected plant growth and biomass accumulation, with effects depending on both the bisphenol analog and the tested concentration. Bisphenol A and F inhibited growth at all tested concentrations, while bisphenol S caused an increase in frond number growth rate at a low concentration range. Biomass accumulation and concentrations of chlorophyll a, chlorophyll b, total chlorophylls, and carotenoids were reduced across all treatments, with BPA exerting the most pronounced adverse effect on pigment content. Estimated EC_{50} values for growth inhibition revealed similar toxicity levels for BPA and BPS, while BPF exhibited lower toxicity. Despite structural similarities, differences in chemical properties among bisphenol analogs may cause distinct effects on organisms relevant to environmental risk assessment. These results highlight the importance of monitoring multiple biological endpoints to assess bisphenol toxicity accurately and suggest that different parameters may underestimate or overestimate the impact of bisphenol analogs on aquatic primary producers.

Keywords: risk assessment, bisphenols, *Lemna minor*, standard toxicity test

Ekotoksikološki učinci bisfenola na vodenu biljku *Lemna minor*

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Sažetak

Bisfenol A i njegovi analozi sve se češće detektiraju u vodenim ekosustavima, no njihovi učinci na primarne producente još su nedovoljno istraženi. Cilj ovog istraživanja bio je procijeniti utjecaj BPA, BPS i BPF na rast i koncentraciju fotosintetskih pigmenata vodene makrofite *Lemna minor* u standardnom OECD testu inhibicije rasta. Svi ispitivani bisfenoli značajno su utjecali na rast biljaka i akumulaciju biomase, pri čemu su učinci ovisili o analogu i primijenjenoj koncentraciji. Bisfenol A i F inhibirali su rast pri svim ispitivanim koncentracijama, dok je bisfenol S pri nižim koncentracijama uzrokovao povećanje prirasta broja biljaka. Akumulacija biomase i koncentracije klorofila a, klorofila b, ukupnih klorofila i karotenoida bile su smanjene u svim tretmanima, pri čemu je BPA pokazao najsnažniji negativni učinak na sadržaj pigmenata. Procijenjene EC_{50} vrijednosti za inhibiciju rasta ukazale su na sličnu razinu toksičnosti BPA i BPS, dok je BPF pokazao nižu toksičnost. Unatoč strukturnim sličnostima, razlike u kemijskim svojstvima među analozima bisfenola mogu dovesti do različitih učinaka na organizme važne za procjenu rizika za okoliš. Dobiveni rezultati naglašavaju važnost praćenja više bioloških pokazatelja za točnu procjenu toksičnosti bisfenola te upućuju na mogućnost podcjenjivanja ili precjenjivanja utjecaja bisfenolskih analoga na vodene primarne producente ovisno o odabranom parametru.

Ključne riječi: procjena utjecaja na okoliš, bisfenoli, Lemna minor, standardni tekst toksičnoti

3rd European GREEN Conference
10-13 June 2025
Hotel Olympia SKY
Vodice CROATIA

Environmental Monitoring
Monitoring okoliša

Occurrence of polychlorinated biphenyls and perfluoroalkyl substances in fish from the Adriatic Sea and the Danube River

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Abstract

Persistent organic pollutants, specifically polychlorinated biphenyls (PCBs) and per- and polyfluoroalkyl substances (PFAS), accumulate in the environment and, consequently, in both marine and freshwater fish. The aim of this study was to assess the contamination levels of seven PCB congeners, PCB-28, PCB-52, PCB-101, PCB-118, PCB-138, PCB-153, and PCB-180 (ICES-7), as well as six PFAS compounds in three marine fish species caught in the Adriatic Sea (bluefin tuna, swordfish and red mullet), along with two freshwater fish species from the Danube River (wels catfish and northern pike). The highest mean levels of PCB-138 (5.30 µg/kg), PCB-153 (13.0 µg/kg), PCB-180 (8.83 µg/kg), and the sum of ICES-7 (29.6 µg/kg) were observed in bluefin tuna. Significant differences in the mean levels of PCB-153, PCB-180, and ICES-7 among the five fish species were identified. Conversely, the highest mean value of perfluorooctane sulfonic acid (PFOS) at 4.94 µg/kg was found in northern pike, while perfluorodecanoic acid (PFDA) was detected in wels catfish at 0.47 µg/kg. Perfluorooctanoic acid (PFOA) was only detected in red mullet. Perfluoroundecanoic acid (PFUnDA) and perfluorotridecanoic acid (PFTrDA) were measured at the highest levels in tuna, whereas perfluorononanoic acid (PFNA) was measured in red mullet. Significant differences were observed among the five fish species for all six PFAS compounds.

Keywords: marine fish, freshwater fish, pollutants, polychlorinated biphenyls, perfluoroalkyl substances

Acknowledgement: The research was funded by the European Union – NextGenerationEU, project PFASsFoodWildlife.

The development of a potentiometric sensor for the determination of cationic surfactants based on single-walled carbon nanotubes

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Abstract

Cationic surfactants (CSs) are surface-active substances that possess a positively charged hydrophilic part, which is why they strongly bind to negatively charged surfaces. This property makes them useful as disinfectants, antimicrobial agents, and additives that reduce static electricity, etc. Because of their wide application, their presence in the environment has become an increasingly significant concern. Therefore, their monitoring is crucial for environmental protection. The reference method for their determination is two-phase titration. In line with the need for greener and more sustainable analytical approaches, alternative methods are increasingly being investigated to replace conventional, environmentally unfriendly, techniques. Among these, ion-selective electrodes have shown great potential as precise, fast, and more environmentally friendly sensors for the determination of CSs. Their membrane usually consists of sensor material, plasticizer, and polyvinyl chloride (PVC), and the incorporation of nanomaterials in the membrane composition further improves the sensitivity and selectivity of the sensor. The sensor material of the electrode was prepared by chemical functionalization of single-walled carbon nanotubes with the $–OSO_3\text{-}CP^+$ group. Then the material was embedded into a PVC membrane with a plasticizer and incorporated into the sensor with a liquid inner electrolyte. The developed sensor was characterized using direct potentiometry.

Keywords: cationic surfactants, ion-selective electrode, potentiometry

ECOREG project: The impact of organic pollutants on the ecological footprint of the region

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Abstract

The presence of various types of xenobiotics in the environment is of increasing concern worldwide due to their toxic and carcinogenic properties and their tendency to bioaccumulate in living organisms. Particularly important groups of pollutants are pesticides, polychlorinated biphenyls (PCBs), and polycyclic aromatic hydrocarbons (PAHs), which enter the ecosystem as a result of human activities. In order to determine the actual concentrations of these chemicals in the environment, one of the main objectives of the project is to develop a highly sensitive and selective analytical method using chromatography with tandem mass spectrometry systems (UHPLC-MS/MS and GC-MS/MS). The implemented methodology will be applied to different types of water (drinking, surface, and waste water) and soil samples as well as urine and milk from dairy cows and eggs from laying hens. Samples will be collected quarterly over a period of one year from small farms at a selected microsite in northwestern Croatia. A comprehensive research approach will provide new knowledge on the retention of residues of the observed contaminant groups in specific matrices (water, soil, animal-derived food and excreta), their transfer through the environment, and possible routes of human exposure, which will contribute to the protection of consumer health. This study was funded by the European Union – Next Generation EU.

Keywords: pesticides, PCB, PAH, environmental health, consumer protection

Long-term monitoring of floodplain plankton communities

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Abstract

Long-term plankton data are essential for understanding changes in the ecosystem and for appropriate management protection measures. The plankton monitoring programme was carried out in the Kopački Rit Nature Park (Croatia), one of the largest floodplains in the Central European part of the Danube. From 2007 to 2016, monthly samples were taken from Lake Sakadaš during the ice-free period. In the warmer months (spring/summer), phytoplankton was influenced by water depth and transparency, while zooplankton was influenced by water temperature, conductivity, organic and total nitrogen levels. In the colder months (fall/winter), the phytoplankton correlated strongly with the water depth and water level of the Danube, while the zooplankton showed only a weak correlation with the water temperature. During the long-term period studied, the phytoplankton was dominated by cyanobacteria and diatoms, with decreasing and increasing trends in biomass, respectively. Zooplankton was dominated by rotifers, with copepod developmental stages contributing equally to the community biomass. Although we have observed only minor changes in the plankton community over the years, these data can serve as a basis for modelling future climate change scenarios.

Keywords: phytoplankton, zooplankton, freshwater, Danube

Preliminary results on pH variability in Mali Ston Bay – implications for ocean acidification research

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Abstract

Global change is having a profound impact on marine ecosystems. In addition to global warming, increasing anthropogenic carbon dioxide emissions are leading to changes in seawater carbonate chemistry, a phenomenon known as ocean acidification. After more than two decades of research, it is now known that species' response to ocean acidification is strongly influenced by natural pH fluctuations in their habitats. In particular, coastal environments are characterized by highly dynamic carbonate chemistry parameters. In this study, we present preliminary data on pH variability in Mali Ston Bay, southeastern Adriatic Sea, an important marine habitat known for the cultivation of the European flat oyster, *Ostrea edulis*. Over ten months, pH on the total scale (pH_T) and total alkalinity (TA) were measured alongside temperature and salinity. Additional parameters, including pCO_2, aragonite (Ω_{Ar}) and calcite (Ω_{Ca}) saturation states, were calculated using the CO2SYS software. In addition to the expected seasonal changes in temperature and salinity, results revealed significant variability in pH and alkalinity. pH values ranged from 7.75 to 8.05, while the total alkalinity varied between 2680 and 3200 µmol kg^{-1}. These results emphasise the importance of localised monitoring when assessing the potential resilience of species to future seawater conditions. The observed natural variability suggests that populations inhabiting this area might already possess a degree of acclimatisation to environmental change, highlighting the need to incorporate such baseline data into future experimental designs.

Keywords: global change, ocean acidification, carbonate chemistry, Adriatic Sea, Mali Ston Bay

Vector Potential of *Halyomorpha halys* for Aflatoxigenic and Ochratoxigenic Fungal Species

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Abstract
In Europe, the accidental introduction of the brown marmorated stink bug, Halyomorpha halys (Stål, 1855) (Heteroptera: Pentatomidae), native to Eastern Asia, has been followed by its rapid spread across the continent, resulting in substantial damage to agriculturally important crops. In addition to direct feeding damage, several members of the Pentatomidae family have been documented as vectors capable of transmitting plant pathogenic bacteria and fungi. Concurrently, mycotoxigenic fungi—organisms that produce mycotoxins as secondary metabolites—pose a growing threat to food safety by contaminating crops, animal feed, and consequently, the human food chain. In this study, we investigated the potential role of *H. halys* as a vector of mycotoxigenic fungi. Adult insects were collected from a maize test field in Osijek, Croatia. Fungal cultures isolated from the insects revealed the presence of *Aspergillus flavus*, a well-known producer of aflatoxin B1, one of the most potent and carcinogenic mycotoxins. These findings suggest a previously undocumented pathway for fungal contamination of crops and highlight the potential of *H. halys* as a biological vector of aflatoxigenic fungi in agroecosystems.

Keywords*:* *Halyomorpha halys*, aflatoxin B1, food safety

Monitoring of cushion coral (*Cladocora caespitosa*) in the Zadar Archipelago

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Abstract
Cushion coral (*Cladocora caespitosa*) is an endemic and the only reef-building coral in the Mediterranean Sea. In Croatia, it's a strictly protected species, with the largest reef in Mljet National Park, which regularly monitors the population. The second-largest recorded population is near the Ljubačka vrata, though it is in poor condition, with the cause remaining unknown due to a lack of systematic monitoring. The research was conducted as part of the ReefQuest: *Cladocora caespitosa* Exploration project during 2024 to assess the status of the *C. caespitosa* population in the Zadar archipelago. For each coral colony along a transect set at a depth of 10 m, 20 m long and 2 m wide, sea temperature, diameter, height, and colony health were recorded. The results indicate good overall health but a high percentage of mechanical damage with unknown causes. Additionally, mobile colonies not attached to the substrate were observed. Regular monitoring, such as that conducted in Mljet, is crucial for the successful conservation of this species, especially given threats like rising sea temperatures and anthropogenic pressure. Collecting data on environmental parameters would contribute to a better understanding of changes. This research provides an important foundation for further studies and conservation measures for *C. caespitosa*.

Keywords: Cushion coral, *Cladocora caespitosa*, monitoring

Monitoring busenastog koralja (*Cladocora caespitosa*) u zadarskom arhipelagu

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Sažetak

Busenasti koralj (*Cladocora caespitosa)* endemska je vrsta i jedini grebenotvorni koralj u Sredozemnom moru. U Hrvatskoj je zaštićen temeljem Pravilnika o strogo zaštićenim vstama (NN 144/2013-3086) najveći greben nalazi u NP Mljet koji redovno provodi monitoring populacije. Druga po veličini evidentirana populacija je u blizini Ljubačkih vrata, populacija je u lošem stanju no uzroci nisu poznati zbog nedostatka sustavnog monitoringa. Istraživanje je provedeno u sklopu projekta ReefQuest: *Cladocora caespitosa* Exploration tijekom 2024. godine kako bi se ustanovilo stanje populacije *C. caespitosa* u zadarskom arhipelagu. Za svaku koloniju koralja duž transekta postavljenog na dubini 10 m, duljine 20 m i širine 2 m evidentirana je temperatura mora, promjer i visina te zdravstveno stanje kolonija. Rezultati pokazuju dobro zdravstveno stanje, ali s visokim postotkom mehaničkih oštećenja. Uzroci mehaničkih oštećenja nisu poznati iako je sumnja da je mogući uzrok sidrenje brodova i korištenje ribolovnih alata. Osim toga, zabilježene su mobilne kolonije koje nisu pričvršćene za podlogu. Redovito praćenje, poput onog na Mljetu, ključno je za uspješno očuvanje ove vrste, posebno s obzirom na prijetnje poput porasta temperature mora i antropogenog pritiska. Prikupljanje podataka o okolišnim parametrima pridonijelo bi boljem razumijevanju promjena. Ovo istraživanje pruža važne temelje za daljnje studije i mjere zaštite *C. Caespitose.*

Ključne riječi: busenasti koralj, *Cladocora caespitosa*, monitoring

Adaptive biodiversity monitoring for infrastructure projects: Ensuring continuity from planning to operation

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Abstract
Pre-construction biodiversity monitoring plays a critical role in the planning and implementation of large infrastructure projects, such as highways, by providing a scientifically grounded baseline for assessing potential environmental impacts. This paper argues that effective biodiversity monitoring should go beyond generic methodologies and instead adapt standard survey protocols to the specific ecological context and target taxonomical groups. By tailoring the monitoring approach and strategically selecting key survey areas and points, based on ecological value, sensitivity, and spatial relevance, the collected data becomes more robust, meaningful, and directly applicable to subsequent project phases, including execution and operation. This replicability not only ensures continuity in assessing biodiversity trends but also supports adaptive management and compliance with environmental regulations. The proposed framework enhances ecological data quality, facilitates informed decision-making, and contributes to minimizing long-term environmental impacts associated with infrastructure development.

Keywords: biodiversity monitoring, adaptive methodology, pre-construction, infrastructure

Croatian case study on pesticide residues in olive farming systems within the SPRINT project

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Abstract

As part of the HORIZON 2020 SPRINT project, Croatia took part in a multinational assessment of pesticide exposure across diverse agricultural systems. The Croatian case study focused on the Istrian region, where pesticide residues were analysed in environmental matrices - such as soil, air, water, sediment, and household dust - as well as in biological samples from humans (blood, urine, feces, nasal swabs), livestock (sheep milk and feces), and companion animals (cats and bats). The study covered organic (ECO) and conventional (IPM) farming practices.

Among the ten case studies targeting different crops, Croatian olive groves exhibited the lowest diversity of pesticide residues in soil. However, legacy pollutants such as DDT were still present, with DDT metabolite, DDE, detected in 85% of soil samples, indicating the long-term persistence of banned substances. Surface water and sediment samples from Croatia similarly contained the fewest pesticide types and showed generally low concentrations. Household dust from olive-farming

households also contained traces of multiple pesticides, though concentrations remained low regardless of production type. Notably, some of the detected compounds were classified as dual-use pesticides—used both in agriculture and in public health-related DDD measures (Disinfection, Disinsection, and Deratization).
The SPRINT project revealed substantial differences in pesticide levels between farming systems across countries. While Croatia demonstrated a comparatively lower overall pesticide burden, it is not immune to environmental contamination.
This research was supported by the European Union's Horizon 2020 research and innovation programme (Grant Agreement No. 862568).

Keywords: environment, plants, animals, humans, plant protection products

Occurrence of the parasite *Anguillicoloides crassus* in European eel (*Anguilla anguilla*) in Croatia

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Abstract

European eel (*Anguilla anguilla*, Linnaeus, 1758) is a catadromous fish species classified as critically endangered. Causes of its population decline are believed to be a combination of overfishing, habitat deterioration due to the construction of hydropower plants, drainage of wetlands, pollution, as well as climate change, introduced alien species, and diseases, including parasite infestations. Among parasites, the well-known and widespread eel parasite is the nematode *Anguillicoloides crassus*. This parasite originates from East Asia and was accidentally introduced to almost all European countries, including Croatia. It has an indirect life cycle, with *A. anguilla* serving as a final host. *A. crassus* inhabits the swim bladder of the European eel, where it reproduces sexually. Adult nematodes feed on blood, impairing swim bladder function, and reducing swimming ability in infected fish while causing damage to other organs, leading to increased mortality. Although the European eel is present in numerous waterbodies of the Adriatic basin in Croatia, its infestation by *A. crassus* has not been studied in detail so far. This paper presents a review of previous research and highlights the need for more extensive research.

Keywords: nematode, Neretva Delta, infestation

Daily and seasonal variations in dissolved oxygen concentration in the Drava (Water body CDR00002_265327)

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Abstract
According to environmental impact studies of the hydroelectric power plant on the Drava River they monitoring of water conditions at locations that make up the monitoring network, surface and underground waters of the hydroelectric system. The locations and quality parameters being tested are defined by the Water Testing Program, and the obtained results are submitted to the relevant authorities. Although hydropower plants hydromorphologically change the river, they do not have wastewater discharge, but the water bodies that are managed and whose water quality is tested by the recipient are municipal wastewater. The aim of this work is to present the daily fluctuations in the concentration of dissolved oxygen in left drainage ditch Hydroelectric Power Plant Čakovec, who is the recipient of wastewater from the 'Varaždin' Agglomeration during 2024. The consequence is that the water does not meet the recommendations prescribed for waters suitable for freshwater fish. Monitoring quality and detecting deviations in the value of individual parameters is an indicator of changes in the state of the water body. The results of water quality monitoring provide the basis for making strategic decisions about the management of this water body by applying regulatory frameworks which define the procedures in cases of not achieving good status. Due to the complexity and integrity of the purpose of the water body and the need to synchronize flood protection, energy production, and wastewater acceptance, monitoring water quality must be considered through a wide range of users of the Drava River.

Keywords: water monitoring, hydroelectric system, recipient of wastewater, melted oxygen

Dnevne i sezonske varijacije koncentracije otopljenog kisika u Dravi (vodno tijelo CDR00002_265327)

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Sažetak

Prema studijama utjecaja na okoliš hidroelektrane na rijeci Dravi provode monitoring stanja voda na postajama koje čine monitoring mrežu nadzemnih i podzemnih voda hidroenergetskog sustava. Lokacije i parametri kakvoće koji se ispituju definirani su Programom ispitivanja voda, a dobiveni rezultati dostavljaju se Hrvatskim vodama. Iako hidroelektrane hidromorfološki mijenjaju rijeku, one nemaju emisiju otpadnih voda, ali vodna tijela kojima upravljaju i čiju kakvoću vode ispituju recipijent su komunalnih otpadnih voda. Cilj ovog rada jest prikazati dnevna kolebanja koncentracije otopljenog kisika u desnom drenažnom jarku Hidroelektrane Čakovec koji je recipijent otpadnih voda Aglomeracije „Varaždin“ tijekom 2024. Posljedica pada koncentracije otopljenog kisika ispod preporučenih vrijednosti je da voda ne odgovara preporukama propisanim za vode pogodne za život slatkovodnih riba. Praćenje kakvoće i detekcija odstupanja vrijednosti pojedinog parametra pokazatelj promjene stanja vodnog tijela. Rezultati monitoringa kakvoće vode predstavljaju temelj za donošenje strateških odluka o upravljanju ovim vodnim tijelom primjenjujući regulativne okvire koji definiraju postupanje u slučajevima ne postizanja dobrog stanja. Zbog kompleksnosti i cjelovitosti namjene vodnog tijela i potrebe usklađivanja zaštite od poplava, proizvodnje energije i prihvata otpadnih voda, praćenje kvalitete voda mora se razmatrati kroz širok spektar korisnika voda rijeke Drave.

Ključne riječi: monitoring voda, hidroenergetski sustav, recipijent otpadnih voda, otopljeni kisik

Sustainable determination of VOCs in water using Headspace GC-MS/MS

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Abstract
In modern analytical chemistry, increasing emphasis is placed on the development of methods aligned with the principles of green chemistry, while maintaining high sensitivity, selectivity, and reliability. This study presents the application of gas chromatography coupled with tandem mass spectrometry (GC-MS/MS) and the Headspace technique for the identification and quantification of volatile organic compounds (VOCs) in water samples. VOCs are important indicators of pollution, originating from various sources such as industrial processes, landfills, petroleum products, and wastewater systems. Their presence in the environment is associated with numerous adverse effects on human health and aquatic ecosystems. The Headspace technique enables the extraction of volatile analytes from aqueous matrices without the use of organic solvents, thereby significantly reducing chemical waste generation and enhancing analytical safety. When combined with GC-MS/MS, this method provides highly specific and sensitive detection of target compounds at trace levels. The described approach offers an efficient, rapid, and environmentally friendly alternative to conventional analytical techniques, fully in line with green chemistry principles. Its application in routine water quality monitoring presents a sustainable solution for environmental and public health laboratories, contributing to the broader goal of minimizing the ecological footprint of analytical practices.

Keywords: VOC, water analysis, green chemistry, GC-MS/MS Headspace, sustainable analytical methods

Određivanje hlapljivih organskih spojeva (VOC) u vodi primjenom Headspace GC-MS/MS metode

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Sažetak

U suvremenoj analitičkoj kemiji sve je veći naglasak na razvoju metoda koje su u skladu s načelima zelene kemije, a istovremeno osiguravaju visoku osjetljivost, selektivnost i pouzdanost. U ovom radu predstavljena je primjena plinske kromatografije u kombinaciji s tandemskom masenom spektrometrijom (GC-MS/MS) i Headspace tehnikom za identifikaciju i kvantifikaciju lakohlapivih organskih spojeva (VOC) u uzorcima vode. Lakohlapivi spojevi su važni pokazatelji onečišćenja jer potječu iz brojnih izvora, uključujući industrijske procese, odlagališta otpada, naftne derivate i kanalizacijske sustave, a njihova prisutnost u okolišu povezana je s nizom štetnih učinaka na ljudsko zdravlje i vodene ekosustave. Headspace tehnika omogućuje izdvajanje hlapivih spojeva iz vodene matrice bez upotrebe organskih otapala, čime se značajno smanjuje količina otpadnih otapala i povećava sigurnost analitičkog postupka. Kombinacija s GC-MS/MS sustavom omogućuje visoko specifično i osjetljivo određivanje ciljanih spojeva pri vrlo niskim koncentracijama. Opisana metoda predstavlja učinkovitu, brzu i ekološki prihvatljivu alternativu klasičnim analitičkim pristupima, u potpunosti usklađenu s načelima zelene kemije, s velikim potencijalom za primjenu u rutinskom monitoringu kvalitete voda.

Ključne riječi: lakohlapivi spojevi, analiza vode, zelena kemija, GC-MS/MS Headspace, održive analitičke metode

Beaver - An engineer of changes in the physical and ecological characteristics of aquatic habitats

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Abstract

The Eurasian beaver (*Castor fiber* Linnaeus, 1758) is a protected species that began to disappear from Croatia at the beginning of the 20th century. At the end of the same century, efforts were made to reintroduce it to suitable habitats in our country. Since beavers build dams in places where they need higher water levels for their movement, thus creating reservoirs, they are often referred to as "ecosystem engineers". The project aims to study the effects of beaver dams on water quality and the invertebrate community, both near the dams and in the reservoirs created. The samples were collected in spring 2021 at the Grabovac Krnjački and Prodin Dol sites. At these sites, samples of invertebrates and water were taken from upstream locations, in the reservoir, and downstream of the beaver dams. During sampling, the substrate composition was estimated. Some physicochemical parameters of the water (water temperature, pH, conductivity and oxygen) were measured on site, while others (nutrients and alkalinity) were analysed in the laboratory. The presence of beavers at the sites was confirmed using camera traps, assessing the stability of the dams and signs of their activity. Beavers have altered the habitat at the studied sites by building dams, creating reservoirs and directly destroying vegetation. A uniform muddy substrate was found in the reservoirs. The invertebrate community consists mainly of the most resistant species, precisely because of their rapid adaptation to a variety of environmental conditions.

Keywords: beaver pond, invertebrates, physicochemical parameters

Dabar - inženjer promjene fizičkih i ekoloških karakteristika vodenog staništa

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Sažetak

Euroazijski dabar (Castor fiber Linnaeus, 1758) zaštićena je vrsta, koja početkom 20. stoljeća nestaje s područja Hrvatske. Krajem istog stoljeća, provodila se reintrodukcija ove vrste na pogodnim staništima diljem naše države. S obzirom na to da dabar gradi brane na mjestima gdje mu je, potrebna veća razina vode za kretanje, stvarajući akumulacijska jezera, naziva se „inženjerom ekosustava“. Cilj projekta je proučiti utjecaj dabrovih brana na vodu i zajednicu beskralješnjaka - u neposrednoj blizini brana i uz posljedično nastala akumulacijska jezera. Uzorci su prikupljeni na lokalitetima Grabovac Krnjački i Prodin Dol, u proljeće 2021. godine. Na lokalitetima su prikupljeni uzorci beskralješnjaka i vode na uzvodnoj poziciji, u akumulacijskom jezeru te nizvodno od dabrovih brana. Prilikom uzorkovanja procijenjen je sastav supstrata. Dio fizikalno-kemijskih parametara vode izmjeren je in situ (temperatura vode, pH, provodljivost i kisik), a dio je analiziran u laboratoriju (hranjive tvari i alkalitet). Prisutnost dabra na lokalitetima potvrđena je pomoću foto zamki, procjenom održavanosti brane i tragova obitavanja. Dabar je gradnjom brana izmijenio izgled staništa na istraživanim lokalitetima stvarajući akumulacijska jezera te neposredno uništavajući vegetaciju. U akumulacijskim jezerima zabilježena je ujednačenost muljevitog supstrata. Zajednicu beskralješnjaka pretežito čine najotpornije svojte, upravo zbog njihovog brzog prilagođavanja na širok raspon različitih okolišnih uvjeta.

Ključne riječi: euroazijski dabar, akumulacijsko jezero, fizikalno-kemijski parametri, beskralješnjaci

Surface water sampling protocol for physicochemical analysis in an accredited laboratory

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Abstract

Accurate and reliable analytical results in environmental water research fundamentally depend on the proper implementation of water sampling procedures. Therefore, it is essential to develop a comprehensive and detailed sampling strategy before initiating any analysis. The objectives of the study, along with the specific environmental conditions in the field, determine the procedural approach for water sampling. Given the diversity of available sampling and sample handling methodologies, the appropriate procedures must be carefully structured and adapted to the specific situation to obtain optimal research results. This study outlines key principles for designing a sampling protocol for physical and chemical analyses of surface waters based on international standards (ISO), focusing on sampling techniques, sample types, analytical parameters to be analysed, sampling locations, frequency, equipment, field measurements, and sample handling procedures during field collection, transport, and storage until laboratory analysis. Laboratories accredited following ISO/IEC 17025 are required to perform regular quality control of sampling and sample handling processes in order to promptly detect and correct errors, thus enhancing the overall reliability and efficiency of sampling performance.

Keywords: sampling strategy, surface water analysis, ISO standards, quality assurance

Tracking pesticide residues in European air: A harmonised, low-cost approach

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Abstract

Unravelling air contamination with pesticide residues is an emerging challenge. The lack of large-scale studies and unstandardised sampling methodologies has led to fragmented assessments. This study, part of the EU project SPRINT, presents the first

harmonised, pan-European evaluation of pesticide residues in ambient air, addressing a critical gap in pesticide monitoring. 20 TIEM devices were installed across Europe (two per country) during the 2021 growing season, adjacent to conventional (IPM) and organic (ECO) fields. A total of 161 pesticide residues were analysed, with 75 detected, including eight currently not approved in the EU. All samples contained pesticide residues, ranging from 3 to 26 residues per sample. Glyphosate, AMPA, and pendimethalin were the most frequently detected compounds. In Croatia, the number of detected pesticides ranged between 3 (organic/ECO) and 8 (conventional (IPM)), with 100% detection frequency for glyphosate and folpet PHI. Phosmet had the highest levels (323.6 ng/sample), followed by folpet PHI (138.4 ng/sample). Our results show that TIEM diffusive samplers are a cost-effective approach to pesticide residue monitoring in air, particularly in regions with limited resources. This methodology can potentially assist regulatory procedures, providing an accessible tool for environmental and public health assessment.

Keywords: passive air samplers, pesticide mixtures, environment

Investigation of the periphytic diatoms of the Erzen River

Skerdilaid XHULAJ

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Abstract

The Erzen is a river in central Albania. The 109 km long Erzen has a 760 km^2 catchment area, including the southern Tirana District and eastern Durrës District. We collected periphyton along the Erzen twice in total, once in April 2022 and once in September 2022. Based on the number of indicator species, we were able to determine that the current trophic status of the Erzen has increased in recent years. Regarding the proportions of the genera, we have also observed significantly changed conditions at this level compared to previous times. Several species were still present in 2000 till 2010. Representatives of the genera *Eunotia*, *Fragilaria*, *Gyrosigma*, *Hantzschia*, *Pinnularia*, *Stauroneis* and *Surirella* were found in the Erzen, while currently we encounter far more species and individuals from the genera *Achnanthes* and *Nitzschia*. Interestingly, four new genera, *Caloneis*, *Frustulia*, *Luticola* and *Sellaphora*, have recently appeared in the Erzen. Between April 2022 and September 2022, both the species composition and the dominance ratios of the species changed. Among the dominant species in April, 11 genera occurred, while this number dropped to just under 5 in September. The most dominant species in April were *Achnanthes minutissima*, *Cocconeis placentula*, *Cocconeis pediculus*, *Cymbella microcephala* and *Diatoma moniliformis*; in September, *Achnanthes minutissima*, *Nitzschia palea*, *N. sigmoidea*, *N. dissipata* and *N. umbonata* were found.

Keywords: Diatoms, periphyton, trophic status, Erzen River

Lichenized and lichenicolous fungi from the Central Mountainous Region of Albania (Bulqizë District)

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Abstract

This study deals with the species composition of lichens in the Central Mountainous Region of Albania. A total of 220 species of lichenized and 25 species of lichenicolous fungi were recorded at 10 localities in the Bulqizë district. The findings show many aspects. *Biatora beckhausii*, *Pectenia atlantica*, *Peltigera collina*, *Nephroma laevigatum*, *N. parile*, *Leptogium saturninum*, *Lecanora intumescens*, *Ramonia luteola*, *Catinaria atropurpurea* show that the forest (locality 4, Liqeni i Zi) is primeval, i.e., that the area has never been without forest. The last two mentioned species also show an alpine feature together with *Glaucomaria leptyrodes*, *Tetramelas chloroleucus*, *Physciella poeltii,* and *Lecanora pulicaris*. Clean exposed surfaces (locality 7, Stavec) with a vegetation characterized by *Collema* species and various immersed species. Notable species: *Scytinium schraderi* and *Scytinium leptogioides*; *Caloplaca circumalba* var. *candida* and *Kuettlingeria erythrocarpa*. *Pisutiella conversa* and *Eiglera flavida* are northern species; here, they must be on the southernmost limit of their distribution. This may possibly be explained by the NW exposure of the locality. Major component analysis illustrated that lichen assemblages reflected the geographical distribution of localities and that the occurrence of many species is closely associated with some environmental factors.

Keywords: lichens, biodiversity, flora of Albania

3rd European GREEN Conference
10-13 June 2025
Hotel Olympia SKY
Vodice CROATIA

Environmental Regulations and Laws
Okolišno pravo i zakonska regulativa

Golf resort on Srđ Hill above Dubrovnik – The place where law nearly lost the battle

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Abstract

On the hill above Dubrovnik, overlooking the UNESCO-protected city, a megalomaniac project was planned – a golf resort spanning over 300 hectares, including villas, hotels, and two golf courses. Behind it all: the company Razvoj golf d.o.o., backed by foreign capital and quietly supported by political structures. On paper – development. In reality, a silent occupation of public land. The Environmental Impact Assessment (EIA) was outdated, created for a project three times smaller. Nevertheless, the investor was allowed to proceed without a new assessment. Citizens rebelled. A referendum was held – 84% voted NO. But turnout didn't reach the legal threshold, so the authorities dismissed the result. The fight moved to the courts. NGOs and citizens filed lawsuits. In 2016, the High Administrative Court ruled: the environmental permit was unlawful, the procedure was manipulated, and the public interest was ignored. Srđ became both a legal and civic lesson: when institutions fail, the public can be the last line of defense for the rule of law and the environment. This battle was won, but the war against the abuse of law and favoring of private capital is far from over.

Keywords: Dubrovnik, golf resort, public interest, environmental permit

Golf resort na Srđu iznad Dubrovnika – mjesto gdje je pravo zamalo izgubilo bitku

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Sažetak

Na brdu iznad Dubrovnika, s pogledom na grad pod UNESCO zaštitom, planiran je megalomanski projekt – golf resort od preko 300 hektara s vilama, hotelima i dva igrališta. Iza svega: tvrtka Razvoj golf d.o.o., pod stranim kapitalom, uz tihu podršku političkih struktura. Na papiru – razvoj. U stvarnosti – tiha okupacija javnog dobra. Studija utjecaja na okoliš bila je zastarjela, izrađena za projekt tri puta manjeg opsega. Ipak, investitoru je omogućeno da nastavi bez nove procjene. Građani su se pobunili. Organiziran je referendum – 84% je reklo NE. No izlaznost nije dosegnula zakonski prag, pa vlast ignorira poruku. Borba se nastavlja sudskim putem. Udruge i građani podnose tužbe. Godine 2016. Visoki upravni sud presuđuje: okolišna dozvola je nezakonita, procedura manipulirana, a javni interes zanemaren. Srđ postaje pravna i građanska lekcija: kad institucije zakažu, javnost može biti posljednja obrana pravnog poretka i okoliša. Ova bitka je dobivena – ali rat protiv zlouporabe prava i pogodovanja kapitalu nije završen.

Ključne riječi: Dubrovnik, golf resort, javni interest, okolišna dozvola

Criminal–legal protection of the environment

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Abstract

This paper examines the mechanisms of criminal environmental law in the European Union (EU), the Republic of Croatia (RH), and Bosnia and Herzegovina (BIH), to assess their effectiveness in preventing and sanctioning environmental crimes. Through a comparative analysis of legal frameworks, implementation practices and recent cases of violations of environmental standards, the paper reveals key differences and systemic shortcomings. The EU, through cohesive policies such as the Environmental Crime Directive (2008/99/EC and the new Directive (EU) 2024/1203) and the activities of Eurojust, sets global standards, but internal disparities in implementation remain a challenge, especially in peripheral regions. The Republic of Croatia, although formally aligned with the acquis communautaire, faces insufficient preventive effectiveness due to low penalties under the Environmental Protection Act (Official Gazette 80/13, 153/13, 78/15, 12/18, 118/18) and slow court proceedings. In Bosnia and Herzegovina, the decentralized system - with entity, cantonal and state jurisdiction - results in duplication of regulations, unclear accountability and infrequent prosecution, which undermines sustainable development. The paper emphasizes that successful environmental protection requires a multi-layered approach: strengthening the capacity of supervisory bodies (e.g. specialized environmental protection units within the police), training legal experts on environmental crimes, and innovative sanctions (e.g. suspended sentences with an obligation to remediate damage). Harmonization of laws at the state level is crucial for BiH, while the Republic of Croatia needs to introduce progressive penalty rates depending on the severity of the damage. The development of common platforms for data exchange between the EU, the Republic of Croatia and Bosnia and Herzegovina is a priority, with the use of funds such as IPA III to finance joint environmental protection projects. Civil society also plays an indispensable role through media monitoring and support for victims of environmental violence.

Keywords: environmental protection, criminal law framework, Environmental Protection Act, competent authorities, cross-border cooperation

Kazneno–pravna zaštita okoliša

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Sveučilište u Mostaru, Matice hrvatske bb, Mostar, Bosna i Hercegovina

Sažetak

Ovaj rad istražuje mehanizme kaznenog prava zaštite okoliša u Europskoj uniji (EU), Republici Hrvatskoj (RH) i Bosni i Hercegovini (BIH), s ciljem procjene njihove učinkovitosti u sprječavanju i sankcioniranju kaznenih djela protiv okoliša. Kroz komparativnu analizu pravnih okvira, praksi provedbe i recentnih slučajeva kršenja ekoloških standarda, rad otkriva ključne razlike i sistemske nedostatke. EU, putem kohezivnih politika poput Direktive o kaznenim djelima protiv okoliša (2008/99/EZ i nove Direktive (EU) 2024/1203) i aktivnosti Eurojusta, postavlja globalne standarde, ali unutarnje nejednakosti u provedbi i dalje predstavljaju izazov, posebno u perifernim regijama. Republika Hrvatska, iako formalno usklađena s pravnom stečevinom EU, suočava se s nedovoljnom preventivnom učinkovitošću zbog niskih kazni prema Zakonu o zaštiti okoliša (Narodne novine 80/13, 153/13, 78/15, 12/18, 118/18) i sporih sudskih postupaka. U Bosni i Hercegovini, decentralizirani sustav - s entitetskom, kantonalnom i državnom jurisdikcijom - rezultira dupliciranjem propisa, nejasnom odgovornošću i rijetkim kaznenim progonom, što potkopava održivi razvoj. U radu se naglašava da uspješna zaštita okoliša zahtijeva višeslojni pristup: jačanje kapaciteta nadzornih tijela (npr. specijaliziranih jedinica za zaštitu okoliša unutar policije), edukaciju pravnih stručnjaka o kaznenim djelima protiv okoliša te inovativne sankcije (npr. uvjetne osude s obvezom sanacije štete). Usklađivanje zakona na državnoj razini ključno je za BIH, dok Republika Hrvatska treba uvesti progresivne kaznene stope ovisno o težini štete. Kao prioritet ističe se razvoj zajedničkih platformi za razmjenu podataka između EU, Republike Hrvatske i Bosne i Hercegovine, uz korištenje sredstava poput IPA III za financiranje zajedničkih projekata zaštite okoliša. Civilno društvo također ima neizbježnu ulogu kroz praćenje medija i podršku žrtvama ekološkog nasilja.

Ključne riječi: zaštita okoliša, kaznenopravni okvir, Zakon o zaštiti okoliša, nadležna tijela, prekogranična suradnja

The importance of horizontal themes in EU projects across programming periods

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Public Institution County Development Agency of Osijek-Baranja County, županije, Stjepana Radića 4, Osijek, Croatia

Abstract

The Public Institution County Development Agency of Osijek-Baranja County (CDA OBC), as a regional coordinator, prepares county development strategies, other strategic and development documents, and provides expert assistance in the preparation and implementation of support programs for public bodies and institutions founded by the Republic of Croatia or Osijek-Baranja County. It also assists in the preparation and implementation of development projects of interest, especially those co-financed by the Structural and Investment Funds of the EU. Throughout all programming periods, the importance of horizontal themes in EU projects has been significant, as they represent the fundamental principles and policies of the European Union that must be integrated into all phases of planning and implementing projects financed by EU funds. Horizontal themes are multidisciplinary and universal values that are integrated in all aspects of EU projects, regardless of their specific topic. The most important horizontal themes include: the promotion of equal opportunities and gender equality, combating all forms of discrimination, accessibility for persons with disabilities, sustainable development and environmental protection, and the principles of good governance. The development and application of horizontal themes in EU projects demonstrate the growing importance of social and environmental values in European policies. Over time, the requirements have become stricter and the expectations from beneficiaries higher, with the aim that all EU projects contribute to an inclusive, sustainable, and just society in the long term.

Keywords: promotion of equal opportunities and gender equality, combating all forms of discrimination, accessibility for persons with disabilities, sustainable development and environmental protection, the principle of good governance

Značaj horizontalnih tema u EU projektima kroz programska razdoblja

Adela SADIKOVIĆ

Javna ustanova Županijska razvojna agencija Osječko-baranjske županije, Stjepana Radića 4, Osijek, Hrvatska

Sažetak

Javna ustanova Županijska razvojna agencija Osječko-baranjske županije (JU ŽRA OBŽ), kao regionalni koordinator, izrađuje županijske razvojne strategije, druge strateške i razvojne dokumente te pruža stručnu pomoć u pripremi i provedbi programa potpore javnopravnim tijelima i javnim ustanovama kojima su osnivači RH ili OBŽ, u pripremi i provedbi razvojnih projekata od interesa, a posebno projekata sufinanciranih sredstvima iz strukturnih i investicijskih fondova EU. Tijekom svih programskih razdoblja značaj horizontalnih tema u EU projektima bio je značajan jer one predstavljaju temeljna načela i politike Europske unije koje se moraju integrirati u sve faze planiranja i provedbe projekata financiranih iz EU fondova. Horizontalne teme su multidisciplinarne i opće vrijednosti koje prožimaju sve aspekte EU projekata, bez obzira na njihovu specifičnu tematiku. Najvažnije horizontalne teme uključuju: promicanje jednakih mogućnosti i ravnopravnosti spolova, suzbijanje svih oblika diskriminacije, pristupačnost za osobe s invaliditetom, održivi razvoj i zaštitu okoliša te načela dobrog upravljanja. Razvoj i primjena horizontalnih tema u EU projektima pokazuje rastuću važnost društvenih i okolišnih vrijednosti u europskim politikama. S vremenom su zahtjevi postali stroži, a očekivanja od korisnika veća, s ciljem da svi EU projekti dugoročno doprinose inkluzivnom, održivom i pravednom društvu.

Ključne riječi: promicanje jednakih mogućnosti i ravnopravnosti spolova, suzbijanje svih oblika diskriminacije pristupačnost za osobe s invaliditetom održivi razvoj i zaštita okoliša načelo dobrog upravljanja

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Forestry and Urban Forestry
Šumarstvo i urbano šumarstvo

Strategic communication of urban forestry through social media: A case study of the NATURAVITA project

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Abstract
Urban forests are essential for sustainable, healthy and climate-resilient cities as they contribute to the overall quality of urban life. Communicating urban forestry issues is crucial for raising public awareness about the ecological, health-related, and general benefits of urban forests. Social media, as a fast and interactive communication channel, has become an important tool for promoting urban forestry topics. By posting strategically designed posts, it is possible to reach various groups of citizens, decision-makers, and the media. As a case study, a content analysis was conducted on the social media platforms Facebook, Instagram and YouTube within the strategic project NATURAVITA. A total of 586 posts were analyzed. The analysis identified key themes such as forest pedagogy, biological forest restoration, forest protection, public education, and visual presentation of forest ecosystems, all of which proved essential for the effective promotion of urban forestry. Facebook stood out as the platform for informative and visually supported content and served as an important channel for informing the public about forestry work. Instagram was focused on visual content that sparked public interest. The YouTube channel featured informative-visual content, providing a comprehensive overview of the project's biodiversity and activities. The greatest public interest was generated by forest pedagogy workshops, interesting forestry stories and the participation of public figures. The positive tone of communication and visually appealing posts contributed to the promotion of urban forestry. This strategy can serve as a foundation for shaping future communication activities.

Keywords: urban forestry, communication, social media, forest pedagogy, education

Strateško komuniciranje urbanog šumarstva kroz društvene mreže: Studija slučaja projekt NATURAVITA

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Sažetak

Urbane šume su nužne za održive, zdrave i klimatrski otporne gradove jer doprinose kvaliteti života u gradovima. Komuniciranje tema urbanog šumarstva ključno je za povećanje svijesti javnosti o ekološkim, zdravstvenim i opće korisnim funkcijama urbanih šuma. Društvene mreže kao brzi i dvosmjerni komunikacijski kanali, postale su važan alat za komunikaciju tema urbanog šumarstva. Kroz ciljano osmišljene objave, moguće je doprijeti do različitih skupina građana, donositelja odluka i medija. Kao studija slučaja provedena je analiza sadržaja društvenih mreža Facebook, Instagram i YouTube strateškog projekta NATURAVITA. Ukupno je analizirano 586 objava. Analizom sadržaja na društvenim mrežama izdvojene su teme poput šumske pedagogije, biološke obnove šuma, zaštite šuma i edukacije javnosti, te vizualne prezentacije šumskog ekosustava koje su se pokazale ključnima za promociju urbanog šumarstva. Facebook se istaknuo kao glavni kanal za informativne i informativno-vizualne objave, te važna platforma za informiranje javnosti o šumarskim radovima. Instagram je bio usmjeren na vizualne sadržaje koji pobuđuju interes javnosti. Na YouTube kanalu objavljivani su informativno-vizualni sadržaji koji su pružali sveobuhvatan prikaz bioraznolikosti projektnog područja i projektnih aktivnosti. Najveći interes publike izazvale su radionice šumske pedagogije, zanimljive šumarske priče i sudjelovanje poznatih osoba. Pozitivan ton komunikacije i vizualno privlačne objave doprinijeli su promociji urbanog šumarstva, a ova strategija može poslužiti kao temelj za oblikovanje budućih komunikacijskih aktivnosti.

Ključne riječi: urbano šumarstvo, komunikacija, društvene mreže, šumska pedagogija, edukacija

Video surveillance and early detection of forest fires - FIRESTOP

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Abstract
As of April 1, 2024, *Croatian Forests Ltd.* is implementing the strategic project "Video Surveillance and Early Detection of Forest Fires – FIRESTOP." The total value of the project amounts to € 3,249,471.71, of which € 2,244,721.40 is funded through non-repayable grants from the European Union via the European Regional Development Fund. The project will be carried out until the end of 2028. The purpose of the project is to expand the early forest fire detection system by installing an additional 82 cameras at 39 locations in the coastal region and 2 in the continental part of the Republic of Croatia. This will cover an area of 95,488 hectares of state-owned forests across nine counties. The expected results of the project include: comprehensive and reliable coverage of the entire protected area, real-time data transmission to the responsible firefighting units with permanent standby teams, automatic smoke and fire detection with visual and audio alarm signals, storage of all data for a minimum of 168 hours, and both real-time and archived data access from 41 internet-connected locations with restricted access. The project strengthens the existing video surveillance system, enabling timely detection of initial fires in real time and significantly reducing response time for firefighting units. Furthemore, it enhances cooperation among firefighting services on the field during fire suppression. This integrated approach contributes to better adaptation to climate change and strengthens resilience to increased forest fire risks in endangered areas of the Republic of Croatia.

Keywords: early detection of forest fires, climate change adaptation

Videonadzor i rano otkrivanje šumskih požara – FIRESTOP

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Sažetak

Hrvatske šume d.o.o. od 1.travnja 2024. godine provode strateški projekt "Videonadzor i rano otkrivanje šumskih požara – FIRESTOP". Ukupna vrijednost projekta iznosi 3.249.471,71 eura od čega je 2.244.721,40 eura osigurano iz bespovratnih sredstava Europske unije putem Europskog fonda za regionalni razvoj. Projekt će se provoditi do kraja 2028. godine. Svrha projekta je proširenje sustava za rano otkrivanje šumskih požara postavljanjem dodatne 82 kamere na 39 lokacija u priobalju i 2 u kontinentalnom dijelu Republike Hrvatske. Time će se pokriti površina od 95.488 ha državnih šuma na području devet županija. Očekivani rezultati projekta su: kvalitetno i pouzdano pokrivanje cijele štićene površine, prijenos podataka u stvarnom vremenu prema nadležnim vatrogasnim postrojbama sa stalnim dežurstvom, automatsko prepoznavanje dima i vatre uz svjetlosni i zvučni alarmni signal, pohranjivanje svih podataka u trajanju od najmanje 168 sati i pristup trenutnim i omogućavanje pristupa trenutnim i pohranjenim podacima s 41 internetski povezane lokacije uz ograničeni pristup. Projektom se jača postojeći sustav videonadzora, čime se omogućuje pravovremeno otkrivanje početnih požara u stvarnom vremenu te se značajno skraćuje vrijeme do reakcije vatrogasnih postrojbi. Uz to, poboljšava se suradnja vatrogasnih službi na terenu tijekom gašenja požara. Ovaj integrirani pristup doprinosi boljoj prilagodbi klimatskim promjenama te jačanju otpornosti na povećane rizike od šumskih požara u ugroženim područjima Republike Hrvatske.

Ključne riječi: rano otkrivanje šumskih požara, prilagodba klimatskim promjenama

Urban tree plantation management: the example of the city of Slunj

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Abstract

Plants in urban areas, especially woody plants, significantly contribute to the quality of life by reducing noise, dust, and mitigating heat islands. Trees in urban plantations are often endangered due to traffic accidents, bark damage from oversized vehicles, winter maintenance of roads and sidewalks with chemicals or salt. Additionally, in urban areas, soil profile compaction occurs, i.e., the disappearance of macro- and micropores, which reduces the soil's capacity for water and air. The result is the physiological weakening of trees and susceptibility to attacks by various insects and fungi. The paper presents an example of the development of an integrated management and monitoring system for the purpose of preserving woody plantations in the city of Slunj as well as their ecological and social benefits. Initially, a green cadastre was established, in which the following data was entered: species name (Croatian and scientific), basic dimensions, health status using the visual (VTA) method, and spatial coordinates. The next level of monitoring includes checking the stability of trees (rootstocks, trunks, and branches) using a resistograph. By using the software tool, the monitoring data is displayed in maps and tables. Such systematized information enables better decision-making by companies responsible for the maintenance of urban trees and local government units in space planning.

Keywords: urban forestry, VTA, climate change, Slunj, ecosystem services

Upravljanje urbanim drvenastim nasadima: primjer grada Slunja

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Sažetak

Biljke u urbanim sredinama, pogotovo drvenaste, značajno pridonose kvaliteti života smanjenjem buke, prašine i ublažavanjem toplinskih otoka. Stabla u urbanim nasadima često su ugrožena, primjerice zbog prometnih nesreća, ozljeda kore od vangabaritnih vozila, zimskog održavanja kolnika i pločnika kemijskim sredstvima ili solju. Dodatno, u urbanim sredinama dolazi do zbijanja profila tla, odnosno nestajanja makro- i mikropora čime se smanjuje kapacitet tla za vodu i zrak. Posljedica je fiziološko slabljenje stabala i podložnost napadima različitih kukaca i gljiva. U radu je prikazan primjer razvoja sustava za integralno upravljanje i monitoring u svrhu očuvanja drvenastih nasada u gradu Slunju kao i njihovih ekoloških i društvenih dobrobiti. Inicijalno je uspostavljen katastar zelenila u koji su uneseni sljedeći podaci: naziv vrste (hrvatski i znanstveni), osnovne dimenzije, zdravstveno stanje vizualnom (VTA) metodom, koordinate u prostoru. Sljedeća razina monitoringa uključuje provjeru stabilnosti stabala (žilišta, debla i grana) pri čemu se koristi rezistograf. Korištenjem softverskog alata podaci monitoringa prikazuju se kartografski i tablično. Takve sistematizirane informacije omogućuju kvalitetnije donošenje odluka zaposlenicima u tvrtkama zaduženim za održavanje urbanih stabala i jedinicama lokalne uprave i samouprave kod planiranja prostora.

Ključne riječi: urbano šumarstvo, VTA, klimatske promjene, Slunj, usluge ekosustava

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Green Arhitecture and Construction
Zelena arhitektura i gradnja

Transformation of the existing Hasan Kikić elementary school building in Sarajevo

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Abstract

The building is in the Centar municipality of Sarajevo, at Ulica Gorica 27. It was constructed in 1963 and belongs to the historical period of construction spanning from the Second World War to 1970. The Cantonal Institute for the Protection of Cultural, Historical and Natural Heritage of Sarajevo Canton has not designated the building as a national monument, meaning there are no restrictions on altering the existing facade in terms of visual identity. Situated on the slopes of Sarajevo in the Gorica neighborhood, the site is oriented towards the southeast. The building is a typical example of post-World War II architecture for primary education facilities, a period during which many similar buildings were constructed. These buildings are characterized by design elements such as facades formed with straight lines, creating a horizontal sequence of transparent and opaque surfaces. The structure consists of two distinct volumes, including a visually separated gymnasium hall. Similar architectural compositions are found throughout the former SFR Yugoslavia and pose significant challenges for energy-efficient retrofitting. Based on comprehensive research, including analysis of the envelope's U-values, interior comfort, total energy demand, and CO2 emissions, it has been concluded that the building is a high consumer of energy and a major source of emissions. Therefore, a comprehensive transformation is necessary. This paper presents the current state of the building, the results of the analysis, and the differences achieved through intervention, all of which contribute to a change in its architectural identity.

Keywords: existing architecture, energy, comfort, transformation, new identity

Transformacija postojeće zgrade osnovne škole Hasan Kikić u Sarajevu

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Sažetak

Zgrada se nalazi na području općine Centar u Sarajevu, na adresi Ulica Gorica 27. Izgrađena je 1963. godine i pripada razdoblju gradnje koje obuhvata vrijeme od završetka Drugog svjetskog rata do 1970. godine. Prema evidenciji Kantonalnog zavoda za zaštitu kulturno-historijskog i prirodnog naslijeđa Kantona Sarajevo, zgrada nije zaštićena kao nacionalni spomenik. To znači da ne postoje ograničenja u pogledu transformacije njenih fasada s aspekta vizualnog identiteta. Smještena je na padinskom dijelu naselja Gorica, orijentirana prema jugoistoku. Zgrada predstavlja tipičan primjer arhitekture objekata osnovnog obrazovanja iz pomenutog razdoblja, kada je izgrađen značajan broj školskih objekata sa sličnim oblikovnim karakteristikama. Te karakteristike uključuju fasade oblikovane pravim linijama koje formiraju horizontalni niz transparentnih i netransparentnih ploha, kao i dvovolumensku kompoziciju sa vizualno odvojenom dvoranom za tjelesni odgoj. Slične arhitektonske forme nalaze se širom prostora bivše SFR Jugoslavije i predstavljaju značajan izazov u kontekstu energetske transformacije. Na osnovu sveobuhvatnih istraživanja – uključujući analizu U-vrijednosti ovojnice, komfora unutarnjeg prostora, ukupnih energetskih potreba i emisije CO2 – utvrđeno je da zgrada pripada grupi objekata s visokom potrošnjom energije i emisijama ugljičnog dioksida. Stoga je potrebna temeljita energetska i arhitektonska transformacija, čiji će se rezultati, zajedno s prikazom postojećeg stanja i postignutim razlikama, detaljno prikazati u ovom radu.

Ključne riječi: postojeća arhitektura, energija, komfor, transformacija, novi identitet

Transformation of the existing Skender Kulenović elementary school building in Sarajevo

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Abstract

The building is in the city of Sarajevo, within the Municipality of Novi Grad Sarajevo, at Bulevar Mimar Sinana bb. It was originally constructed in 1970, placing it within the historical construction period following the Second World War, specifically from 1970 to the present. During the most recent war (1992–1995), the building was destroyed. In 1997, it was redesigned and rebuilt on the original site. It is situated in a newer part of Sarajevo, developed during the 1980s. The structure comprises two floors, ground and first floor—with an inner courtyard that was enclosed during the reconstruction and is now part of the energy-treated area. From the perspective of architectural physics, the reconstructed project is of high quality and represents a facility adapted to modern educational needs in Sarajevo. In terms of form, it is a typical example of post-1970 primary school architecture, characterized by a horizontal interplay of solid and void elements on the facade. The building is designed as a single-volume structure. It was selected for analysis not only because of its design but also because it is a reconstructed facility. The analysis revealed certain irregularities and challenges related to the attitudes of investors, designers, and builders toward energy efficiency, raising questions about the adequacy of many other post-war reconstructions in Sarajevo. Based on comprehensive research, including analysis of the envelope's U-values, interior comfort, total energy demand, and CO2 emissions, it can be concluded that the building is a relatively high consumer of energy, with poor interior comfort conditions. A comprehensive transformation is therefore necessary. This paper presents such a transformation and paves the way for further research and application of new architectural design principles.

Keywords: "newer architecture", comfort, old-new identity, renewable energy sources, architectural design

Transformacija postojeće zgrade osnovne škole Skender Kulenović u Sarajevu

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Sažetak

Zgrada se nalazi u Sarajevu, na području Općine Novi Grad, na adresi Bulevar Mimar Sinana bb. Izgrađena je 1970. godine i pripada povijesnom razdoblju poslijeratne gradnje, od 1970. godine do danas. Tokom posljednjeg rata (1992.–1995.) zgrada je bila potpuno uništena, a 1997. godine je redizajnirana i ponovo izgrađena na izvornom lokalitetu. Smještena je u dijelu grada koji je intenzivno građen tokom 1980-ih godina. Zgrada ima dvije etaže, prizemlje i prvi kat, te unutarnje dvorište koje je prilikom rekonstrukcije pretvoreno u zatvoreni prostor, danas integriran u energetski obračun objekta. Rekonstrukcijom je postignuta visoka kvaliteta u pogledu arhitektonske fizike, čime je objekt prilagođen suvremenim standardima obrazovnih ustanova u Sarajevu. Oblikovno, zgrada predstavlja tipičan primjer školskih objekata iz razdoblja kada su se gradile mnogobrojne slične zgrade, karakteristične po horizontalnom ritmu fasade s naizmjeničnim punim i praznim plohama, kao i jednovolumenskom formom. Zgrada je izabrana za analizu zbog činjenice da se radi o rekonstrukciji postojeće strukture. Dobiveni rezultati ukazuju na određene nepravilnosti i izazove u odnosu investitora, projektanta i izvođača prema aspektima energetske efikasnosti. Time je otvoreno pitanje kvalitete drugih sličnih rekonstrukcija izvedenih u Sarajevu nakon rata. Analizom U-vrijednosti, komfora unutarnjeg prostora, ukupnih energetskih potreba i emisije CO_2 zaključeno je da zgrada spada u kategoriju objekata s visokom potrošnjom energije i emisijama, uz nizak nivo unutarnjeg komfora. Stoga je nužna sveobuhvatna transformacija, što je i predstavljeno u ovom radu, a što ujedno otvara prostor za razvoj i primjenu novog arhitektonskog pristupa.

Ključne riječi: “novija arhitektura”, komfor, stari-novi identitet, obnovljivi izvori energije, arhitektonski dizajn

Benefits and drawbacks of using crushed brick as an aggregate in concrete

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Abstract
The paper explores the potential use of crushed brick as an aggregate in concrete. A reference mix of microconcrete with natural aggregate was prepared, along with four additional microconcrete mixes in which natural aggregate was substituted with crushed brick at replacement levels of 25%, 50%, 75%, and 100% by volume. The fresh microconcrete was tested for consistency, while hardened microconcrete samples were evaluated for flexural strength, compressive strength, and water absorption. The results showed that as the proportion of crushed brick increased, the consistency and flexural strength of the microconcrete decreased, while the compressive strength decreased slightly and water absorption increased, suggesting a reduction in durability. However, this durability issue can be mitigated when used in dry environments. These findings support the potential for recycling aggregates derived from crushed remains of masonry buildings that collapsed during earthquakes.

Keywords: crushed brick, concrete, flexural strength, compressive strength, water absorption

Aspects of improving the buildings' energy efficiency by specific heat capacity effects

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Abstract
A sustainable building involves applying multiple measures to improve the energy performance of buildings, thus achieving energy savings. It is essential to objectively evaluate the effects of the key materials on the energy needs of the building. In addition to material conductivity, a key factor in this process is the time interval for heat interaction with materials, determined by their specific heat capacity, which is often insufficiently considered in calculations. The steady-state approach does not provide a reliable estimate of heat balance during the reference time interval. The Energy Performance of a Building (EPB) standard EN ISO 52016-1 proposes methods for calculating energy needs for heating and cooling, allowing for the selection of time intervals for determining energy performance at the national level, ranging from hourly, monthly, and seasonal to annual. While the monthly calculation method contains statistical correction or correlation factors for the dynamic effects, the hourly method can directly calculate dynamic interactions. However, only the average monthly values for climatic parameters for three different climatic zones are used in Montenegro, and no attention is paid to the other parameters except thermal transmittance. This paper aims to present the possibilities of dynamic simulation by applying innovative generated climatic data, such as hourly temperature values and their daily variations, and assessing the effects of increasing the specific heat capacity of built-in materials to improve thermal properties.

Keywords: dynamic simulation, energy efficiency, specific heat capacity, thermal properties

Implementation of a network of urban parks in the spatial development of the city of Ludbreg

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Abstract

The City of Ludbreg is a city with a rich cultural heritage that is developing through sustainable spaces based on the principles of green infrastructure and circular spatial management. The proposed concept of a network of urban gardens aims to implement such a network within the City of Ludbreg and conduct a scientific analysis of the impact of the implemented gardens on sustainable development, tourism offerings, and the quality of life of the local community. The methodological research approach is based on the best practices of the City of Ludbreg and its spatial planning frameworks. It includes an analysis of relevant scientific and professional literature, field research, conceptual solutions, and an evaluation of the impact of urban gardens on the environment, tourism, and the social community. The purpose of this study is to develop a model of urban gardens that will enhance Ludbreg's attractiveness as a tourist destination, strengthen its ecological identity, promote the sustainable use of public spaces, and create additional value for both the local community and visitors. The study results indicate that implementing a network of urban gardens can improve Ludbreg's tourism offerings, increase the number of visitors, and bring long-term benefits to the local community. Through synergy with existing parks (American, English, Japanese, and Podravina parks), Ludbreg has the opportunity to become a recognizable and sustainable tourist destination that successfully integrates nature, history, culture, sports, and tourism. This integrated approach raises environmental awareness, encourages active citizen participation, contributes to the development of innovative content, and leaves a positive impact on future generations.

Keywords: City of Ludbreg, sustainable development, tourism, urban parks, green infrastructure

Implementacija mreže urbanih parkova u prostorni razvoj grada Ludbrega

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Sažetak

Grad Ludbreg, je grad bogate kulturne baštine koji se razvija kroz održive prostore na načelima zelene infrastrukture i kružnog gospodarenja prostorom. Predloženi koncept mreže urbanih vrtova ima za cilj implementaciju takve mreže na području Grada Ludbrega, te znanstvenu analizu utjecaja implementiranih vrtova na održivi razvoj, turističku ponudu i kvalitetu života lokalne zajednice. Metodološki pristup istraživanja temelji se na primjeru dobre prakse gada Ludbrega i njegovih prostorno-planskih okvira, a uključuje analizu relevantne znanstvene i stručne literature, terensko istraživanje, idejna rješenja te evaluaciju utjecaja urbanih vrtova na okoliš, turizam i društvenu zajednicu. Svrha rada je razviti model urbanih vrtova koji će povećati atraktivnost grada Ludbrega kao turističke destinacije, osnažiti njegov ekološki identitet i potaknuti održivo korištenje javnih prostora te stvoriti dodatne vrijednosti za zajednicu i posjetitelje. Rezultati rada pokazuju da implementacija mreže urbanih vrtova može unaprijediti turističku ponudu grada Ludbrega, povećati broj posjetitelja i donijeti dugoročne koristi za lokalnu zajednicu. Sinergijom s postojećim parkovima (Američkim, Engleskim, Japanskim i Podravskim), grad Ludbreg ima priliku postati prepoznatljiva i održiva turistička destinacija koja uspješno spaja prirodu, povijest, kulturu, sport i turizam. Takav integrirani pristup podiže ekološku svijest, potiče aktivno sudjelovanje građana, doprinosi razvoju inovativnih sadržaja i ostavlja pozitivan utjecaj na buduće generacije.

Ključne riječi: Grad Ludbreg, održiv razvoj, turizam, urbani parkovi, zelena infrastruktura

Supertall skyscrapers – Challenge for the environment and society

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Abstract
Supertall skyscrapers are buildings that exceed 300 meters in height, representing remarkable achievements in engineering and architecture, yet they also pose significant challenges in terms of maintenance and environmental sustainability. Due to their scale and complexity, maintaining these structures is a demanding task. Regular inspections of the facade, safety systems, ventilation, and elevators require advanced equipment and highly specialized personnel, leading to substantial operational costs. Furthermore, malfunctions in evacuation systems or climate control can have serious consequences, given the high number of occupants these buildings accommodate daily. From an environmental perspective, supertall skyscrapers consume large amounts of energy, particularly for heating, cooling, and lighting. Although many recent projects incorporate sustainable technologies such as smart facades, renewable energy sources, and water recycling systems, the overall ecological footprint remains considerable. The construction phase itself involves massive amounts of materials and energy, contributing significantly to CO_2 emissions. While supertall skyscrapers symbolize progress and prestige in urban environments, their long-term sustainability and maintenance remain critical concerns. Sustainable urban development increasingly calls for a balance between ambitious architecture and responsible resource management. The future of these towering structures will largely depend on advancements in green building technologies that can reduce energy consumption and minimize environmental impact. Addressing these challenges is essential to ensure that supertall skyscrapers contribute positively to the cities of tomorrow.

Keywords*:* sustainability, construction, skyscrapers

Supervisoki neboderi – izazov za okoliš i društvo

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Sažetak

Posljednjih desetljeća u pojedinim dijelovima svijeta, sve češće niču tzv. super neboderi, građevine koje premašuju visinu od 300 metara. Njihova izgradnja predstavlja tehnološki i arhitektonski izazov, ali i otvaraju brojna pitanja vezana uz njihovo održavanje, a ponajprije utjecaj na okoliš. S obzirom na veličinu i složenost konstrukcije, održavanje takvih građevina izuzetno je zahtjevno. Redoviti pregledi fasade, sigurnosnih sustava, ventilacije i dizala zahtijevaju sofisticiranu opremu i visoko specijaliziranu radnu snagu, što uvelike povećava troškove. Usto, kvarovi u sustavima za evakuaciju ili klimatizaciju mogu imati ozbiljne posljedice, s obzirom na broj korisnika koji svakodnevno borave u tim prostorima. S ekološkog aspekta, super neboderi troše znatne količine energije, osobito za grijanje, hlađenje i rasvjetu. Premda mnogi noviji projekti nastoje primijeniti održive tehnologije poput pametnih fasada, obnovljivih izvora energije i sustava za reciklažu vode, ukupni ekološki otisak i dalje ostaje značajan. Izgradnja takvih zgrada također zahtijeva velike količine građevinskog materijala i energije, što povećava emisije CO_2. Iako super neboderi simboliziraju napredak i luksuz urbanih sredina, dugoročno održavanje i okolišna prihvatljivost ostaju ključni izazovi. Održiv urbanizam sve više zahtijeva ravnotežu između ambiciozne arhitekture i odgovornog gospodarenja resursima. Budućnost super nebodera stoga ovisi o razvoju tehnologija koje će omogućiti njihovu manju potrošnju energije i smanjeni utjecaj na okoliš.

Ključne riječi: održivost, gradnja, neboderi

Solar Systems – A solution for the future or a new challenge?

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Abstract
Solar systems enable the conversion of sunlight into electricity and consist of solar panels, inverters, electrical connections, mounting structures, and supporting equipment. They are most commonly installed on rooftops or building facades, with the possibility of integration into canopies, balconies, or windows. There are three main types of panels: monocrystalline (most expensive but most efficient), polycrystalline (more affordable with slightly lower efficiency), and thin-film (least expensive but also least efficient). To achieve maximum efficiency, proper panel orientation and tilt angle are essential, along with regular maintenance. Maintenance includes cleaning, visual inspections, checking electrical connections and system components, and monitoring operating parameters such as voltage, current, and temperature. Battery systems and inverters require special attention. Monitoring systems provide insight into system performance and allow early detection of irregularities, while thermal cameras and specialized software are used for advanced diagnostics. The economic viability of solar systems is reflected in significant savings and a relatively quick return on investment (typically 5 to 7 years), along with long-term financial and environmental benefits. Advantages include reduced greenhouse gas emissions, increased energy independence, and higher property value. Solar energy is a clean and sustainable solution that does not pollute air or water. However, some disadvantages remain, such as high initial investment costs, the need for sufficient installation space, and risks like fire or mechanical damage. Additional challenges include a still underdeveloped recycling system for decommissioned panels and a lack of aesthetically acceptable integration solutions in certain architectural contexts.

Keywords*:* solar panels, renewable energy, energy efficiency, sustainability

Solarni sustavi – rješenje za budućnost ili novi izazov?

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Sažetak

Solarni sustavi omogućuju pretvorbu sunčeve energije u električnu te se sastoje od solarnih panela, invertera, električnih spojeva, montažnih konstrukcija i prateće opreme. Najčešće se postavljaju na krovove ili fasade zgrada, s mogućnošću integracije u nadstrešnice, balkone ili prozore. Postoje tri osnovne vrste panela: monokristalni (najskuplji, ali najučinkovitiji), polikristalni (povoljniji, ali nešto manje učinkoviti) i tankoslojni (najjeftiniji, ali s najnižom učinkovitošću). Za postizanje maksimalne učinkovitosti ključni su pravilna orijentacija i kut nagiba panela, kao i njihovo redovito održavanje. Održavanje uključuje čišćenje, vizualne inspekcije, provjere električnih spojeva i sustavnih komponenti te praćenje radnih parametara poput napona, struje i temperature. Posebnu pažnju zahtijevaju baterijski sustavi i inverteri. Sustavi za nadzor omogućuju praćenje performansi i pravovremeno otkrivanje nepravilnosti, dok se za naprednu dijagnostiku koriste termalne kamere i specijalizirani softveri. Ekonomičnost solarnih sustava ogleda se u znatnim uštedama i relativno brzom povratu investicije (u prosjeku 5 do 7 godina), uz dugoročne financijske i ekološke koristi. Prednosti uključuju smanjenje emisija stakleničkih plinova, veću energetsku neovisnost i povećanje vrijednosti nekretnine. Solarna energija je čisto i održivo rješenje koje ne zagađuje zrak ni vodu. Među nedostatcima ističu se visoki početni troškovi, potreba za dovoljnom površinom te rizici poput požara ili mehaničkih oštećenja. Dodatne izazove predstavljaju nedovoljno razvijen sustav za reciklažu otpadnih panela i manjak estetski prihvatljivih integracijskih rješenja.

Ključne riječi: solarni paneli, obnovljivi izvori energije, energetska učinkovitost, održivost

3rd European GREEN Conference
10-13 June 2025
Hotel Olympia SKY
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Green Biotechnology
Zelena biotehnologija

Recombinant enzymes and microbial strategies in modern dairy bioprocessing

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Abstract

Milk and dairy products have long been an essential part of human nutrition. Thanks to modern technologies, the dairy industry today can produce a wide variety of products, including butter, sour cream, cheeses, curd, yogurts, ice cream**,** as well as specialized items such as infant formula, sports nutrition**,** and powdered or condensed milk**.** A recombinant chymosin from the Bactrian camel, expressed in yeast, was developed with high milk-clotting activity across various milk types (cow, goat, sheep, camel, mare). This enzyme was used for milk coagulation and cheese production. Whey proteins were isolated using tangential ultrafiltration, and the remaining lactose-rich whey was concentrated via ethanol precipitation. Lactic acid bacteria strains with high β-galactosidase activity were isolated from natural food sources (milk, sauerkraut, kefir, etc.). The corresponding genes were cloned and expressed in *E. coli*, and the recombinant enzymes were studied. Under hydrolytic conditions, the enzyme breaks down lactose into glucose and galactose. In the presence of sugar acceptors, it can catalyze transgalactosylation, forming galacto-oligosaccharides (GOS). GOS are of great interest due to their similarity to human milk oligosaccharides and their prebiotic properties. They resist digestion and reach the colon intact, where they are fermented by gut microbiota, producing short-chain fatty acids beneficial to human health. Certain strains of *Lactobacillaceae* and *Bifidobacterium* selectively utilize GOS, especially those with a low degree of polymerization (2–4). GOS have also been shown to reduce the adhesion of enteropathogenic *E. coli* to HEp-2 and Caco-2 cells and are more effective at suppressing pathogens than other oligosaccharides such as fructooligosaccharides, inulin, lactulose, and raffinose.

Keywords: milk, chymosin, beta-galactosidase, galacto-oligosaccharides

Biological pretreatment of lignocellulosic by-products

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Abstract
An increasing deterioration in environmental conditions can currently be observed. One of the main reasons for this is the large amount of by-products generated by the industry. The main challenge is to choose suitable processing methods for the complete management of such raw materials according to the principles of the circular economy. Nowadays, the application of sustainable, clean and waste-free technologies in the industry is a mandatory requirement, resulting from the concern for the environment. Brewer's spent grains (BSG) are the main lignocellulosic by-product of beer production. Lignocellulose is a renewable, ubiquitous material consisting of cellulose, hemicellulose and lignin. Biological pretreatment with microorganisms and their enzymes is an environmentally friendly and economical method, as no chemicals need to be used during the process. In this study, the improvement of the biological pretreatment of BSG by bioaugmentation and biostimulation was investigated. The experiment was carried out at a temperature of 24.4±0.7 °C under submerged conditions for 7 days. The BSG was characterized by Fourier transform infrared spectroscopy (FTIR). During the experiment, the average pH and dissolved oxygen (DO) concentrations of 4.80±0.79 and 0.46±0.07 mg/L, respectively, indicated increased microbial activity. The chemical oxygen demand (COD) values decreased by 30%.

Keywords: lignocellulose, brewer's spent grains, bioaugmentation

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Green Chemistry and Chemical Engineering
Zelena kemija i kemijsko inženjerstvo

GREEN CHEMISTRY AND CHEMICAL ENGINEERING / *ZELENA KEMIJA I KEMIJSKO INŽENJERSTVO*
Poster presentation / Postersko priopćenje

Enhancing catalytic efficiency of high-entropy rare-earth zirconates towards conversion of greenhouse gases

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Abstract

The ceria-zirconia (CeO_2-ZrO_2) system has attracted attention in the last decade due to its outstanding catalytic activity and stability. Introducing high-entropy by adding rare-earth elements in ordered ceria-zirconia systems gives a whole new promising class of multifunctional materials characterized by their ability to stabilize complex and have enhanced catalytic activity due to oxygen vacancies and lattice distortions[1]. The modified aqueous citrate sol-gel method was used for the synthesis of ceria-zirconia-based solid solutions $Ce_{0.5}Zr_{0.5}O_2$ and $La_{0.1}Ce_{0.1}Pr_{0.1}Gd_{0.1}Y_{0.1}Zr_{0.5}O_2$. Solid solution powders were subjected to a reduction in a high-temperature tubular furnace at 1500°C to obtain pyrochlore phases $Ce_2Zr_2O_7$ and $(La_{0.2}Ce_{0.2}Pr_{0.2}Gd_{0.2}Y_{0.2})_2Zr_2O_7$. Re-oxidation of the reduced powders was performed to obtain κ-phases $Ce_2Zr_2O_8$ and $(La_{0.2}Ce_{0.2}Pr_{0.2}Gd_{0.2}Y_{0.2})_2Zr_2O_8$ at 600 °C in a muffle furnace. Obtained compounds were subjected to structural and microstructural analysis, and insight into the application of these compounds in methane oxidation was given. The photoreduction activity was investigated by conducting the photocatalytic hydrogenation of CO_2.

Keywords: catalysis, high-entropy, rare-earth elements

Green synthesis and anticancer evaluation of a bipyridine-copper(II) complex

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Abstract

Coordinated transition metal compounds are becoming increasingly important in medicinal chemistry due to their structural versatility and bioactivity. In this study, a copper(II) complex containing bipyridine as a chelating ligand was synthesized using green chemistry methods that emphasize environmental sustainability in the production of biologically active metal complexes. The newly obtained complex was investigated for its cytotoxic properties against human liver carcinoma cells (Hep G2). The structural properties resulting from bipyridine coordination proved to be key in improving the biological activity compared to the free ligand and the corresponding copper salt. The green synthesis strategy not only reduced the environmental impact but also resulted in a complex with promising antiproliferative potential. These results emphasize the crucial influence of ligand design in modulating the activity of metal-based therapeutics and highlight the role of bipyridine as a structural and electronic modulator. The study encourages further exploration of environmentally friendly synthetic routes for the development of next-generation metal therapeutics.

Keywords: bipyridine, copper(II) complex, cytotoxicity, green synthesis, medicinal chemistry

Eco-friendly synthesis of hydroxyapatite from eggshell waste

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Abstract

Calcium phosphates, in particular hydroxyapatite (HAP, $Ca_{10}(PO_4)_6(OH)_2$), are used in medicine, chemistry, environmental protection and various industrial fields due to their excellent biocompatibility, their structural similarity to human hard tissue and their versatile functional properties. HAP is the most thermodynamically stable form of calcium phosphate and is the primary inorganic phase of bones and teeth. This makes it a key material for biomedical applications such as bone regeneration, dental implants, drug delivery systems and heterogeneous catalysis. Due to its unique apatite crystal structure, hydroxyapatite has a high capacity for ion exchange, which extends its utility in biological and ecological systems. However, conventional synthesis methods often rely on chemical reagents and processes that can hurt the environment. With global efforts towards sustainable development and green chemistry, more and more attention are being paid to environmentally friendly synthesis strategies. One promising approach is the reuse of old eggshells as a natural and renewable source of calcium. Eggshells, an abundant by-product of the food industry, represent an environmental burden if not properly treated. Their use in HAP synthesis not only contributes to waste reduction, but also to the principles of circular economy and the conservation of non-renewable resources. In this study, hydroxyapatite was successfully synthesized from eggshell calcium by hydrothermal methods under different pH conditions. A comprehensive chemical and structural characterization of the obtained materials was performed. The results show the potential of sustainable waste-derived materials for the development of advanced biomaterials for medical and industrial purposes.

Keywords: biomaterials, calcium phosphates, eggshell waste, hydroxyapatite, sustainable synthesis

Effect of eucalyptol addition on the properties of chitosan-based edible films

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Abstract

Consumers of packaged foods nowadays are becoming more conscious of the need to reduce, if not completely prevent, the everyday usage of plastic materials. Plastic packaging materials are being replaced not only with environmentally friendly materials, but various formulations based on natural components, such as edible films or coatings, are increasingly being tested as their replacement. Edible films are a thin layer of material that provides a barrier to products against gases and water vapor, but they must also have good mechanical and organoleptic properties. Polysaccharides as a raw material for edible films are the most abundant in nature, and for edible films alginates, pectins and chitosan are most commonly used. Chitosan is a polysaccharide from which edible films are obtained by dissolving chitosan in various acids. Chitosan films are biodegradable and have smooth and shiny surfaces. Eucalyptol (also called cineole) is a monoterpenoid colorless liquid and because of its pleasant, spicy aroma and taste, eucalyptol is used in flavorings, fragrances, and cosmetics. This work investigated the possibility of preparing edible films made from chitosan, with the addition of different concentrations of eucalyptol and the plasticizer glycerol. Some physico-chemical and mechanical properties of the obtained films were tested.

Keywords: chitosan, edible films, eucalyptol, film properties

Acknowledgment: This work was supported by Karlovac University of Applied Sciences through an internal project: Nutrition innovative three-dimensional 3D-esserts (HRID).

Acetylation reactions catalyzed by ash from food industry waste

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Abstract

Green chemistry is an approach to chemistry that focuses on the development of sustainable and more environmentally friendly chemical processes and products. The fundamental principles of green chemistry include, among others, reducing waste, minimizing the use of toxic substances, and identifying alternative solvents and catalysts. Organic synthesis reactions are commonly carried out using standard catalysts that are often highly toxic, flammable, and corrosive (e.g., H_3PO_4). Research by numerous authors has demonstrated that food industry by-products—such as onion peels, peanut skins, and orange peels—can serve as alternatives to conventional catalysts. This study investigated the potential use of ash derived from waste onion peels, garlic husks, peanut skins and shells, spent hops and barley, as well as cocoa shells and beans, as a substitute for phosphoric acid in the acetylation of alcohols. It was hypothesized that metals present in the ash could act as Lewis acids and catalyze the reaction. Acetylsalicylic acid was successfully synthesized from salicylic acid and acetic anhydride with the addition of 20 mg of ash, by heating the reaction mixture at 80–100 °C in a water bath. Reaction yields ranged from 11% (peanut shell ash) to 78% (spent barley ash from brewing). High yields were also obtained with cocoa bean shell ash (61%) and garlic husk ash (59%). The study confirmed the potential application of food industry waste as catalysts in organic synthesis reactions.

Keywords: green chemistry, acetylation, acetylsalicylic acid, ash, food industry waste

Reakcije acetiliranja katalizirane pepelom otpada prehrambene industrije

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Sažetak

Zelena kemija je pristup kemiji koji se fokusira na razvoj održivih i ekološki prihvatljivijih kemijskih procesa i proizvoda. Osnovni principi zelene kemije, između ostalog, uključuju smanjenje količine otpada, smanjenje upotrebe toksičnih tvari te pronalazak alternativnih otapala i katalizatora. Reakcije organske sinteze uglavnom se provode uz upotrebu standardnih katalizatora koji su u velikoj mjeri toksični, zapaljivi i korozivni (npr. H_3PO_4).Istraživanja brojnih autora pokazala su da se nusproizvodi prehrambene industrije, poput ljuske luka, kožice kikirikija i kore naranče, mogu koristiti kao alternativa standardnim katalizatorima. U ovom radu istražena je mogućnost primjene pepela otpadne ljuske luka, bijelog luka, kožice i ljuske kikirikija, otpadnog hmelja i ječma, kakao ljuske i zrna kao zamjene za fosfornu kiselinu u reakciji acetiliranja alkohola. Pretpostavljeno je da metali prisutni u pepelu mogu djelovati kao Lewisove kiseline i katalizirati reakciju. Acetilsalicilna kiselina uspješno je sintetizirana iz salicilne kiseline i acetanhidrida, uz dodatak 20 mg pepela, zagrijavanjem reakcijske smjese pri temperaturi od 80 do 100 °C na vodenoj kupelji. Iskorištenja reakcije kretala su se od 11 % (pepeo ljuske kikirikija) do 78 % (pepeo otpadnog ječma iz proizvodnje piva). Vrlo visoko iskorištenje zabilježeno je i pri upotrebi pepela ljuske kakao zrna (61 %) te ljuske bijelog luka (59%). Istraživanje je potvrdilo potencijal primjene otpada prehrambene industrije u reakcijama organske sinteze.

Ključne riječi: zelena kemija, acetiliranje, acetilsalicilna kiselina, pepeo, otpad prehrambene industrije

Osmolality of isotonic beverages on the Croatian market

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Abstract

Many athletes and physically active individuals rely on isotonic drinks to maintain proper hydration during intense physical activity. According to the European Food Safety Authority (EFSA), isotonic drinks should have an osmolality between 270 and 330 mOsm/kg, which corresponds to the osmolality of human body fluids. A wide range of sports drinks labeled as isotonic and intended for physically active individuals is available on the Croatian market. In this study, the osmolality of 18 isotonic drinks available on the Croatian market was measured and compared with the EFSA-defined isotonic range. Osmolality was determined using a cryoscopic osmometer, which measures freezing point depression. Thirteen of the analyzed drinks had osmolality values between 279 and 330 mOsm/kg, thus meeting the criteria for isotonicity. However, five drinks labeled as isotonic showed osmolality values ranging from 331 to 373 mOsm/kg, classifying them as hypertonic. According to EFSA standards, such products should not be marketed as isotonic. The presence of mislabeled products highlights the need for stricter quality control and regulatory oversight of isotonic drinks on the Croatian market.

Keywords: isotonic drinks, osmolality, athletes, Croatian market

Green Economy
Zelena ekonomija

Challenges of sustainability in the agricultural sector

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Abstract
Nowadays, sustainability is one of the most important problems in the agricultural sector. In our research project, the main focus is to identify the key challenges related to the sustainability of the agricultural sector. Additionally, we aim to understand the motivating and inhibiting factors that influence innovation and green investments in agricultural enterprises. Innovation, the digitalization of agriculture and food production, and green investments are crucial not only for generating returns and additional income, but also for reducing harmful emissions—a requirement under the increasingly strict EU regulations and directives. These changes are essential for agricultural companies to remain compliant and to retain access to future funding and resources within the European Union framework.

Keywords: sustainability of agricultural production, digitalization of agricultural sector, green finance

Green public procurement and EU co-financed public procurement issues from practice

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Abstract

Using green public procurement is one of the ways of reducing the negative effects of human activities on the environment. Through many policies, rules, and guidelines, the European Union emphasizes the need for green public procurement by highlighting the problem of human impact on the environment. Adopting a Decision to apply green public procurement for all government agencies and public procurement entities, the Republic of Croatia's government established this as a practice. Adopting green public procurement policies helps create a sustainable market that supports interaction between environmental issues and the public sector by fostering the purchase of ecologically friendly goods and services while supporting economic development. Therefore, Green public procurement represents a mechanism that ensures public entities are motivated to purchase "green" goods and services and helps promote sustainability. Despite the requirement for "green" procurement, the volume of "green" contracts does not match the dynamic strategy described in the strategic framework for public procurement. Particularly about EU co-financed projects, the execution of public procurement processes is quite complicated, and most financial corrections in EU co-financed projects come especially from these procurement processes. With an emphasis on EU co-financed projects, this paper investigates the difficulties of applying green public procurement in Croatia. Focusing on procedural efficiency and a lower project risk of financial corrections, it identifies frequent mistakes in using green procurement.

Keywords: green public procurement, European Union Directive, EU co-financed projects

Green public procurement – procurement of vehicles

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Abstract
On 28 November 2024, the Government of the Republic of Croatia adopted a "Decision on the Implementation of Green Public Procurement", which regulates the implementation of green public procurement, specifies green benchmarks and targets, indicators and a monitoring and reporting system for green public procurement. The aforementioned Decision, in Article 3, point 2, clarifies which road transport vehicles are classified, in accordance with the regulation governing the technical conditions for vehicles in road traffic, into categories M1, N1, N2, N3, M2, and M3. The Decision of the Government of the Republic of Croatia is another in a series of documents aimed at raising awareness of the economy and citizens about the need and obligation to reduce CO2. The presentation will highlight the guidelines of the Decision and the impact of the transport sector on the presence of CO2, and how, using the example of criteria in public procurement procedures, we can ensure a better quality of life in the long term. The proposed criterion for the public procurement procedure, the most economically advantageous tender (ENP), is one of the possible ones, which, with its features and characteristics, follows the guidelines of the Government of the Republic of Croatia and the EU Directive.

Keywords: Clean Vehicle Promotion Act, green public procurement, green criteria, EU Green Deal

Zelena javna nabava – nabava vozila

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Sažetak

Vlada Republike Hrvatske, dana 28. studenog 2024., donijela je „odluku o provedbi zelene javne nabave“, kojom se uređuje provedba zelene javne nabave, određuju se konkretna zelena mjerila i ciljevi, pokazatelji te sustav praćenja i izvješćivanja o zelenoj javnoj nabavi. Navedenom odlukom u članku 3. točka 2. pojašnjeno je koja vozila za cestovni prijevoz su vozilo koja su u skladu s propisom kojim se uređuju tehnički uvjeti vozila za promet na cestama, razvrstano u kategoriju M1, N1, N2, N3, M2 i M3. Odluka Vlade Republike Hrvatske je još jedan u nizu dokumenata kojim se nastoji osvijestiti gospodarstvo pa i građane o potrebi i obvezi smanjenja CO_2. Prezentacijom ćemo ukazati na smjernice Odluke te koliki je utjecaj sektora transporta na prisutnost CO_2, i kako primjerom kriterija u postupcima javne nabave, dugoročno možemo osigurati bolju kvalitetu života. Predloženi kriterij postupka javne nabave, ekonomski najpovoljnija ponuda (ENP), jedan je od mogućih koji svojim obilježjem i karakteristikama prati smjernice Vlade Republike Hrvatske i Direktivu EU.

Ključne riječi: Zakon o promicanju čistih vozila, zelena javna nabava, zeleni kriterij, EU Green Deal.

Green Fintech for sustainability: Toward a conceptual understanding of its environmental impact

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Abstract

In the face of accelerating climate change and environmental degradation, the financial sector is under increasing pressure to support its transition to a sustainable, low-carbon economy. At the intersection of financial innovation and environmental responsibility, green fintech is a rapidly evolving domain that leverages digital technologies to promote environmentally conscious financial behavior, investment, and policy. To better understand the role of green fintech in advancing environmental sustainability, it is essential to clarify, organize, and structure our understanding of how it contributes to sustainability. This involves identifying the key components of green fintech and examining how these components interact with sustainability objectives. This study proposes a conceptual framework for understanding how green fintech contributes to environmental sustainability. Drawing on the literature on sustainable finance and fintech innovation, this framework identifies key aspects that may influence environmentally positive outcomes. The framework aims to clarify the role of green fintech within the sustainability ecosystem and serves as a foundation for further empirical research and policy development. The proposed framework contributes to a clearer understanding of the role of green fintech in advancing sustainability and offers a foundation for future empirical validation, regulatory development, and strategic implementation in financial technology ecosystems.

Keywords: green fintech, environmental sustainability, financial innovation, sustainable finance

Zeleni fintech i održivost: prema konceptualnom okviru za razumijevanje njegova utjecaja na okoliš

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Sažetak

Suočen s ubrzanim klimatskim promjenama i degradacijom okoliša, financijski sektor je pod sve većim pritiskom da podrži prijelaz na održivo, niskougljično gospodarstvo. Na sjecištu financijskih inovacija i odgovornosti prema okolišu razvija se zeleni fintech – brzo rastuće područje koje koristi digitalne tehnologije za poticanje ekološki osviještenog financijskog ponašanja, ulaganja i politika. Za bolje razumijevanje uloge zelenog fintech-a u promicanju ekološke održivosti, nužno je razjasniti, organizirati i strukturirati naše razumijevanje njegovog doprinosa održivosti. To uključuje identificiranje ključnih komponenti zelenog fintech-a te ispitivanje načina na koji te komponente djeluju u odnosu na ciljeve održivosti. Ova studija predlaže konceptualni okvir za razumijevanje načina na koji zeleni fintech doprinosi ekološkoj održivosti. Temeljen na relevantnoj literaturi iz područja održivog financiranja i financijskih inovacija, okvir identificira ključne aspekte koji mogu utjecati na postizanje pozitivnih okolišnih ishoda. Cilj okvira je pojasniti ulogu zelenog fintech-a unutar ekosustava održivosti te poslužiti kao temelj za daljnja empirijska istraživanja i razvoj politika. Predloženi okvir doprinosi jasnijem razumijevanju uloge zelenog fintech-a u poticanju održivosti te pruža osnovu za buduću empirijsku provjeru, regulatorni razvoj i stratešku primjenu u ekosustavu financijskih tehnologija.

Ključne riječi: ekološka održivost, financijska inovacija, održive financije, zeleni fintech

3rd European GREEN Conference
10-13 June 2025
Hotel Olympia SKY
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Green Education
Ekološko obrazovanje

Building a sustainable society through school community actions

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Abstract

A comprehensive integration of sustainable development into the primary school environment is crucial for shaping environmentally responsible individuals. Sustainability topics must be systematically embedded across all subject areas, taking into account students' developmental stages and contemporary challenges such as climate change, biodiversity loss, consumerism and the digital transition. At Oskar Kovačič Primary School Škofije, through the project " Building a Sustainable Society Through School Community Actions ", we pursued three main goals: (1) to develop a vertical strategy for integrating sustainability themes according to subjects and students' age levels, (2) to reduce the school's carbon footprint, and (3) to meaningfully incorporate digital technologies in teaching sustainability-related content. With 34 international mobilities (job shadowing, structured courses and group mobility of students and teachers), we achieved our goals, enhanced the professional development of teachers, and aligned sustainability content through vertical integration across the curriculum. A key outcome was a didactic handbook with lesson plans, tested during an international Eco-Day, where students from grades 1 to 9 actively explored various aspects of sustainable development through experiential learning, research tasks, collaboration, and outdoor education. The project demonstrates that a strategic approach, international cooperation, and thoughtful use of digital tools can effectively foster sustainability competencies that go beyond behavior, aiming at a mindset shift among students, teachers, and the wider community. This approach serves as a model of good practice for other educational institutions, both nationally and internationally.

Keywords: sustainable development, primary education, teacher's handbook

Developing a digital-based curriculum of water footprint awareness in Mediterranean fisheries for sustainable resources in Europe

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Abstract
Water resources are not only the basis of ecological systems, but also an important factor for the stability of the global economy. Despite the vital role of fisheries for human nutrition, their expansion contributes to increased water consumption and the degradation of freshwater ecosystems. The WANTOFISH project aims to raise awareness of the water footprint in fisheries within the European Union, with the aim of promoting more sustainable practices. It is based on the assessment of the current water footprint of fisheries at global and European level, the development of a training methodology for more efficient resource use and water saving, the design of a structured training program to implement sustainable strategies and the production of a comprehensive guidebook to support their application. Digital and visual educational material will illustrate strategies to rationalize water use and reduce water consumption in Mediterranean fisheries, with special attention to the hydrogeographic and demographic characteristics of the region. The project not only ensures education on sustainable fishing practices, but also promotes a culture of responsible use of water resources, laying the foundations for the long-term sustainability of aquatic ecosystems and for future generations living in harmony with the natural environment.

Keywords: water footprint, EU fisheries, sustainability, educational curriculum

Acknowledgements: This study is supported by 2024-1-TR01-KA220-HED-000247730 project which is part of the EU ERASMUS+ programme (www.wantofish.eu)

Razvoj digitalnog kurikuluma za podizanje svijesti o vodnom otisku u mediteranskom ribarstvu u svrhu održivog korištenja resursa u Europi

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Sažetak

Vodeni resursi nisu samo temelj ekoloških sustava, već i ključni pokretač globalne gospodarske stabilnosti. Unatoč vitalnoj ulozi ribarstva u prehrani čovječanstva, njegova ekspanzija doprinosi povećanoj potrošnji vode i ugrožavanju slatkovodnih ekosustava. Projekt WANTOFISH nastoji podići svijest o vodnom otisku u ribarstvu unutar Europske unije, s ciljem promoviranja održivijih praksi. Temelji se na procjeni trenutnog vodnog otiska ribarstva na globalnoj i europskoj razini, razvoju metodologije obuke za učinkovitije korištenje resursa i zaštitu vode, dizajniranju strukturiranog nastavnog programa za primjenu održivih strategija te izradi sveobuhvatnog priručnika koji podržava njihovu implementaciju. Digitalni i vizualni edukativni materijali ilustrirat će strategije racionalne uporabe i smanjenja potrošnje vode u mediteranskom ribarstvu, uz poseban naglasak na hidrogeografske i demografske specifičnosti regije. Projekt ne samo da osigurava edukaciju o održivim ribarstvenim praksama, već i potiče kulturu odgovornog gospodarenja vodnim resursima, stvarajući temelje za dugoročnu održivost vodenih ekosustava i buduće generacije u harmoniji s prirodnim okolišem.

Ključne riječi: vodni otisak, EU ribarstvo, održivost, obrazovni kurikulum

Zahvala: Ovu studiju podržava projekt 2024-1-TR01-KA220-HED-000247730, koji je dio EU ERASMUS+ programa (www.wantofish.eu).

Enhancing competencies on resource utilisation in higher education

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Abstract

One-third of all food is lost along the food value chain, and lost valuable nutrients from processing side-streams make this number even higher. To address this societal challenge, we are developing a new master's course with significant contributions from food industry actors. Regardless of the food value chains these industries represent (fishery, dairy, brewery, poultry, bakery sectors), they have identified resource utilisation as a major challenge and opportunity they want to tackle. The new course, "Resource Utilisation in the Food System," starts in August and exemplifies how education can contribute to the green transition. The course will be student-active and include industry-relevant cases that students will transfer to the lab. It will involve some students in the development and course delivery. Furthermore, it will feature industry workshops, AI-assisted discussions of scientific papers, and lectures. The lectures will cover raw materials, food systems and value chain understanding, resource hierarchy, food actors, relevant technologies, qualities, applications, regulations, methods, hurdles, and possibilities. This comprehensive approach will equip students to actively tackle relevant challenges both during and after their studies. The presentation will outline the development of the new sustainability course, highlighting industry involvement, key course elements, and industry-relevant cases. International partners are invited to collaborate.

Keywords: food value chain, resource utilisation, green education, industryrelevant cases, green transition

Reducing food waste in a student dormitory

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Abstract

Food waste is becoming a growing global problem, and school canteens are a significant generator of this waste. The role of each educational institution is to nurture the value of sustainability, therefore to raise individuals who behave less wastefully. This paper explores the possibilities of reducing food waste in the Maksimir dormitory, which, due to various special regulations, is precluded from reducing waste interventions used in households or other catering facilities. By introducing regular food waste measurement, surveying students, and gaining insight into the type of food waste, interventions were planned that had different impacts on different types of waste. Meal planning with students, considering the number of attendees and reducing the quantity of prepared food, resulted in reducing serving waste. Additionally, encouraging individual to discard their plate waste, introducing different portion sizes, and displaying the quantities of food waste resulted in reducing plate waste. Undoubtedly, interventions aimed at raising awareness of the amount of food waste and its environmental impact, as well as the resulting social inequalities, had a greater impact. Thus, reducing food waste in a student dormitory should include interventions targeting different levels of waste generation with a focus on developing responsibility and empathy among students.

Keywords: food waste, plate waste, meal planning, dormitory, sustainability

Green competency development for emerging roles in sustainable textile production: Insights from the SiT project

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Abstract

The textile sector is undergoing a rapid transformation driven by environmental imperatives and the need for sustainable innovation. The Erasmus+ "Sustainability in TCLF" (SiT) project (101140058 — ERASMUS-EDU-2023-PI-ALL-INNO) addresses this transition by identifying and mapping green skills for two emerging professional profiles: the Bio-Textile Technician and the Recycling Manager. This study presents the results of comprehensive field research conducted across eight European countries, involving SMEs, higher education (HE), and vocational education and training (VET) institutions. The findings outline the skills gaps, training needs, and key competencies required to support sustainability in textile production and waste management. A new competence framework, the SiT TCLF GreenComp, was developed based on the EU GreenComp model to structure green, functional, and transversal competences relevant to the sector. The study also proposes a training structure that integrates industry expectations with European qualification standards (EQF, ESCO), ensuring relevance and cross-border recognition. The results contribute to the development of two curricula for the emerging roles and provide a practical roadmap for advancing environmental responsibility in the TCLF sector.

Keywords: green skills, sustainable textiles, Bio-Textile technician, recycling manager, GreenComp framework

Harnessing driving simulators for an eco-friendly and safe driving in education

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Abstract

Technologies such as simulators have been more widely used in society and in teaching, and can be applied to increase knowledge about environmental choices. Driver simulators can be a powerful tool to educate future drivers in driver safety, environmental driving behaviour and choices. A prerequisite is that the driving instructor is present during parts of the simulator training. At Nord University in Norway, we have more than 15 years' experience in using driving simulators, and today, environmental thinking is a major part of the education for future driving instructors. Concretely, using a simulator can reduce environmental impact by reducing the use of cars, but it can also facilitate environmental learning by driving and improving eco-driving skills. Major factors of eco-driving are, for example, driving styles such as driving speed, acceleration and deceleration, idling and route planning. Recently, we have studied the advantages and disadvantages of using simulators, especially in improving traffic safety, but are now implementing this technology also to improve the learners' eco-driving skills. Our learners are future instructors of drivers of vehicles such as cars, tractors, buses and trucks, including professional drivers of these. Our simulators have programs for all these categories, making it possible to improve eco-driving. This presentation will show the possibilities by using simulators to raise awareness of the environmental impact of driving.

Keywords: driving simulators, eco-driving, environmental impact, driver safety, simulator training

Advancing bioeconomy research: The BEAMING project approach

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Abstract

The BEAMING project, funded under the Horizon Europe WIDERA work program, is dedicated to promoting innovation and valorization of knowledge in the field of bioeconomy. The project ensures building the BEAMING Alliance and Communities of Practice for boosting open science practices, knowledge valorization practices, and an inclusive innovation culture for excellent science and research. The main focus of the project is achieved through the strengthening of cooperation between higher education institutions. With a special emphasis on the enlargement of countries in Central-Eastern Europe, South-Eastern Europe, and the Western Balkan, this project aims to foster geographically inclusive cooperation among higher education institutions while raising excellence in science and valuing creation and improving global competitiveness and visibility of Europe's Higher Education Institutions. This work presents the obtained results of the key objectives of the BEAMING project, including advocating for structural reforms within academia, facilitating international collaboration and knowledge transfer, promoting bioeconomy strategies to reduce the technology and knowledge transfer gaps, and enhancing innovation capacity and practical application of research results through the Quadruple Helix innovation model. By driving these initiatives, the project contributes to building a more sustainable, resilient, and competitive European research and innovation ecosystem.

Keywords: BEAMING, bioeconomy alliance, sustainability

Acknowledgements: This work was funded by the European Union under grant agreement N° 101137131.

ESG Junior program: Developing resilience, responsibility and system thinking in schools

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Abstract

The ESG Junior Program, implemented during the 2024/2025 school year in six primary schools in Croatia, is an innovative educational initiative aimed at integrating ESG (Environmental, Social, and Governance) principles into non-formal education. By combining STEAM, critical thinking, and problem-solving with socio-emotional learning and inclusive pedagogical approaches, the program empowers students and teachers to explore sustainability challenges through local community engagement. Activities include interdisciplinary workshops on health and environmental responsibility, supported by relational pedagogy. In schools, students identify local sustainability-related problems and, through collaborative work, develop possible solution scenarios. These are grounded in systems thinking and involve partnerships with local authorities, businesses, and civil society. The process encourages community awareness, civic responsibility, and practical problem-solving, while educational scenarios created by students and teachers serve as replicable models. This hands-on approach strengthens the link between schools and communities, and positions students as active contributors to a sustainable and resilient future. Preliminary evaluations indicate a rise in students' motivation, collaboration skills, and awareness of sustainability issues. By bridging formal curricula and real-world relevance, ESG Junior Program will support schools by ESG accreditation, as recognition for schools that embody sustainability in every aspect of their school ecosystem.

Keywords: ESG, education, sustainability

Program ESG Junior program: razvijanje otpornosti, odgovornosti i sistemskog razmišljanja u školama

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Sažetak

ESG Junior Program, proveden tijekom školske godine 2024./2025. u šest osnovnih škola u Hrvatskoj, inovativna je obrazovna inicijativa usmjerena na integraciju ESG načela (okolišnih, društvenih i upravljačkih) u neformalno obrazovanje. Kombiniranjem STEAM sadržaja, kritičkog mišljenja i rješavanja problema sa socio-emocionalnim učenjem i uključivim pedagoškim pristupima, program osnažuje učenike i učitelje za istraživanje izazova održivosti kroz aktivno djelovanje u lokalnoj zajednici. Aktivnosti uključuju interdisciplinarne radionice o zdravlju i odgovornosti prema okolišu, uz podršku relacijske pedagogije. Učenici identificiraju lokalne probleme povezane s održivošću te u timskom radu razvijaju moguće scenarije rješenja, temeljem sistemskog razmišljanja i suradnje s lokalnom upravom, gospodarstvom i civilnim društvom. Time se potiče osviještenost zajednice, građanska odgovornost i praktično rješavanje problema, a razvijeni obrazovni scenariji služe kao primjenjivi modeli i u drugim školama. Program ESG Junior jača povezanost škola i zajednice te učenike pozicionira kao aktivne dionike održive budućnosti. Također, ESG Junior Program podržava proces buduće ESG akreditacije škola, čime će škole dobiti priznanje za sustavan pristup održivosti u svim aspektima školskog ekosustava.

Ključne riječi: ESG, edukacija, održivost

Ecological education for a sustainable future in Swedish kindergartens

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Abstract

The development of ecological awareness in children is crucial for building a sustainable future. Sweden is an example of a country that is a leader in environmental protection and sustainable development, which is reflected in its educational policies and everyday practices. Numerous Swedish organizations are dedicated to fostering ecological awareness among children, educators, and parents, emphasizing the importance of collective action in addressing environmental challenges. The Swedish kindergarten curriculum integrates ecology and sustainability as fundamental aspects of education, with kindergarten programs focused on learning about recycling, energy conservation, and understanding natural cycles. Particular attention is given to children's autonomy and active participation in decision-making on environmental issues, thereby encouraging the development of responsibility and active engagement in nature conservation. Sweden is committed to education that promotes ecological, social, and economic sustainability, to raise environmentally conscious and responsible citizens. Research highlights the importance of ongoing professional development for educators to successfully integrate all aspects of sustainability into educational practice. Practical examples demonstrate that children can adopt sustainability values in a fun and engaging way. It is important to note that education for sustainability goes beyond the boundaries of the formal education system and requires cooperation from the wider community. This paper analyzes and presents ecological education in Swedish kindergartens with the aim of building a sustainable future through the development of ecological awareness and responsibility from an early age.

Keywords: sustainability, forest kindergartens, ecological awareness, education

Ekološki odgoj i obrazovanje za održivu budućnost u švedskim dječjim vrtićima

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Sažetak

Razvoj ekološke svijesti kod djece danas je ključan za izgradnju održive budućnosti. Švedska se ističe kao predvodnik u zaštiti okoliša i održivom razvoju, što se ogleda u njezinim obrazovnim politikama i svakodnevnoj praksi. Brojne švedske organizacije posvećene su poticanju ekološke svijesti kod djece, odgojitelja i roditelja, naglašavajući važnost zajedničkog djelovanja u rješavanju ekoloških izazova. Švedski predškolski kurikulum integrira ekologiju i održivost kao temeljne aspekte odgoja i obrazovanja, a programi u dječjim vrtićima usmjereni su na učenje o recikliranju, očuvanju energije i razumijevanju prirodnih ciklusa. Posebna pažnja pridaje se dječjoj autonomiji i aktivnom sudjelovanju u odlučivanju o pitanjima koja utječu na okoliš, čime se djecu potiče na razvoj odgovornosti i aktivno sudjelovanje u očuvanju prirode. Švedska je predana obrazovanju koje promiče ekološku, socijalnu i ekonomsku održivost, s ciljem odgoja ekološki osviještenih i odgovornih građana. Istraživanja naglašavaju važnost kontinuiranog profesionalnog usavršavanja odgojitelja kako bi se svi aspekti održivosti uspješno integrirali u odgojno-obrazovni rad, a primjeri iz prakse pokazuju kako djeca mogu na zabavan i angažiran način usvojiti vrijednosti održivosti. Važno je istaknuti da obrazovanje za održivost nadilazi okvire obrazovnog sustava te zahtijeva suradnju šire društvene zajednice. Ovaj rad analizira i prikazuje ekološko obrazovanje u švedskim dječjim vrtićima s ciljem izgradnje održive budućnosti kroz razvoj ekološke svijesti i odgovornosti kod djece od najranije dobi.

Ključne riječi: održivost, šumski vrtići, ekološka svijest, obrazovanje

The challenges of generation renewal in the agricultural sector

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Abstract
Generational renewal is one of the most important goals of the Common Agricultural Policy (CAP) for the 2021–2027 period. Among the horizontal objectives of the CAP after 2020 are *knowledge and innovation*. There are several future challenges in agricultural production that the new generation will need to address. The key elements for sustainable agricultural production are generational renewal, innovation, and education. In our research project, we seek to answer the question of what the hindering and motivating factors are for generational renewal in the agricultural sector, and which future challenges young farmers must face in agricultural production. The most important goals that support generational renewal in agriculture include rural development, improving the competitiveness of agricultural production to ensure fair income levels for agricultural enterprises and their employees, promoting innovation and digitalization in agricultural production and food processing, and modernizing education and training. In our research, we examined the factors influencing generational change and the attitudes of students, young farmers, and professionals toward generational renewal in the agricultural sector.

Keywords: generation renewal in the agricultural sector, young farmers, future challenges of agricultural production

3rd European GREEN Conference
10-13 June 2025
Hotel Olympia SKY
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Green Technology
Zelene tehnologije

Ultrasound - A promising technology for the non-thermal foodstuff processing

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Abstract

There has been high demand for the past three decades in the improvement of food production. Namely, the world faces the challenge of the emerging amounts of waste and byproducts as a result of the traditional approaches, but also with huge amounts of wasted heat as a result of the technologies developed in the 20th century. However, many research teams tried to develop new paths towards the processing of the various foodstuffs by using novel and non-thermal technologies such as: high hydrostatic pressures (HHP), pulsed electric fields (PEF), cold plasma (CP), microwave heating (MW), radio waves (RW) and Ultrasound (US). Mentioned technologies are now well established in both experimental facilities but also some of them are incorporated in industrial applications. The advantages over the traditional approaches are significant. Ultrasound as one of these technologies could be used to improve extraction, drying, homogenization, particle size distribution, sieving, distillation and many other processes. Depending on the process, it could be used in liquid samples or as an air-born technique. Besides, the ultrasound in high frequency ranges, which are over 2 MHz, is applicable as a non-destructive application and could be used for characterization, unwanted foreign bodies determination or analysis technique as well. The choice of optimal processing conditions is of high importance to obtain the best physicochemical properties of non-thermally treated foods. This goes to the choice of the ultrasonic frequency, amplitude and cycle when optimizing the process.

Keywords: ultrasound, processing, waste

Ultrasound-assisted extraction of phenolic compounds from grape pomace

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Abstract

During wine production, a significant amount of grape pomace is generated as a valuable by-product, which is currently primarily used as fertilizer in vineyards. The waste remaining after grape processing and wine production mainly consists of solid bioproducts (skins, stems, and seeds), representing approximately 20–30% of the processed grape mass. The primary aim of this study was to explore the potential utilization of by-products generated during the production of *Pinot Noir* wine, with a particular focus on grape seeds and skins. An innovative ultrasound-assisted extraction technique was applied under varying extraction conditions (solvent type, ultrasound amplitude, and impulse). The resulting extracts were analyzed for total phenolic content (using the Folin–Ciocalteu method), antioxidant activity (via the DPPH method), and individual phenolic compounds (using HPLC analysis). Furthermore, process optimization was performed using response surface methodology (RSM). The analyses revealed that grape seeds contain significantly higher levels of total phenols and exhibit stronger antioxidant activity compared to grape skins. HPLC analysis confirmed high concentrations of catechin and epicatechin in the extracts. Statistical analysis (ANOVA) showed that increasing the amplitude and impulse of the applied ultrasound leads to higher total phenolic content and enhanced antioxidant activity.

Keywords: ultrasound extraction, grape pomace, polyphenols, antioxidant activity, optimization

Ekstrakcija fenolnih spojeva iz komine grožđa primjenom ultrazvuka

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Sažetak

Tijekom proizvodnje vina nastaje znatna količina komine kao vrijedan nusproizvod, koja se danas uglavnom koristi kao gnojivo u vinogradima. Otpad zaostao nakon prerade grožđa i proizvodnje vina sastoji se uglavnom od čvrstih bioprodukata (kožica, peteljki i sjemenki) koji čine prosječno 20 - 30 % mase prerađenog grožđa. Primarni cilj ovog rada je istražiti mogućnost iskorištenja nusproizvoda koji nastaju tijekom proizvodnje vina sorte Pinot crni, s posebnim naglaskom na sjemenkama i kožici grožđa. Primijenjena je inovativna tehnika ekstrakcije potpomognuta ultrazvukom te različiti uvjeti ekstrakcije (otapalo, amplituda i impuls ultrazvuka). Dobiveni ekstrakti analizirali su se na udio ukupnih fenola (Folin-Ciocalteuovom metodom), antioksidacijsku aktivnost (DPPH metodom) te na pojedinačne fenole (HPLC analizom). Nadalje, provela se optimizacija procesa primjenom metode odzivnih površina. Navedenim analizama utvrđeno je kako su udjeli ukupnih fenola te antioksidacijska aktivnost znatno veći u sjemenki grožđa u odnosu na kožicu grožđa. Provođenjem HPLC analize utvrđene su visoke koncentracije katehina i epikatehina u dobivenim ekstraktima. Statističkom analizom (ANOVA) utvrđeno je kako porastom amplitude i impulsa primijenjenog ultrazvuka raste udio ukupnih fenola te antioksidacijska aktivnost.

Ključne riječi: ultrazvučna ekstrakcija, komina grožđa, polifenoli, antioksidacijska aktivnost, optimizacija

Environmental potential of microorganisms in the detoxification of pharmaceutical pollutants

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Abstract

Bioremediation is a sustainable method for the removal of pharmaceutical pollutants from the environment. Microbes play an important role in this process, emphasizing their exceptional biodegradation ability, which initiates and accelerates environmental remediation. Certain bacterial species are able to degrade the complex chemical compounds in pharmaceuticals, reducing their toxicity and preventing harmful effects on ecosystems. This process can be applied in different media such as contaminated water, soil or sediment, depending on the type of drug and the environmental conditions. In this study, bacterial cultures from an industrial waste stream with bioremediation potential were investigated. Samples of the waste stream were inoculated onto a nutrient medium at 37 °C for 24-48 hours. The most dominant bacterial culture was isolated and purified, and the characteristics and biochemical reactions were performed according to standard procedures. The growth curve of the bacterial isolate was determined by optical density. Morphological examinations under the microscope, oxidase, catalase, methyl red, Voges-Proskauer and indole tests were performed and recorded. The growth rate of the bacterial isolate was 0.1149 1/h. Thanks to the versatile metabolism of the bacteria, they can be used to degrade otherwise non-degradable compounds. Bioremediation is a key technology for protecting the environment and reducing the impact of human activities on nature.

Keywords: pharmaceuticals, microorganisms, bioremediation

Acknowledgements: The financial support by NPOO.C3.2.R3-I1.05.0207 is greatly appreciated.

Funded by the European Union
NextGenerationEU

3rd European GREEN Conference
10-13 June 2025
Hotel Olympia SKY
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Green transport
Zeleni transporti

Reducing the aviation industry's environmental impact by implementing artificial intelligence solutions

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Abstract

For the purpose of environmental protection, the use of artificial intelligence in the aviation industry is focused on reducing the adverse environmental impact by optimizing operations and increasing energy efficiency. Various AI tools have been developed to help reduce the aviation industry's environmental footprint and achieve sustainable development goals. Examples include the Airbus Skywise platform that uses AI for predictive maintenance and optimization of operations, Honeywell Forge for route optimization, and the Lufthansa CO2-Optimized Flight Planning Tool for flight planning optimization and meteorological data analysis. The LVNL GreenPilot tool uses AI to optimize the route and altitude, while IBM Watson uses advanced analytics to predict fuel consumption and optimize the route. SITA's OptiFlight AI tool optimizes routes in real time, and GE Aviation's Digital Twin Technology predicts maintenance needs and improves engine efficiency. Other solutions include CDB Aviation's Fleet Management with AI, Boeing EcoDemonstrator for testing emissions-reducing innovations, and NATS AI for airspace optimization. This paper provides an overview of artificial intelligence solutions that help optimize aviation operations, increase energy efficiency, and improve aviation sustainability to reduce adverse emissions from the aviation industry. With increased implementation of AI technologies in aviation, further reduction of the aviation's environmental impact is expected.

Keywords: environmental impact, reduction, aviation industry, artificial intelligence, solutions

Significance of material selection in the design of energy-efficient electric cargo bikes

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Abstract

Climate change mitigation and environmental sustainability are critical global concerns. As cities grapple with congestion, pollution, and the need for efficient logistics, e-bikes emerge as a viable solution. However, research on factors influencing e-bike adoption remains limited. During the COVID-19 pandemic, food and home delivery increased enormously, and till now, it is also growing in smaller cities. Electric cargo bikes (e-bikes) have gained prominence as sustainable alternatives for urban transportation and goods delivery. Their adoption contributes to the environmental goals of sustainable transport, but currently, there is not much focus on their efficiency. E-bike motors are generally not optimised well; manufacturers use low-quality materials, magnets have poor temperature resistance, etc. We tested and validated different types of motors, showing significant deviation for some test motors from new motors and after use for some time, especially at higher loads, which are common on cargo e-bikes. Our work presents results by comparing measured data with calculations using the finite elements method, where we present our conclusions and suggestions for improvements. More efficiently designed e-bikes can travel further with less charging and at lower costs. The benefits will be less pollution to the environment and lower costs for consumers.

Keywords: green transportation, electric bikes, electric drives

GREEN TRANSPORT I *ZELENI TRANSPORTI*
Poster presentation / *Postersko priopćenje*

Značaj odabira materijala u dizajnu energetski učinkovitih električnih teretnih bicikala

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Sažetak

Ublažavanje klimatskih promjena i održivost okoliša ključni su globalni problemi. Dok se gradovi bore sa zagušenjem, zagađenjem i potrebom za učinkovitom logistikom, e-bicikli se pojavljuju kao održivo rješenje. Međutim, istraživanja o čimbenicima koji utječu na usvajanje e-bicikla i dalje su ograničena. Tijekom pandemije COVID-19 dostava hrane i kućne dostave enormno je porasla, a do sada raste i u manjim gradovima. Električni teretni bicikli (e-bicikli) postali su značajni kao održive alternative za gradski prijevoz i dobru dostavu. Njihovo usvajanje pridonosi ekološkim ciljevima održivog prometa, ali trenutačno nema previše fokusa na njihovu učinkovitost. Motori za e-bicikle općenito nisu dobro optimizirani, proizvođači koriste materijale niske kvalitete, magneti imaju slabu otpornost na temperaturu, itd. Testirali smo i validirali različite vrste motora, pokazujući značajna odstupanja za neke testne motore od novih motora i nakon upotrebe neko vrijeme, posebno pri većim opterećenjima, koja su uobičajena na teretnim e-biciklima. Naš rad prikazuje rezultate usporedbom izmjerenih podataka s proračunima metodom konačnih elemenata, gdje iznosimo svoje zaključke i prijedloge za poboljšanja. Učinkovitije dizajnirani e-bicikli mogu putovati dalje uz manje punjenja i nižih troškova. Prednosti će biti manje onečišćenje okoliša i niži troškovi za potrošače.

Ključne riječi: zeleni transport, električni bicikli, električni pogoni

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10-13 June 2025
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Renewable Energy
Obnovljivi izvori energije

Novel approaches in the sustainable use of water and energy in urban areas

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Abstract
Urbanization is reshaping the global landscape, leading to significant challenges in resource management, particularly regarding water and energy. Urban areas exhibit a high demand for these resources as centers of human activity. Conventional approaches to water and energy supply often rely on centralized systems and non-renewable sources, which are inefficient, unsustainable, and prone to disruptions. Despite these obstacles, urban areas offer unique opportunities for promoting sustainable resource management due to their density, infrastructure, and innovation capacity. Collaborative efforts can also foster the adoption of decentralized systems, community-based initiatives, and green urban infrastructure that prioritize resource conservation. From the technical aspect, there is always a problem of pressure reduction in cases of small or too high values. With the increasing population, water storage also becomes questionable. Potential solutions are the use of one renewable energy source. Adequate strategies could be using the internal renewable energy sources of the water supply systems, like the turbines, and the external renewable energy sources, such as solar photovoltaic energy. It calls for a commitment to innovation, inclusivity, and long-term thinking to ensure a balanced coexistence between urban development and the natural world.

Keywords: water, energy, sustainability, innovations, management

Biologically adapted underwater storage of renewable energy

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Abstract

Inspired by hydrogen storage in gravel and pipes, this concept will work in a manner that is also beneficial for the ecosystem. To combine as many elements as possible, underwater capsules would be made to both store energy and adapt to the environment. They would be placed at the bottom of a body of water and store energy produced by nearby power plants. When the plants need it, compressed air is released from the storage backup to drive the turbines and supply electricity back on the grid. Since they are made of mostly recyclable materials and are expected to last a minimum of 50 years, they are more sustainable. To eliminate the harm done to the ecosystem, their surface would be textured so marine life could live on it. It can even be adapted based on the area where the ecosystem and water are different; it would be adjusted to the pressure from different waters, and the surface to the ecosystems. Hybrid systems are essential because they can adapt to their environment and support each other; when one slows down, another takes over to supply energy and stores it until it is needed somewhere else.

Keywords: energy storage, sustainability, hybrid systems, energy production, renewable energy, water ecosystems

Methane yield database of various substrates

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Abstract
This study aimed to expand the methane yield database (http://methane.fe.uni-lj.si/) by integrating a broader spectrum of methane yield data and metadata from literature and experiments. The updated database now includes 2,348 entries and 40,876 data points, doubling its original size. A key addition is methane yield data from lignocellulosic substrates, such as various wood types and milling residues, collected as part of the targeted research project V4-24026 SMART: Strategies for Methane. Anaerobic Degradation and Sustainable Use of Lignocellulosic Biomass and Digestate. Lignocellulosic biomass shows highly variable methane yields influenced by substrate type, pretreatment, and inoculum characteristics. While hardwoods with high lignin content typically yield less methane, softwoods and pretreated materials perform better. These data enable improved modeling and prediction of methane yields and support deeper insights into anaerobic digestion processes. Aligned with the project's goals, methane production from lignocellulosic materials is being evaluated under Slovenian-relevant conditions. Using mixture design modeling, optimal substrate combinations with nutrient-rich co-substrates are tested and experimentally validated. The project also explores digestate valorization as fertilizer, compost additive, biocomposite component, or lignin-rich extract source. The expanded database serves as a valuable resource for researchers and industry professionals, facilitating the development of tailored strategies for sustainable biogas production and waste valorization.

Keywords: methane yield, database, lignocellulosic biomass, anaerobic digestion, metadata

Geothermal energy in the context of the green transition: potential, challenges, and development opportunities

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Abstract

Geothermal energy represents an important but insufficiently explored source of renewable energy. Despite numerous advantages, including supply stability and low environmental impact, the broader implementation of geothermal technologies faces a range of technical, economic, and regulatory challenges. This paper analyzes the origin of geothermal energy, the historical development of its application, and the technological evolution of different systems, including those for direct use of thermal energy and geothermal power plants. Special attention is given to global trends and statistical indicators related to the use of geothermal sources for heating and electricity generation. The potential of geothermal energy in the Republic of Croatia is also analyzed, with emphasis on existing projects, available geological data, and strategic development plans. Key factors limiting the wider application of geothermal energy are identified, and measures for overcoming them are proposed, including possible adjustments to the legislative framework, increasing investment attractiveness, and strengthening institutional support. In conclusion, the paper highlights the need for a systematic approach in the promotion of geothermal energy as an important element of Croatia's energy transition, aiming to increase energy independence and reduce greenhouse gas emissions.

Keywords: renewable energy, geothermal power plants, energy independence

Geotermalna energija u kontekstu zelene tranzicije: potencijali, izazovi i mogućnosti razvoja

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Sažetak

Geotermalna energija predstavlja važan, ali nedovoljno istražen izvor obnovljive energije. Unatoč brojnim prednostima, uključujući stabilnost opskrbe i nizak utjecaj na okoliš, šira implementacija geotermalnih tehnologija suočava se s nizom tehničkih, ekonomskih i regulatornih izazova. U radu se analizira porijeklo geotermalne energije, povijesni razvoj njezine primjene te tehnološka evolucija različitih sustava, uključujući sustave za izravno korištenje toplinske energije i geotermalne elektrane. Posebna pažnja posvećena je globalnim trendovima i statističkim pokazateljima vezanima uz korištenje geotermalnih izvora za potrebe grijanja i proizvodnje električne energije. Analiziran je i potencijal geotermalne energije u Republici Hrvatskoj, s naglaskom na postojeće projekte, dostupne geološke podatke te strateške razvojne planove. Identificirani su ključni čimbenici koji ograničavaju širu primjenu geotermalne energije, a predložene su i mjere za njihovo prevladavanje, uključujući moguće prilagodbe zakonodavnog okvira, povećanje investicijske privlačnosti te jačanje institucionalne podrške. Zaključno, rad naglašava potrebu za sustavnim pristupom u promicanju geotermalne energije kao važnog elementa energetske tranzicije Republike Hrvatske, s ciljem povećanja energetske neovisnosti i smanjenja emisija stakleničkih plinova.

Ključne riječi: obnovljiva energija, geotermalne elektrane, energetska neovisnost

Renewable energy sources at Medvedgrad

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Abstract
On the roof of the Medvedgrad Visitor Center, situated within the medieval town of Medvedgrad, a cultural property in the Medvednica Nature Park, an integrated 32 kW solar power plant was constructed to enhance energy efficiency by utilizing renewable energy sources. It has been installed on the roof of the Western Palace, covering an area of 210 m², and the Eastern Palace, covering an area of 85 m². The electricity generated will not be sold to the grid but will be used for the center's own needs. Photovoltaic modules were mounted on flat roof surfaces, with confirmation of the main architectural project by the City Institute for Cultural and Natural Heritage Conservation. Two units with a total of 56 modules have been installed on the roof of the Western Palace, and two units with 24 modules on the roof of the Eastern Palace. The solar power system includes a photovoltaic generator, an inverter, measuring and connection equipment and a supporting metal structure. The construction of the solar power plant will reduce the Medvedgrad Visitor Center's dependence on conventional energy sources, thereby lowering carbon dioxide emissions and minimizing environmental impact. The use of sunlight contributes to the protection of the natural and cultural landscape and the preservation of the Medvednica Nature Park. This project is an example of sustainable practice that merges modern technology with heritage conservation through the use of natural resources, promoting the development of energy in accordance with ecological and social values.

Keywords: renewable energy sources, solar power plant, sustainability, Medvednica Nature Park, Medvedgrad cultural heritage

Obnovljivi izvori energije na Medvedgradu

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Sažetak

Na krovu Centra za posjetitelje Medvedgrad, smještenog unutar srednjovjekovnog grada Medvedgrada, kulturnog dobra u Parku prirode Medvednica, izgrađena je integrirana sunčana elektrana snage 32 kW s ciljem povećanja energetske učinkovitosti korištenjem obnovljivih izvora energije. Postavljena je na krovu Zapadnog palasa površine 210 m^2 i Istočnog palasa površine 85 m^2. Proizvedena električna energija neće se prodavati u mrežu, već će se koristiti za vlastite potrebe. Fotonaponski moduli montirani su na ravne krovne plohe uz potvrdu glavnog arhitektonskog projekta od strane Gradskog zavoda za zaštitu spomenika kulture i prirode. Na krovu Zapadnog palasa postavljene su dvije cjeline sa ukupno 56 modula, a na Istočnom dvije cjeline s 24 modula. Sustav sunčanih elektrana uključuje fotonaponski generator, inverter, mjernu i priključnu opremu te nosivu metalnu konstrukciju. Izgradnjom sunčanih elektrana smanjit će se ovisnost Centra za posjetitelje Medvedgrad o konvencionalnim izvorima energije, čime se smanjuje emisija ugljikovog dioksida i negativan utjecaj na okoliš. Korištenjem sunčeve svjetlosti doprinosi se zaštiti prirodnog i kulturnog krajolika te očuvanju Parka prirode Medvednica. Projekt je primjer održive prakse koji spaja suvremenu tehnologiju s očuvanjem baštine korištenjem prirodnih resursa, potičući razvoj energetike u skladu s ekološkim i društvenim vrijednostima.

Ključne riječi: obnovljivi izvori energije, sunčana elektrana, održivost, Park prirode Medvednica, kulturno dobro Medvedgrad

3rd European GREEN Conference
10-13 June 2025
Hotel Olympia SKY
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Waste Management
Gospodarenje otpadom

Microbial degradation of poultry feather waste by *Bacillus* spp.

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Abstract
Feather waste, a major byproduct of poultry farming, presents an environmental challenge due to its keratin-rich, degradation-resistant structure. In this work, we focused on the biodegradation potential of *Bacillus subtilis* and *Bacillus paralicheniformis*, previously isolated from feather-contaminated soil. We grew both strains on chicken feathers without adding any extra nutrients. The feathers were used as the only source of carbon and nitrogen. During cultivation, the feathers became softer and thinner, and in some flasks, they almost disappeared after several days. According to the results, it was expected that these strains could be used to treat feather waste straightforwardly, especially where resources for more complex processing are limited.

Keywords: keratin, *Bacillus subtilis*, *Bacillus paralicheniformis*, feather degradation, microbial valorization

Optimizing food utilization in restaurants: An integrated approach to waste reduction

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Abstract

Food waste is a pressing global issue with significant environmental, economic, and social implications. In developing countries, losses occur primarily at the production stage, while in developed countries, consumer behavior contributes most to food waste, particularly in the hospitality sector. High living standards and lifestyle changes have led to increased dining out, amplifying restaurant-related waste. In Croatia, where food waste is legally regulated, the hospitality sector accounts for 22% of total food waste, with 25% comprising edible portions. Major sources include kitchen waste, unserved meals, and plate leftovers. Key contributors to waste include inefficient procurement, storage, food preparation, and portion sizing. Preventive strategies such as menu planning, inventory control, portion size reduction, and staff training are essential. Raising consumer awareness and implementing sustainable food waste management practices, such as donation, composting, and responsible disposal, are also crucial. International initiatives like the United Nations' 2030 Agenda for Sustainable Development and the European Green Deal emphasize waste reduction goals. This review underscores the importance of a multidisciplinary approach involving consumers, food service professionals, and policymakers. By identifying effective strategies and synthesizing current findings, it contributes to the development of sustainable practices in food services, supporting broader efforts to enhance food security and minimize the environmental footprint of waste.

Keywords: food waste, hospitality, sustainability, waste management, restaurants

Innovative strategies for repurposing and recycling waste solar panels

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Abstract

As the global adoption of solar energy accelerates, the disposal of aging or damaged solar panels poses a growing environmental challenge. Innovative strategies for reusing and repurposing waste solar panels can mitigate this issue while unlocking new economic opportunities. One promising approach is the refurbishing and resale of functional panels for secondary markets, particularly in off-grid or developing regions. Panels no longer meeting high-efficiency standards can still provide power for low-demand applications such as charging stations, street lighting, or agricultural sensors. Additionally, dismantling and recovering valuable materials, like silicon, silver, and rare metals, through advanced recycling processes is gaining traction, reducing the need for mining. Creative reuse applications are also emerging, such as integrating solar panel glass into building materials, using panels in architectural and artistic installations, or as educational material in schools or universities. Moreover, decentralized micro-recycling units are being explored to process panels locally, lowering transportation costs and emissions. These innovative pathways address the environmental impact of solar waste and support circular economy principles. By investing in scalable, cost-effective solutions, industries and governments can ensure the long-term sustainability of solar energy technologies and reduce the ecological footprint of clean energy systems.

Keywords: solar panel recycling, photovoltaic waste, circular economy, renewable energy sustainability, material recovery

Critique of circular economy in the context of neglecting landfills

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Abstract

There are many definitions of the circular economy, but they all essentially revolve around the same concept. In recent years, the theme of sustainability has increasingly been linked to the circular economy, which has become one of the main areas of interest. Supporting the transition from a linear to a circular economy, the emphasis is placed on the efficient use of resources, their reuse, prolonging product lifecycles, and closing production cycles. However, discussions about the circular economy often overlook waste management issues, particularly the role of landfills. Landfills are perceived in the public mind as outdated and unnecessary, even though practice shows the opposite—waste is still significantly disposed of, albeit mostly after some form of treatment. This creates a false impression that landfills are a thing of the past, while the reality indicates their still indispensable role in the waste management system. This paper will analyze the goals of the circular economy and the actual state on the ground, with a particular focus on landfill rehabilitation, management, and reduction. A review of data from the European Union and the Republic of Croatia will highlight the continued reliance on landfills despite circular economy obligations, as well as the spatial and social consequences of neglecting the final stages of waste management. The aim of this paper is to encourage a discussion on a more realistic and comprehensive interpretation of the circular economy and emphasize the need for including landfills in formal policies and strategies of the circular economy.

Keywords: circular economy, landfills, sustainability, waste management

Kritika cirkularne ekonomije u kontekstu zanemarivanja odlagališta otpada

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Sažetak
Postoji niz definicija kružnog gospodarstva, no sve se u osnovi svode na isti koncept. Posljednjih godina tema održivosti sve se češće povezuje upravo s kružnim gospodarstvom, koje je postalo jedno od glavnih područja interesa. Podržavajući prijelaz s linearnog na kružno gospodarstvo, naglasak se stavlja na učinkovito korištenje resursa, njihovu ponovnu upotrebu, produljenje vijeka trajanja proizvoda te zatvaranje proizvodnih ciklusa. Međutim, u raspravama o kružnom gospodarstvu često se izostavlja problematika upravljanja otpadom, posebno uloga odlagališta otpada. Odlagališta se u javnoj percepciji prikazuju kao zastarjela i nepotrebna, iako praksa pokazuje suprotno – otpad se i dalje u značajnom udjelu odlaže, premda uglavnom prethodno obrađen. Stvara se pogrešna predodžba da su odlagališta stvar prošlosti, dok stvarnost ukazuje na njihovu i dalje neizostavnu ulogu u sustavu gospodarenja otpadom. U radu će se analizirati ciljevi kružnog gospodarstva i stvarno stanje na terenu, s posebnim naglaskom na sanaciju, upravljanje i smanjenje odlagališta otpada. Pregledom podataka iz Europske unije i Republike Hrvatske ukazat će se na i dalje prisutnu ovisnost o odlagalištima unatoč obvezama kružnog gospodarstva te na prostorne i društvene posljedice zanemarivanja krajnjih faza upravljanja otpadom. Cilj rada je potaknuti raspravu o realističnijem i sveobuhvatnijem tumačenju kružnog gospodarstva te ukazati na potrebu za uključivanjem odlagališta otpada u formalne politike i strategije kružne ekonomije.

Ključne riječi: cirkularna ekonomija, odlagališta otpada, održivost, gospodarenje otpadom

Water and WastewaterTreatments
Prerada i pročišćavanje voda

The potential of using treated wastewater for the irrigation of urban green areas

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Abstract

In modern cities, there is an increasing need for sustainable water resource management. One effective solution is the reuse of wastewater for irrigation of public urban areas, such as parks, green belts and sports fields. Treated wastewater, which is previously treated in treatment plants, can meet irrigation needs without endangering the health of citizens or the environment. The aim of this research was to determine the potential of treated wastewater from the EL-TO Zagreb plant for the irrigation of public green areas in the Trešnjevka settlement, Zagreb. Sampling and analysis of wastewater were carried out in a certified laboratory for the analysis of waste, surface, technological and process waters of the National Institute of Public Health "Dr. Andrija Štampar" and included the determination of the following parameters: relevant flow, dissolved oxygen content, pH, dry residue, total suspended solids, heavy metal content, SAR, RSC, total dissolved salts content. The obtained results of the values of the analyzed parameters of the treated wastewater indicate that the water was within the limits prescribed by the Ordinance on limit values of emissions in wastewater (OG 26/20) and that such water is suitable for irrigation of green areas. However, for the wider application of this practice, it is necessary to conduct additional analyses, such as traffic impact analysis, analysis of storm water from roads, as well as to ensure investment in infrastructure and strengthening of the legal framework, as well as regular education of the public and professional services.

Keywords: wastewater, irrigation, green areas

Potencijal upotrebe pročišćene otpadne vode za navodnjavanje urbanih zelenih površina

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Sažetak

U suvremenim gradovima sve je izraženija potreba za održivim upravljanjem vodnim resursima. Jedno od učinkovitih rješenja predstavlja ponovna upotreba otpadne vode za navodnjavanje javnih urbanih površina, poput parkova, zelenih pojasa i sportskih terena. Pročišćena otpadna voda, koja se prethodno obrađuje u uređajima za pročišćavanje, može zadovoljiti potrebe za navodnjavanjem bez ugrožavanja zdravlja građana ili okoliša. Cilj ovog istraživanja bio je utvrditi potencijal pročišćene otpadne vode iz pogona EL-TO Zagreb za navodnjavanje javnih, zelenih površina u naselju Trešnjevka, Zagreb. Uzorkovanje i analize otpadne vode provedene su u certificiranom laboratoriju za analizu otpadnih, površinskih, tehnoloških i procesnih voda NZJZ-a „Dr. Andrija Štampar“ i uključivale su određivanje sljedećih parametara: mjerodavni protok, sadržaj otopljenog kisika, pH, suhi ostatak, ukupna suspendirana tvar, sadržaj teških metala, SAR, RSC, sadržaj ukupno otopljenih soli. Dobiveni rezultati vrijednosti analiziranih parametara pročišćene otpadne vode ukazuju da je voda bila unutar granica propisanih Pravilnikom o graničnim vrijednostima emisija u otpadnim vodama (NN 26/20) te da je ovakva voda prikladna navodnjavanje zelenih površina. Međutim, za širu primjenu ove prakse nužno je provesti dodatne analize, poput analize utjecaja prometa, analize oborinske vode s cesta kao i osigurati ulaganje u infrastrukturu i jačanje zakonskog okvira, te redovitu edukaciju javnosti i stručnih službi.

Ključne riječi: otpadne vode, navodnjavanje, zelene površine

Anaerobic/oxic/anoxic process with endogenous denitrification for nutrient removal from low C/N wastewater

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Abstract
Biological nitrogen and phosphorus (N and P) removal from low-carbon to nitrogen (C/N) wastewater is challenging due to the required balance of the different metabolic demands of functional microorganisms by providing appropriate process factors. An anaerobic/oxic/anoxic (A/O/A) configuration with endogenous denitrification of 2 h/2 h/4 h at a dissolved oxygen (DO) concentration of DO ≥2 mg/L in the oxic phase and DO <0.5 mg/L in the anoxic phase during 30 days was investigated. The configuration operated with influent synthetic wastewater with 30±2 mg NH_4-N/L and a C/N ratio of 4. The achieved average removal efficiencies of COD (chemical oxygen demand), NH_4-N, total N and P amounted as follows 90.4%, 91.4%, 80.3% and 59.2%. The results suggest that for higher efficiency of N and P removal, more electron donors (organic compounds) should be provided, i.e. a higher C/N ratio, as well as extending the oxic phase to ensure complete oxidation of NH_4-N.

Keywords: anaerobic/oxic/anoxic (A/O/A) process with endogenous denitrification, low C/N ratio, dissolved oxygen concentration, nutrient removal

Anaerobno/aerobno/anoksični proces uz endogenu denitrifikaciju za uklanjanje nutrijenata iz otpadne vode niskoga omjera C/N

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Sažetak

Biološko uklanjanje dušika i fosfora (N i P) iz otpadne vode niskoga omjera ugljika i dušika (C/N) predstavlja izazov zbog potrebe za usklađivanjem različitih metaboličkih zahtjeva funkcionalnih mikroorganizama osiguravanjem odgovarajućih procesnih čimbenika. Istražena je anaerobno/aerobno/anoksična (engl. *Anaerobic/Oxic/Anoxic* A/O/A) konfiguracija procesa uz endogenu denitrifikaciju u trajanju 2 h/2 h/4 h pri koncentraciji otopljenog kisika (engl. *Dissolved Oxygen*, DO) DO ≥2 mg/L u aerobnoj fazi i DO <0,5 mg/L u anoksičnoj fazi, tijekom 30 dana. Konfiguracija je vođena s ulaznom sintetskom otpadnom vodom s 30±2 mg NH_4-N/L i omjera C/N 4. Postignuta je prosječna učinkovitost uklanjanja KPK (kemijska potrošnja kisika), NH_4-N, ukupnog N i P kako slijedi: 90,4 %, 91,4 %, 80,3 % i 59,2 %. Rezultati sugeriraju da bi za veću učinkovitost uklanjanja N i P trebalo osigurati više donora elektrona (organskih sastojaka), odnosno veći omjer C/N, kao i produljiti aerobnu fazu za osiguravanje potpune oksidacije NH_4-N.

Ključne riječi: anaerobno/aerobno/anoksični (A/O/A) proces uz endogenu denitrifikaciju, nizak omjer C/N, koncentracija otopljenog kisika, uklanjanje nutrijenata

New trends in wastewater treatment within the framework of the EU Green Deal strategy

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Abstract

Modern wastewater treatment trends focus on higher efficiency, environmental protection, and resource recovery. Advanced technologies such as membrane bioreactors (MBR), advanced oxidation, and anaerobic digestion are increasingly used to improve treatment performance and generate renewable energy. There is a growing focus on removing micropollutants such as pharmaceuticals and microplastics. Smart monitoring and automation systems (IoT, artificial intelligence) help optimize processes and reduce operational costs. Water recycling and nutrient recovery—especially phosphorus—are also becoming standard practice. The European Union, through the Urban Wastewater Treatment Directive (91/271/EEC) and its upcoming revision, sets stricter standards, including mandatory micropollutant removal and implementation of the "polluter pays" principle. The Water Reuse Regulation (EU 2020/741) promotes the safe use of treated wastewater, especially in agriculture. These trends support the circular economy and the goals of the EU Green Deal, with the ultimate aim of achieving energy-efficient and environmentally sustainable treatment plants by 2050.

Keywords: wastewater treatment, micropollutants, resource recovery, EU directives, circular economy

Suvremeni trendovi u pročišćavanju otpadnih voda i zahtjevi EU

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Sažetak

Današnji trendovi u pročišćavanju otpadnih voda usmjereni su na veću učinkovitost, zaštitu okoliša i obnovu resursa. Primjenjuju se napredne tehnologije poput membranskih bioreaktora (MBR), napredne oksidacije i anaerobne digestije, koje omogućuju bolji tretman i proizvodnju obnovljive energije. Sve je veći naglasak na uklanjanju mikroonečišćivača poput farmaceutika i mikroplastike. Pametni sustavi nadzora i automatizacije (IoT, umjetna inteligencija) pomažu u optimizaciji procesa i smanjenju troškova. Također, recikliranje vode i povrat nutrijenata (posebno fosfora) sve više postaju standardna praksa. Europska unija kroz Direktivu o pročišćavanju komunalnih otpadnih voda (91/271/EEZ) i njezinu nadolazeću reviziju postavlja strože zahtjeve, uključujući obavezno uklanjanje mikroonečišćivača i primjenu načela "onečišćivač plaća". Direktiva o ponovnoj uporabi vode (EU 2020/741) potiče sigurno korištenje pročišćene vode, osobito u poljoprivredi. Ovi trendovi doprinose kružnom gospodarstvu i ciljevima Zelenog plana EU, s krajnjim ciljem energetski učinkovitih i ekološki prihvatljivih postrojenja do 2050. godine.

Ključne riječi: pročišćavanje otpadnih voda, mikrozagađivači, oporavak resursa, direktive EU, kružno gospodarstvo

Application of ferritization products for the sorption of zinc ions from wastewater

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Abstract

Protection of the environment is substantively associated with the treatment of industrial wastewater flows. In order to resolve this problem, a process of integrated wastewater treatment has been proposed. The processing of exhausted etching solutions via ferritization using different activation methods and aeration rates was studied. The chemical composition and structure of the obtained ferritization sediments were analyzed, detecting ferromagnetic crystalline phases of lepidocrocite (ɣ-FeOOH), ferrooxygite (δ-FeOOH), and high chemically stable magnetite (Fe_3O_4). Increasing the aeration rate and use of ultrasound treatment enhances Fe_3O_4 content and iron ion removal efficiency. Adsorption properties of the obtained samples for Zn2+ removal in modes of mechanical mixing and ultrasound at different pH values of the solution were studied. At pH = 8 the highest level of Zn^{2+} removal 92.0% was reached using ultrasound treatment with sorbents containing 61.3% δ-FeOOH and 38.7% Fe_3O_4. At pH = 10, magnetite-based sorbent ensured over 98.9% of Zn^{2+} removal, making treated water suitable for reuse in industrial rinsing processes. Electron microscopy and X-ray fluorescence analysis confirmed the presence of highly dispersed particles and spherical aggregates, primarily magnetite and zinc ferrite. The findings convincingly demonstrated the potential of magnetic sorbents for effective and eco-friendly Zn^{2+} removal from galvanic wastewater. Proposed integrated "green" technology ensures the application of closed circle resource management systems in industrial production.

Keywords: wastewater treatment, sorption, zinc, green technology

Comparison of experiences with wet and dry pumping stations

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Abstract

Agglomeration system projects in Croatia, co-financed by the European Union aim the environmental protection and raising the standards of municipal infrastructure. The Varaždin agglomeration includes a sewage system network with more than 100 pumping stations and a treatment plant reconstruction. This article is based on the experiences of the Varaždin agglomeration and firstly describes the operation principle of two types of pumping stations, known as wet and dry pumping stations. Wet pumping stations, which contain submersible pumps located in a concrete shaft filled with wastewater, have been used for a long time. Dry stations have been increasingly used recently, and have a smaller wastewater tank and pumps located in a shaft that remains dry during their operation. The focus of this paper is on comparing their characteristics that affect the selection, as well as on the problems that arise during installation, use and maintenance. The analysis is made based on the experience of contractors, supervisory engineers and users of the agglomeration. Finally, recommendations are given for improvements in the maintenance of both types of pumping stations, as well as for additional measurements that should be performed at the pump start for more efficient operation control.

Keywords: agglomeration, maintenance, pumping station, wastewater

3rd European GREEN Conference
10-13 June 2025
Hotel Olympia SKY
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Water Management
Upravljanje vodama

AI support for a clean future

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Abstract
The development of artificial intelligence (AI) opens new possibilities for enhancing customer support in the wastewater treatment sector. By introducing an internal AI assistant, we provide users of our treatment systems with fast, reliable, and continuous access to technical information, diagnostics, and support, without the need for direct contact with the service team. This solution enables more efficient system management, reduces downtime, and improves operational reliability. The virtual assistant is trained on real user queries and scenarios and is available 24/7 via mobile and desktop platforms. It assists users in their daily operations by offering user manuals, maintenance advice, troubleshooting for common issues, and support for urgent malfunctions. This approach increases user autonomy, relieves the burden on technical support, and facilitates faster decision-making in critical situations. The implementation of AI in this field contributes not only to efficiency but also to a more sustainable approach to resource and environmental management. Through faster support and reduced need for on-site interventions, this model represents a step toward smarter, digitally supported solutions for a cleaner future.

Keywords: artificial intelligence (AI), virtual assistant, wastewater treatment, technical support, sustainable management

AI kao podrška za čistu budućnost

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Sažetak

Razvoj umjetne inteligencije (AI) otvara nove mogućnosti za unapređenje korisničke podrške u sektoru pročišćavanja otpadnih voda. Uvođenjem internog AI asistenta osiguravamo korisnicima naših uređaja brz, pouzdan i neprekidan pristup tehničkim informacijama, dijagnostici i podršci – bez potrebe za neposrednim kontaktom sa servisnim timom. Ova rješenja omogućuju efikasnije upravljanje sustavima, smanjenje vremena zastoja te povećanje operativne pouzdanosti. Virtualni asistent treniran je na bazi stvarnih korisničkih upita i scenarija te je dostupan 0-24 putem mobilnih i desktop platformi. Pomaže korisnicima u svakodnevnom radu pružajući upute za rukovanje, savjete o održavanju, rješavanje čestih problema i hitnih kvarova. Ovim pristupom povećavamo samostalnost korisnika, rasterećujemo tehničku podršku te potičemo brže donošenje odluka u kritičnim situacijama. Implementacija AI tehnologije u ovu domenu ne doprinosi samo učinkovitosti, već i održivijem pristupu upravljanju resursima i okolišem. Kroz bržu podršku i smanjenu potrebu za intervencijama na terenu, ovaj model predstavlja korak prema pametnijim, digitalno podržanim rješenjima za čistu budućnost.

Ključne riječi: umjetna inteligencija (AI), virtualni asistent, pročišćavanje otpadnih voda, tehnička podrška, održivo upravljanje

Mitigation of urban runoff through eco-friendly infrastructure: A case study of Podgorica, Montenegro

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Abstract

Uncontrolled urban expansion significantly drives localized flooding within catchment areas. This paper investigates the potential of sustainable, eco-friendly infrastructure to mitigate urban runoff volumes. With the ongoing growth of metropolitan regions, traditional stormwater management systems are frequently inadequate for managing the increased runoff, thereby exacerbating flood risks and contributing to water quality degradation. Green infrastructure, which includes green roofs, permeable pavements, and infiltration rain gardens (trenches), offers a sustainable alternative by enhancing the natural infiltration and evapotranspiration processes. This study examines various green infrastructure techniques and their implementation in urban settings in Podgorica, Montenegro. Through planned case studies and empirical data analysis, the paper demonstrates how these approaches can significantly reduce runoff volumes. The findings underline the potential of green infrastructure as a viable solution for sustainable urban water management, highlighting the need for broader adoption and integration into city planning and policy frameworks.

Keywords: urban flooding, green solutions, runoff control

Ublažavanje urbanog otjecanja ekološki prihvatljivom infrastrukturom: Studija slučaja Podgorice, Crna Gora

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Sažetak

Nekontrolirano širenje urbanih područja značajno potiče lokalizirane poplave unutar slivnih područja. Ovaj rad istražuje potencijal održive, ekološki prihvatljive infrastrukture za ublažavanje količina urbanog otjecanja. S kontinuiranim rastom metropolitanskih regija, tradicionalni sustavi upravljanja oborinskim vodama često su neadekvatni za upravljanje povećanim otjecanjem, čime se pogoršavaju rizici od poplava i doprinosi degradaciji kvalitete vode. Zelena infrastruktura, koja uključuje zelene krovove, propusne kolnike i infiltracijske kišne vrtove (rovove), nudi održivu alternativu poboljšanjem prirodnih procesa infiltracije i evapotranspiracije. Ova studija ispituje različite tehnike zelene infrastrukture i njihovu primjenu u urbanim okruženjima u Podgorici, Crna Gora. Kroz planirane studije slučaja i empirijsku analizu podataka, rad pokazuje kako ovi pristupi mogu značajno smanjiti količine otjecanja. Nalazi naglašavaju potencijal zelene infrastrukture kao održivog rješenja za održivo upravljanje urbanim vodama, ističući potrebu za širim prihvaćanjem i integracijom u urbanističko planiranje i okvire politike.

Keywords: poplave u urbanim područjima, zelena rješenja, kontrola otjecanja

Impact of climate type on the performance of ET0 estimation models: A comparative study across Algerian Watersheds

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Abstract
Accurate estimating reference evapotranspiration (ET0) is critical for water resource management, agricultural planning, and climate studies. This study evaluates the performance of multiple machine learning and regression models in estimating ET0 across three watersheds with distinct climate types: Oued Rhumel (sub-humid), Soummam (sub-humid), and Cheliff (semi-arid). Using combinations of meteorological variables (e.g., Tmax, RHmean, WindSpeed, Tmin) and four modeling approaches (Multiple Regression, Bagged Trees, SVM, Neural Networks), we assess model accuracy through RMSE, MAE, MRE, and R^2 metrics. Results reveal that Neural Networks consistently outperform other models, achieving near-perfect R^2 values (1.000) with optimal variable combinations. While both sub-humid watersheds show high model performance, the semi-arid Cheliff basin exhibits greater sensitivity to variable selection, with simpler models (e.g., Regression) showing higher errors under limited inputs. Climate type significantly influences model robustness, with sub-humid conditions allowing flexibility in variable choice, whereas semi-arid systems demand precise variable-model pairing. These findings underscore the need for climate-specific ET0 estimation strategies to enhance hydrological and agricultural applications in contrasting environments.

Keywords: Algerian watershed, reference Evapotranspiration (ET0), machine learning models, climate influence, meteorological variables

Hydrology-hydraulic analysis of the rivers in the arid areas – case study of the river Chellif, Algeria

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Abstract
Reliable predictions of flooding and drought events require precise and quality analysis of the hydrological and hydraulic parameters of the water courses. Flow, velocity, cross-profile sections area, and other parameters are relevant for defining different water course models. Accurate modeling is also important in arid regions, like Algeria, due to the limited water resources. Research consists of determining the functional dependencies of the hydrological and hydraulic parameters on the river Chellif, at the measurement station Arib. Due to the insight of the existing state-of-the-art of research, which deals with the mentioned functional dependencies, it has been concluded that such research is not widely conducted and applied worldwide. The presented work contributes not only to the scientific level but also to the applicable level. This means that when some of the parameters cannot be measured, due to technical or other (for example, storm period) issues, by defining the functional dependencies, all other parameters can be calculated, i.e., determined. This provides far greater possibilities of predicting extreme hydrological events in the future.

Keywords: hydrology, hydraulics, Algeria, flooding, droughts, arid area

The role of the Josip Juraj Strossmayer Water Institute in increasing the efficiency of public water service providers in the Republic of Croatia

Šime KOVAČ

Josip Juraj Strossmayer Water Institute, Ulica grada Vukovara 220, Zagreb, Croatia

Abstract
The Josip Juraj Strossmayer Water Institute plays an important role in increasing the efficiency of public water service providers in the Republic of Croatia through the implementation of continuous professional training for their employees and by participating in the monitoring of their operational performance. Based on the Regulation on Special Conditions for Performing Water Services Activities (Official Gazette 70/2023), the Institute is responsible for developing and implementing the curriculum for continuous professional training of employees of public water service providers. It is also in charge of managing the credit point system and issuing certificates upon completion of the training. Public water service providers are required to ensure continuous professional training of their employees to obtain a sufficient number of credit points, which is one of the conditions for meeting the special requirements for efficient operations. To improve operations and achieve the quality and service delivery standards in line with the requirements of European directives regulating the water utility sector, in addition to education, the Institute also provides technical and professional support in implementing a performance evaluation system for public water service providers. These activities will contribute to strengthening the resilience of public water service providers to climate change in the areas of water supply and wastewater management.

Keywords: professional training, efficiency, public water service providers, climate resilience

Uloga Instituta za vode Josip Juraj Strossmayer u povećanju učinkovitosti rada javnih isporučitelja vodnih usluga u Republici Hrvatskoj

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Sažetak

Institut za vode Josip Juraj Strossmayer ima važnu ulogu u povećanju učinkovitosti rada javnih isporučitelja vodnih usluga u Republici Hrvatskoj provedbom trajnog stručnog osposobljavanja njihovih djelatnika te sudjelovanjem u praćenju učinkovitosti njihovog poslovanja. Institut za vode je temeljem Uredbe o posebnim uvjetima za obavljanje djelatnosti vodnih usluga (NN 70/2023) nadležan za donošenje i provedbu nastavnog plana trajnog stručnog osposobljavanja za djelatnike javnog isporučitelja vodnih usluga, te uređivanje sustava bodovanja i izdavanje potvrda o završenom osposobljavanju. Javni isporučitelji vodnih usluga obvezni su osigurati trajno stručno osposobljavanje svojih zaposlenika kako bi postigli odgovarajući broj bodova, što je jedan od uvjeta za ispunjenje posebnih uvjeta za učinkovito poslovanje. Kako bi se unaprijedilo poslovanje i dostigla kvaliteta i standard isporuke vodnih usluga sukladna zahtjevima europskih direktiva koje uređuju područje vodnokomunalnih usluga, osim provedbe edukacije, Institut pruža tehničku i stručnu podršku u implementaciji sustava vrednovanja učinkovitosti poslovanja JIVU-a. Navedene aktivnosti Instituta rezultirat će jačanjem otpornosti javnih isporučitelja vodnih usluga na klimatske promjene u vodoopskrbi i odvodnji.

Ključne riječi: stručno osposobljavanje, učinkovitost, javni isporučitelji vodnih usluga, otpornost na klimatske promjene

Fusion Approach of Remote Sensing and Geospatial Science (FARGS): Assessing agricultural dynamics in Bardhaman, West Bengal, India

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Abstract

This study aimed to assess agricultural dynamics in Bardhaman District, West Bengal, India, using a fusion approach combining Remote Sensing (RS), Geospatial Science, and Best Available Technology (BAT). Utilizing space-based inputs coupled with geospatial technologies, image analysis, statistical approaches, and socio-economic data, we analyzed changes in agricultural practices, factors affecting cropping patterns, intensity, productivity, dependency on agriculture, etc. Spectral indices such as NDVI and NDWI were also studied to understand the relation between vegetation and waterbodies with agricultural practices. A hot-spot analysis of cropping intensity was also carried out, which describes the areas with high, medium, and low intensity of production. The study demonstrates the effectiveness of integrating RS and GIS for monitoring agricultural dynamics, providing valuable insights for sustainable agricultural development, policy-making, and resource management. The findings have significant implications for optimizing crop yields,

improving agricultural productivity and ensuring regional food security. Overall, this research contributes to developing evidence-based agricultural policies and decision-support systems, ultimately enhancing the livelihoods of farmers and rural communities.

Keywords: remote sensing, GIS, BAT, NDVI, NDWI

The role of riparian buffer zones in preventing contamination of aquatic habitats

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Abstract
Environmental pollution is one of the global issues of today, resulting from the direct impact of human activity on soil, water, and air. Agriculture is considered one of the main causes of pollution and water quality degradation due to excessive input of agrochemicals (mainly fertilizers and pesticides) that reach watercourses through leaching and surface runoff. Vegetated buffer zones act as natural barriers that filter and retain pollutants through physical, chemical and biological processes, including infiltration, plant absorption and the action of microorganisms. They are highly effective in reducing the runoff of fertilizers and pesticides from cultivated fields, and provide multiple benefits for climate change adaptation by creating microclimates, mitigating floods and droughts, providing habitats, improving biodiversity and ecological connectivity, reducing erosion problems, and adding aesthetics to the area. They are inexpensive and require little maintenance, making them an attractive option for controlling diffuse sources of pollution. The effectiveness of buffer zones depends on their width, vegetation type and density, terrain slope, soil characteristics, and seasonal variations. Wetlands also serve as buffer zones, acting as natural solutions for water management by increasing watershed resilience to floods and flash floods, and by purifying water. European policies, such as the Common Agricultural Policy, support their implementation through incentives and regulations. Riparian buffer zones represent an important tool for the preservation of water resources, but further research is needed to assess their long-term effectiveness under varying conditions.

Keywords: pollution, riparian buffer zones, agriculture, water

Uloga vodozaštitinih pojaseva u sprječavanju kontaminacije vodenih staništa

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Sažetak

Onečišćenje okoliša jedan je od globalnih problema današnjice nastao neposrednim utjecajem ljudske djelatnosti na tlo, vodu i zrak. Poljoprivreda se smatra jednim od glavnih uzroka onečišćenja i degradacije kvalitete vode zbog prekomjernog unosa agrokemikalija (uglavnom umjetnih gnojiva i pesticida) koje dospijevaju u vodotoke ispiranjem i površinskim otjecanjem. Vegetacijske tampon zone djeluju kao prirodne barijere koje filtriraju i zadržavaju onečišćivače putem fizičkih, kemijskih i bioloških procesa, uključujući infiltraciju, apsorpciju biljaka i djelovanje mikroorganizama. Vrlo su učinkovite za smanjenje otjecanja umjetnih gnojiva i pesticida s obrađenih polja, a pružaju višestruke koristi za prilagodbu klimatskim promjenama stvaranjem mikroklime, ublažavaju poplave i suše, osiguravaju staništa, poboljšavaju biološku raznolikost i ekološku povezanost, smanjuju probleme erozije, te dodaju estetiku području. Jeftine su i zahtijevaju malo održavanja, što ih čini atraktivnim pri kontroli raspršenih izvora onečišćenja. Učinkovitost tampon zona ovisi o širini, vrsti i gustoći vegetacije, nagibu terena, karakteristikama tla i sezonskim varijacijama. Močvare također imaju ulogu tampon zona kao prirodna rješenja za upravljanje vodama povećavajući otpornost sliva na poplave i bujice te pročišćavanjem voda. Europske politike, poput zajedničke poljoprivredne politike, podupiru njihovu implementaciju kroz poticaje i regulative. Vodozaštitni pojasevi predstavljaju važan alat za očuvanje vodnih resursa, ali je potrebno dodatno istražiti njihovu dugoročnu učinkovitost u različitim uvjetima.

Ključne riječi: onečišćenje, vodozaštitni pojasevi, poljoprivreda, voda

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