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HOTEL OLYMPIA SKY
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Book of Abstracts

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Where is the circular economy going?

Aleksandra ANIĆ VUČINIĆ

University of Zagreb, Faculty of Geotechnical Engineering, Hallerova aleja 7, Varaždin, Croatia

Abstract: The consumer society we live in is becoming a serious threat to future generations due to excessive consumption of resources. Therefore, in the past ten years, the circular economy has become imperative in the waste management sector, and the primary guiding thought has been the preservation of existing resources and the exploitation of valuable resources from waste through recycling. A number of strategies, plans and directives were adopted as a direction in achieving the goals of the circular economy at the level of the European Union. System shifts towards a circular economy are visible, however, the implementation of measures to achieve a number of different goals continuously encounters environmental, economic (commercial) and technological challenges. On the one hand, there are demands for a high rate of recycling of certain materials, which very often includes serious industrial plants, however, as the public's awareness of environmental protection and climate change grows more and more, the construction of new plants is almost impossible. The thesis that the implementation of the circular economy will create savings turned out to be unfounded. Implementing a circular economy represents a significant cost that must be paid in order to conserve resources. The pursuit of the concept of "zero waste" is still technologically unfeasible. The practice has shown that global economic events significantly affect the possibility of achieving goals in the implementation of the circular economy postulate. Thus, the war in Ukraine, the energy crisis, as well as the COVID pandemic showed all the vulnerability of the waste management system and the circular economy implementation at the EU level.

Keywords: circular economy, waste management, European Union

The impact of organic gardening on biodiversity and nature protection

Kornelija BENYOVSKY ŠOŠTARIĆ

Tustika d.o.o, Ulica Frane Petrića 3, Zagreb, Croatia

Abstract: The conventional way of maintaining gardens implies a whole series of techniques and materials that reduce biodiversity and soil fertility. A special problem is the systematic use of pesticides and artificial fertilizers that harm groundwater and air purity. On the contrary, in organic gardens protection and feeding of plants are carried out by means that are not harmful to the environment. In addition, diversity is encouraged, both in the selection of seeds and perennial species, especially old varieties, as well as regarding the implementation of autochthonous plants from the immediate area environment. Thanks to this, different microhabitats are created within an organic garden that makes life possible for many endangered species whose habitats are slowly disappearing. That is why such gardens are always rich in birds, mammals, insects and microorganisms. The positive results of organic gardening go beyond the border of an individual garden, thus increasing biodiversity in the wider area as well.
Keywords: organic gardening, biodiversity, nature protection

Utjecaj organskog vrtlarstva na bioraznolikost i zaštitu prirode

Kornelija BENYOVSKY ŠOŠTARIĆ

Tustika d.o.o, Ulica Frane Petrića 3, Zagreb, Hrvatska

Sažetak: Konvencionalan način održavanja vrtova podrazumijeva čitav niz tehnika i materijala koji smanjuju bioraznolikost i plodnost tla. Poseban je problem sustavna upotreba pesticida i umjetnih gnojiva koji negativno djeluju na pozemne vode i čistoću zraka. Naprotiv, u organskim vrtovima zaštita i prihrana bilja obavljaju se sredstvima koja nisu štetna za okoliš. Usto potiče se raznolikost, kako u izboru sjemena i višegodišnjih vrsta, osobito starih sorti, tako i u pogledu impelmentacije autohtonih biljaka iz neposrednog okoliša. Zahvaljujući tome unutar jednog organskog vrta nastaju različita mikrostaništa koja omogućuju život mnogim ugroženim vrstama čija staništa polako nestaju. Zbog toga su takvi vrtovi uvijek bogati pticama, sisavcima, kukcima i mikoroorganizmima. Dapače pozitivni rezultati organskog vrtlarstva izlaze i izvan granica pojedinog vrta pa se time povećava bioraznolikost i u široj okolici.
Ključne riječi: organsko vrtlarstvo, bioraznolikost, zaštita okoliša

AI orchestrates biodiversity monitoring in Nature Park Kopački Rit

Ivana MAJIĆ

Josip Juraj Strossmayer University of Osijek, Faculty of Agrobiotechnical Sciences Osijek, V. Preloga 1, Osijek, Croatia

Abstract: Monitoring biodiversity is crucial for understanding global changes caused by human activity and climate change. Technological advancements, open science, and collaborative efforts in the past decade promise global access to rapid and affordable biodiversity monitoring tools. Researchers have long used sound to study wildlife, now often employing audio recording technology instead of relying solely on identifying species by ear. Sound is crucial for vocal animals in communication, mating, navigation, and territorial defences. Bioacoustics and ecoacoustics are used to monitor biodiversity of the animal community, including insect, bird, amphibian, mammal, fish, and bat species. Passive acoustic monitoring devices are easy to deploy and can operate for long durations, providing valuable insights into habitats, animal behaviours, and potential illegal activities. Although this technology offers considerable advantages, researchers find the processing of the substantial amounts of generated data time-consuming. Deep learning algorithms have greatly advanced bioacoustics research, with convolutional neural networks being prominently featured in recent scientific articles on bioacoustic classification models. In this talk, we outline the bioacoustic monitoring project's in Nature Park Kopački Rit and its current developments, also an approach that utilizes passive acoustic monitoring and machine learning techniques to automatically extract features from time-series audio signals and employ deep learning models for classifying different animal species based on their vocalizations. The project has been granted under the Tech4All program.

Keywords: wildlife identification**,** bioacoustics, passive acoustic monitoring; machine learning

Fungi Biorefinery: From basic science to industrial applications

Mohammad J. TAHERZADEH

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Abstract: Filamentous fungi play a crucial role in the natural world, fundamentally shaping the environment we live in. These organisms are capable of breaking down diverse materials, ranging from sugars, carbohydrate polymers, and lignocelluloses to fats and proteins found in various sources and wastes. Through this process, they generate a variety of enzymes and metabolites, and the resulting fungal biomass itself has applications as both feed and food. Consequently, filamentous fungi hold the key to pioneering biorefineries designed to repurpose residuals and waste into valuable products such as food, feed, metabolites, enzymes, and biopolymers. Since 1999, our research group has been at the forefront of exploring the potential of filamentous fungi, focusing on the development of fungi-based biorefineries. This presentation, delve into the fungi's capacity to transform a broad spectrum of wastes and by-products into ethanol, enzymes, bioplastics, fish feed, and human food. Given the rising global interest in sustainable and alternative protein sources to replace meat and animal proteins, our recent efforts have concentrated on deriving human food from fungal mycelium. This initiative aims to create food products that not only offer nutritional benefits but also closely replicate the taste and texture of meat- or chicken-based foods. The efforts on moving the results from academia to industry will also briefly be addressed.
Keywords: fungi, biorefinery, food products

Invited Lectures
Pozvana predavanja

The importance of informing and participating the public and the interested public in the administrative procedure of assessing the environmental impact

Ana ĐANIĆ ČEKO

Josip Juraj Strossmayer University of Osijek, Faculty of Law Osijek, S. Radića 13, Osijek, Croatia

Abstract: The area of environmental protection and access to environmental information, the obligation to inform the public and interested public in procedures related to environmental issues, indicates the need to strengthen awareness of the importance of the same and promote the activities of citizens and interested stakeholders. The aforementioned is also proclaimed through the principle of access to information and public participation in the Environmental Protection Act. The possibility of public and interested public involvement in decision-making on issues related to environmental protection, especially administrative procedures for assessing the impact of interventions on the environment, is of exceptional importance for the public interest and represents a particularly special administrative area. Through European and national regulations, competent authorities are given the authority to make decisions that have a significant impact on the environment and health, and therefore procedures should be harmonized and subjected to an increasingly strict regime of supervision. Therefore, the environmental policies of the EU emphasize that the potential effects on the environment should be considered in all stages of the decision-making process, especially in its initial stages (principle of caution, principle of preventive action). Procedures for assessing the impact of interventions on the environment are precisely one of the legally regulated mechanisms/instruments of environmental protection. The above-mentioned procedure is carried out as a certain pre-stage, a preliminary procedure before applying for the issuance of a location permit. In the same way, the environmental permit is issued after the decision on the acceptability of the intervention on the environment has been issued. For this purpose, the national legal framework is presented in relation to the participation of the public and interested public in the selected special administrative procedure for assessing the environmental impact of interventions, and its specificities in terms of the process are indicated.

Keywords: environmental information, public and the interested public, special administrative procedure, Environmental Protection Act, Regulation on information and participation of the public and interested public in matters of environmental protection

Značaj informiranja i sudjelovanja javnosti i zainteresirane javnosti u upravnom postupku procjene utjecaja zahvata na okoliš

Ana ĐANIĆ ČEKO

Sveučilište Josipa Jurja Strossmayera u Osijeku, Pravni fakultet Osijek, Osijek, S. Radića 13, Hrvatska

Sažetak: Područje zaštite okoliša i pristup informacijama o okolišu, obveza informiranja javnosti i zainteresirane javnosti u postupcima koji se odnose na okolišna pitanja, ukazuju na potrebu jačanje svijesti o važnosti istoga i promicanja aktivnosti građana i zainteresiranih dionika. Navedeno se proklamira i kroz načelo pristupa informacijama i sudjelovanja javnosti u Zakonu o zaštiti okoliša. Mogućnost sudjelovanja javnosti i zainteresirane javnosti u odlučivanju o pitanjima koja se odnose na zaštite okoliša, posebice upravnih postupaka procjene utjecaja zahvata na okoliš, od iznimnog je značaja za javni interes te predstavlja osobito posebno upravno područje. Kroz europsku i nacionalnu regulativu, nadležnim se tijelima daju ovlasti za donošenje odluka, a koje imaju značajan utjecaj na okoliš i zdravlje, pa stoga treba uskladiti postupke i podvrgnuti sve strožem režimu nadzora. Stoga se, okolišnim politikama EU-e, naglašava kako se o potencijalnim učincima na okoliš, treba razmatrati, u svim fazama postupaka donošenja odluka, osobito već i u njegovim početnim fazama (načelo opreznosti, načelo preventivnog djelovanja). Postupci procjena utjecaja zahvata na okoliš upravo predstavljaju jedan od zakonski reguliranih mehanizama/instrumenta zaštite okoliša. Navedeni se postupak provodi i kao određena predfaza, preliminarni postupak prije podnošenja zahtjeva za izdavanje lokacijske dozvole. Isto tako, okolišna se dozvola izdaje nakon izdanog rješenja o prihvatljivosti zahvata na okoliš. U tu se svrhu prikazuje nacionalni zakonski okvir u odnosu na sudjelovanje javnosti i zainteresirane javnosti u odabranom posebnom upravnom postupku procjene utjecaja zahvata na okoliš te se ukazuje na njegove specifičnosti u procesnom smislu.

Ključne riječi: informacije o okolišu, javnost i zainteresirana javnost, posebni upravni postupak, Zakon o zaštiti okoliša, Uredba o informiranju i sudjelovanju javnosti i zainteresirane javnosti u pitanjima zaštite okoliša

Design of Processes for Wastewater Treatment using Green Sorbents

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Abstract: The global industry development and growing population led to enormous environmental pollution. Different contaminants are released into wastewater, including heavy metal ions, organics, dyes, bacteria, viruses and so on. The removal of pollutants from wastewater is very important for environmental protection and thus public health. The modern trends in water resources management, lately, are more oriented for development of the methods for wastewater treatment using low-cost natural materials. In compliance with the principles of green technology and circular economy, we have focused on the design of processes for wastewater treatment using green sorbents. Raw and bio-porous materials that possess suitable characteristics are applied as sorbents for removal of hazardous components from wastewater. The main point of this study refers to the application of precise process technologies, such as adsorption and biosorption as conventional methods and contemporary ultrasound - assisted adsorption, which are the most widely used for elimination of the different types of pollutants from wastewater.

Keywords: pollution, green sorbents, wastewater

Hydrogen as the paradigm of future energy vector - analysis of strengths, weaknesses, opportunities, and threats in achieving the energy transition goals

Darko PAVLOVIĆ

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Abstract: Within the intensive transformation of the energy sector towards sustainable development, this paper examines the potential of hydrogen as a key "energy vector." The SWOT (Strengths, Weaknesses, Opportunities, Threats) analysis enables a structured assessment of hydrogen's role in the energy transition process, systematically identifying key factors. The emphasis is placed on hydrogen's ability to store and transmit energy, making it a crucial resource with the expected potential to replace fossil fuels in the future. The Green Deal of 2020 marks an essential framework for reshaping European society towards the goals of climate neutrality, fairness, and prosperity. The process of energy transition towards complete decarbonization, including reducing greenhouse gas emissions, promoting renewable energy, and increasing energy efficiency, represents a central element of this plan. Although a gradual transition from natural gas as a transitional energy source is planned, the importance of natural gas in providing a flexible, secure, and diverse source of energy is emphasized. Concurrently, support is given to the decarbonization process towards a low-carbon economy, considering the availability and expansion of natural gas infrastructure. The analysis further highlights the crucial role of hydrogen in replacing fossil fuels and reducing carbon dioxide emissions. Its perspective not only contributes to achieving the goals of the Green Deal but also signifies a key factor in shaping Europe's energy future with a focus on sustainable development. Analysing the historical context from just over a century and a half ago, it should be emphasized that the arrival of internal combustion engines and steam engines marked a turning point in technological progress. This technological transition, on the one hand, accelerated human advancement and industrial development, but on the other hand, undeniably resulted in a high cost of development, causing significant negative impacts on the environment. In this context, it is necessary to highlight that the modern understanding of sustainable development is necessarily directed towards the transformation of the energy sector. The key role of hydrogen in this process becomes evident, as it balances achieving energy efficiency and environmental protection. Sustainable development requires careful planning of energy innovations to ensure that technological progress does not compromise the ecological balance. This analysis emphasizes the imperative of properly directing the transformation of the energy sector to achieve sustainable progress and long-term societal well-being.

Keywords: energy transition, energy vector, SWOT analysis matrix, sustainable development, hydrogen

Vodik kao paradigma energetskog vektora budućnosti – analiza potencijala snage, slabosti, mogućnosti i prijetnji u postizanju ciljeva energetske tranzicije

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Sažetak: U okviru intenzivne transformacije energetskog sektora prema održivom razvoju, ovaj rad proučava potencijal vodika kao ključnog "energetskog vektora". Analiza snaga, slabosti, mogućnosti i prijetnji (SWOT) omogućuje strukturiranu procjenu uloge vodika u procesu energetske tranzicije, sustavno identificirajući ključne čimbenike. Naglasak je stavljen na sposobnost vodika da skladišti i prenosi energiju, čime postaje ključni resurs s očekivanim potencijalom zamjene fosilnih goriva u budućnosti. Zeleni plan iz 2020. označava esencijalni okvir za preoblikovanje europskog društva prema ciljevima klimatske neutralnosti, pravednosti i prosperiteta. Proces energetske tranzicije (prijelaza) prema potpunoj dekarbonizaciji, uključujući smanjenje emisija stakleničkih plinova, poticanje obnovljive energije i povećanje energetske učinkovitosti, predstavlja centralni element tog plana. Iako se planira postupno odvajanje od prirodnog plina kao prijelaznog energenta, naglašava se važnost prirodnog plina u pružanju fleksibilnog, sigurnog i raznovrsnog izvora energije. Paralelno, podržava se proces dekarbonizacije prema niskougljičnom gospodarstvu, uvažavajući dostupnost i proširenje infrastrukture prirodnog plina. Analiza dublje ističe ključnu ulogu vodika u zamjeni fosilnih goriva i smanjenju emisije ugljičnog dioksida. Njegova perspektiva ne samo da doprinosi ostvarivanju ciljeva Zelenog plana, već i označava ključni faktor u oblikovanju energetske budućnosti Europe s fokusom na održivi razvoj. Analizirajući povijesni kontekst prije nešto više od stoljeća i pol, treba naglasiti da je dolazak motora s unutarnjim izgaranjem i parnih strojeva označio prekretnicu u tehnološkom napretku. Ovaj tehnološki prelazak, s jedne strane, ubrzao je ljudski napredak i industrijski razvoj, no s druge strane, neosporno je rezultirao i visokom cijenom razvoja, izazivajući značajne negativne utjecaje na okoliš. U tom kontekstu, potrebno je istaknuti da je suvremeno shvaćanje održivog razvoja nužno usmjereno ka transformaciji energetskog sektora. Ključna uloga vodika u tom procesu postaje očita, jer se balansira između postizanja energetske učinkovitosti i zaštite okoliša. Održivi razvoj zahtijeva pažljivo planiranje energetskih inovacija kako bi se osiguralo da tehnološki napredak ne kompromitira ekološku ravnotežu. Ova analiza naglašava imperativ pravilne orijentacije transformacije energetskog sektora u svrhu ostvarivanja održivog napretka i dugoročne dobrobiti za društvo.

Ključne riječi: energetska tranzicija, energetski vektor, matrica SWOT analize, održivi razvoj, vodik

Water governance in the context of achieving the UN Sustainable Development Goals

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Abstract The implementation of the 2030 Agenda, as a global agreement and political program that, through the Sustainable Development Goals, encourages and promotes a peaceful and inclusive society, the creation of better jobs and finding answers to the environmental challenges of the modern age, is entering the last five-year period of implementation. According to estimates, to date, only 18% of the goals outlined in the Agenda have been achieved or are on track to be achieved by 2030, while the rest are either stagnant or have negative trends. Nevertheless, appropriate policies can still ensure the achievement of the 17 Sustainable Development Goals and their 169 targets, and water plays a key role in this. Namely, in addition to the fact that water management policy is directly included within two goals (SDG 6 and SDG 14), water is also a fundamental prerequisite for achieving all other Sustainable Development Goals. Unfortunately, at the midpoint of the 2030 Agenda, the world still faces significant (SDG 6) and major challenges (SDG 14) in terms of achieving the water-related Goals. Since local communities are key to the operationalization of the 2030 Agenda, this paper examines the challenges and opportunities of sustainable water management in the region, with a special emphasis on highly sensitive water ecosystems in the karst area.
Keywords: sustainable development, Agenda 2030, Water Framework Directive, water quality, water infrastructure

Upravljanje vodama u kontekstu postignuća Ciljeva održivoga razvoja UN-a

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Sažetak: Implementacija Agende 2030, kao globalnog sporazuma i političkog programa koji kroz Ciljeve održivoga razvoja potiče i promovira miroljubivo i uključivo društvo, otvaranje boljih radnih mjesta i pronalaska odgovora na okolišne izazove suvremenoga doba, ulazi u posljednje petogodišnje razdoblje provedbe. Prema procjenama, do danas svega je 18% Agendom zacrtanih ciljeva postignuto ili je na dobrom putu da bude postignuto do 2030. godine, dok preostali ili stagniraju ili imaju negativne trendove. Ipak, odgovarajućim politikama još uvijek se može osigurati postignuće 17 Ciljeva održivoga razvoja i njihovih 169 podciljeva, a pri tome ključnu ulogu ima voda. Naime, osim što je politika upravljanja vodama izravno obuhvaćena unutar dva cilja (SDG 6 i SDG 14), voda je i temeljni preduvjet za postizanje svih ostalih Ciljeva održivoga razvoja. Nažalost, na sredini provedbe Agende 2030., svijet se još uvijek suočava sa značajnim (SDG 6), odnosno velikim izazovima (SDG 14) u smislu postignuća Ciljeva povezanih s vodom. Kako su za operacionalizaciju Agende 2030 ključne lokalne zajednice, u ovom radu razmatraju se izazovi i mogućnosti održivog upravljanja vodama u regiji, s posebnim naglaskom na osjetljive krške vodene ekosustave.

Ključne riječi: održivi razvoj, Agenda 2030, Okvirna direktiva o vodama, kvaliteta voda, vodna infrastruktura

Presentations
Priopćenja

Climate change
Klimatske promjene

Co-financing of climate change adaptation projects to strengthen the resilience of urban areas

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Abstract: As we are witnessing the consequences of climate change, "green activities" are becoming inevitable since they contribute to climate change adaptation and mitigation, they improve air quality, increase biodiversity, reduce noise levels, and generally improve the quality of life in urban areas. Climate change adaptation projects in urban areas of Croatia, as an important factor of positive impact on citizens' health and life, are developing rapidly and have yet to significantly contribute to sustainable development in the upcoming period, and achieve social, environmental, and economic benefits. The Environmental Protection and Energy Efficiency Fund, following European and global practice of development of urban adaptation measures to climate change, financially supports adaptation projects aimed at increasing the resilience of local and regional communities and reducing the vulnerability of natural systems to the negative impacts of climate change, which will consequently contribute to the development of a green and climate neutral Croatia. In 2022, the Fund published the first public call for co-financing climate change adaptation projects under the slogan "Green Side of the Street", followed by new public calls in 2023 and 2024. This paper discusses the mechanism of financing climate change adaptation measures and presents examples of the best practices.

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

Sufinanciranje projekata prilagodbe klimatskim promjenama u svrhu jačanja otpornosti urbanih sredina

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Sažetak: Obzirom da smo i sami svjedoci posljedica klimatskih promjena, „zelene aktivnosti“ postaju nezaobilazne jer doprinose prilagodbi na klimatske promjene kao i njihovom ublažavanju, poboljšavaju kvalitetu zraka, povećavaju bioraznolikost, smanjuju razinu buke i općenito unapređuju kvalitetu života u urbanim sredinama. Projekti prilagodbe klimatskim promjenama u urbanim sredinama Republike Hrvatske, kao bitan čimbenik pozitivnog utjecaja na zdravlje i život građana, ubrzano se razvijaju te će tek u predstojećem razdoblju značajnije doprinijeti održivom razvoju te postići društvene, okolišne i gospodarske koristi. Fond za zaštitu okoliša i energetsku učinkovitost, prateći europsku i svjetsku praksu razvoja mjera urbane prilagodbe klimatskim promjenama, financijski podržava projekte prilagodbe sa ciljem povećanja otpornosti lokalne i regionalne zajednice te smanjenja ranjivosti prirodnih sustava na negativne utjecaje klimatskih promjena što će posljedično pridonijeti izgradnji zelene i klimatski neutralne Hrvatske. Fond je u 2022. godini objavio prvi javni poziv kojim je omogućeno sufinanciranje projekata prilagodbe klimatskim promjenama uz slogan „Zelena strana ulice“ te su u 2023. i 2024. godini slijedili novi javni pozivi. U radu se razmatra mehanizam financiranja mjera prilagodbe klimatskim promjenama te predstavljaju primjeri dobre prakse.

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

CO_2 footprint mitigation by implementing geothermal heating source in cities - case study of Krapinske Toplice and Sveta Nedelja

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Abstract: The Ministry of Regional Development and Funds of the European Union, in the role of Manager of the "Energy and Climate Change" Program, after the verification and selection of projects within the framework of the Open Call for submission of project proposals "Development of technical documentation for the use of geothermal energy", made a Decision on the financing of the "HypoKraT" project (Hydrothermal potential of Krapinske Toplice) and the project "Development of documentation during the phase of geothermal water research in the area of Sveta Nedelja". In the area of the City of Sveta Nedelja, based on the confirmed geothermal potential of previously drilled Nedjelja-1 (N1) geothermal borehole, a new exploratory geothermal borehole Sveta Nedjelja GT2 (SNGT-2) is planned and located so that, after the drilling and a positive outcome of the new borehole, the use of geothermal energy for energy purposes would be implemented for the area of the City. On the territory of the Municipality of Krapinske Toplice, there is an existing borehole Krapinske Toplice-1 (KRT-1), for which the Base design, Feasibility Study and Hydrodynamic Model of the reservoir for the use of geothermal energy were prepared. The Energy Development Strategy of the Republic of Croatia until 2030, with a view to 2050 (Official Gazette 25/20) prescribes the need to stimulate the potential of geothermal energy through new tenders for exploration and exploitation of geothermal water for energy purposes at existing known locations. For both mentioned projects, the reduction of greenhouse gas emissions in the atmosphere was estimated by comparing the carbon footprint of potential technical solutions using geothermal energy and energy-equivalent natural gas heating.
Keywords: carbon footprint, geothermal energy, domestic geothermal resources, renewable energy source, energy independence, "clean" and sustainable future

Smanjenje CO_2 otiska implementacijom geotermalnog izvora grijanja u gradovima - studija slučaja Krapinske Toplice i Sveta Nedelja

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Sažetak: Ministarstvo regionalnoga razvoja i fondova Europske unije u ulozi Upravitelja Programa „Energija i klimatske promjene" nakon provedenog postupka provjere i odabira projekata u okviru Otvorenog poziva na dostavu projektnih prijedloga „Izrada tehničke dokumentacije za korištenje geotermalne energije", donijelo je Odluku o financiranju projekta „HyPoKraT" (Hidrotermalni potencijal Krapinskih Toplica) te projekta „Izrada dokumentacije tijekom faze istraživanja geotermalne vode na području Svete Nedelje". Na području Grada Svete Nedelje, temeljem potvrđenog geotermalnog potencijala ranije izvedenom bušotinom Nedjelja-1 (N1) planirana je i locirana nova istražna geotermalna bušotina Sveta Nedjelja GT2 (SNGT-2) po čijoj je izvedbi i pozitivnom ishodu planirano korištenje geotermalne energije u energetske svrhe na području Grada. Na području Općine Krapinske Toplice nalazi se postojeća bušotina Krapinske Toplice-1 (KRT-1) za koju je izrađen Idejni projekt, Studija izvodljivosti te Hidrodinamički model ležišta za korištenje geotermalne energije. Strategija energetskog razvoja Republike Hrvatske do 2030. godine, s pogledom na 2050. godinu (NN 25/20), propisuje potrebu poticanja potencijala geotermalne energije kroz nova nadmetanja za istraživanje i eksploataciju geotermalne vode za energetske svrhe na postojećim poznatim lokacijama. Za oba navedena projekta procijenjeno je smanjenje emisije stakleničkih plinova u atmosferu usporedbom ugljičnog otiska potencijalnih tehničkih rješenja korištenja geotermalne energije i energetski jednakovrijednog grijanja na prirodni plin.

Ključne riječi: ugljični otisak, geotermalna energija, domaći geotermalni resursi, obnovljivi izvor energije, energetska neovisnost, „čista" i održiva budućnost

CLIMATE CHANGE I *KLIMATSKE PROMJENE*
Oral presentation / *Usmeno priopćenje*

Challenges in facing climate change in the Neretva River Valley through Interreg projects

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Abstract: Climate change represents a significant challenge for the Republic of Croatia, given its geographical position and diverse ecosystems. Croatia is actively involved in the fight against climate change through various projects financed by European Union funds, including Interreg projects. Interreg projects play a key role in strengthening Croatia's resilience to climate change. Through cooperation with neighboring countries, Croatia implements concrete measures to reduce the risk of natural disasters, adapt to climate change, and promote sustainable development. These projects not only help to protect the environment but also improve the quality of life of the local population and stimulate economic growth and regional cooperation. One such project, which he has just started, is Subsurface water monitoring and management to prevent drought risk in coastal systems (project acronym "SWAMrisk"). It is the continuation of a series of successfully completed projects in the Neretva river valley. The goal of the project is to increase awareness of the impact of climate change on coastal aquifers through the prediction of climate change at multiple levels and to ensure and improve preparedness for droughts caused by climate change and their negative effects on groundwater in the coastal system along the coastal areas of the Adriatic Sea. Groundwater in the Adriatic basin is a strategic resource of exceptional importance for dealing with increasingly frequent droughts that affect the maritime cross-border area between Italy and Croatia. Projections of climate change emphasize an increase in air temperature and a decrease in precipitation, while mean sea level tends to rise. To develop sustainable water management in coastal systems facing droughts caused by climate change, specific actions are needed that involve planning to combine an integrated approach for monitoring, modeling and forecasting to enable the achievement of the main project objectives. The duration of the project is 30 months, and the budget is around €2 million, of which 80% is non-refundable.

Keywords: climate change, Interreg projects, SWAMrisk project, Neretva River Valley, water salinization

CLIMATE CHANGE I *KLIMATSKE PROMJENE*
Oral presentation / *Usmeno priopćenje*

Izazovi u suočavanju sa klimatskim promjenama u dolini rijeke Neretve kroz Interreg projekte

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Sažetak: Klimatske promjene predstavljaju značajan izazov za Republiku Hrvatsku, s obzirom na njezinu geografsku poziciju i raznolike ekosustave. Hrvatska je aktivno uključena u borbu protiv klimatskih promjena kroz različite projekte financirane iz fondova Europske unije, među kojima su i Interreg projekti. Interreg projekti igraju ključnu ulogu u jačanju otpornosti Hrvatske na klimatske promjene. Kroz suradnju sa susjednim zemljama, Hrvatska provodi konkretne mjere za smanjenje rizika od prirodnih katastrofa, prilagodbu klimatskim promjenama i promicanje održivog razvoja. Ovi projekti ne samo da pomažu u zaštiti okoliša, već i unapređuju kvalitetu života lokalnog stanovništva te potiču gospodarski rast i regionalnu suradnju. Jedan od takvih projekata, koje je upravo započeo, je i Praćenje i upravljanje podzemnim vodama za spriječavanje rizika od suše u obalnim sustavim (akronim projekta "SWAMrisk"). To je nastavak niza uspješno završenih projekata u dolini rijeke Neretve. Cilj projekta je povećati svijest o utjecaju klimatskih promjena na sustave obalnih vodonosnika kroz predviđanje klimatskih promjena na više razina te osigurati i poboljšati spremnost na suše uzrokovane klimatskim promjenama i njihove negativne učinke na podzemne vode u obalnom sustavu duž obalnih područja Jadranskog mora. Podzemne vode u jadranskom bazenu strateški su resursi od iznimne važnosti za suočavanje sa sve češćim sušama koje pogađaju morsko prekogranično područje između Italije i Hrvatske. Projekcije klimatskih promjena naglašavaju povećanje temperature zraka i smanjenje količine oborina, dok srednja razina mora ima tendenciju povećanja. Za razvoj održivog upravljanja vodama u obalnim sustavima suočenim sa sušama izazvanim klimatskim promjenama, potrebne su posebne akcije koje podrazumijevaju planiranje spajanja integralnog pristupa za praćenje, modeliranje i predviđanje kako bi se omogućilo postizanje glavnih ciljeva projekta. Trajanje cijelog projekta je 30 mjeseci, a vrijednost je oko 2 mil. €, od čega je 80 % bespovratno.
Ključne riječi: klimatske promjene, Interreg projekti, SWAMrisk projekt, dolina rijeke Neretve, zaslanjenje voda

Computer Science in Environmental Protection
Računalne znanosti u zaštiti okoliša

Transforming Food Waste into Value: Leveraging AI for Sustainable Resource Optimization in the Food Industry

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Abstract: Annually, the food industry discards approximately 1.3 billion tons of waste, rich in untapped nutrients, presenting an opportunity for innovation in the development of nutritionally enhanced products. This review synthesizes findings from extensive open-access research, forming the basis for a customized Generative Pre-trained Transformer (GPT) model "WasteSmartAI: Your Food Waste Wizard", which was developed to optimize strategies for reducing waste and improving resource efficiency in food industry processes. Our analysis confirms that a considerable portion of this waste retains valuable nutrients that can be transformed into commercially viable food products and other commercially interesting products for pharmaceutical, biotechnological, and cosmetic industry. By employing artificial intelligence, specifically large language models like GPT, we can process vast datasets and extract precise, actionable insights. These insights are instrumental in shaping strategic waste management decisions, emphasizing upcycling and recycling tailored to industry-specific needs. The adoption of such artificial intelligence-driven approaches not only facilitates the transformation of waste into useful products but also enhances the sustainability and operational efficiency of the food industry. This contributes significantly to reducing environmental impacts and advancing global sustainability goals, demonstrating the pivotal role of artificial intelligence in sustainable food management.

Keywords: food loss, large language model, sustainability, resource efficiency

Culture, Art and Sustainability
Kultura, umjetnost i održivost

History through the present - creation of a scaled-down replica of the door of the portal of the Rector's Palace in Dubrovnik

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Abstract: This paper shows the interdisciplinary approach of two departments of the University of Dubrovnik in researching and applying skills that have been acquired and developed over the centuries and which are still insufficiently researched today. In 2010, during conservation and restoration work on the wooden gate of the portal of the Ducal Palace in Dubrovnik, a letter was found addressed to "whoever finds it". The author of the letter is Pasquale Brigola, a carpenter, craftsman, master builder and restorer who worked on these very gates in 1802. The hidden message has the unique function of a testamentary legacy for the salvation of souls. Because of the significance of such a discovery, a miniature replica of the wooden gates of the portal was made by hand. The whole story is stored in this interdisciplinary work, which shows the connection between science, history and art. In addition to the historical research, the production of the gates is also presented in detail in the work: Analysis and selection of wood species, structural elements, joints, small and detailed carvings on the gates and the surface treatment.
Keywords: interdisciplinary, history, technology, carving, wooden portal gates

Ecological activities and sustainability of the Croatian National Theatre in Osijek

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Abstract: The paper titled "Ecological Activities and Sustainability of the Croatian National Theatre" examines the efforts and initiatives of the Croatian National Theatre (HNK) in Osijek aimed at achieving sustainability and reducing environmental impact. The study analyzes the implementation of various ecological practices within the HNK, including energy efficiency, waste management (and sorting), the use of renewable energy sources, and the promotion of environmental awareness among employees and audiences of all ages. A key aspect of the research is the assessment of the energy efficiency of the building currently housing the HNK in Osijek. The study investigates measures taken by the HNK to reduce energy consumption, such as the introduction of LED lighting, improvements in building insulation, and the use of more energy-efficient heating and cooling systems. Additionally, the potential installation of solar panels and other renewable energy sources is considered as a means to reduce carbon dioxide emissions. Waste management is another significant segment of the paper. The research analyzes recycling and waste reduction strategies, including waste sorting and the reduction of single-use plastic products, as well as the reduction of office paper usage. Special emphasis is placed on the recycling of scenographic materials and costumes, representing a significant step towards a more sustainable theatrical production process. The paper also explores possible initiatives for educating and raising environmental awareness among employees and the audience through various campaigns, workshops, and collaborations with environmental organizations. The HNK aims to promote sustainable practices and encourage the community to adopt environmentally responsible behaviors. In conclusion, the study demonstrates that the HNK is actively working on integrating ecological principles into its operational processes. Although there are challenges in achieving full sustainability, the efforts of the HNK in Osijek represent a significant step towards reducing carbon dioxide emissions and promoting sustainability in the cultural industry.

Keywords: energy efficiency, waste management, renewable energy sources, environmental awareness, sustainable theatrical production

Ekološke aktivnosti i održivost Hrvatskog narodnog kazališta u Osijeku

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Sažetak: U radu pod naslovom *Ekološke aktivnosti i održivost Hrvatskog narodnog kazališta* istražuju se napori i inicijative Hrvatskoga narodnog kazališta u Osijeku usmjereni postizanju održivosti i smanjenju nepovoljnog utjecaja na okoliš. Rad analizira implementaciju različitih ekoloških praksi unutar HNK-a, uključujući energetsku učinkovitost, upravljanje otpadom (i razvrstavanje), uporabu obnovljivih izvora energije, te promicanje ekološke svijesti među zaposlenicima i kazališnom publikom svih uzrasta. Jedan od ključnih aspekata istraživanja je procjena energetske učinkovitosti zgrade u kojoj se HNK u Osijeku trenutačno nalazi. Studija ispituje mjere koje je HNK poduzeo da bi smanjio potrošnju energije, poput uvođenja LED rasvjete, poboljšanja izolacije zgrade, te uporabu energetski učinkovit(ij)ih sustava grijanja i hlađenja. Također, razmatra se postavljanje solarnih panela i drugih obnovljivih izvora energije kao sredstava za smanjenje emisije ugljičnoga dioksida. Upravljanje otpadom još je jedan važan segment rada. Istraživanje analizira strategije recikliranja i smanjenja otpada, uključujući razvrstavanje otpada te smanjenje uporabe jednokratnih plastičnih proizvoda, kao i reduciranje potrošnje uredskog papira. Poseban naglasak je stavljen na recikliranje scenografskih materijala i kostima, što predstavlja značajan korak ka održivijem kazališnom proizvodnom procesu. Rad također proučava moguće inicijative za edukaciju i podizanje svijesti o ekologiji među zaposlenicima i publikom, kroz razne kampanje, radionice i suradnju s ekološkim organizacijama. HNK nastoji promovirati održive prakse i potaknuti zajednicu na ekološki odgovorno ponašanje. Zaključno, studija pokazuje da HNK aktivno radi na integraciji ekoloških načela u svoj radni proces i djelovanje. Iako postoje izazovi u postizanju potpune održivosti, napori HNK-a u Osijeku predstavljaju značajan korak ka smanjenju emisije ugljičnoga dioksida i promoviranju održivosti u kulturnoj industriji.

Ključne riječi: energetska učinkovitost, upravljanje otpadom, obnovljivi izvori energije, ekološka svijest, održiva kazališna produkcija

Ecological Agriculture and Food Production
Ekološka poljoprivreda i proizvodnja hrane

Organic sheep and goat farming for the preservation of rural areas in the Republic of Croatia

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Abstract: Organic sheep and goat farming is most common in the rural areas of the Republic of Croatia (CRO). The development of these animal husbandry branches has numerous advantages. One is preserving and revitalizing rural areas in economic, social, and environmental terms. In the Republic of Croatia, the situation is similar to that in the EU, where there is a growing interest in organic livestock farming and its products, as well as in organic sheep and goat farming. Over the last ten years, a significant increase in organic pasture areas (by 340%) has been observed, accompanied by a 330% increase in the number of sheep (from 19.411 to 82.941) and a 280% increase in the number of goats (from 1.769 to 6.742) on organic farms. As in the EU countries, a considerable depopulation of rural areas can also be observed in Croatia. Therefore, the greater development of organic sheep and goat farming as one of the development "niches", in addition to the quality and market demand for their products and the preservation of the environment, could also bring an increase in the demand for labor, which would also increase the employment of the rural population. This would also have an impact on improving the financial stability of farmers, which would increase their interest in remaining in rural areas, which could reduce their further depopulation. Although numerous measures have already been taken, significant investment is still needed in the development of organic sheep and goat farming, which would give new impetus to the preservation and prevention of further depopulation of rural areas.

Keywords: organic sheep farming, organic goat farming, Republic of Croatia, rural area, development

Ekološko ovčarstvo i kozarstvo u funkciji očuvanja ruralnog prostora u Republici Hrvatskoj

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Sveučilište Josipa Jurja Strossmayera u Osijeku, Fakultet agrobiotehničkih znanosti Osijek, V. Preloga 1, Osijek, Hrvatska

Sažetak: Ekološka ovčarska i kozarska proizvodnja je najčešće organizirana u ruralnim prostorima Republike Hrvatske (RH). Razvitak ovih stočarskih grana ima brojne prednosti, a jedna od njih je i očuvanje i revitalizacija ruralnih prostora s ekonomskog, društvenog i ekološkog stajališta. U RH je slična situaciji kao i u EU gdje je sve veći interes za ekološkom stočarskom proizvodnjom i njihovim proizvodima pa tako i za ekološkim ovčarstvom i kozarstvom. U posljednjem desetljeću utvrđeno je značajno povećanje ekoloških pašnjačkih površina (za 340 %), što je pratilo i povećanje broja ovaca za 330 % (od 19411 do 82941) i koza za 280 % (od 1769 do 6742) u ekološkim uzgojima. Kao i u zemljama EU i u RH je primjetna značajna depopulacija ruralnih prostora. Stoga bi se jačim razvojem ekološkog ovčarstva i kozarstva, kao jedna od razvojnih "niša", mogla uključiti, osim kvalitete i tržišne potražnje za njihovim proizvodima te održavanja okoliša, i povećanje potrebe za radnom snagom, što bi povećalo i zapošljavanje ruralnog stanovništva. Navedeno bi utjecalo i na poboljšanje financijske stabilnosti farmera što bih povećalo interes za ostanak u ruralnim prostorima čime bi se mogla smanjiti njihova daljnja depopulacija. Iako su poduzete brojne aktivnosti još uvijek su potrebna značajnija ulaganja u razvoj ekološkog ovčarstva i kozarstva što bi dalo novi zamah u očuvanju i sprečavanju daljnje depopulacije ruralnih prostora.

Ključne riječi: ekološko ovčarstvo, ekološko kozarstvo, Republika Hrvatska, ruralni prostor, razvoj

Underutilized and alternative food sources

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Abstract: Strengthening and transforming food systems through interdisciplinary design solutions at local, regional, national and international levels has become extremely necessary in the near future. Food insecurity will force people to accept different alternative food sources. Priorities such as the development of alternative proteins, microbiome-based foods, climate-adapted food systems, rethinking food packaging, short food supply chains and replacement with sustainable alternatives collectively contribute to reducing the environmental footprint of the current food system. To maintain overall health, people should focus more on environmental farming, personalized nutrition and changes in eating habits. Non-conventional foods and grains, edible wild plants grown alternatively in urban areas that can be easily adapted to the environment and are free of pesticides and fertilizers could strengthen food systems. Alternative protein sources would also lead to a decrease in livestock farming, consequently reducing the impact of global warming. Food 2030's research and innovation policy emphasizes the importance of sustainable, affordable diets for all, climate-resilient and circular food systems, and community empowerment. These alternatives could improve the nutritional status of the population in a more sustainable way, reduce the risk of various diseases through a healthier diet and improve the quality of life.

Keywords: food sources, food insecurity, alternative food, sustainable food, environment

Structure and Trends in Bioclimatic Parameters of Wine-Growing Regions in Slovenia

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Abstract: This study examined the structure and trends of bioclimatic parameters important for grape production from 1952 to 2022 in the wine-growing regions of Podravje, Posavje and Primorska in Slovenia. Average and extreme temperature and precipitation data from 6 climatic stations in three wine-growing regions were divided into annual and growing seasons. The results show that in the period 1991-2022, there was a warming in the growing season in all regions by 1.4 – 1.7 °C, except the southern part of Primorska (Koper station) 0.6 °C, compared to the reference period 1961-1990. The heat accumulation indices (GDD, HI) have increased significantly, which is mainly due to the increase in the maximum temperature in the growing season temperature (GST max) and the number of days with Tmax > 30°C (NDT30). The NDT30 increased the most, by a factor of more than four. In the reference period (1961–1990), however, the trend in the number of hot days was even slightly negative. The mean growing-season temperature rose to around 17°C in regions with a continental climate and to around 19°C in the Mediterranean part, which could be reflected in the earlier ripening of the grapes. The trends show a decrease in total annual precipitation (AP) after 1991, but this was significant only at one inland location (Maribor), while the total precipitation during the growing season (GSP) decreased significantly at three locations (Maribor, Bilje and Koper).

Keywords: climate change; bioclimatic parameters, wine-growing regions; Slovenia

Ecological Medicine and Biomedicine
Ekološka medicina i biomedicina

The role of the digital platforms in reducing vaccination in the (children's) population

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Abstract: Vaccination is a medical procedure that passively or actively increases immunity to infectious diseases. Statistics show a decreasing trend in the number of children vaccinated. Croatia experienced a pertussis outbreak in 2023 as the results of inadequate childhood vaccination. According to HZJZ data, 6,528 patients were registered, and the number of patients has increased compared to the pre-epidemic era. The decline in vaccination rates is linked to a succession of articles posted on the Internet, such as the assertion that vaccination causes autism or that it contains hazardous substances that cause negative effects. It is important to consider that digital platforms can influence the attitudes of parents regarding vaccination, such as forums, TikTok, Instagram or Facebook. An infodemic occurs when an excessive amount of information about a problem appears. This is especially dangerous in health care because the spread of rumors suppresses scientific facts. The Internet may be utilized to expand the population's knowledge by integrating experts on platforms and distributing educational content. Creating various applications might also be useful for tracking and recording immunization appointments. To conclude, it is necessary to educate the population, by using digital platforms, because media are the primary source of information nowadays.
Keywords: digital, children, infodemic, pertussis, vaccination

Nature-based therapy in disease prevention

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Abstract: The rapid changes in the world, technostress and the use of artificial elements as part of today's modern lifestyle are alienating people from nature, which is known to be an antidote to stress. Our intuitive tendency to seek connection with nature confirms this unbreakable relationship between humans and nature. Research has shown that psychiatric diagnoses are more common in urban than in rural areas, and spending time in nature during childhood has been shown to reduce the risk of mental disorders later in life. In particular, the presence of green and blue spaces close to home has been shown to reduce the occurrence of mental illness later in life. Spending time in nature also has a positive effect on mental health symptoms such as depression, anxiety, anger, confusion, vitality and anger, as well as lowering heart rate and blood pressure, and ultimately reducing the risk of cardiovascular and chronic diseases. Nature has also been linked to improved cognitive function, brain and body activity, as well as improved mood and sleep. Nature therapy and forest-based interventions such as forest bathing, urban green spaces and interactions with nature could have a positive impact on well-being, both hedonic and endaimonic well-being, as well as valuable interdisciplinary health outcomes such as alleviation, empowerment and restoration, leading to the complete physical, mental and social health of the individual.

Keywords: exposure, nature, forest bathing, therapy, health, disease

Ecology and Society
Ekologija i društvo

How can we all contribute to achieving the goals of the EU Mission "Restore Our Ocean and Waters"?

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Abstract: In September 2021, the European Commission launched five EU Missions: Restore Our Ocean and Watres, Soil, Climate Adaptation, Cities and Cancer. These Missions present new broad mobilisation initiatives to face the major challenges of our time and to deliver concrete results by 2030, and present the novelty of the Horizon Europe research and innovation programme for the years 2021-2027. The new approach of the EU Mission ``Restore our Ocean and Waters" addresses the ocean and waters as one, and plays a key role in achieving climate neutrality and restoring nature. With clearly defined and measurable targets by 2030, the Mission aims to protect and restore the health of our ocean and waters, not only through research and innovation, but also through citizen engagement and blue investments. This multidisciplinary approach with the inclusion of a wide spectrum of players presents a guarantee of success because the achievement of a given set of goals is only possible through joint action. Apart from important broad public mobilization and mutual engagement, the second main enabler is the digital ocean and water knowledge system, known as the Digital Twin Ocean (DTO). Here are presented these two main enablers, as well as the latest trends set out in the Manifesto for a European Ocean Pact that proposes a ground-breaking initiative aimed at catalyzing a transformative approach to ocean governance and sustainable economic development within the European Union.

Keywords: Digital Twin Ocean; Endorse Mission Charter, Europe, blue economy, nature protection

What does *Green* really mean? One word and many definitions

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Abstract: The word or term *green* in different circumstances, societies, cultures, political economies, the level of development of states and other aspects of life and work has different meanings. Therefore, the description of the term *green* as well as the term freedom, for which there are more than two hundred definitions, is not unambiguous but manifold, depending on the field of activity and the society to which it refers. Is the term *green* innovation more related to the economic or social aspect of human activities? Rather, we could say that it is related to the "and" with one and the other. Given that social goals are primarily oriented towards Man and his evaluation of lifestyles, they come into conflict with the global goals contained in the idea of permanent infinite growth as the only benchmark for success, which is contrary to the goals of caring for Man and nature. The third aspect of the word *green* can be associated with identity policies. And while the global concept encourages oneness, identity politics advocate developing community life that its members value, on beliefs that are often inconsistent with certain interpretations of the term *green*. Given that we cannot say that there is one, "true" definition because this would mean that the term becomes transcendent, the debate about the realization *of green* life on Earth should first of all begin with the questionability of the idea of infinite growth.
Keywords: green, society, profit, state, man

Što *Green* zapravo znači? Jedna riječ a mnogo definicija

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Sažetak: Riječ ili pojam *green* u različitim okolnostima, društvima, kulturama, političkim ekonomijama, stupnju razvijenosti država i drugim aspektima života i rada ima različita značenja. Stoga opis pojma *green* kao i pojma sloboda, za koji postoji više od dvjesto definicija, nije jednoznačan već mnogostruk, ovisno o području aktivnosti i društvu na koje se odnosi. Je li pojam *green* inovacija više povezana s ekonomskim ili socijalnim aspektom ljudskih aktivnosti? Prije bismo mogli reći da je povezan „i“ s jednim i s drugim. S obzirom da su socijalni ciljevi prije svega okrenuti prema čovjeku i njegovom vrednovanju načina života, oni dolaze u sukob sa globalnim ciljevima sadržanih u ideji trajnog beskonačnog rasta kao jedinog mjerila za uspjeh, što je u suprotnosti je s ciljevima brige o čovjeku i prirodi. Treći aspekt riječi *green* možemo povezati s identitetskim politikama. I dok globalni koncept potiče istovjetnost, identitetske politika zagovaraju razvijati život u zajednici koji njezini članovi vrednuju, na uvjerenjima koja su vro često u neskladu s pojedinim tumačenjima pojma *green*. S obzirom da ne možemo reći kako postoji jedna „istinska“ definicija, jer bi to značilo da pojam postaje transcendentan, raspravu o ostvarenju *green* života na Zemlji ponajprije treba započeti o upitnosti ideje beskonačnog rasta.
Ključne riječi: green, društvo, profit, država, čovjek

Nature and (Networked) Society

Ljiljana KENCEL, Barbara MARAS

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Abstract: The Student Dormitory Podmurvice Rijeka has an eco-school diamond certificate and systematically implements key educational activities related to development of environmental awareness and sustainable lifestyle through active citizenship. With the project NATURE AND (Networked) SOCIETY we wanted to raise awareness about the importance of preserving the environment and the impact on climate change and to promote outdoor living through safe and balanced use of social networks and digital tools. In this project we have included 300 students and employees of our Dormitory, the Association of Physically Disabled of the City of Rijeka, Children's Home "Tić" and Caritas Home for Women and Children Sv. Ana. In addition to workshops and lectures, we have designed an eco-leaflet and a video for students, employees and partners on the topics of climate change, digital transformation, creativity and outdoor living. By including our students and employees, people with fewer opportunities and the local community in the project, we educate environmentally conscious, socially sensitive and active young generations, while empowering them in the fight against climate change, enabling them to adopt healthy behaviors towards the environment in everyday life, motivate them to use social networks and digital tools responsibly and to apply the acquired knowledge in their communities.
Keywords: ecology, climate change, inclusion, digital literacy, active citizenship

Priroda i (umreženo) društvo

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Učenički dom Podmurvice Rijeka, Branka Blečića 3, Rijeka, Hrvatska

Sažetak: Učenički dom Podmurvice Rijeka ima dijamantni certifikat eko-doma te sustavno provodi ključne odgojno-obrazovne aktivnosti vezane uz razvoj ekološke osviještenosti i održivi način življenja kroz aktivno građanstvo. Projektom „PRIRODA I (umreženo) DRUŠTVO" nastojali smo postići veću svjesnosti o važnosti očuvanja okoliša i utjecaja na klimatske promjene te promovirati boravak na otvorenom kroz sigurno i uravnoteženo korištenje društvenih mreža i digitalnih alata. U projekt smo uključili 300 učenika i djelatnika Učeničkog doma, Društvo tjelesnih invalida grada Rijeke, Dječji dom "Tić" i Sv. Anu - Caritasov dom za žene i djecu. Osim radionica i predavanja, osmislili smo eko-letak i video uradak za učenike, djelatnike i partnere na temu klimatskih promjena, digitalne transformacije, kreativnosti i boravka na otvorenom prostoru. Uključivanjem naših učenika i djelatnka, osoba s manje mogućnosti i lokalne zajednice u projekt, odgajamo ekološki osviještene, socijalno osjetljive i aktivne mlade generacije, a pritom ih osnažujemo u borbi protiv klimatskih promjena, omogućujemo im da usvoje zdrava ponašanja prema okolišu u svakodnevnom životu, motiviramo ih da odgovorno koriste društvene mreže i digitalne alate te da stečena znanja primjene u svojim zajednicama.
Ključne riječi: ekologija, klimatske promjene, inkluzija, digitalna pismenost, aktivno građanstvo

ECOLOGY AND SOCIETY I *EKOLOGIJA I DRUŠTVO*
Oral presentation / *Usmeno priopćenje*

SMEs sustainability and transparency towards social welfare: where is the nexus and research gap?

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Abstract: Small and medium entities (SMEs) are unique agents of society towards a more resource-efficient green economy and social welfare, focusing on start-ups and innovations in waste management, recycling or making a social impact. Sustainability efforts and the enchanting of the SME's transparency are the drivers of the speed-up of SMEs' green transition, according to the European Commission SME strategy and EU Industrial Strategy. SMEs' sustainability disclosure and communication signal better access to finance under the InvestEU Programme, CSRD and CS3D. The paper employs a systematic review approach, using the SPAR methodology, to map the scientific landscape of SMEs' sustainability, transparency, and social welfare roles in the EU. We combine this with bibliometric analysis techniques to provide a comprehensive overview. Our analysis includes a description of key actions in SMEs' sustainability and transparency, their inter-relation with social welfare, a scholarly output, citation, authors' productivity, and topic cluster and gaps analysis of Scopus- and WoS-indexed publications. We utilize Scopus and WoS in-built tools, VOS Viewer, Biblioshiny, and Infranodus from 2013 to 2023. Results of the bibliometric mapping and review create a ground for eliminating the barriers to the SMEs' green transition towards sustainability practice, promoting transparent communication with stakeholders and socially oriented policy-making.

Keywords: social responsibility, sustainability, small and medium entities, transparency, welfare

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Application of environmental goals through project examples

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Abstract: Public Institution County Development Agency of Osijek-Baranja County (CDA OBC) was founded as a public institution with the role of a regional coordinator, with a special aim of providing effective coordination and enticing regional development in Osijek-Baranya County territory. The mission of CDA OBC is to create a development strategy, and other strategic and development documents for Osijek-Baranya County, as well as provide technical expertise in the preparation and implementation of support programs for public bodies and public institutions (they have to be founded by the Republic of Croatia or Osijek Barany County). Yet another role of CDA OBC is to prepare and implement development projects of interest for Osijek Barany County's prosperity, and especially projects co-financed by the European Structural and Investment (ESI) funds. In May 2022, the Eighth Environmental Action Program entered into force, which represents the EU's agreement on a joint environmental policy program until the end of 2030. This program supports and builds on the previous goals from the European Green Plan, including six priority goals: mitigation of climate change, adaptation to climate change, sustainable use and protection of water and marine resources, transition to a circular economy, prevention and control of pollution, and protection of biodiversity and ecosystems. Any investment, reform, or measure should follow the principle of "Do no significant harm" as part of all stated environmental objectives defined by the EU taxonomy and all measures under the EU taxonomy must absolutely meet the minimum criteria for each environmental objective.

Keywords: development strategy, environment, Osijek-Baranja County

Primjena okolišnih ciljeva kroz primjere projekata

Adela SADIKOVIĆ, Ivana KIŠĆINAL

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Sažetak: Javna ustanova Županijska razvojna agencija Osječko-baranjske županije (JU ŽRA OBŽ) osnovana je od strane Osječko-baranjske županije za obavljanje poslova regionalnog koordinatora s ciljem učinkovite koordinacije i poticanja regionalnog razvoja za područje Osječko-baranjske županije. Zadatak JU ŽRA OBŽ je izrada županijske razvojne strategije, drugih strateških i razvojnih dokumenata te pružanje stručne pomoći 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 (JU ŽRA OBŽ, 2024). U svibnju 2022. godine na snagu je stupio Osmi program djelovanja za okoliš, koji predstavlja dogovor EU-a o zajedničkom programu za politiku u području okoliša do kraja 2030. godine. Ovim programom podupiru se i nadograđuju dosadašnji ciljevi iz europskog zelenog plana, uključujući šest prioritetnih ciljeva: ublažavanje klimatskih promjena, prilagodba klimatskim promjenama, održiva upotreba i zaštita vodnih i morskih resursa, prijelaz na kružno gospodarstvo, sprečavanje i kontrola onečišćenja te zaštita bioraznolikosti i ekosustava. Svaka investicija, reforma ili mjera trebaju biti u skladu s načelom „Ne nanosi bitnu štetu“ u sklopu svih navedenih okolišnih ciljeva definiranih EU taksonomijom i sve mjere pod EU taksonomijom apsolutno moraju zadovoljiti minimalne kriterije za svaki okolišni cilj.
Ključne riječi: razvojna strategija, okoliš, Osječko-baranjska županija

Environmental Engineering
Inženjerstvo okoliša

Toxic impact of green concrete leachates to water plant *Lemna minor*

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Abstract: With many new materials that have appeared in recent decades, the emphasis is often on their potential of applicability and less on the environmental impact. Despite everything, both mechanical, physical, and chemical properties as well as environmental behaviour are the key factors in their acceptance, both by experts and the public. Green concrete, whose main purpose is to reduce the environmental impact of the production of cement and natural aggregates, which are key components for its production, further highlights the need for an ecotoxicological assessment of such material. They could come into contact with rain or surface water causing leaching of different components and affecting organisms in the ecosystem. Green concrete which contained wood waste biochar as partial cement replacement, and recycled PET plastic as partial natural aggregate replacement was used in this study. The main purpose of the research was to assess the toxicity of leachates from designed green concrete to floating water plant *Lemna minor*. *Lemna* (duckweed) growth inhibition test was performed according to OECD guidelines. It was exposed to different concentrations of green and conventional concrete leachates, which were prepared according to EN 12457-4. It was confirmed that biochar and PET plastic content had no effect or could even slightly increase the growth of duckweed compared to conventional concrete leachate. Experiments confirm, that both materials did not increase the hazardous characteristics of concrete and thus it can be reliably labeled as green material.

Keywords: ecotoxicology, green concrete, leachate, *Lemna minor*, waste

Carbon capture, utilization, and storage

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Abstract: Climate change, solely caused by human activities in recent decades, results in increasingly frequent extreme weather events. Europe is making significant efforts to mitigate the negative impact, with the Paris Agreement playing a crucial role. Member states committed to limiting the rise in average temperature to below 2 °C, with additional efforts to keep it within 1.5°C. Greenhouse gas emissions bear responsibility for the escalating climate change. The Paris Agreement sets a goal of zero greenhouse gas emissions by 2050. Industries face significant challenges in reducing emissions and decarbonization. According to the International Energy Agency, achieving climate goals will require capturing and storing 5.6 Gt CO_2 by 2050. The cement industry, due to its production methods and raw materials, must adopt innovative carbon capture and storage technologies. This paper will explore various carbon capture technologies, with a particular focus on Osijek-Baranja County.

Keywords: decarbonization, carbon capture, utilization, and storage, cement industry

Prikupljanje i skladištenje ugljikovog dioksida

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Sažetak: Klimatske promjene nastale isključivo ljudskim djelovanjem posljednjih desetljeća rezultiraju sve češćim ekstremnim vremenskim događajima. Europa ulaže velike napore kako bi se negativan utjecaj smanjio. Važnu ulogu u tome ima Pariški sporazum kojim su se države članice obvezale o ograničavanju porasta prosječne temperature na razini manjoj od 2 °C, te s dodatnim naporima za zadržavanje temperature na 1,5 °C. Odgovornost za rastuće klimatske promjene imaju emisiije stakleničkih plinova. Prema Pariškom sporazumu naveden je cilj nulte emisije stakleničkih plnova do 2050. godine. Velike izazove u procesu smanjenja emisija stakleničkih plinova i dekarbonizacije imaju industrije. Prema Međunarodnoj agenciji za energiju da bi se postigli klimatski ciljevi moralo bi se uhvatiti i skladištiti 5,6 Gt CO_2 do 2050. godine. Industrija cementa koja zbog svog načina proizvodnje i zbog same sirovine nema alternativu morati će primjeniti inovativne tehnologija prikupljanja i skladištenja ugljikovodika. U ovom radu prikazat će se različite tehnologije prikupljnja ugljikovog dioksida s posebnim osvrtom na Osječko-baranjsku županiju.

Ključne riječi: dekarbonizacija, prikupljanje i skladištenje ugljikovodika, industrija cementa

Environmental Impact and Assessment
Procjene utjecaja na okoliš

Projection of transport sector environmental impact in the European Union

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Abstract: Transport is one of the vital sectors of the EU economy. The transport sector includes road, rail, air and water modes that connect people, cultures, cities, countries, continents and boost the economy. However, the current transport mobility system, from a long-term perspective, is not sustainable. Shifting towards green transport modes is necessary to reduce transport impact on the environment, climate and human health. The transport sector is responsible for approximately a quarter of the EU's total greenhouse gas emissions. With the exception to fast-track increase, due to severe pandemic restrictions in 2020, the transport sector continues to grow from 2000 onwards. In 2019, the European Commission has adopted a package of policy initiatives, called the European Green Deal, to reduce greenhouse gas emissions by at least 55% by 2030, compared to 1990 levels. This paper analyses the impact of the transport sector in the European Union on the environment using the Eurostat data and IBM statistics software. The results present the environmental impact of the transport sector for the period 2010-2023 in the European Union, the comparison with European Green Deal objectives, and the projected environmental impact in the near future.
Keywords: environment; impact; projection; transport sector; European Union

The impact of air transport: An environmental perspective

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Abstract: Air transport provides the movement of passengers and cargo. It generates approximately 13 million jobs, carries around 1% of world trade-in volume, and represents over 35% of world trade-in value. Advantages of air transport include speed and efficiency, global connectivity, safety and reliability, covering long distances, delivering time-sensitive goods, etc. On the other hand, air transport is very expensive, weather-dependent, with limited accessibility, and negative impacts on the environment. Aircraft use fossil fuels which release emissions of carbon dioxide, nitrogen oxides, sulfur oxides, and other particulates into the atmosphere, causing significant air pollution. The European transport sector is responsible for about 25% of total carbon dioxide emissions, 14% of which come from air transport. The European Green Deal is a package of policy initiatives to reduce greenhouse gas emissions from all sectors, including air transport. The paper analyses the environmental impact of the air transport sector in the European Union using the available data and IBM statistics software. The results present the environmental impact of the air transport sector for the period 1990-2021 in the European Union and the projected environmental impact in the future.
Keywords: impact, air transport, environment

Environmental Protection and Energy Efficiency Fund investments in projects in protected areas

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Abstract: Abundant and diverse nature is one of Croatia's most valuable resources. Preserved nature is essential for providing all functions that are vital for life and economic development. From establishment, the Fund has been allocating significant resources to co-finance projects relevant to the Nature Protection Sector. Its co-finances the national component of EU projects, particularly investment in infrastructure aimed at protection, conservation and better natural heritage management. Of special importance are ecosystems and green infrastructure restoration projects, renewal of existing visitor infrastructure, strengthening the visitor management system in protected and ecological network areas, reducing tourism ecological footprint, increasing resilience to climate change in protected areas and Natura 2000 ecological network, and informing visitors about the importance of ecosystems conservation and climate goals. The Fund also co-finances the implementation of projects that contribute to priority invasive alien species (IAS) population control in areas defined according to the level of threat IAS pose to strictly protected species and ecological network nature protection areas, and the necessary urgency of action. The Fund is co-financing the implementation of over 50 projects worth more than EUR 90 million, of which EUR 65m are eligible costs and the Fund participates with over EUR 14m EUR.

Keywords: protected areas, green infrastructure, visitor infrastructure, invasive alien species (IAS)

Ulaganja Fonda za zaštitu okoliša i energetsku učinkovitost u projekte koji se provode u zaštićenim područjima

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Sažetak: Bogata i raznolika priroda jedan je od najvrjednijih resursa kojima raspolaže Republika Hrvatska. Očuvana priroda doprinosi osiguravanju svih funkcionalnosti neophodnih za život i ekonomski razvoj. Fond od svog osnutka izdvaja značajna sredstva za sufinanciranje projekata važnih za Sektor zaštite prirode. Sufinancira nacionalnu komponentu EU projekata, posebno ulaganje u infrastrukturu s ciljem zaštite i očuvanja i boljeg upravljanja prirodnom baštinom. Posebnu važnost imaju projekti restauracije ekosustava i zelene infrastrukture, obnova postojeće posjetiteljske infrastrukture i jačanje sustava upravljanja posjetiteljima zaštićenih područja i područja ekološke mreže u cilju povećanja sigurnosti i otpornosti turističke infrastrukture, smanjivanja ekološkog otiska posjećivanja, povećanju otpornosti na klimatske promjene u zaštićenim područjima i područjima ekološke mreže Natura 2000, povećanja kvalitete života i zdravlja ljudi te informiranja posjetitelja o važnosti očuvanih ekosustava i klimatskih ciljeva. Fond financira i provedbu projekata koji doprinose kontroli populacija prioritetnih invazivnih stranih vrsta (IAS) na određenim područjima koja su definirana uzevši u obzir razinu ugroženosti pojedinih strogo zaštićenih vrsta te područja ekološke mreže od strane IAS te neophodnu hitnost djelovanja. Fond sufinancira provedbu preko 50 projekata ukupnog iznosa investicije preko 90 mil EUR, odnosno 65 mil EUR opravdanih troškova od čega Fond sudjeluje sa više od 14 mil EUR.

Ključne riječi: zaštićena područja, zelena infrastruktura, posjetiteljska infrastruktura, invazivne strane vrste (IAS)

Geochemistry of elements and TOC in the sediments of the lower watercourse and estuary of the karst Cetina River

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Abstract: This study highlights the geochemistry of elements and TOC in the sediments of the lower watercourse and estuary of the Cetina River situated on the eastern Adriatic coast (Croatia). The spatial distribution of 28 geochemical elements and TOC in the sediments was analyzed by ICP-MS and described with multivariate statistical methods. The systemic analysis approach shows anthropogenic pressure on the lower watercourse and estuary of the Cetina River. According to PCA for elements and TOC in the sediments, PC1 describes combined lithogenic and anthropogenic influence, with a partial oxidative-reductive influence in terms of the content of Se and Mo. PC2 describes positive values that reflect the influence of seawater. Depending on the element composition, the factor values for PC1 and PC2 resulted in four different site groups. The second and the third group are most strongly influenced by the first component, the fourth group is under the influence of the second component, while the first group is under the combined influence of the first and second. The hierarchical cluster analysis showed two clusters concerning the content of the elements. The cluster analysis of all elements and TOC in sediments showed grouping in two clusters, where the first cluster consists of Ca and the second of TOC with other elements.
Keywords: elements, TOC, sediment quality, multivariate statistical analysis

Environmental Monitoring
Procjene utjecaja na okoliš

Spatial and temporal changes in cyanobacterial assemblages across the floodplain aquatic network identified by eDNA metabarcoding

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Abstract: Due to their potential negative impacts on aquatic ecosystems, identifying and quantifying cyanobacteria in freshwater ecosystems is essential for bioassessment programs. Consequently, spatial and temporal changes in benthic cyanobacteria in the Danube River and its associated floodplain area (Kopači Rit Nature Park) were investigated monthly in 2021 using 16S rRNA gene amplicon sequencing. Surface sediments were collected from the Danube, and its floodplain aquatic network, consisting of channels (Hulovo and Čonakut), and lakes (Kopačko and Sakadaš), with hydrological conditions fluctuating due to occasional flooding in February and during summer. A total of 13105 reads composed of 208 different cyanobacterial ASVs, of which 31.2% belonged to a core community shared among all aquatic biotopes. The lowest number of unique core ASVs was in the Danube River (9 ASVs), while the highest was in the lakes (34 ASVs). In the river, taxa affiliated with the genus *Nostoc* dominated in winter (56.5%), *Tychonema* in summer, and *Cyanobium* in early autumn (78.5%). The same genera significantly contributed to cyanobacterial abundance in the channels and lakes. The lakes displayed heterogeneity in diversity, with *Leptolyngbya* prevalent for several months, accompanied by *Cyanothece*, *Phormidiaceae*, and *Merismopedia*, highlighting the dynamic nature of cyanobacteria across different aquatic environments and seasons.

Keywords: phytobenthos; 16S rRNA; Danube floodplain system

Non-native benthic macroinvertebrates and biocontamination of Croatian large rivers

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Abstract: Non-native (alien) species are defined as those that have been intentionally or unintentionally introduced by humans, outside their past or present natural range and that have the potential to spread. Gradual replacement of native fauna by non-native macroinvertebrate species in large European rivers has been happening since the beginning of the 20th century. This work aimed to identify non-native species in Croatian large rivers: the Sava, Drava, Mura and Danube rivers. The level of biocontamination was also assessed. The research was conducted in the period 2015-2016 at 49 sampling stations, where benthic macroinvertebrates were sampled twice. A total of 22 non-native species were recorded, most of which were crustaceans and molluscs. Three non-native species were identified for the first time in Croatia. Of a total of 576,087 collected specimens, 41% were non-native, in most cases of Ponto-Caspian origin. Non-native species were not recorded at only 6 upstream stations (12.2%) in the Sava, the Drava and the Mura rivers. The lower reaches of the Sava and the Drava rivers, as well as the entire course of the Danube, exhibited high/severe biocontamination. This is the result of a high richness contamination index (proportion of non-native taxa) or/and a high abundance contamination index (proportion of non-native specimens).

Keywords: macrozoobenthos, non-indigenous species, biological pressure, Croatia

Strane vrste bentoskih makrobeskralješnjaka i biokontaminacija velikih rijeka u Hrvatskoj

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Sažetak: Strane (alohtone) vrste su one koje su ljudi namjerno ili nenamjerno unijeli izvan prirodnog područja rasprostranjenosti u prošlosti ili sadašnjosti i koje imaju potencijal širenja. Postupna zamjena autohtone faune bentoskih makrobeskralješnjaka (makrozoobentosa) stranim vrstama događa se u velikim europskim rijekama od početka 20. stoljeća. Cilj ovog rada bio je identificirati strane vrste u velikim hrvatskim rijekama: Savi, Dravi, Muri i Dunavu. Procijenjena je i razina biokontaminacije zajednica makrozoobentosa. Istraživanja su provedena u razdoblju od 2015. do 2016. godine na 49 postaja, pri čemu su bentoski makrobeskralješnjaci uzorkovani dva puta. Ukupno su zabilježene 22 strane vrste, s dominacijom rakova i mekušaca. Tri su strane vrste po prvi put zaaabilježene u Hrvatskoj. Od ukupno prikupljenih 576.087 jedinki, 41 % je bilo stranog, većinom ponto-kaspijskog podrijetla. Strane vrste nisu zabilježene na svega 6 najuzvodnijih postaja (12,2 %) u Savi, Dravi i Muri. Donji tokovi Save i Drave, kao i cijeli tok Dunava u Hrvatskoj, ukazivali su na veliku ili vrlo veliku biokontaminaciju koja je bila rezultat velikog udjela stranih vrsta i/ili velikog udjela jedinki stranog porijekla.

Ključne riječi: makrozoobentos, strane vrste, biološki pritisak, Hrvatska

Perceptions and cellular response to thermal stress in fish

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Abstract: Oceans play an important role in regulating global warming by absorbing heat and greenhouse gases, leading to imbalances in ocean ecosystems. Increased sea temperatures directly affect ectothermic fish, causing stress and negatively impacting growth and survival. Fish have developed various mechanisms for regulating body temperature and responding to thermal stress (heat shock response, HSR). The cellular response to thermal stress involves the production of heat shock proteins (HSP) to stabilize proteins and prevent coagulation. Protein transcription factors called heat shock factors (HSF) bind to heat shock elements in the promoter region of genes encoding HSPs. HSFs are activated via signaling pathways, including cascades activated by protein kinases that respond to changes in the cellular environment. Fish living in different thermal conditions have different responses to thermal stress. For example, Antarctic notothenioids have completely lost HSR, while species living in intertidal zones constantly induce HSP genes.

Ke words: global warming, fish, heat-shock response, heat-shock proteins

Microplastics in the environment – soil

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Abstract: Microplastics (MPs) is synthetic solid particles or polymer matrix, with dimensions of 1 µm – 5 mm. It can be found in various shapes, from regular to irregular. MPs have been detected almost everywhere in the environment, in waters, soil, and air, with reported damaging effects on living organisms. Although MPs can be removed at different stages at wastewater treatment plants (WWTP), 35-59% at the preliminary stage, 50-98% at the primary stage, 0.2-14% at the secondary stage, and 0.2-2% at the tertiary stage of treatments, still the significant amount of MPS remained in treated effluent enters water bodies. For removal of MPs different removal methods can be applied, such as microbial degradation, membrane filtration, magnetic extraction, adsorption, and biofiltration. Detection of MPs can be performed with different methods, and usually are applied multi-detection techniques since MPs exist in the range of colors, sizes, types of polymer, and structures, which complicates the detection. For counting and morphological analysis of MPs, the stereomicroscope is usually used, and for chemical characteristics of MPs, the most often methods are Raman spectroscopy and Fourier transform infrared spectroscopy. This study monitored the occurrence and characterization of MPs in the soil environment.

Keywords: microplastics, environment, soil

Cadmium (Cd) accumulation in selected tissues of hares (*Lepus europaeus* P.) from Croatia

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Abstract: Due to the anthropogenic effect, environmental pollution with heavy metals is increasing. Cadmium (Cd), as one of the pollutants, bioaccumulates in tissues and causes harmful health consequences. Wild animals such as hares (*Lepus europaeus* P.) are commonly used as bioindicators of environmental pollution with heavy metals. In this research, we analyzed cadmium concentrations in muscle, liver, kidney and fat tissue of hares from eastern (Osijek), central (Zagreb) and southern Croatia (Šibenik). In total, the tissues of 73 rabbits were analyzed. The average cadmium concentration with a range (µg/kg fresh weight) is 9.92 (0.84-92.99), 355.28 (7.68-2497.81), 3259.39 (93.48-25124.58) and 21.67 (0.48-361.52) in muscle, liver, kidney and fat tissue, retrospectively. There is a statistically significant difference ($p<0.01$) in the average cadmium concentration in the liver (545.83 µg/kg vs. 209.11 µg/kg) and kidney (5038.01 µg/kg vs. 1684.97 µg/kg) of hares from Šibenik and those from Osijek. Higher cadmium concentrations in tissues were recorded in females than in males, although the difference was not statistically significant. Analysis according to age groups (<1y, 1-2y, 2-3y and >3y) clearly indicates the cadmium accumulation in tissues, especially in the liver and kidney. Cadmium concentrations in muscle tissue are within the permissible levels, while 16.5% of liver samples and 70% of kidney samples exceed permissible levels.

Keywords: bioaccumulation, environmental pollution, heavy metals, *Lepus europaeus*, cadmium

Akumulacija kadmija (Cd) u odabranim tkivima zečeva (*Lepus europaeus* P.) s područja Hrvatske

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Sažetak: Zbog antropogenog učinka povećava se zagađenje okoliša teškim metalima. Kadmij (Cd), kao jedan od zagađivača, bioakumulira se u tkivima organizama i izaziva štetne posljedice za zdravlje. Divlje životinje poput zeca (*Lepus europaeus* P.) uobičajeno se koriste kao bioindikatori zagađenja okoliša teškim metalima. U ovom istraživanju analizirali smo koncentracije kadmija u mišićnom tkivu, jetri, bubregu i masnom tkivu zečeva s područja istočne (Osijek), središnje (Zagreb) i južne Hrvatske (Šibenik). Ukupno su analizirana tkiva 73 zeca. Prosječna vrijednost kadmija s rasponom (µg/kg svježe težine) iznosi 9,92 (0,84 - 92,99), 355,28 (7,68 - 2497,81), 3259,39 (93,48 - 25124,58) i 21,67 (0,48 - 361,52) u mišićnom tkivu, jetri, bubregu i masnom tkivu, retrospektivno. Statistički je značajna razlika ($p < 0,01$) u prosječnim koncentracijama kadmija u jetri (545,83 µg/kg vs. 209,11 µg/kg) i bubregu (5038,01 µg/kg vs. 1684,97 µg/kg) zečeva s područja Šibenika i onih s područja Osijeka. Više koncentracije kadmija u tkivima zabilježene su u ženki nego u mužjaka iako razlika nije statistički značajna. Analiza prema dobnim skupinama (<1 g, 1 – 2 g, 2 – 3 g i > 3 g) jasno ukazuje na akumulaciju kadmija u tkivima, pogotovo u jetri i bubregu. Koncentracije kadmija u mišićnom tkivu su u granicama dopuštenih razina dok 16,5 % uzoraka jetre i 70 % uzoraka bubrega prelaze dopuštene razine.
Ključne riječi: bioakumulacija, zagađenje okoliša, teški metali, *Lepus europaeus*, kadmij

Road traffic impact on stormwater quality

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Abstract: Urbanization and the construction of transport infrastructure have a significant impact on the environment. In addition to noise and vibration, stormwater runoff from roads contributes to considerable pollution. During precipitation, rainwater washes away pollutants from the roads, which are a byproduct of fossil fuel combustion in car engines. Research on the impact of roads on stormwater quality, conducted at various locations worldwide, shows that road runoff often contains elevated concentrations of inorganic nitrogen compounds, including nitrate (NO_3^-), nitrite (NO_2^-), and ammonium (NH_4^+), while organic nitrogen compounds are typically found in the composition of solid particles. High concentrations of phosphorus compounds—namely organic compounds in solid particles and inorganic orthophosphates—are also found in some road runoff. In terms of metal ions, scientific research has recorded the presence of arsenic (As), antimony (Sb), beryllium (Be), barium (Ba), cadmium (Cd), chromium (Cr), cobalt (Co), copper (Cu), iron (Fe), lead (Pb), selenium (Se), silver (Ag), and zinc (Zn) in rainwater. Polycyclic aromatic hydrocarbons (PAHs), which are mutagenic and carcinogenic, are included in the list of priority pollutants. The occurrence, type, and concentration of these pollutants depend on several factors, including the proximity of agricultural land, hydrological conditions, the intensity of agricultural activities, traffic levels, drainage capabilities, the duration of water retention on roads, climatic conditions, and the time of year. To reduce the harmful impact on the environment, it would be beneficial, where feasible (e.g., highways, tunnels), to collect rainwater from roads, periodically analyze it, and treat it using one of the alternative wastewater treatment methods before releasing it into the environment.
Keywords: road traffic, stormwater, environmental impact

Utjecaj cestovnog prometa na kvalitetu oborinskih voda

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Sažetak: Urbanizacija i izgradnja prometne infrastrukture imaju značajan utjecaj na okoliš. Osim buke i vibracija, značajno zagađenje dolazi od oborinskih voda uz cestu, koje tijekom oborina odnose nečistoće s cesta koje nastaju sagorijevanjem fosilnih goriva u motorima vozila. Istraživanja o utjecaju cesta na kvalitetu oborinskih voda provedena na nekoliko lokacija diljem svijeta pokazuju da oborinske vode s cesta često sadrže povišene koncentracije anorganskih spojeva dušika, odnosno nitrata (NO_3^-), nitrita (NO_2^-) i amonijaka (NH_4^+), dok se organski spojevi dušika najčešće nalaze u sastavu čvrstih čestica. Visoke koncentracije fosfornih spojeva, naime organskih spojeva u sastavu čvrstih čestica i anorganskih ortofosfata, također su zabilježene u nekim oborinskim vodama s cesta. Iz skupine metalnih iona, znanstvena istraživanja u oborinskim vodama bilježe prisutnost arsena (As), antimona (Sb), berilija (Be), barija (Ba), kadmija (Cd), kromi (Cr), kobalta (Co), bakra (Cu), željeza (Fe), olova (Pb), selena (Se), srebra (Ag) i cinka (Zn). Policiklički aromatski ugljikovodici (PAH), koji imaju mutageni i kancerogeni učinak, uključeni su na popis prioritetnih onečišćivača. Pojava, vrsta i koncentracija pesticida, kao i svih navedenih onečišćivača, ovise o nekoliko faktora, uključujući blizinu poljoprivrednih površina, hidrološke uvjete, intenzitet poljoprivrednih aktivnosti, intenzitet prometa, mogućnosti odvodnje, vrijeme zadržavanja vode na cestama, klimatske uvjete i doba godine. Kako bi se smanjio štetan utjecaj na okoliš, bilo bi poželjno, gdje tehnički uvjeti to dopuštaju (npr. autoceste, tuneli), prikupljati oborinsku vodu s cesta, povremeno je analizirati i prije puštanja u okoliš pročišćavati je nekim od alternativnih metoda za pročišćavanje otpadnih voda.
Ključne riječi: cestovni promet, oborinske vode, utjecaj na okoliš

Integration of advanced sensors in environmental protection

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Abstract The natural environment is the most valuable resource, and life on Earth cannot exist without it. Human interaction with the environment grows exponentially with the increase in the human population. Humans are the only species on Earth that can modify the environment to themselves to create suitable living conditions, which increases the need to regulate human activities for environmental protection. The concept of progress that considers environmental protection is called sustainable development. Unfortunately, even with the rising human consciousness regarding the importance of environmental protection, we are witnessing significant negative changes caused by human activities. Identifying the sources and causes of these changes is the most crucial step in eliminating negative environmental impacts. For many years, remote sensing and research methods have been used at global and local levels for this purpose. Through these methods, it is possible to detect activities that cause significant harm to the environment, human health, or both, encompassing various forms of pollution, wildlife habitat degradation, loss of biodiversity, and disruption of ecological balance. The use of modern technologies and sensors in the field of remote sensing allows the collecting detailed information that can be used to identify suspicious areas, monitor changes, detect pollution, map terrain, and more. There are several methods of data collection classified by sensor type, spatial resolution, and temporal component. The development of sensors and computers has enabled the development of new research and detection methods, as well as the combination of results obtained by individual sensors to achieve more reliable outcomes. This article presents the applicability of LiDAR, satellite imagery, aerial photogrammetry techniques, thermal and hyperspectral imagery, and their integration for the purpose of detecting and combating environmentally harmful activities.

Keywords: environmental protection, remote sensing, change detection

Integracija naprednih senzora u zaštiti okoliša

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Sažetak: Prirodni okoliš je najveće bogatstvo bez kojeg na Zemlji nije moguć život. Interakcija ljudi s okolišem eksponencijalno raste s porastom ljudske populacije. Ljudi su jedina vrsta na Zemlji koja okoliš prilagođava sebi kako bi stvorila pogodne uvjete za život što povećava potrebu reguliranja ljudskih djelatnosti radi zaštite okoliša. Koncept napretka koji uzima u obzir zaštitu okoliša naziva se održivi razvoj. Na žalost, usprkos sve većoj svijesti o potrebi zaštite okoliša, svjedoci smo značajnim negativnim promjenama uzrokovanim ljudskom djelatnošću. Otkrivanje izvora i uzroka promjena je najznačajniji korak u otklanjanju negativnih posljedica za okoliš. Već dugi niz godina se na globalnoj i lokalnim razinama u tu svrhu koriste metode daljinske izmjere i istraživanja. Pomoću njih je moguće otkriti aktivnosti koje uzrokuju značajnu štetu za okoliš, ljudsko zdravlje ili oboje, a obuhvaćaju razne oblike zagađenja, degradaciju staništa divljih životinja, smanjenje biološke raznolikosti i narušavanje ekološke ravnoteže. Korištenje suvremenih tehnologija i senzora iz domene daljinskih istraživanja omogućuje prikupljanje detaljnih informacija koje se mogu koristiti za identifikaciju sumnjivih područja, praćenje promjena, detekciju onečišćenja, mapiranje terena i dr. Dostupno je više metoda prikupljanja podataka klasificiranih prema vrsti senzora, prostornoj rezoluciji i vremenskoj komponenti. Razvoj senzora i računala omogućio je razvoj novih metoda istraživanja i detekcije kao i kombiniranje rezultata dobivenih pojedinim senzorima u svrhu ostvarivanja pouzdanijih rezultata. U ovom članku predstavljena je primjenjivost LiDAR-a, satelitskih snimki, aerofotogrametrijskih tehnika, termalnih i hiperspektralnih snimki te njihova integracija u svrhu otkrivanja i suzbijanja ekološki štetnih djelatnosti.

Ključne riječi: zaštita okoliša, daljinska istraživanja, detekcija promjena

Teaching for a Sustainable Future on Examples of the Swallow (*Hirundo rustica* L.) and Sand Martin (*Riparia riparia* L.) as Bioindicators

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Abstract: Local regional and national identity are difficult to define, but there are areas such as natural science, which in particular provide a number of options. By singling out the content on life proximity, the child is being introduced to the world of phenomena and processes that surround them. This paper starts from the prior knowledge and experiences resulting from the child's immediate environment, i.e. the milieu such as the family environment, its language, and local region. On the examples of the swallow (*Hirundo rustica* L.) and the sand martin (*Riparia riparia* L.) as bioindicators, children are being introduced to a sustainable future through games and learning through activities in nature, because a dramatic drop in the number of swallows and sand martins is caused by the destruction of their habitat, drying out of wetland areas, and the use of pesticides that kill insects, their main source of food.
Keywords*:* kindergarten teacher, natural science, project preparation

Integrated analysis of air pollution and meteorological conditions in Osijek and Slavonski Brod

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Abstract: Ozone, nitrogen oxides and particulate matter are the key indicators of air quality with potentially harmful impacts on human health and the environment. As a part of the air quality research in Osijek and Slavonski Brod, the goal was to analyze the key indicators of air pollution: ozone, nitrogen oxides and particulate matter. The data collected from the state air quality monitoring network during 2022 and 2023 enabled the analysis of the concentrations of these pollutants and their connection with the meteorological parameters to understand their distribution. The research results revealed seasonal variations in the concentrations of ozone, nitrogen oxides and particulate matter, with an emphasis on elevated ozone levels during the summer and higher concentrations of nitrogen oxides and particulate matter during the winter. In particular, the strong connection between nitrogen oxides and particulate matter is highlighted, which has important implications for public health, given their link to respiratory and cardiovascular diseases. The results of this research can provide useful guidelines for the development of strategies to reduce air pollution and improve the quality of the environment in Slavonia.

Keywords: ozone, nitrogen oxides, particulate matter, statistical analysis, air pollution

Integrirana analiza onečišćenja zraka i meteoroloških prilika u Osijeku i Slavonskom Brodu

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Sažetak: Ozon, dušikovi oksidi i lebdeće čestice ključni su indikatori kvalitete zraka s potencijalno štetnim utjecajima na ljudsko zdravlje i okoliš. U istraživanju kvalitete zraka u Osijeku i Slavonskom Brodu, cilj je bio analiza ključnih indikatora zagađenja zraka: ozona, dušikovih oksida i lebdećih čestica. Podaci prikupljeni iz državne mreže za praćenje kvalitete zraka tijekom 2022. i 2023. godine omogućili su analizu koncentracija tih zagađivača te njihovu povezanost s meteorološkim parametrima za razumijevanje njihove distribucije. Rezultati istraživanja otkrili su sezonske varijacije u koncentracijama ozona, dušikovih oksida i lebdećih čestica, s naglaskom na povišene razine ozona tijekom ljeta i više koncentracije dušikovih oksida i lebdećih čestica tijekom zime. Posebno je istaknuta snažna povezanost između dušikovih oksida i lebdećih čestica, što ima važne implikacije za javno zdravlje, s obzirom na njihovu vezu s respiratornim i kardiovaskularnim bolestima. Rezultati ovog istraživanja mogu pružiti korisne smjernice za razvoj strategija za smanjenje onečišćenja zraka i unaprjeđenje kvalitete životne sredine u Slavoniji.

Ključne riječi: ozon, dušikovi oksidi, lebdeće čestice, statistička analiza, zagađenje zraka

The Brown Marmorated Stink Bug (*Halyomorpha halys* Stål, 1855) as a vector of aflatoxigenic and ochratoxigenic fungi

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Abstract: The Brown Marmorated Stink Bug (*Halyomorpha halys*) is an invasive polyphagous species of stink bug. It was first recorded in Europe in 2004, and favorable climatic conditions enabled the rapid spread of the species to about ten countries, including Croatia in 2017. Adult bugs can be potential vectors for the transmission of mycotoxigenic fungi, which contaminate food and feed, causing harmful effects on human and animal health and significant economic losses in agriculture. This study aims to determine the potential of *H. halys* as a vector for fungal spores, with a focus on fungal species that produce aflatoxin B1 (AFB1) and ochratoxin A (OTA). During the summer of 2023, 100 *H. halys* individuals were collected in a test field in Osijek. The samples were washed with sterilized water, and the suspension was inoculated onto nutrient media and incubated for three days at 25 °C. Morphological identification and genotyping of 207 fungal samples using the beta-tubulin gene identified 13 fungal species. After transferring to media that induce mycotoxin production, thin-layer chromatography confirmed that 21 samples produced AFB1, while the presence of OTA was not confirmed in any sample.
Keywords: *Halyomorpha halys*, aflatoxin B1, ochratoxin A

Monitoring of glyphosate in surface waters

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Abstract: Glyphosate-based herbicides are the most widely used herbicides in the world due to their effectiveness in controlling a broad spectrum of weeds. Their intensive and growing application during the last few decades has generated an increase in glyphosate concentrations in the environment, including in surface water and groundwater. Glyphosate has been the subject of debate and controversy due to its potentially harmful effects on the environment and health. Scientific evidence has shown that it can have an adverse effect on aquatic organisms and water quality, so it is important to regularly monitor glyphosate in water. In this work, monitoring of glyphosate at the *Josip Juraj Strossmayer Water Institute* is presented. During 2023, a total of 374 water samples were collected at 35 monitoring sites in Croatia. The samples were analyzed by IC-MS/MS, and the limit of quantification was 0.01 µg/L. Glyphosate was found in 115 out of 374 samples (30.7%), at 20 out of 35 sites. In 22 samples (5.9%) at 9 sites, glyphosate concentrations exceeded 0.1 µg/L, the maximum permissible concentration for water intended for human consumption and for groundwater. The analysis of spatial and temporal variations of measured concentrations reveals that glyphosate was more present in water samples taken near agricultural and urban areas and that its concentration reached maxima in spring and autumn.

Keywords: herbicides; monitoring; water pollution

Monitoring fiber emissions during the textile tumble-drying process

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Abstract: The emissions of microfibers, released during and after the drying process, contaminate the household environment, posing a concern. Therefore, it is important to research and evaluate the negative influences of household tumble-drying on textiles and the environment and aim for development towards their reduction. The primary objective of this study was to analyze and evaluate fiber emissions throughout the entire process of textile drying using a tumble dryer, utilizing the principle of measuring differential pressure as outlined in EN 14683. The drying air containing released fibers from the textile ballast was sampled during the drying process and pumped through the measurement cell with a mounted borosilicate glass filter. The pressure differences before and after the filter were measured. To realize the monitoring fiber emissions, the following equipment was used: a household tumble dryer (with a capacity of 8 kg), a cotton ballast (4kg-6kg-8kg with an initial moisture content of 70%), measurement cell (top and bottom holder, borosilicate glass filter), differential pressure manometer, mass flowmeter (10L/min) and diaphragm air pump. The testing conditions met the Standards EN 60456 and EN 61121. From the results, it can be concluded that the pressure difference occurs barely in 5 min (4 kg ballast), 15 min (6 kg ballast) and 25 min (8 kg ballast) from the beginning of the drying process. This is followed by a slow increase in pressure differences when they reach their maximum after 90 min (4 kg ballast), 120 min (6 kg ballast) and 130 min (8 kg of ballast). It can be concluded that secondary fibers (residual fibers from previous dryings) begin to be eliminated first, and with gradual heating of the ballast, lowering the moisture content of the ballast and rubbing, primary fibers from the substrate begin to be released.

Keywords: household textiles, tumble-drying, microfibers, sustainable textiles

From planning to building: Biodiversity impact assessment for a Romanian highway project

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Abstract: The paper investigates the variation in species distribution associated with the construction of a 30 km highway in Argeș County, Romania. Spanning six months of pre-construction assessment and six months of construction period monitoring, this research encompasses data from all taxonomical groups, with a particular focus on species of conservation interest at the European level. Methodologies included field surveys, remote sensing, and GIS mapping to document baseline biodiversity and subsequent changes in the species distribution and abundance. Initial findings from the pre-construction phase indicated a diverse ecosystem with several species of high conservation value. The changes in species distribution were analyzed in relation to habitat fragmentation, noise pollution, and other construction-related disturbances. Our results highlight the critical impact of large infrastructure projects on local biodiversity, underscoring the importance of continuous environmental monitoring and mitigation measures. The study concludes with recommendations for enhancing conservation strategies to mitigate adverse effects on vulnerable species and to promote biodiversity conservation in future infrastructure developments.

Keywords: monitoring, biodiversity, highway

Can sample preparation for chromatographic analysis become "greener"?

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Abstract: Instrumental analyses, especially gas chromatography, require a specific sample preparation method for analyte extraction. Various solvents like n-hexane, dichloromethane, acetone, methanol, etc. are employed for extraction but are subsequently discarded, requiring proper storage. For example, to determine pesticides in water, by liquid-liquid extraction large volumes of solvents are used and the limiting factor of the number of prepared samples is the time used for sample preparation. A contemporary approach, solid phase extraction (SPE) on an automated extraction system, reduces solvent consumption by 50%. Another emerging method is µDrop, which consumes very small amount of the extraction solution and a small amount of water sample to be analyzed. Notably, µDrop facilitates the extraction of multiple analyte groups in a single preparation, a capability lacking in conventional methods which typically focus on extracting one group (e.g., pesticides) per extraction. The purpose of this paper is to demonstrate the significant reduction in solvent usage for sample preparation in chromatographic analysis through modern methods. Considering these advantages, it's evident that µDrop represents a more environmentally friendly option compared to traditional techniques, owing to its reduced solvent usage and enhanced analytical efficiency.
Keywords: chromatography, water, sample preparation, µDrop

Može li priprema uzoraka za kromatografske analize postati "zelenija"?

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Sažetak: Instrumentalne analize, naročito plinska kromatografija, zahtijevaju određeni način pripreme uzoraka kojim se analiti od interesa ekstrahiraju. Za ekstrakciju se koriste različita otapala (n-heksan, diklormetan, aceton, metanol...) koja se nakon ekstrakcije odbacuju te ih je potrebno skladištiti na odgovarajući način. Na primjer, za analizu pesticida u vodama, ekstrakcijom tekuće-tekuće koriste se veliki volumeni otapala, a ograničavajući faktor broja pripremljenih uzoraka je i vrijeme utrošeno za pripremu uzoraka. Moderniji pristup pripremi uzoraka je ekstrakcija čvrstom fazom (SPE – "solid phase extraction") na automatiziranom sustavu za ekstrakciju kojom se utrošak otapala smanjuje za 50 %. Relativno nova metoda za pripremu uzoraka je µDrop kojom se troši znatno manja količina otopine za ekstrakciju i mala količina uzorka vode koji se analizira. Prednost µDrop-a je također što se u jednoj pripremi ekstrahira više skupina analita, dok je kod prethodno navedenih metoda iz jedne ekstrakcije moguće ekstrahirati samo jednu skupinu analita (npr. pesticidi). Cilj ovog rada je prikazati da se modernim metodama pripreme uzoraka za kromatografske analize može uvelike smanjiti količina otapala koja se koristi za pripremu uzoraka. Uzimajući u obzir sve navedeno, može se reći da je µDrop "zelenija" i ekološki prihvatljivija tehnika u odnosu na prethodno navedene.

Ključne riječi: kromatografija, voda, priprema uzoraka, µDrop

Environmental Regulations and Laws
Okolišno pravo i zakonska regulativa

Legal framework for organic food: Maintaining integrity and transparency in food production

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Abstract: Organic food has become extremely popular due to the growing awareness of health and environmental protection. Legal regulation plays a key role in ensuring the transparency, safety and integrity of these products. However, the lack of a consistent definition of organic food, the complexity of certification processes and the unevenness of supervision and transparency represent the main challenges. Organic food is defined as food produced without synthetic chemicals and GMOs, with at least 95% organic ingredients. Historically, all food was organic until the 20th century, but in the last decade, the organic food market has experienced significant growth, which further emphasizes the importance of uniform legal regulation. Within the European Union, a strict system of control and enforcement ensures compliance with organic production rules. Each member state appoints control bodies that supervise subjects in the ecological food chain. In Croatia, the Ministry of Agriculture leads this control, issuing certificates after inspections that confirm compliance with organic production standards. Regulation (EU) 2018/848, which entered into force in 2022, provides the legal framework for organic production and labeling. This regulation establishes stricter rules for controls and ensures equal standards for imported organic products. The organic food certification process includes application, inspection, adjustment period, issuing of certificates and regular inspections. The certificate enables producers to use the EU logo for organic products, ensuring a unique visual identity and consumer trust. The main challenges include a lack of consistency among member states, complexity of certification, administrative burdens, and costs. Solutions such as harmonization of standards, simplification of certification procedures, digitization and increased transparency through educational campaigns are key to maintaining integrity and trust in organic nutrition.

Keywords: organic food, certification, supervision, transparency, consumer trust

ENVIRONMENTAL REGULATIONS AND LAWS I *OKOLIŠNO PRAVO I ZAKONSKA REGULATIVA*
Oral presentation / *Usmeno priopćenje*

Zakonski okvir organske prehrane: Održavanje integriteta i transparentnosti u proizvodnji hrane

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Sažetak: Organska hrana postaje sve traženija zbog porasta svijesti o zdravlju i očuvanju okoliša. Pravna regulacija igra ključnu ulogu u osiguravanju transparentnosti, sigurnosti i integriteta ovih proizvoda. Međutim, nedostatak dosljedne definicije organske hrane, složenost certifikacijskih procesa te neujednačenost nadzora i transparentnosti predstavljaju glavne izazove. Organska hrana definira se kao hrana proizvedena bez umjetnih kemikalija i GMO-a, s najmanje 95 % ekoloških sastojaka. Povijesno gledano, sva hrana je bila organska do 20. stoljeća, no u posljednjem desetljeću tržište organske hrane doživjelo je značajan rast, što dodatno naglašava važnost ujednačene pravne regulacije. Unutar Europske unije, strogi sustav kontrole i provedbe osigurava poštivanje pravila organske proizvodnje. Svaka država članica imenuje kontrolna tijela koja nadziru subjekte u ekološkom lancu prehrane. U Hrvatskoj, Ministarstvo poljoprivrede vodi ovu kontrolu, izdajući certifikate nakon inspekcija koje potvrđuju zadovoljenje standarda ekološke proizvodnje. Uredba (EU) 2018/848, koja je stupila na snagu 2022. godine, pruža pravni okvir za organsku proizvodnju i označavanje. Ova uredba donosi stroža pravila za kontrole i osigurava jednake standarde za uvezene ekološke proizvode. Proces certificiranja organske hrane uključuje prijavu, inspekciju, period prilagodbe, izdavanje certifikata i redovite nadzore. Certifikat omogućava proizvođačima korištenje EU logotipa za organske proizvode, osiguravajući jedinstveni vizualni identitet i povjerenje potrošača. Glavni izazovi uključuju nedostatak dosljednosti među državama članicama, kompleksnost certificiranja, administrativna opterećenja i troškove. Rješenja poput harmonizacije standarda, pojednostavljenja postupaka certificiranja, digitalizacije i povećanja transparentnosti kroz edukativne kampanje ključni su za održavanje integriteta i povjerenja u organsku prehranu.

Ključne riječi: organska hrana, certificiranje, nadzor, transparentnost, povjerenje potrošača

Light pollution: The path to cleaner skies through legal regulation

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Abstract: Light pollution, as defined by the Law on Protection against Light Pollution, represents a change in natural night light due to emission from artificial sources. This phenomenon has harmful consequences for human health, traffic safety, ecosystems and wildlife, disrupts astronomical observations, and consumes energy, disrupting the natural balance and beauty of the night landscape. Light pollution includes four main types: light pollution, light shock, light intrusion and light clutter. Within the European Union, although there is no specific regulation that exclusively deals with light pollution, various directives and standards, such as the Directive on ecological design and the Directive on the energy efficiency of buildings, indirectly contribute to its reduction. Standards such as EN 13201 and EN 12464-2 provide guidelines for controlling lighting systems, reducing upward emissions and directing light to required areas. In Croatia, the Law on Protection from Light Pollution and by-laws precisely define the technical requirements for lighting, prohibit the unnecessary use of light beams, and obligate the supervision of the State Inspectorate and municipal wardens. Local initiatives, such as the programs "Zvezdarnica Zagreb" and "Rijeka – Zvijezdano nebo", actively promote the use of energy-efficient lighting fixtures and the reduction of light pollution. Recommended measures include technical innovation, legal regulations, and public education to achieve significant energy savings and reduce the negative effects of light pollution. Alignment with EU regulations will enable an effective solution to this global problem, contributing to the preservation of the environment and human health.
Keywords: light pollution, environmental protection, public education, international standards

Svjetlosno onečišćenje: Put prema čistijem nebu kroz pravnu regulaciju

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Sažetak: Svjetlosno onečišćenje, kako je definirano Zakonom o zaštiti od svjetlosnog onečišćenja, predstavlja promjenu prirodne noćne svjetlosti zbog emisije iz umjetnih izvora. Ova pojava ima štetne posljedice po ljudsko zdravlje, sigurnost u prometu, ekosustave i divlje životinje, remeti astronomska opažanja i troši energiju, narušavajući prirodnu ravnotežu i ljepotu noćnog krajobraza. Svjetlosno onečišćenje obuhvaća četiri glavne vrste: svjetlosno zagađenje, svjetlosni tres, svjetlosni upad i svjetlosni nered. Unutar Europske unije, iako ne postoji specifična regulativa koja se isključivo bavi svjetlosnim onečišćenjem, razne direktive i standardi, poput Direktive o ekološkom dizajnu i Direktive o energetskoj učinkovitosti zgrada, neizravno pridonose njegovom smanjenju. Standardi poput EN 13201 i EN 12464-2 pružaju smjernice za kontrolu rasvjetnih sustava, smanjujući emisije prema gore i usmjeravajući svjetlost na potrebna područja. U Hrvatskoj, Zakon o zaštiti od svjetlosnog onečišćenja i podzakonski akti precizno definiraju tehničke zahtjeve za rasvjetu, zabrane nepotrebne upotrebe svjetlosnih snopova i obvezuju nadzor Državnog inspektorata i komunalnih redara. Lokalne inicijative, poput programa "Zvjezdarnica Zagreb" i "Rijeka – Zvijezdano nebo", aktivno promoviraju korištenje energetski učinkovitih rasvjetnih tijela i smanjenje svjetlosnog onečišćenja. Preporučene mjere uključuju tehničke inovacije, pravne regulative i edukaciju javnosti kako bi se postigla značajna ušteda energije i smanjenje negativnih učinaka svjetlosnog onečišćenja. Usklađivanje s regulativama EU omogućit će učinkovito rješavanje ovog globalnog problema, doprinoseći očuvanju okoliša i zdravlju ljudi.

Ključne riječi: svjetlosno onečišćenje. zaštita okoliša, edukacija javnosti, međunarodni standardi

Historical overview of Croatian water protection legislation

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Abstract: The Water Framework Directive, as a leading water law document, is obligatory for all members of the European Union, making water protection and monitoring in all member states more organized, efficient, and comparable. Croatia, as other member states, had to implement a Directive in its legislation. Extended water monitoring started in Croatia in the middle of the 20th century, and has been developing ever since, as knowledge of the environment, the development of methods and instruments advanced through time. Even before the official date of membership, in 2013, Croatia started implementing WFD, expanding water protection measures to a higher level using making biological indicators based on developing environmental law structure. Ensuring that there is enough water to support wildlife at the same time as human needs WFD applies to inland, transitional and coastal surface waters as well as groundwaters, considering individual differences and specificity thus making all of these water bodies more visible and protected in a better way than before (in Croatia all waters were legally regarded the same despite differences between them). Considering that over 1/3 of river basin districts are cross-border, and one of WFD's main purposes is integrated water protection, it is necessary to develop good connections and joint water samplings with neighboring countries. Croatia is a member of ICPDR (International Commission for the Protection of the Danube River) and International Sava River Basin Commission, but is also developing stronger bonds with neighboring countries by forming subcommissions (Slovenia, Hungary).

Keywords: legislation, Water Framework Directive, monitoring

Forestry and Urban Forestry
Šumarstvo i urbano šumarstvo

Ginkgo Tree's Fallen Yellow Leaves: Green Waste or Source of Bioactive Compounds?

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Abstract: Ginkgo (*Ginkgo biloba* L.), an ornamental tree prevalent in urban parks globally, exhibits varying heights from 20 up to 50 meters, accompanied by diameters spanning from 50 centimeters to 5 meters. Recognized for its characteristic foliage, transitioning from green to yellow before shedding in autumn, the ginkgo tree contributes significantly to the accumulation of what is commonly termed as park green waste. Ginkgo green leaves are well known in traditional and modern medicine, but yellow leaves are not used for pharmaceutical preparations. This study endeavors to assess fallen ginkgo leaves as a prospective reservoir of bioactive compounds. We conducted analyses encompassing the quantification of total polyphenols, total flavonoids, total phenolic acids, individual biflavonoids (amentoflavone, bilobetin, ginkgetin, isoginkgetin, sciadopitisyin), carotenoids, and chlorophylls in yellow ginkgo leaves before and after detachment from the tree. Our findings indicate that fallen yellow ginkgo leaves harbor noteworthy concentrations of bioactive compounds, particularly biflavonoids, which hold promise for the treatment of neurodegenerative, metabolic, and oncological conditions. Furthermore, these leaves present a cost-effective and easily accessible reservoir of such compounds. Future research endeavors should prioritize the optimization of biflavonoid extraction methodologies from fallen ginkgo leaves, aiming to enhance their potential utilization as a source of bioactive compounds.
Keywords: ginkgo, green waste, bioflavonoids, bioactive compounds

Green Arhitecture and Construction
Zelena arhitektura i gradnja

Building composites based on brick waste

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Abstract: Construction waste is generated in the production of building materials, in the construction of structures and buildings, and in the recovery/recycling/removal of existing buildings. The problem of disposal and disposal in the environment creates big problems both in terms of pollution and in terms of occupying significant and high-quality space where people live and stay. Finding new possibilities for recycling existing material into products that can find their new application is extremely topical. This paper emphasizes the production of concrete/mortar without cement. The basis for making the binder is crushed brick waste in combination with an alkaline activator made from a KOH solution and a water glass solution (Na_2SiO_3) in a ratio of 1:2.5. The test results show that it is possible to produce concrete/mortar entirely from waste material and without cement, which significantly contributes to waste disposal and reduces the amount of CO_2 emitted into the environment.

Keywords: construction waste, recycling, alkaline activator, concrete without cement, water glass

Propagation of the EM wave through traditionally constructed objects

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Abstract*:* In this paper, the electromagnetic potential of traditional buildings is analyzed from the point of view of protection against EM radiation. Measurements of S parameters (transmission and reflection) during the propagation of EM waves through the walls of residential buildings built with traditional construction were carried out in the frequency range from 30 MHz to 18 GHz. The objects built from wood-rammed earth, raw bricks with the addition of straw (*cro.*cerpic) and baked bricks (as a reference) were examined. During the measurement, the thickness, humidity and temperature of the walls and the environment were controlled. Based on measurements carried out on traditionally built buildings, it was determined that buildings made of rammed earth and raw bricks with the addition of straw significantly reduce the transmission (level of propagation parameters) of EM wave energy through them concerning buildings made of wood as well as buildings made of baked bricks, while the level of reflection parameters does not change significantly. Furthermore, the increase in moisture content and the thickness of the building walls significantly reduce the levels of transmission parameters. In the future, this research will be extended to all traditionally built buildings.
Keywords: electromagnetic shielding, raw brick, rammed earth, transmission parameter, reflection parameter

The impact of data on climate conditions on buildings' energy efficiency assessment

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Abstract: The assessment of the mutual impact between the environment and the buildings considers the impact of the outside climate conditions on the required net energy consumption and energy performance improvement to achieve sustainable construction. The Energy Performance of a Building (EPB) standard EN ISO 52016-1 proposes the methods for calculating the energy needs for heating and cooling based on the environmental load. It includes a preliminary analysis of climate parameters and external and internal temperatures with sensible and latent heat loads. The proposed standard enables the choice of time intervals for calculating energy performance at the national level between hourly, monthly, seasonal, and annual. Most frequently, one of the monthly or hourly calculation procedures is applied. While the monthly calculation method contains statistical correction or correlation factors for the dynamic effects, the hourly method can directly calculate dynamic interactions. Consequently, the choice of time interval also refers to the used set of climate data, which usually contains monthly average values and daily weather variations or is a reference year with hourly parameter values. The paper aims to determine to what extent different selections of climate data sets time intervals can affect sustainable building energy performance calculation.
Keywords: buildings, energy efficiency, environmental impact, climatic data, calculation method

Green Chemistry and Chemical Engineering
Zelena kemija i kemijsko inženjerstvo

Deep eutectic solvents as promising green solvents in lipase-catalyzed organic reactions

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Abstract: Deep eutectic solvents (DES) are a new type of environmentally green solvents composed of a hydrogen bond donor (HBD) mixed with a hydrogen bond acceptor (HBA) in a certain molar ratio. Compared with conventional organic solvents DESs have more advantages such as non-toxicity, negligible vapor pressure, biodegradability, recyclability, non-flammability, good chemical and thermal stability, and low price. Therefore, they are considered today as environmentally benign alternatives to hazardous volatile organic solvents and might replace them in part. An increasing number of scientific researchers use DESs as green solvents in biotransformations. Lipases from different sources have been investigated for their hydrolytic as well as synthetic activity. Since it was established that lipases can be active in non-aqueous solvents, their roles as biocatalysts in various organic reactions in DESs have been investigated. In this context, it seems very promising to develop a lipase-compatible DESs from inexpensive and biodegradable salts. This paper discusses the achievements that have been made so far in the use of DESs as organic reaction media for lipase-catalyzed reactions. Some of these organic reactions are transesterification, esterification, hydrolysis, Henry reaction (nitro-aldol reaction), epoxidation, amidation, oxidation, and others.

Keywords: green chemistry, deep eutectic solvents, lipase-catalyzed reactions

High-Entropy Oxide–Driven Enhancement of Ceria's Photocatalytic CO_2 Hydrogenation: Synergy of Experiment and DFT Simulations

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Abstract: Herein, we investigate the potential of nanostructured high–entropy oxides (HEOs) for photocatalytic CO_2 hydrogenation, a process with significant implications for environmental sustainability and energy production. Several cerium–oxide–based rare–earth HEOs with fluorite structures were prepared for UV–light–driven photocatalytic CO_2 hydrogenation towards valuable fuels and petrochemical precursors. The cationic composition profoundly influences the selectivity and activity of the HEOs, where the $Ce_{0.2}Zr_{0.2}La_{0.2}Nd_{0.2}Sm_{0.2}O_{2-\delta}$ catalyst showed outstanding CO_2 activation (14.4 mol_{CO} kg_{cat}^{-1} h^{-1} and 1.27 mol_{CH3OH} $kg_{cat}^{-1}h^{-1}$) and high methanol and CO selectivity (7.84% CH_3OH and 89.26% CO) at ambient conditions with 4–times better performance in comparison to pristine CeO_2. Systematic tests showed the effect of a high–entropy system compared to mid–entropy oxides. XPS, *in–situ* DRIFTS as well as DFT calculation elucidate the synergistic impact of Ce, Zr, La, Nd, and Sm, resulting in an optimal Ce^{3+}/Ce^{4+} ratio. The observed formate–routed mechanism and a surface with high affinity to CO_2 reduction offer insights into the photocatalytic enhancement. While our findings lay a solid foundation, further research is needed to optimize these catalysts and expand their applications.

Keywords: high–entropy oxides; photocatalytic CO_2 hydrogenation; selectivity; DFT

Use of renewable raw materials in the production of active pharmaceutical ingredients (APIs)

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Abstract: Active pharmaceutical ingredients (APIs) constitute a significant and growing market. In recent decades, high production costs as well as stricter environmental regulations in developed countries impose the need to change old synthetic processes and design new ones that are in line with the principles of green chemistry. A focus on the principles of green chemistry can help developed environmentally friendly and sustainable processes that meet the environmental and safety regulations. A big problem in the production of APIs is the generation of a large amount of waste, which is best seen from the E factor (kilograms of waste per kilogram of product), which for some compounds is over 200. Another big problem is that most APIs contain benzene ring that are most easily accessible through petrochemical sources. Biomass is a promising renewable feedstock for the synthesis of various chemicals. Lignin, the second most prevalent component of plant biomass fills several criteria for a desirable fossil resource substitute through its abundance, renewability, and carbon neutrality. Scientific research shows that lignin can serve as a raw material for obtaining phenol and catechol, which can be converted into bulk pharmaceuticals such as paracetamol, acetylsalicylic acid, and amoxicillin.
Keywords: green chemistry, active pharmaceutical ingredients, biomass, lignin

Green concrete: Reuse of waste biomass and recycled PET plastic

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Abstract: The development of new materials in the last decades caused major changes. The demand for them significantly increased over the years, but at the same time, a problem arose when these materials after their lifespan became waste. Plastic waste presents an environmental issue in terms of collection and recycling management. The packaging industry accompanied by food industry is heavily dependent on plastic, especially PET. The increased environmental impact of the food industry is a response to the ever-increasing need for food production due to the growth of the world population resulting in the intensification of agricultural activities and an increasing amount of biomass wastes, which present the main feedstock for the production of biochar by thermochemical conversion. Biochar could be used as a soil supplement, but it also has the potential to be used as a cement replacement in concrete. To reduce greenhouse gas emissions, natural resources consumption, and amount of waste the main purpose of our research was to determine the properties of concrete containing a mixture of biochar and recycled PET. XRD analysis and SEM were used for determination of morphological and crystallographic structure of concretes. The results showed the mechanical properties of composites containing a mixture of recycled PET plastic and biochar were comparable to plain concrete and have great potential as a solution regarding increased need for raw material in concrete production and the increasing amount of waste in packaging industry.

Keywords: biomass waste, climate change mitigation, green concrete, recycled PET plastic, waste reduction

Green Biotechnology
Zelena biotehnologija

GREEN BIOTECHNOLOGY I *ZELENA BIOTEHNOLOGIJA*
Oral presentation / *Usmeno priopćenje*

Upcycling processing side streams from the food industry

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Abstract: Food resources are limited while the global food demand increases. At the same time, food and nutrients are lost along the food value chains. It is estimated that 1/3 of all food is lost, accounting for 6% of the greenhouse gas emission. Additionally, valuable non-food resources, rich in nutrients, are overlooked. Adopting a circular economy approach, these resources can be repurposed as food ingredients. This presentation will explore emerging green food processing techniques to optimize side streams, prioritizing eco-friendly methods that minimize chemical use, high temperatures and consumption of scarce natural resources. Nutrient-rich components such as proteins, lipids, and carbohydrates can be utilized for food or dietary supplements. Specifically, omega-3 oils show promise for microencapsulation, with proteins from food side streams serving as suitable wall materials. Additionally, proteins can be utilized as a basis for protein hydrolysates or gelatine, offering diverse applications in food production.

Keywords: green biotechnology, circular economy, food science, sustainability, food resources

Vegetable waste bioplastics as sustainable packaging

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Abstract: The excessive use of conventional petrochemical plastics and their resistance to decomposition has led to a significant problem, contributing to landfill overflows and water pollution due to their sheer mass. From the point of view of ecological sustainability, bioplastics are an ideal alternative to petrochemical plastics. Bioplastics has many advantages over conventional plastics, including biodegradability, reduced carbon footprint, energy efficiency, versatility, characteristic mechanical and thermal properties, and social acceptance. This literature review investigates the potential of vegetable waste as a bioplastic material for sustainable packaging. Many vegetable wastes contain biopolymers such as polysaccharides, i.e., starch, cellulose, and proteins such as gluten, making them suitable for bioplastics production. Due to the profitability of vegetable waste and its wide availability, its use as a primary source for bioplastics is increasing. The food processing industry receives vegetable waste that is rich in biopolymers. Its use in bioplastics production brings a double benefit by reducing plastic and agricultural waste and promoting environmental sustainability. Bioplastics are a significant innovation that stimulates the transition from fossil fuels to bio-based products and a circular economy.

Keywords: vegetable waste, biopolymers, bioplastics, sustainable packaging, waste reduction

GREEN BIOTECHNOLOGY | *ZELENA BIOTEHNOLOGIJA*
Poster presentation / *Postersko priopćenje*

The role of spermidine in increasing the energy potential of microalgae

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Abstract: This study investigates the benefits of using spermidine to enhance photosynthetic efficiency and stress resistance in freshwater green algae *Desmodesmus communis*. The algae were cultivated under nitrogen deficiency (1% N) and increased salinity (7.5 PSU), both alone and combined, with and without spermidine (1 mM) in the nutrient medium. The results showed that nitrogen deficiency significantly reduced photosynthetic efficiency indices, maximum quantum yield, and pigment content by 95%, total carbohydrates, proteins, and lipids by 50%, resulting in reduced biomass (0.124 g DW L^{-1} alone; 0.184 mg DW L^{-1} N def with salinity). Increased salinity alone caused smaller reductions in pigment content (19%), photosynthetic efficiency, and total carbohydrates (30%), resulting in a lower biomass reduction to 0.306 g DW L^{-1} compared to the control (0.377 g DW L^{-1}). As expected, the algae accumulated significant amounts of starch under nitrogen deficiency (up to 54% w/w), while elevated salinity increased lipid content (up to 26% w/w) and lipid peroxidation products. Spermidine alone increased lipids, pigments, and biomass by 30, 43, and 16%, respectively. Under nitrogen deficiency with spermidine, pigment content fully recovered and increased under elevated salinity with spermidine. Maximum photosynthetic efficiency also recovered, resulting in increased biomass yield. However, starch and lipid contents decreased or remained the same. Spermidine mitigated nutrient stress, allowing alternative water sources for algae cultivation in larger quantities, thereby enhancing the sustainability of third-generation biofuel production.
Keywords: *Desmodesmus communis*, spermidine, chlorophyll fluorescence, nutrient deficiency, salinity

Possible ways of fisheries by-catch disposal by its' inclusion into a circular economy

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Abstract: Globally, it is estimated that between 7 and 10 million tons of commercial fisheries catch is discarded annually. Discarding constitutes a substantial waste of resources and negatively affects the sustainable exploitation of marine biological resources and the financial viability of fisheries. The levels of discards vary across regions, and there are different reasons for discarding: the fish is smaller than the legal size, the fisherman does not have a quota for it, the fish is of low market value or damaged, or it is prohibited to catch that species. Croatia currently has no long-term solutions to this issue, except for one company that disposes of this waste, there are no innovations, and so-called by-products of category 3 i.e. fish that must not be used for human consumption, go for processing in some other countries from which new products are created. The various purposes of organisms in the by-catch are determined by their technological potential, which is assessed by the general chemical composition, as well as the biological value of proteins, lipids, etc. Most often, by-catch is used in the production of livestock and fish feed, fertilizers, serve as raw materials to produce biofuels and biogas, to obtain chitin and collagen, or become ingredients in human nutrition. This paper presents the latest trends and possibilities of the disposal of fishing by-catch and by-products created during fish processing.

Keywords: unwanted catch, animal by-products, fisheries waste

Mogući načini zbrinjavanja ribolovnog prilova uključivanjem u kružna ekonomija

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Sažetak: Globalno se procjenjuje da se godišnje odbaci između 7 i 10 milijuna tona ulova komercijalnog ribolova, što predstavlja značajno rasipanje resursa i negativno utječe na održivo iskorištavanje morskih bioloških resursa i financijsku održivost ribarstva. Količine prilova razlikuju se po regijama, a različiti su razlozi za odbacivanje: riba je manja od minimalne lovne veličine, ribar nema kvotu za nju, riba je niske tržišne vrijednosti, oštećena je ili je zabranjen ulov te vrste. Hrvatska trenutno nema dugoročnih rješenja po tom pitanju, osim jedne tvrtke koja zbrinjava ovaj otpad, nema inovacija, a tzv. nusproizvodi kategorije 3, odnosno riba koja se ne smije koristiti za ljudsku prehranu odlazi i prerađuje u nekim drugim zemljama. Različite namjene organizama u prilovu određene su njihovim tehnološkim potencijalom koji se procjenjuje općim kemijskim sastavom, kao i biološkom vrijednošću proteina, lipida itd. Najčešće se prilov koristi u proizvodnji hrane za stoku i ribe, gnojiva, služi kao sirovina za proizvodnju biogoriva i bioplina, za dobivanje hitina i kolagena ili postaje sastojak ljudske prehrane. U ovom radu su prikazani najnoviji trendovi i mogućnosti zbrinjavanja prilova i nusproizvoda nastalih tijekom prerade ribe.
Ključne riječi: neželjeni ulov, životinjski nus-proizvodi, otpad ribarstva

Polymerization of apigenin catalysed by horseradish peroxidase and laccase in a batch and microreactor

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Abstract: Flavonoids are widely distributed secondary metabolites in plants known for their diverse biological activities, including antioxidant, anti-inflammatory and anti-cancer properties. Apigenin, one of the most abundant flavonoids in foods and plants, has attracted considerable attention due to its potential therapeutic benefits, including its anti-cancer activity. However, its limited bioavailability and stability restrict its application in medicine and the food industry. In this context, the enzymatic polymerization of apigenin to biflavonoids and polyflavonoids represents a promising strategy that could improve the pharmacological properties of this flavonoid. In this study, three enzymes, laccases from *Aspergillus sp*. and *Trametes versicolor* and horseradish peroxidase, were used to synthesize biflavonoids and polyapigenin to discover the new bioactive compounds. The reaction was conducted in a biocompatible buffer/ethanol mixture under mild conditions in a batch reactor (V = 50 mL) and a microreactor (V = 273.15 µL). Similar conversions (≈ 45%) were obtained in a much shorter time when the reaction was carried out in the microreactor. Fourier transform infrared spectroscopy (FTIR) was used to analyze the specific chemical groups of the resulting product, poly(apigenin), while HPLC-DAD analysis was used to identify and quantify the biflavonoids produced. In the final step, the biological activity of the products obtained was tested.
Keywords: apigenin, laccase, horseradish peroxidase, polymerization

Green Economy
Zelena ekonomija

Polymerization of apigenin catalysed by horseradish peroxidase and laccase in a batch and microreactor

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Abstract: Flavonoids are widely distributed secondary metabolites in plants known for their diverse biological activities, including antioxidant, anti-inflammatory and anti-cancer properties. Apigenin, one of the most abundant flavonoids in foods and plants, has attracted considerable attention due to its potential therapeutic benefits, including its anti-cancer activity. However, its limited bioavailability and stability restrict its application in medicine and the food industry. In this context, the enzymatic polymerization of apigenin to biflavonoids and polyflavonoids represents a promising strategy that could improve the pharmacological properties of this flavonoid. In this study, three enzymes, laccases from *Aspergillus sp*. and *Trametes versicolor* and horseradish peroxidase, were used to synthesize biflavonoids and polyapigenin to discover the new bioactive compounds. The reaction was conducted in a biocompatible buffer/ethanol mixture under mild conditions in a batch reactor (V = 50 mL) and a microreactor (V = 273.15 µL). Similar conversions (≈ 45%) were obtained in a much shorter time when the reaction was carried out in the microreactor. Fourier transform infrared spectroscopy (FTIR) was used to analyze the specific chemical groups of the resulting product, poly(apigenin), while HPLC-DAD analysis was used to identify and quantify the biflavonoids produced. In the final step, the biological activity of the products obtained was tested.
Keywords: apigenin, laccase, horseradish peroxidase, polymerization

GREEN ECONOMY I *ZELENA EKONOMIJA*
Oral presentation / *Usmeno priopćenje*

Complexity of carbon capture, utilization and storage technologies in Hungary

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Abstract: Global climate change has been one of the most serious questions for decades. To offset its consequences, global cooperation and complex perspectives are needed. Especially in the case of emerging green technologies since they are characterized by a high degree of uncertainty. Including social science aspects in natural science innovations can contribute to their successful application. To mitigate climate change and to achieve the set goals, it is necessary to switch from the conventional fossil-based economy to low-carbon, even zero-carbon energy systems. As there is no one-size-fits-all solution, a wide range of different technologies are needed. Carbon capture, utilization, and storage (CCU/S) technologies may serve as the only solution to reduce emissions in key sectors where other alternatives are not economically favorable. Moreover, in line with the circular carbon economy model, it is more expedient to consider CO2 as a resource rather than waste. However, besides the technological side, we need to consider the stakeholders, to do so, we conducted primary research to understand their attitude. In Hungary, significant emission reduction could be achieved with a relatively small number of stakeholders as there are a few big emitters in the country.

Keywords: carbon capture, carbon utilization, carbon storage, CCUS technologies, survey

Economic analysis of carbon capture and utilization technologies

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Abstract: Global climate change demands global cooperation and multifaceted solutions, especially in the realm of emerging green technologies. Carbon capture and utilization (CCU) technologies are crucial for reducing emissions in sectors where other alternatives are not economically favorable. These technologies are gaining prominence in the European Union due to their strategic value. For these technologies to spread widely, alongside the necessary developments for practical implementation, the conditions for economic feasibility must be defined. Given their lower technology readiness level and our limited experience with them, traditional cost-benefit analyses require significant adjustments for CCU technologies. Techno-economic analysis (TEA) has become essential for assessing their economic feasibility, integrating financial costs, potential revenue, environmental impacts, and technological challenges. During analysis, specific factors like industrial structure, infrastructure, and regulations are considered. This ensures the effective integration of CCU technologies to reduce carbon dioxide emissions and reach sustainability goals. Such analyses drive technological innovation, facilitate the transition to a greener economy, and promote economic growth and environmental sustainability. This techno-economic perspective highlights the strategic importance of CCU technologies to sustainability and EU compliance. Our research highlights the strategic importance of CCU technologies, aiming to inform the professional community about their economic potential and application.
Keywords: carbon capture and utilization, techno-economic analysis, sustainability

Green Education
Ekološko obrazovanje

Sustainability education: a multidisciplinary field of study

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Abstract: The importance of education for environmental sustainability is fundamental in any course of study, regardless of the educational objectives. With this paper, we would like to present the establishment of the course 'Ecology in Artistic Design' within the higher education program at the University of Dubrovnik. The innovation of the course is that waste materials are recycled and not reused. There are many examples of artists using waste to create artworks, but few where the waste is actually recycled, i.e. transformed into new materials that can then be used. In our region, mollusk farming is increasing due to tourist demand and the growing need for fish restaurants, and with it the waste from aquaculture, especially mussel shells. This type of waste, as well as paper and plastic, is recycled in the course. During the course, students learn not only the importance of recycling but also the importance of the circular economy by being involved in producing small souvenirs used by our University as gifts for guests at conferences and meetings. Multidisciplinary is ensured by the choice of course teachers: a chemist, a wood technologist, but also an artist and a restorer.

Keywords: education, recycling, multidisciplinary

Citizen science in the mosquito monitoring educational project

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Abstract: Citizen science is the act of involving the public in scientific research to enhance our understanding of the world based on scientific evidence. The term "citizen science" emerged in the 1990s and has subsequently gained popularity, typically being linked to the concept of open science. Primary school Juraj Dobrila Rovinj (Croatia) collaborated with the Institute of Public Health of the Istrian County (NZZJZIŽ) to participate in a mosquito monitoring educational project. The project took place from May to October 2023. The pupils of the school received education from the experts of the NZZJZIŽ regarding mosquitoes and the diseases they carry, as well as strategies to decrease their population in the environment. Throughout the project's execution, the pupils placed oviposition traps for mosquitoes at designated sites, which were then sent bi-monthly to NZZJZIŽ for analysis. According to the statistics, the highest number of mosquito eggs were found in Bale, followed by Rovinj, and the lowest number in the suburban region of Rovinj and Rovinjsko Selo. In September, the largest quantity of mosquito eggs was gathered, with somewhat smaller amounts in August and October, while the smallest quantity was seen in July and June. Through the implementation of the educational project, the pupils became aware of the early detection of invasive mosquitoes and the possibilities of their participation in projects of mosquito control measures within the framework of citizen science.
Keywords: citizen science, educational project, mosquito monitoring, primary school pupils

GREEN EDUCATION I *EKOLOŠKO OBRAZOVANJE*
Oral presentation / *Usmeno priopćenje*

Strategic dialogue-based models in higher education to meet society's need for more sustainable food systems

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Abstract: Transforming the food systems is crucial for delivering on UN's 17 Sustainable Development Goals and higher education may play an important role in this transformation. This presentation shares an education concept where students and educators interact with relevant stakeholders in the food systems like food businesses, policymakers, citizens, and experts on other disciplines necessary for food transformation. The adopted methodology guarantees a holistic approach implemented through different dialogue arenas: digital classrooms with policymakers, co-creation workshops with regional food actors and guest lecturers from the student's future work life. This presentation describes the applied dialogue-based models and discusses the potential of these models, and the degree of success by comparing the planned learning outcome for the students with their perception of it. The main finding is that our students experience that they are better prepared to fulfill their role in implementing sustainability in the food sector.
Keywords: green education, food policy, systems approach, sustainability, higher education

A Biodiverse School Garden for the Coexistence of Man and Nature

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Abstract: Biodiversity is essential for life, and its loss and the climate crisis are interdependent and worsening. One of the responses of the Maksimir Dormitory in its efforts to increase its sustainability and reduce its carbon footprint is the planting of a biodiverse garden whose primary goal was to create an "urban green oasis" for urban wildlife as a precondition for mitigating the consequences of climate change and thereby creating a space for students to live and learn outdoor in harmony with nature, that is, a space for the coexistence of man and nature. Students, participate in activities that include planting and caring for the garden, making and setting up habitats for insects and animals, designing students' living space, learning about biodiversity and the impact of their behavior on the environment, and following the progress and effects of the garden reduces their feeling of helplessness in facing the climate crisis. The paper shows how the journey from an empty backyard to a biodiverse urban garden took place in several key elements: planting trees and a pollinator garden, mowing in the "let it grow" style, attracting and caring for the garden's inhabitants; birds, insects and hedgehogs and the use of natural materials and upcycling in decoration.

Keywords: biodiversity, climate change, sustainability, school garden, urban wildlife

Bioraznoliki domski vrt za suživot čovjeka i prirode

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Sažetak: Bioraznolikost je neophodna za život, a njen gubitak i klimatska kriza međuovisni su i međusobno se pogoršavaju. Jedan od odgovora Učeničkog doma Maksimir u nastojanjima da poveća svoju održivost i smanji ugljični otisak je sadnja bioraznolikog vrta čiji je primarni cilj bio kreirati „urbanu zelenu oazu“ za gradske životinjske vrste kao preduvjeta za ublažavanje posljedica klimatskih promjena i time stvoriti prostor za boravak i učenje na otvorenom u skladu s prirodom odnosno prostor za suživot čovjeka i prirode. Učenici, sudjelujući u aktivnostima koja uključuju sadnju i brigu o vrtu, izradu i postavljanje nastambi za kukce i životinje, uređenje prostora za boravak učenika, uče o bioraznolikosti i utjecaju svojeg ponašanja na okoliš, a prateći napredak i učinke vrta smanjuje se njihov osjećaj bespomoćnosti u suočavanju s klimatskom krizom. Rad prikazuje kako je tekao put od praznog stražnjeg dvorišta do bioraznolikog urbanog vrta u nekoliko ključnih elemenata: sadnja stabala i vrta za oprašivače, način košnje u stilu „let it grow“, privlačenje i briga o stanovnicima vrta; pticama, kukcima i ježevima te upotreba prirodnih materijala i ponovne upotrebe u uređenju.
Ključne riječi: bioraznolikost, klimatske promjene, održivost, školski vrt, urbana fauna

Incorporating sustainability principles in driving instructor education: Perspectives from first and second-grade students

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Abstract: The imperative of sustainable development within educational frameworks has garnered significant attention, particularly in fields directly impacting societal well-being. In Norway, aspiring driving instructors must complete a two-year education program at Nord University. The curriculum includes social sciences, physics, law, and pedagogy. This presentation explores the attitudes of 200 students, comprising equal numbers from first and second grades of driving instructor education, regarding the integration of sustainability principles into their curriculum. The study aims to discern the perceived importance of such inclusion from the standpoint of future driving instructors, who are poised to play a pivotal role in encouraging responsible road user behavior. Preliminary findings suggest a strong preference among students towards embracing sustainability as a core component of their education, reflecting a broader recognition of its relevance in shaping a safer and greener driving culture in Norway. The presentation will delve into the implications of these attitudes for curriculum development and the potential ripple effects on road safety and environmental stewardship. The discussion is anchored in the broader context of sustainable development's impact on society. Driver instructors meet all coming drivers. The potential influence of their environmental focus will therefore be huge, which again will benefit society.
Keywords: higher education, green education**,** curriculum, driver instructors, environmental impact.

Interdisciplinary STEM workshops with an emphasis on green energy, green chemistry and biodiversity

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Abstract: Interdisciplinary teaching approaches are essential for modern education and instruction, especially for STEM subjects. Project-Based Learning (PBL) in STEM subjects, with an emphasis on interdisciplinarity (iSTEM), has been implemented as part of the establishment of the Regional Science Center of Panonian Croatia (RZC PAN HR). Josip Juraj Strossmayer University of Osijek and the School of Applied Mathematics and Informatics (FPMI), as partners on the project, have designed and organized iSTEM workshops aimed at developing the skills and competencies of elementary school teachers for implementing interdisciplinary PBL (iPBL) and teaching (potentially) gifted and highly motivated students. The specificity of the iSTEM workshops lies in the collaborative work of teachers from nearly all STEM subjects, who, by selecting themes/problems from real life and incorporating learning outcomes from all STEM subjects, highlight the necessity of knowledge and curricular integration of concepts from different fields in problem-solving. The focus is on creating a product/service/application that enables improvement or enhancement of the current state or is an innovation. In this contribution, there will be showcase examples of project tasks, with an emphasis on topics such as Green Chemistry (OKEM), Green Energy (OFIZ), Biodiversity (OBIO), and Quantities and Their Relationships (FPMI), which are interdisciplinary in nature. The topics were chosen to cover global sustainable development goals and goals according to the European Green Plan, all with the aim of acquiring knowledge and skills and developing 21st-century competencies.

Keywords: iSTEM, iPBL, sustainable, teaching, giftedness

GREEN EDUCATION I *EKOLOŠKO OBRAZOVANJE*
Oral presentation / *Usmeno priopćenje*

Interdisciplinarne STEM radionice s naglaskom na zelenu energiju, zelenu kemiju i bioraznolikost

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Sažetak: Interdisciplinarni pristup poučavanju je nužnost suvremenog poučavanja i nastave, naročito STEM predmeta. Projektno orijentirana nastava (PBL) STEM predmeta, s naglaskom na interdisciplinarnost (iSTEM), primijenila se u sklopu projekta uspostave regionalnog znanstvenog centra Panonske Hrvatske (RZC PAN HR). Sveučilište Josipa Jurja Strossmayera u Osijeku (OBIO, OKEM, OFIZ), i Fakultet primijenjene matematike i informatike (FPMI), kao partneri na projektu, osmislili su i organizirali iSTEM radionice s ciljem razvijanja vještina i kompetencija učitelja OŠ za provedbu interdisciplinarne PBL (iPBL) nastave i poučavanje (potencijalno) darovitih i visokomotiviranih učenika. Specifičnost iSTEM radionica je u timskom radu učitelja skoro svih STEM predmeta, koji izborom teme/problema iz stvarnog života, i uključivanjem ishoda učenja svih STEM predmeta, ukazuju na nužnost potrebnog znanja i kurikularnog povezivanja koncepata različitih područja u rješavanju problema, s naglaskom na izradu nekog proizvoda/usluge/aplikacije koja omogućuje poboljšanje ili unapređenje trenutnog stanja ili je pak inovacija. Kroz izlaganje će se prikazati primjeri projektnih zadataka, s naglaskom na teme Zelena Kemija (OKEM), Zelena energija (OFIZ), Bioraznolikost (OBIO), i Veličine i njihove veze (FPMI) koje su interdisciplinarnog karaktera. Teme su izabrane kako bi pokrile globalne ciljeve održivog razvoja i ciljeve prema Europskom zelenom planu, a sve u svrhu usvajanja znanja i vještina te razvijanju kompetencija 21. stoljeća.
Ključne riječi: iSTEM, iPBL, održivost, poučavanje, darovitost

Education for sustainable development in inclusion

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Abstract: Education for Sustainable Development in Inclusion is an elective course enrolled by students attending the 1st year of the University Undergraduate Study of Educational Rehabilitation at the Faculty of Education, Josip Juraj Strossmayer University in Osijek. This course aims to train students to carry out environmental activities with children with developmental disabilities. In addition to acquiring ecological terms, the development of ecological science and the implementation of ecological content in inclusive programs, certain fundamental principles of nature protection and the meaning of education for sustainable development are introduced to the students. During the course, students integrate the practical knowledge and skills following ecological laws, to apply these in practice. Students design, implement and evaluate activities aimed at protecting nature in inclusive education. The goal of the course is to train students to prepare and implement activities for children with developmental disabilities, focusing on the protection of natural values and a sustainable lifestyle, as well as to apply various didactic-methodical means. In the course of two academic years (2022/23 and 2023/24), the course was attended by more than a hundred students, and classes were held, apart from the faculty premises, in the partner institutions: Podravlje Education and Visitor Center (Forest House "Podravlje", Hrvatske šume) and in the Shellfish Museum ("Permanent Exhibition of the Aquatic World", Gloria Maris Association). During their education, students develop values such as equality, respect and acceptance of diversity, which are a prerequisite for overall human development, so that they can pass them on to future generations in their further life and work.
Keywords: education and sustainable development, inclusion, educational rehabilitation

Odgoj za održivi razvoj u inkluziji

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Sažetak: Odgoj za održivi razvoj u inkluziji izborni je kolegij kojega upisuju studenti koji pohađaju 1. godinu Sveučilišnog prijediplomskog studija Edukacijska rehabilitacija na Fakultetu za odgojne i obrazovne znanosti Sveučilišta Josipa Jurja Strossmayera u Osijeku. Cilj je ovoga kolegija osposobiti studente za provođenje ekoloških aktivnosti s djecom s teškoćama u razvoju. Uz usvajanje ekoloških pojmova, razvoja ekološke znanosti i implementacije ekoloških sadržaja u inkluzivne programe, studenti se upoznaju i s temeljnim načelima zaštite prirode i značenjem odgoja i obrazovanja za održivi razvoj. Studenti u okviru kolegija integriraju praktična znanja i vještine slijedeći ekološke zakonitosti koje će moći primijeniti u praksi. Osmišljavaju, provode i vrednuju aktivnosti usmjerene na zaštitu prirode u inkluzivnom odgoju i obrazovanju. Cilj je kolegija osposobiti studente za pripremanje i provođenje aktivnosti za djecu s teškoćama u razvoju usmjerenih na zaštitu prirodnih vrijednosti i održivi način života, kao i pri tome primjenjivati različita didaktičko-metodička sredstva. Tijekom dvije akademske godine (2022./23. i 2023./24.) kolegij je pohađalo više od sto studenata, a nastava je realizirana, osim na fakultetu, i u suradničkim ustanovama: Edukacijsko-posjetiteljskom centru Podravlje (Šumska kuća „Podravlje“, Hrvatske šume) i u Muzeju školjkaša („Stalna izložba vodenog svijeta“, Udruga Gloria Maris). Studenti tijekom obrazovanja razvijaju vrijednosti poput jednakopravnosti, uvažavanja i prihvaćanja različitosti, a koje su preduvjet sveukupnog razvoja čovjeka, kako bi ih u daljnjem životu i radu mogli prenijeti generacijama koje dolaze.

Ključne riječi: odgoj i obrazovanja ze održivi razvoj, inkluzija, edukacijska rehabilitacija

Promoting mental health through ecological awareness among high school students

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Abstract: The Lovran Student Dormitory implements a comprehensive ecological awareness program to enhance students' mental well-being and promote sustainability. Key initiatives include waste sorting, nurturing a Mediterranean garden, monitoring water and energy consumption, reusing rainwater, and engaging in composting. Students also participate in redesigning old furniture using eco-friendly materials and utilizing garden-grown vegetables in the kitchen, which is especially beneficial for those studying culinary arts. The student cooperative teaches eco-friendly entrepreneurship skills, and educational workshops emphasize sustainable living practices. These activities foster a sense of responsibility towards the environment, reduce mental health issues, and equip students with practical skills for a sustainable future. Exploring the connection between ecological awareness and mental health, the program demonstrates how sustainable practices can significantly enhance psychological well-being. Themes such as eco-anxiety, eco-therapy, and the impact of personal lifestyle choices on mental health are examined. By integrating ecological principles into daily life, students experience reduced stress and increased resilience. This holistic approach highlights the importance of fostering sustainable habits and environmental caretaking in educational settings, ultimately contributing to the overall well-being and mental health of students.
Keywords: ecological awareness, mental health, sustainable living, student engagement, environmental education

GreenTechnologies
Zelene tehnologije

Green Technology and Advanced Pretreatment for Sustainable Valorization of Fruit and Vegetable By-Products

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Abstract: The integration of green drying technology in combination with advanced pretreatment methods such as ultrasound is a promising approach for the valorization of fruit and vegetable by-products. Green technology offers innovative approaches to adapt these principles and transform agricultural waste into valuable resources. Green technology, complemented by ultrasonic pretreatment, enables the extraction and preservation of beneficial compounds, paving the way for their incorporation into various food and non-food applications. From antioxidant-rich extracts to fibers, fruit and vegetable by-products offer versatile solutions for the production of sustainable and health-promoting products. In this work, the use of advanced pretreatment method (sonication), increases the efficiency of upgrading processes when utilizing pumpkin by-products. Ultrasonic pretreatment facilitates the degradation of cell structures, which increases the accessibility of bioactive compounds (carotenoids) and enhances extraction yields. In addition, ultrasonic pre-treatment prior to microwave hot air drying of pumpkin by-products contributes to a further improvement in sustainability. By optimizing the drying parameters, these methods reduce processing time and energy consumption while maintaining the quality and nutritional value of the final products.

Keywords: by-products, ultrasound, microwave-hot air drying
Acknowledgments: The work was supported by the Croatian Science Foundation (research project "Hybrid drying and valorization of plant food waste and by-products" IP-2019-04-9750) - HYDRYBY.

TECCO® cell for shore protection against erosion: A comparative assessment of the potential for CO_2-footprint reduction of a new type of engineered solution

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Abstract: Rising sea levels and ocean water temperatures are mostly due to the emission of greenhouse gas (GHG) as CO_2, caused by anthropic activities. The detrimental effects of this action have inflicted consequences for many coastlines around the world in the form of erosion and risks of floods. Several shorelines in Europe are subject to erosion; approximately 2,300 km of Great Britain's shorelines are artificially protected. For many other countries in Europe with long shorelines, such as Norway, Greece, Italy, Croatia, and Denmark (including Greenland), etc., wave erosion and artificial protection against it, is and will remain a major issue for local communities, politicians, researchers, and planners. Nevertheless, protecting the shoreline by utilizing coastal defenses and preventing erosion is not always suitable and taking a sustainable approach in finding a fit solution with a minimum carbon footprint is mandatory. The purpose of this study is to portray how one shore protection solution provides a more sustainable approach in comparison to traditional solutions such as rock armor or concrete revetments. A new type of specially engineered solution, i.e. an array of high tensile stainless-steel mesh cells filled with locally sourced blocks, stones, or pebbles called TECCO® cell is presented. Using a qualitative comparison of CO_2 footprints based on literature, data, and a case study in Beesands, UK at the project appraisal stage shows low carbon emissions of TECCO® cell.

Keywords: coastal erosion protection, sustainability, CO_2 emission reduction, TECCO® cell, greenhouse gases

Limonene and carvone as green corrosion inhibitors for steel protection in hydrochloric acid solution

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Abstract: Most stainless steels will corrode in a hydrochloric acid environment because their chromium content is not sufficient to form a protective passive layer. When this passive layer is missing, the steel begins to corrode actively. One of the ways to protect steel from corrosion in aqueous acid solutions is the application of corrosion inhibitors. Green corrosion inhibitors are natural compounds, usually, plant extracts that contain different chemical components that have oxygen, sulphur and nitrogen atoms in their structure as the main carriers of adsorption centers. They are natural antioxidants, cheap and do not harm the environment. Therefore, the aim of this work was to examine the inhibitory effect of limonene and carvone on the corrosion of steel in a 10% hydrochloric acid solution, as well as their synergistic effect. Steel corrosion rates were determined in a 10% hydrochloric acid solution without and with the addition of certain concentrations of limonene and carvone ethanol solutions, gravimetrically using the mass loss method, while corrosion currents were determined using the potentiodynamic polarization method. To confirm the action of these inhibitors, measurements of the surface roughness of the steel samples (14NiCr14) were carried out, while the steel surfaces were recorded with an optical electron microscope.
Keywords: carvone, corrosion, limonene, inhibitors, steel

Environmental sustainability and innovation ecosystems in EU member states

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Abstract: Environmental issues have been at the heart of the policy agenda in the EU and its Member States at least for the last decade. They are part of the strategic political as well as social objectives of resilience and future growth of both the EU and its Member States as well as their economies. Related to the abovementioned, support to innovation is one of the focal areas of specific strategic development, with a focus on digitization and information technology as leading characteristics of the current sixth wave of innovation development. In light of the above, this paper will link the study of the highlighted leading growth ecosystems and examine whether and how environmental sustainability and the level of innovation development of each country are linked in the EU Member States. To this end, we will use multiple regression to test how the innovation-related independent variables 1) digitization; 2) use of information technology; and 3) innovators affect the dependent variable of environmental sustainability, as measured by the EU Innovation Scoreboard (European Commission 2023). According to the conducted literature review and analysis of the main EU policy documents we will assume that there is a high positive correlation between the variables under study, as well as a positive correlation between the environmental sustainability variable itself and the innovation index of each EU Member State. The findings will provide valuable insights for the design of possible future policy actions by countries to promote entrepreneurial initiatives in the highlighted areas of environmental sustainability and innovation in EU Member States.

Keywords: environmental sustainability, information technology, digitalization, innovation

Application of high hydrostatic pressure pre-treatments for vacuum drying of pumpkin pulp and peel

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Abstract: Drying can lead to irreversible physical and chemical changes in food, affecting its nutritional value and sensory quality. The prevention of food damage and the selection of suitable drying processes that require low energy consumption are top priorities in food processing worldwide. Novel non-thermal technologies such as pulsed electric fields, high pressure, ultrasound and microwaves have proven to be promising techniques for improved drying. These technologies can be used as pre-treatment to improve the drying procedure, extend the shelf life of food products and preserve their nutritional and bioactive properties. The present work aimed to describe the application of high hydrostatic pressure (HHP) as a pre-treatment for vacuum drying to preserve the nutritional properties not only of the pumpkin pulp but also of the pumpkin peel, which usually remains after the pulp is consumed. The HHP pre-treatments of 50 and 150 MPa for 4 and 8 minutes, followed by vacuum drying at 100 mbar, preserves the main chemical composition of pulp and peel, e.g. ash, total fat, total fibre, total proteins and total sugars. In addition, such pre-processed and dried peels consist a high fat and fibre content and can therefore be used as excellent food ingredients. The combination of HHP pre-treatment and vacuum drying would therefore be an innovative and useful approach to extend the shelf life of the pulp and utilize the peels as new food ingredients.

Keywords: high hydrostatic pressure, vacuum drying; pumpkin pulp, pumpkin peel

Acknowledgements: The work was supported by the Croatian Science Foundation (research project "Hybrid drying and valorization of plant food waste and by-products" IP-2019-04-9750) – HYDRYBY.

Green technologies and information technology in the Republic of Croatia

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Abstract: At the beginning of 2021, a strong development of digitalization of the entire society, public and private, was launched, which was named "Digital transformation". Digital transformation involves the integration of digital technologies to increase productivity and economic efficiency across all sectors of society. In parallel with the digital transformation, the concept of "Green Transition" appears, focused on the appliance of ecological solutions relevant to the transition to an economy with neutral impacts on the climate and the environment. Green and digital technologies hold immense potential for growth and increased productivity within the Croatian economy, particularly in the IT sector, which is primarily service-oriented. This shift towards eco-friendly and digital solutions can pave the way for a brighter, more sustainable future for our economy. In this report, we highlight the key role of data centers in the context of digital transformation. Efficient operation, supported by renewable energy sources based on green technologies, is key to the successful implementation of our digitization efforts. Data centers consume over 54 GW of total estimated energy consumption, which is expected to reach 90 GW by 2028. This raises concerns about the energy efficiency and sustainability of such capacity growth in data centers. For this reason, we consider strategies such as wastewater treatment, elimination of industrial emissions, recycling and waste management, construction of self-sustainable buildings, and using renewable energy sources such as solar energy and natural gas boilers. The goal is to reduce dependence on fossil fuels and optimize energy management, considering that the energy consumption of data centers is projected to rise dramatically by 2028. This paper primarily refers to the data centers managed by APIS IT.

Keywords: digitalization, digital transformation, green technologies, data center, renewable energy

Management of Natural Protected Areas
Upravljanje zaštićenim područjima prirode

MANAGEMENT OF NATURAL PROTECTED AREAS I
UPRAVLJANJE ZAŠTIĆENIM PODRUČJIMA PRIRODE
Oral presentation / *Usmeno priopćenje*

Preparation of protection, conservation, restoration and sustainable use of the Natura 2000 area for the Programme Competitiveness and Cohesion 2021 – 2027

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Abstract: EPEEF provides resources for financing nature protection schemes in Croatia, including for the preparation of project documentation for applying projects under the Programme Competitiveness and Cohesion 2021 – 2027. EPEEF finances project documentation with 100% thus significantly contributing to the implementation of activities that improve the management of protected areas, EN Natura 2000 in Croatia and species, by implementing strategic priorities and priority conservation, restoration and management measures according to the Prioritised Action Framework (PAF) for EN, and management plans for protected areas and EN. Public institutions managing national and nature parks and other protected areas will, as part of the project documentation prepare expert bases for monitoring target species and habitat types in the area of the EN to observe management effectiveness, determine additional requirements related to 'good status' of water bodies arising from ecological requirements of target species in the EN area and strictly protected species and endangered and rare habitat types related to the aquatic ecosystems of the EN area. Research of target species and habitat types in the EN area will be carried out since the 2019 reports from Croatia under Article 17 of the Habitats Directive, showed unknown conservation status or unknown conditions in the EN area.

Keywords: protected areas, biodiversity, ecological network, financing

MANAGEMENT OF NATURAL PROTECTED AREAS I
UPRAVLJANJE ZAŠTIĆENIM PODRUČJIMA PRIRODE
Oral presentation / *Usmeno priopćenje*

Priprema projekata zaštite, obnove i održivog korištenja područja mreže Natura 2000 za Program Konkurentnost i kohezija 2021-2027

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Sažetak: FZOEU osigurava sredstva za financiranje zaštite prirode u RH, što uključuje i pripremu projektne dokumentacije za prijavu projekata u Programu konkurentnost i kohezija 2021. – 2027. Financiranjem projektne dokumentacije sa 100% sredstava, FZOEU daje značajan doprinos provedbi aktivnosti kojima se postiže poboljšano up ravljanje zaštićenim područjima, EM Natura 2000 u RH i vrstama, kroz provedbu strateških prioriteta i prioritetnih mjera očuvanja i obnove, upravljačkih aktivnosti sukladno Prioritetnom akcijskom okviru (PAO) za EM i provedbi planova upravljanja zaštićenim područjima i EM. Javne ustanove za upravljanje nacionalnim parkovima i parkovima prirode i ostalim zaštićenim područjima će u sklopu projektne dokumentacije pripremati stručne podloge za praćenje ciljnih vrsta i stanišnih tipova na području EM u svrhu praćenja učinkovitosti upravljanja, utvrditi dodatne zahtjeve vezane uz dobro stanje vodnih tijela, a koji proizlaze iz ekoloških zahtjeva ciljnih vrsta područja EM te strogo zaštićenih vrsta i ugroženih i rijetkih stanišnih tipova vezanih uz vodene ekosustave područja EM. Provest će se istraživanja ciljnih vrsta i stanišnih tipova na području EM za koje su izvješća RH iz 2019. godine prema članku 17. Direktive o staništima pokazala nepoznato stanje očuvanosti ili je stanje nepoznato na području EM.

Ključne riječi: zaštićena područja, bioraznolikost, ekološka mreža, financiranje

Evaluation of climate change implications on park management: Case study Divjaka-Karavasta National Park, Albania

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Abstract: Managing protected areas from climate change is a complex process. The purpose of this study was to evaluate how climate change impacts on protected areas can be better understood at the park manager and local community level. Managers of the protected area expressed that this National Park is important as the only habitat in Albania used for the growth and reproduction of the curly pelican (*Pelecanus crispus* Bruch) but also for the Mediterranean forest with wild and soft pines (*Pinus halepensis* Mill. and *Pinus pinea* L.), which make it one of a kind. According to community perception, the main causes of climate change were deforestation, pollution, and carbon emissions. Three of the foremost elements perceived as most sensitive to climate change were: extreme weather events (58.2%), water supply, and agriculture (40%). There were also concerns about how climate change will affect tourism and recreation, the disturbance of function and loss of ecosystem services, and the economic activity of the area. The survey results gave an understanding of the socio-ecological characteristics of the region. This is an important step to improving park management adaptation to climate change by understanding people's perceptions and values relating to climate change and where significant differences lie.

Keywords: climate change, community, ecosystem, management, park

The role of traditional ecological knowledge practices in the conservation of the Divjakë-Karavasta National Park Forest ecosystem

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Abstract: Through traditional ecological practices, local communities ensure the sustainable utilization and management of different ecosystem services. To have effective biodiversity conservation, it is important to take into consideration the local knowledge, its intergenerational transmission, limitations in the use of natural resources, and sustainable use of biodiversity inside and outside of a protected area. This study examines the role, evolution, and local perceptions of impacts on forest ecosystem diversity conservation. Our objective in this case study is to comprehend the development of traditional ecological knowledge in the Divjak-Karavasta National Park by gathering information on local management techniques and their effects on the state of the forest ecosystem. Results suggest that the perception of local communities for landscape change and traditional knowledge are vital for the sustainability of natural resources. During our fieldwork, we discovered that the forest's infrastructure was lacking—open trails and the road system, for example, since the closed routes were not being maintained. Several issues make it difficult to build recreational and educational facilities and increase the intensity of the forestry economy. According to this study, rural communities can provide valuable information about environmental changes, and future conservation initiatives may consider this to halt the loss of biodiversity.

Keywords: traditional knowledge, biodiversity, conservation, rural community

Sustainable Tourism
Održivi turizam

Challenges of ecotourism development: Stakeholders perspectives

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Abstract: Ecotourism is a form of sustainable travel that supports the conservation of natural environments and the well-being of local communities and tourists. It focuses on responsible travel to natural areas, emphasizing environmental protection and fostering cultural awareness and respect. Ecotourism in Croatia is gaining popularity due to the country's rich natural beauty, diverse ecosystems, and commitment to sustainable tourism practices. Croatia offers a variety of ecotourism opportunities, from exploring national parks and nature reserves to participating in eco-friendly activities and staying in sustainable accommodations. The paper is focused on the challenges of sustainable tourism development in the County of Istria, one of the most developed counties in Croatia. Trying to regulate the key sustainability challenges of the current tourism model, through its innovative tourism development program "Eco experience" the County promotes and supports eco-tourism projects in various fields: Eco-Friendly Activities, Museums and Theme Parks, Eco Events, Eco producers, Eco-Friendly Accommodation, Eco Hotels, Eco Campsites et al. The research presented in the paper combined qualitative and quantitative methodology, including interviews with representatives of key stakeholders involved in eco-tourism activities in the County. As a case study, the research elaborates on the most important sustainable management issues in the Significant landscape of Lower Kamenjak, a very fragile ecosystem visited by thousands of daily tourists. The expected results of the research are the identification of current challenges in the management of vulnerable natural sites and the proposal of recommendations for a more sustainable management model based on a participatory approach.

Keywords: ecotourism, tourists, local communities, County of Istria

Sustainable equestrian tourism in Koprivnica-Križevac County

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Abstract: Equestrian tourism, as a specific form of tourism in Croatia, can become a sustainable economic activity if it utilises all its potential due to the ambient features of the area using local, cultural, hospitality and other capacities and resources. The rich geographical, cultural, gastronomic and other diversity of Croatia enables activities of various forms of tourism, connecting man with animals and nature. This form of tourism requires exceptional expertise and experience in everyday work with horses, education and adequate equipment. Using rich natural resources as tourist attractions can contribute to the sustainability of equestrian tourism, and consequently to the breeding of autochthonous and sports horse breeds. The most commercially attractive form of using horses in equestrian tourism is recreational riding, followed by carriage driving, equestrian sports, and other horse-related activities. Koprivnica-Križevci County is facing deindustrialisation, deruralisation, deagrarisation, emigration and urbanisation. Continental tourism, including equestrian tourism, can be an opportunity to bring part of the population back to rural areas and further develop the county. Sustainable development can be encouraged by integrating the economy, agriculture, society, the education system, and environmental protection. This paper aimed to analyze the development potential of Koprivnica-Križevci County to improve the equestrian tourism offers through the implementation of the Interreg EquiEdu project created in collaboration between the Križevci University of Applied Sciences and the Hungarian University of Agriculture and Life Sciences (MATE) in Kaposvár.
Keywords: horses, sustainability of equestrian tourism, Koprivnica-Križevci County

Održivi konjički turizam u Koprivničko-križevačkoj županiji

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Sažetak: Konjički turizam, kao specifičan oblik turizma u Hrvatskoj, može postati održiva gospodarska aktivnost ukoliko iskoristi sav svoj potencijal zbog ambijentalne značajke prostora koristeći lokalne, kulturne, ugostiteljske i ostale kapacitete i resurse. Bogata geografska, kulturna, gastronomska i druga raznolikost Hrvatske omogućuje aktivnosti različitih oblika turizma povezujući pri tome čovjeka sa životinjom i prirodom. Za ovakav oblik turizma neophodna je izuzetna stručnost i iskustvo u svakodnevnome radu s konjima, edukacija te adekvatna oprema. Korištenjem bogatih prirodnih resursa kao turističkih atrakcija može se doprinijeti održivosti konjičkoga turizma, a posljedično tome i uzgoju autohtonih i sportskih pasmina konja. Komercijalno najatraktivniji oblik uporabe konja u konjičkome turizmu jest rekreacijsko jahanje, zatim vožnja zaprege, konjički sport, a potom sve ostale aktivnosti pomoću konja. Koprivničko-križevačka županija suočava se s deindustrijalizacijom, deruralizacijom, deagrarizacijom, iseljavanjem i urbanizacijom. Kontinentalni turizam, a samim time i konjički turizam može biti prilika za vraćanje dijela stanovništva na selo i daljnji razvoj županije. Kroz integraciju gospodarstva, poljoprivrede, društva, obrazovnog sustava i zaštite okoliša može se potaknuti održivi razvoj. Cilj ovoga rada bio je analizirati mogućnost razvojnog potencijala Koprivničko-križevačke županije u svrhu poboljšanja ponude konjičkog turizma provedbom Interreg projekta EquiEdu nastalog u suradnji Visokog gospodarskog učilišta iz Križevaca i Mađarskog sveučilišta za poljoprivredu i biotehničke znanosti (MATE) iz Kaposvára.
Ključne riječi: konji, održivost konjičkog turizma, Koprivničko-križevačka županija

The tourism offers and nature conservation in Kopački Rit Nature Park

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Abstract: Protected areas require management following various legal and strategic acts. Kopački Rit is one of 12 nature parks in the Republic of Croatia, located in the northeastern part of the country, i.e. in the floodplain of Baranja. Like other parks, this one also hides numerous landscape peculiarities, biological diversity and animal species. The park has been declared a special zoological reserve, it is on the List of Important Ornithological Areas of Europe and on the List of Wetlands of International Importance. Due to its peculiarities, Kopački rit is a tourist attraction visited by many tourists. Tourism is important for every region, and the tourist offer, to attract an increasing number of tourists, needs to be improved over time. However, in protected areas such as nature parks, tourism can only be developed by the legal and strategic framework for nature protection, meaning that tourist activities and operations must not disturb the existing ecosystem and natural heritage. This paper examines nature protection measures in Kopački Rit Nature Park, reviews the current tourism offers, evaluates their balance, and proposes possibilities for improvement.
Keywords: tourism, nature park, nature protection, protected areas, Kopački Rit

Turistička ponuda i zaštita prirode u parku prirode Kopački rit

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Sažetak: Zaštićenim područjem potrebno je upravljati sukladno različitim zakonskim i strateškim aktima. Kopački rit jedan je od 12 parkova prirode u Republici Hrvatskoj. Taj se park prirode nalazi u sjeveroistočnom dijelu Hrvatske, odnosno u poplavnom području Baranje. Kao i drugi parkovi, i ovaj krije brojne krajobrazne posebnosti, biološku raznolikost te životinjske vrste. Proglašen je posebnim zoološkim rezervatom, nalazi se na Listi važnih ornitoloških područja Europe te na Popisu vlažnih staništa od međunarodnog značaja. Zbog svojih posebnosti, Kopački rit predstavlja turističku atrakciju koju posjećuju brojni turisti. Turizam je od značaja za svaku regiju, a turistička ponuda, kako bi privlačila sve veći broj turista, s vremenom se treba unaprjeđivati. Međutim, u zaštićenim područjima kao što su parkovi prirode, turizam se može razvijati jedino sukladno zakonskom i strateškom okviru zaštite prirode, što znači da turističke aktivnosti i djelatnosti ne smiju narušavati postojeći ekosustav i prirodnu baštinu. Ovaj rad bavi se pregledom mjera zaštite prirode u parku prirode Kopački rit te pregledom aktualne turističke ponude, ocjenom njihove ravnoteže i prijedlogom mogućnosti unaprjeđenja.
Ključne riječi: turizam, park prirode, zaštita prirode, zaštićena područja, Kopački rit

Zero waste gastronomy – A Student perspective

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Abstract: Gastronomy as one of the branches of hospitality is developing intensively. This is influenced by the increasing development of tourist services, migration of the population, a fast lifestyle that has new ways of spending free time, most often outside the home. There is a growing awareness of the economic and environmental effects of food waste. Based on this, there is also a growing incentive to take simple and effective steps to reduce food waste in the gastronomic sector. Food waste in restaurants accounts for 13% of the total amount of waste. Research has shown that people between the ages of 18 and 34 waste more food than other age groups. This work aimed to investigate the perception of students of the Faculty of Tourism and Rural Development in Požega about zero waste gastronomy. Using the online survey method, the research was conducted on a sample of 37 students of Enogastronomy and Tourism. The results of the research showed that almost all students are familiar with the zero-waste concept and believe that it is possible to apply the concept in gastronomy. As future gastronomic experts, the main solution to reducing food waste is the full use of raw materials in the kitchen, smart waste management, and shopping from local producers.

Keywords: zero waste, gastronomy, tourism, student

Sustainable Development of Green Mobility and Green Tourism

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Abstract: The multidisciplinary approach to the development of green mobility and green tourism includes environmental impact analysis and the promotion of sustainable development and environmental protection practices in accordance with the principles of national and international strategic development documents. Directing users of the mobility program through the application of digital transformation to the use of promote sustainable green mobility is a sustainable and socially ecologically responsible approach to the development of sustainable green tourism. It is our responsibility to choose how we communicate and gather information about mobility. This includes choosing our means of travel and behaviors. When we are exposed to environmentally friendly messages, it can influence us to choose greener ways of traveling to reduce negative emissions and protect the environment. By the developing ecological trends, network communication represents a sustainable way of information and supports the digital transition. The quality of online information is based on the availability of information that conveys the desired message about green tourism and mobility and their graphic presentation. The analysis of web pages is carried out with the aim of determining a targeted communication message that contributes to an ecological approach to mobility and green tourism, and the results of the research are guidelines for the graphic, environmentally oriented design of online content.

Keywords: sustainable green tourism, sustainable green mobility, graphic design

Waste Management
Gospodarenje otpadom

Biowaste (food waste) prevention as a good practice example in the circular economy

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Abstract: The new Circular Economy Action Plan (CEAP 2020) adopted by the European Commission encourages EU Member States to improve circularity at the national level by adopting policies and initiatives that transcend EU regulations, at the same time preserving the single market. The European Environment Agency (EEA) drew up profiles of EU Members providing an overview of circular economy policies implemented at the national level, and good practice examples. In the national profile of the Republic of Croatia, EPEEF's pilot project "Reduce food waste" implemented in Croatian hotels is listed as one of the examples of good practice. Results of the pilot show that applying simple methods prevents food waste to 30%, while digestors reduce the amount of food waste by up to 75%. Project activities were extended to include student centres, hospitals, specialty hospitals, nursing homes, student dorms, preschools, and prison systems. To monitor the progress of transition to a circular economy, and to encourage the exchange of knowledge and experience among EU Members, their revised national profiles will be published in 2025. The continuation of the project with data on implemented public calls and procured devices for biowaste (food waste) prevention will show good practice in Croatia.

Keywords: environment, circular economy, biowaste, food waste

Sprječavanje nastanka biootpada (otpada od hrane) kao primjer dobre prakse u kružnom gospodarstvu

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Sažetak: Usvajanjem novog akcijskog plana za kružno gospodarstvo (CEAP 2020) Europske komisije države članice EU potiču se unaprijediti kružnost na nacionalnoj razini usvajanjem politika i inicijativa koje nadilaze EU propise, a sve uz očuvanje jedinstvenog tržišta. Europska agencija za okoliš (EEA) izradila je profile država članica EU koji nude prikaz politika kružnog gospodarstva koje se provode na nacionalnoj razini kao i primjere dobre prakse. U nacionalnom profilu RH kao jedan od primjera dobre prakse naveden je i pilot projekt FZOEU-a „Smanji otpad od hrane“ proveden u hotelima u RH. Rezultati provedenog Pilot projekta pokazali su da primjena jednostavnih metoda sprječava rasipanje hrane do 30 %, dok se uređajima za sprječavanje nastanka otpada količine otpadne hrane smanjuju do 75 %. Aktivnosti projekta proširene su na studentske centre, bolnice i specijalne bolnice, domove za starije i učeničke domove, dječje vrtiće te zatvorske sustave. U cilju praćenja napretka prelaska na kružno gospodarstvo, te poticanja razmjene znanja i iskustva između država članica EU, revidirani nacionalni profili država članica EU bit će objavljeni 2025. godine. Nastavak projekta s podacima o provedenim javnim pozivima i nabavljenim uređajima za sprječavanje nastanka biootpada (otpada od hrane) pokazat će dobru praksu u RH.

Ključne riječi: okoliš, kružno gospodarstvo, biootpad, otpad od hrane

Impact of legislative framework on the composition of mixed municipal waste

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Abstract: Back in 2006, the Republic of Croatia introduced a deposit system for packaging, which includes beverage packaging made of glass, plastic (PET), and metal (Al and Fe). The paper will show the composition of waste obtained by waste sorting in the years before and after the introduction of the deposit system. The analysis will see into the impact of the entry into force of the law on the change in the composition of mixed municipal waste. The composition of waste from the City of Velika Gorica will be compared over several comparative years. The composition of the waste was obtained through investigative work, i.e. sorting of mixed municipal waste. The results of determining the morphological composition of mixed municipal waste were obtained by the method of direct sampling and analysis. Before starting the analysis, the thesis was made that the analysis would show a decrease in the amount of PET in mixed municipal waste after the introduction of the deposit system. The deposit system separates the packaging of the best composition from the waste, reducing the caloric value of the future processed waste, but a low degree of impurities is achieved in the waste packaging thus collected, which enables a high degree of recovery. In this way, the end user is encouraged to collect beverage packaging waste separately.

Keywords: legislation, deposit system, packaging, sorting, composition of waste

Utjecaj zakonodavnog okvira na sastav miješanog komunalnog otpada

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Sažetak: Još 2006. godine Republika Hrvatska uvela je depozitni sustav za ambalažu koji obuhvaća ambalažu za pića izrađenu od stakla, plastike (PET) i metala (Al i Fe). Rad analizira i prikazuje sastav otpada dobiven sortiranjem otpada tijekom godina prije i nakon uvođenja depozitnog sustava. Analiza istražuje utjecaj donošenja zakona na promjenu sastava miješanog komunalnog otpada i uspoređuje sastav otpada iz Grada Velike Gorice tijekom nekoliko usporednih godina. Sastav otpada dobiven je istražnim radovima tj. sortiranjem miješanog komunalnog otpada. Rezultati utvrđivanja morfološkog sastava miješanog komunalnog otpada dobiveni su metodom izravnog uzorkovanja i analize. Prije početka analize postavljena je teza da će analiza pokazati smanjenje količine PET-a u miješanom komunalnom otpadu nakon uvođenja depozitnog sustava. Depozitni sustav iz otpada izdvaja ambalažu najboljeg sastava smanjujući kaloričnu vrijednost budućeg obrađenog otpada te se ostvaruje nizak stupanj nečistoća tako prikupljene otpadne ambalaže što omogućava visok stupanj oporabe. Tako se potiče krajnjeg korisnika na odvojeno prikupljanje ambalažnog otpada od pića.

Ključne riječi: zakonodavstvo, depozitni sustav, ambalaža, sortiranje, sastav otpada

New trends in construction waste management

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Abstract: The construction sector is one of the fastest growing branches of the economy, with the demand for primary raw materials necessary for the construction of new or reconstruction of existing buildings inevitably growing. At the same time, the aforementioned intensive growth of the construction sector is accompanied by an intensive increase in the generation of construction waste. Construction waste is waste generated during the construction of buildings, reconstruction, removal and maintenance of existing buildings, and waste generated during the construction of public projects such as streets and highways, bridges, communal facilities, harbors and dams. Construction waste is also waste generated from excavated material, which cannot be used for construction without prior recovery. Construction waste usually contains concrete, wood, asphalt, gypsum, metals, bricks, glass, plastic, soil waste, etc. During construction, the contractor is obliged to manage construction waste generated during construction on the construction site and to recycle and/or dispose of construction waste. The contractor is also required by law to have prescribed documentation at the construction site by the regulations governing waste management. New trends in construction waste management imply the application of activities according to the following hierarchy: (i) prevention of waste, which can be achieved by preserving existing construction structures instead of building new ones, using less materials in design and production, by adopting construction methods that enable the deconstruction and reuse of materials, and the use of materials that are less harmful to the environment, (ii) preparation of materials for reuse, which includes inspection, sorting, cleaning, repair or replacement of materials (iii) recycling, which includes converting waste into a new product, (iv) other recovery processes such as the application of anaerobic digestion, incineration, pyrolysis, procedures for obtaining energy, and the least desirable (v) disposal, which can be disposal or incineration without energy recovery.

Keywords: construction waste, waste management, recycling, recovery

Novi trendovi u gospodarenju građevinskim otpadom

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Sažetak: Građevinski sector jedan je od najbrže rastućih grana gospodarstva, s kojim neminovno raste i potražnja za primarnim sirovinama potrebnim za izgradnju, ali i porast količina građivinskog otpada. Građevinski otpad je otpad koji nastaje pri izgradnji zgrada, rekonstrukciji, uklanjanju i održavanju postojećih građevina, kao i otpad koji nastaje pri izgradnji javnih objekata kao što su ulice i autoceste, mostovi, komunalni objekti, pristaništa i brane. Građevinski otpad je i otpad koji nastaje pri iskopu sirovina koje se bez prethodne oporabe ne mogu koristiti za građenje. U sastavu građevinskog otpada najčešće dominira beton, drvo, asfalt, gips, metali, cigle, staklo, plastika, otpadna zemlja i slično. Sukladno zakonskoj regulativii izvođač građevinskih radova dužan je tijekom građenja zbrinuti građevinski otpad recikliranjem ili pravovaljanim odlaganjem. Izvođač radova također je dužan propisnom dokumentacijom bilježiti nastale količine i način zbrinjavanja nastalog otpada. U cilju odlaganja što manjih količina građevinskog orpada u okoliš, novi trendovi u gospodarenju građevinskim otpadom podrazumijevaju primjenu aktivnosti prema sljedećoj hijerarhiji: (i) prevencija nastanka otpada očuvanjem postojećih građevinskih objekata umjesto gradnje novih, projektiranjem objekata koji će pri izgradnji zahtjevati manji utrošak materijala, primjenu građevnskih tehnika koje omogućuju laku demontažu i ponovnu uporabu materijala, te korištenje materijala koji su manje štetni za okoliš, (ii) pripremu materijala za ponovnu uporabu, pregledom, sortiranjem, čišćenjem, popravkom ili zamjenom pojedinih vrsta materijala (iii) recikliranje pretvaranjem otpada u novi proizvod, (iv) primjena drugih procesa oporabe kao što je anaerobna digestija, spaljivanje, piroliza i slični postupci za proizvodnju energije, te (v) zbrinjavanje odlaganjem ili spaljivanjem bez postupka korištenja nastale toplinske energije.

Ključne riječi: građevinski otpad, gospodarenje otpadom, recikliranje, oporaba

Reduction of waste solvents amount after washing the water sampling containers for chromatographic analyses

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Abstract: Water sampling plays an important role in analyzing various groups of substances in water using chromatographic methods. Maintenance of the chromatographic instruments, using clean laboratory glassware for sample preparation, employing solvents of appropriate purity, as well as the cleanliness of the containers used for water sample collection are of great importance in order to reduce the possibility of sample contamination. This paper aims to demonstrate that the amount of waste solvents generated from washing sampling containers can be reduced by adopting more advanced sample preparation methods. Proper washing of sampling containers involves use of various washing agents and solvents for the final rinse. Methods like liquid-liquid extraction or automated solid-phase extraction typically extract only one group of analytes (e.g., pesticides). A relatively new method of sample preparation, µDrop, enables the simultaneous extraction of multiple groups of substances from a single sampling container. This significantly reduces the consumption of chemicals and solvents needed for washing. In conclusion, modern sample preparation methods, such as µDrop, can substantially decrease the volume of waste solvents produced during the washing and preparation of sampling containers, leading to more efficient and environmentally friendly laboratory practices.

Keywords: water sampling, sampling containers, sampling container washing, waste solvents

Smanjenje količine otpadnih otapala nakon pranja spremnika za uzorkovanje voda za kromatografske analize

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Sažetak: Uzorkovanje voda ima važnu ulogu u analizi različitih skupina tvari u vodama koje se određuju kromatografskim metodama. Održavanje instrumenata na kojem se izvodi kromatografsko mjerenje, čisto laboratorijsko suđe za pripremu uzoraka, otapala odgovarajuće čistoće, ali i čistoća spremnika u koje se uzorkuju vode za analizu od velike su važnosti radi smanjenja mogućnosti kontaminacije uzorka. Cilj rada je pokazati da se količina otpadnih otapala nastalih od pranja spremnika za uzorkovanje može smanjiti odabirom modernijih metoda pripreme uzoraka. Spremnici za uzorkovanje moraju biti oprani na odgovarajući način, što podrazumijeva korištenje različitih sredstava za pranje i otapala za konačno ispiranje. Ekstrakcijom tekuće-tekuće ili automatiziranom ekstrakcijom čvrstom fazom ekstrahira se obično samo jedna skupina tvari koja se analizira (npr. samo pesticidi). Relativno novi način pripreme uzoraka, µDrop, omogućava istovremenu ekstrakciju više različitih skupina tvari (poluhlapljivi organski spojevi, engl. *Semi Volatile Organic Compounds*) iz jednog spremika za uzorkovanje čime se uvelike smanjuje potrošnja kemikalija i otapala za pranje i ispiranje. Može se reći da se modernijim metodama pripreme uzoraka može utjecati na smanjenje količine otpadnih otapala nastalih prilikom pranja i pripreme spremnika za uzorkovanje što dovodi do učinkovitije i ekološki prihvatljivije laboratorijske prakse.

Ključne riječi: uzorkovanje voda, spremnici za uzorkovanje, pranje spremnika za uzorkovanje, otpadna otapala

Systematic analysis, practices, and perspectives in waste management of Varaždin County

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Abstract: Despite the perception of the terms "sustainable environment" and "sustainable waste management," considered widely known topics with generally accepted attitudes in our society, the question arises - is it really so? The waste management sector currently faces two major challenges: transitioning from a linear waste management model to a circular model and adapting to climate change. Both challenges are primarily viewed from the perspective of necessary investments in infrastructure and equipment, while the impact of these changes on employment relationships is often reduced to a general statement about "creating new green jobs." Waste management in the Republic of Croatia, including Varaždin County, is regulated by laws and regulations that are harmonized with the legal framework of the European Union. This has resulted in the establishment of goals within the Waste Management Plan of the Republic of Croatia and the Waste Management Act, focusing on reducing the total quantity of separately collected municipal waste and its recovery. To monitor the achievement of these goals and improve the municipal waste management system, systematic reports on municipal waste are prepared. This paper analyzes the current state of waste management, waste management measures in line with optimal waste treatment technology, waste disposal in spatial planning documents of Varaždin County, remediation measures, supervision, and monitoring of waste management, as well as unregulated landfills. The results of this paper are based on the analysis of current practices and future perspectives, including potential innovations and technologies that could enhance efficiency and sustainability in waste management in Varaždin County. The paper emphasizes the importance of raising awareness among the population as a key factor in achieving waste reduction and highlights the importance of collaboration among various stakeholders, including local authorities, industries, communities, and individuals, to achieve a sustainable future in waste management.
Keywords: waste management, concessionaires, landfills, spatial plan, recycling centers

Sustavna analiza, prakse i perspektive u gospodarenju otpadom Varaždinske županije

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Sažetak: Unatoč percepciji termina „održivi okoliš“ i „održivo gospodarenje otpadom“, koje se smatraju općepoznatim temama i općeprihvaćenim stavovima u našem društvu, postavlja se pitanje - da li je to stvarno baš tako? Sektor gospodarenja otpadom trenutno se suočava s dva velika izazova: tranzicijom iz linearnog modela gospodarenja otpadom prema cirkularnom modelu, te adaptacijom na klimatske promjene. Oba izazova se uglavnom promatraju s aspekta potrebnih ulaganja u infrastrukturu i opremu, dok se utjecaj ovih promjena na radne odnose često svodi na općenitu konstataciju o „otvaranju novih zelenih radnih mjesta”. Gospodarenje komunalnim otpadom u Republici Hrvatskoj, pa tako i u Varaždinskoj županiji regulirano je zakonima i pravilnicima koji su usklađeni s pravnom stečevinom Europske unije. To je rezultiralo postavljanjem ciljeva koji se nalaze u sklopu Plana gospodarenja otpadom Republike Hrvatske i Zakona o gospodarenju otpadom te se odnose na smanjenje ukupne količine komunalnog odvojenog sakupljanja i oporabe otpada. Kako bi se pratilo ispunjenje ciljeva i unaprjeđenje sustava gospodarenja komunalnim otpadom, izrađuju se sistematizirana izvješća o komunalnom otpadu. U ovom radu analizira se trenutno stanje gospodarenja otpadom, mjere gospodarenja otpadom sukladno optimalnoj tehnologiji obrade otpada, zbrinjavanje otpada u dokumentima prostornog uređenja Varaždinske županije, mjere sanacije, nadzora i praćenja gospodarenja otpadom, te neuređena odlagališta. Rezultati ovog rada temelje se na analizi trenutnih praksi i budućih perspektiva, uključujući potencijalne inovacije i tehnologije koje bi mogle poboljšati efikasnost i održivost u gospodarenju otpadom u Varaždinskoj županiji. Rad naglašava važnost podizanja svijesti među stanovništvom kao ključnog čimbenika u postizanju smanjenja nastajanja otpada, te ističe važnost suradnje između različitih dionika, uključujući lokalne vlasti, industrije, zajednice i pojedince, kako bi se postigla održiva budućnost u gospodarenju otpadom.

Ključne riječi: gospodarenje otpadom, koncesionari, odlagališta, prostorni plan, reciklažna dvorišta

Water Management
Upravljanje vodama

Challenges in incorporating the EU Green Deal into Croatian water management policy

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Abstract: The European Green Deal strategy from 2019 presents multiple challenges for the member states of the European Union. Concerning Croatia, these challenges are generally associated with the incorporation of green policy into the official strategic planning documents. This paper aims to identify the primary environmental and climate challenges that Croatian green policy is going to face as a result of the current European Green Deal strategy and its objectives by taking into consideration the changes that have been made to the strategy up to this point as well as the current situation of integrating green goals into the country's planned documentation. The findings also highlight the implementation of projects that boost green strategies in all state plan documentation and address the research question: Should green goals be a part of multi-year projects? The results will give policymakers an effective foundation on which to promote the implementation of green projects in Croatia, which should be managed specially to meet growing challenges.
Keywords: EU Green Deal, Croatia, strategy, challenges, Water Management Policy

Development of a harmonized water balance modeling system for the Danube River Basin - Danube Water Balance Interreg Project

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Abstract: Hrvatske vode is a partner to the "Danube Water Balance" Interreg project within the Danube Transnational Programme 2021-2027 (Danube Region Programme, DRP). The Project has been implemented since 1 January 2024 under Priority 2 "A greener Danube region", Specific Objective 2.3 "Sustainable, integrated, transnational water and sediment management in the Danube River Basin ensuring good quality and quantity of waters and sediment balance". The foreseen project duration is 30 months. The project includes 20 project partners and 13 associated partners from the Danube River Basin countries. The project has a total budget of EUR 3,028,319.50, of which EUR 115,205.00 is foreseen for Hrvatske vode as the project partner. The purpose of this project is to harmonise and improve a joint approach to water balance modelling in all Danube River Basin countries. Since these countries have different approaches to water balance calculation, it is necessary to establish a single and joint approach to basin-wide water balance calculation. Such an approach would enable better understanding of the main components of the water balance at the level of basins and sub-basins and development of a joint and more efficient framework for the management and assessment of the status of water bodies. Eventually, the jointly accepted tool would be used by the ICPDR and during the preparation of national river basin management plans. The project consists of three specific objectives, and the lead partner of all the activities is the General Directorate of Water Management from Hungary. Within the specific objective, Hrvatske vode will together with the representatives of the Republic of Slovenia harmonise data for the water balance in the pilot area of the Upper Sava, the Upper Kupa, and part of the Zagreb area. Since transnational projects are supposed to affect national, regional and local policies and be triggers of development, the paper presents this important project which will help monitor intensifying climate change that affects the water balance.

Keywords: water balance, climate change, Interreg project, status of water bodies, water resources

Razvoj i harmonizacija sustava modeliranja vodne bilance na slivu rijeke Dunav - Interreg projekt Danube Water Balance

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Sažetak: Hrvatske vode su partner Interreg projekta Danube Water Balance u okviru Programa transnacionalne suradnje dunavske regije 2021. –2027. (Danube Region Programme). Projekt se provodi od 01.01.2024. godine unutar Prioriteta 2 "Zelenija dunavska regija", Specifičnog cilja 2.3 "Održivo, integrirano, transnacionalno upravljanje vodama i sedimentima u slivu rijeke Dunav koje osigurava dobru kvalitetu i količinu vode i ravnotežu sedimenata". Predviđeno trajanje projekta je 30 mjeseci. Projekt obuhvaća 20 projektnih i 13 pridruženih partnera iz zemalja sliva rijeke Dunav. Ukupan budžet projekta iznosi 3.028.319,50 EUR, od kojeg je za Hrvatske vode kao projektnog partnera predviđeno 115.205,00 EUR. Stanje i površinskih i podzemnih vodnih tijela usko je povezano sa zalihama vodnih resursa. Cilj ovog projekta je ujednačenje i poboljšanje zajedničkog pristupa modeliranja vodne bilance u svim zemljama u slivu rijeke Dunav. Kako te zemlje imaju različit pristup računanja vodne bilance, nužno je uspostaviti jedinstven i zajednički pristup računanja vodne bilance na razini cijelog sliva. Takav pristup omogućio bi bolje razumijevanje glavnih sastavnica vodne bilance na razini slivova i podslivova te bi se omogućilo razvijanje zajedničkog i efikasnijeg okvira za upravljanje i ocjenjivanje stanja vodnih tijela. Na kraju bi se zajednički prihvaćeni alat koristio u okviru rada ICPDR-a kao i kod izrade nacionalnih planova upravljanja vodnim područjima. Projekt se sastoji od tri opisana cilja a vodeći partner svih aktivnosti je General Directorate of Water Management iz Mađarske. U okviru specifičnog cilja Hrvatske vode će zajedno s predstavnicima Republike Slovenije uskladiti podatke za vodnu bilancu na pilot području gornje Save, užem području gornje Kupe i dijela područja Zagreba. Kako transnacionalni projekti trebaju utjecati na nacionalne, regionalne i lokalne politike te biti pokretači razvoja, u radu se daje prikaz ovog važnog projekta koji će pomoći kod praćenja sve očitijih klimatskih promjena koje utječu na vodnu bilancu.

Ključne riječi: vodna bilanca, klimatske promjene, Interreg projekt, stanje vodnih tijela, zalihe vodnih resursa

How can we reduce water consumption in the "From farm to fork" chain?

Mirna HABUDA-STANIĆ

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Abstract: Water is an irreplaceable resource in food production. The World Health Organization estimates that more than 70% of daily water catchment from nature is used in the chain "From field to table", i.e. for the needs of agriculture and food production. Population growth and increasing demand for water have already resulted in water shortages in many parts of the world, while climate change contributes to the water crisis additionally. During the past decade, water has become the most critical natural resource exposed to chemical and biological pollution and unsustainable, and often uncontrolled, pumping each day. The Food and Agriculture Organization of the United Nations (FAO) estimates that 2,000 - 5,000 liters are needed for the production of daily food intake per person and that in the last 30 years, food production has increased by more than 100%. That enormous increase in food production was indispensably reflected in the consumption of water for agricultural purposes. The FAO also points out that the production of healthy food (most often fruits and vegetables) implies an average higher consumption of good-quality water. Due to all of the above, it is emphasized that sustainable food production will not be possible without significant changes in the management of water intended for food production, primarily changes in irrigation techniques followed by priority goals: less encroachment in the water cycle, use renewable energy sources, and use of the recycled water, i.e. use of purified wastewater with the highest fourth degree of purification so that it can be safely used in food production.

Keywords: water consumption, food production, recycled water

Kako smanjiti potrošnju vode u lancu „Od polja do stola“?

Mirna HABUDA-STANIĆ

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Sažetak: Voda je nezamjenjiv resurs u proizvodnji hrane, a Svjetska zdravstvena organizacija procjenjuje da više od 70 % vode koja se zahvaća u svijetu svakog dana koristi u lancu "Od polja do stola", odnosno za potrebe poljoprivrede i proizvodnje hrane. Rast stanovništva i sve veća potražnja za vodom već su rezultirali nestašicom vode u mnogim dijelovima svijeta, a klimatske promjene pridonose krizi vode. Tijekom poteklog desetljeća voda je postala najkritičniji prirodni resurs koji je svakodnevno izložen brojnim kemijskim i biološkim onečišćenjima te neodrživom i najčešće nekontroliranom crpljenju. FAO procjenjuje da je za proizvodnju dnevnog unosa hrane po osobi potrebno od 2 000 - 5 000 litara te da se u posljednjih 30 godina proizvodnja hrane povećala za više od 100 % što se odrazilo i na potrošnju vode za potrebe poljoprivrede. FAO također ističe da proizvodnja zdravije hranu (najčešće voće i povrće) podrazumijeva prosječno veću potrošnju vode dobre kvalitete. Uslijed svega navedenog ističe se da održiva proizvodnja hrane neće biti moguća bez pravilnog upravljanja vodama i promjenama u sektoru upravljanja vodama. Pri tome će se naručito morati mjenjati tehnike navodnjavanja uz prioritetne ciljeve - što manje zadirati u zalihe prirodnih voda, koristiti obnovljive izvore energije i reciklirati vodu, odnosno pročišćavati otadne vode najvišim četvrtim stupnjem pročišćavanja kako bi se mogle sigurno mogle koristiti u proizvodnji hrane.
Ključne riječi: potrošnja vode, proizvodnja hrane, recikliranje vode

Irrigation water quality in a framework of Sustainable Development Goal 6

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Abstract: Consideration of irrigation water quality within Sustainable Development Goal (SDG) 6, which focuses on ensuring the availability and sustainable management of water, is crucial in agriculture, and implementation of sustainable irrigation practices that support the assessment of water quality is essential. Given the growth in future demand from this finite resource, as well as potential changes in future climate, a detailed understanding of both water quantity and quality is required to use this resource sustainably. Monitoring of hydrochemical indicators (cations, anions, pH, and EC - electrical conductivity), in assessing the quality of irrigation water, can provide valuable insights into the suitability of water for agricultural use (irrigation). The suitability assessment can be done using Neugebauer, USSL and FAO classification systems. Detailed assessments usually included additional indices, such as soluble sodium percentage (SSP), sodium adsorption ratio (SAR), residual sodium carbonate (RSC), permeability index (PI), sodium adsorption (RSC), magnesium adsorption ratio (MAR) and Total hardness (TH). To achieve SDG 6, it is need to prioritize the monitoring and improvement of irrigation water quality. This can be done through regular water sampling and analysis, implementation of best management practices to reduce contamination from agricultural and other sources, and promotion of sustainable water use through efficient irrigation techniques. In addition, promoting education and awareness among farmers and other stakeholders about the importance of water quality in irrigation can help encourage the adoption of sustainable practices.

Keywords: water quality, SDG 6, groundwater, agriculture

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Water, Wastewater Treatment and Water Reuse
Prerada vode, pročišćavanje otpadnih voda i recikliranje vode

Degradation of atazanavir antiviral in water by UV-C/H_2O_2 and UV-C/$S_2O_8^{2-}$ processes

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Abstract: Antiviral substances and especially SARS-CoV-2 antivirals in the environment are a current problem that will become more expressed in the coming years. Many SARS-CoV-2 antiviral substances are relatively new and information on their behavior in the environment is lacking, and even the known substances are now used in combination with other drugs, potentially altering their effects in the environment (possible synergistic effects). In this study, one widely used recalcitrant SARS-CoV-2 antiviral, atazanavir, which has the potential to be on the watch list was chosen for its degradation study. AOP UV-C/H_2O_2 and UV-C/$S_2O_8^{2-}$ processes as photooxidative advanced oxidation processes (AOPs) were applied. Results, degradation kinetics, were expressed by RSM and optimal conditions were calculated.

Keywords: antivirals, SARS-COV-2, AOP, atazanavir degradation

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Sustainable Oxidation Technologies in Water Treatment Processes

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Abstract: The primary task of the water treatment process is to achieve minimum health and safety requirements in the area of final water quality. However, in the last decade, companies dealing with water treatments have been faced with demands for sustainability achievement and environmental impact reduction, while the innovations in water treatment processes are usually focused on higher efficiency achievement and the replacement of some non-environmentally friendly techniques. Oxidation is one of the frequently used techniques in water treatment processes, which is carried out to convert toxic chemical compounds into a form that is easier to remove by conventional or modern treatment methods or, after conversion, has a less negative effect on the human body. Oxidation is usually carried out in water treatment plants by conventional oxidants such as permanganate, chlorine, or chlorine dioxide, which effectively break down organic compounds into simpler ones, or oxidize, for example, arsenic, iron, or manganese, converting them into less harmful or easier-to-remove compounds. Although named oxidants are very efficient, their production usually implies high energy consumption, while during application undesirable disinfection by-products (DBPs) are form. Therefore, new oxidation techniques are being researched and tested, which will achieve high efficiency without the formation of new harmful compounds that require the application of additional processing procedures. This paper will give an overview of recent studies conducted to test the oxidation efficiency of highly reactive oxygen species (ROS): hydroxyl radicals (HO•), superoxide radicals (O_2•−), and singlet oxygen ($1O_2$).
Keywords: water treatment, oxidation, highly reactive oxygen species

Održive tehnologije oksidacije u procesima obrade voda

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Sažetak: Primarni zadatak procesa obrade vode je postizanje minimalnih zdravstvenih i sigurnosnih zahtjeva u području kvalitete vode za ljudsku potrošnju ili pročišćene otpadne vode. Tijekom posljednjeg desetljeća tvrtke koje se bave obradom voda suočavaju se sa zahtjevima za postizanje održivosti i smanjenje utjecaja njihovih procesa prerade vode na okoliš, dok su inovacije u navedenom području najčešće usmjerene na postizanje veće učinkovitosti i/ili zamjenu pojedinih tehnika koje nisu ekološki prihvatljive. Oksidacija je jedna od često korištenih tehnika u procesima obrade vode koja se provodi s ciljem promjene strukture ili razgradnje toksičnih ili nepoželjnih kemijskih spojeva kako bi se dobili produkti koje je lakše ukloniti konvencionalnim ili suvremenim metodama obrade, ili produkti koji će imati slabije negativne učinke na ljudsko zdravlje. Oksidacija se obično provodi u postrojenjima za pročišćavanje vode konvencionalnim oksidansima kao što su kalijev permanganat, klor ili klorni dioksid, koji učinkovito razgrađuju organske spojeve ili oksidiraju, na primjer, arsen, željezo ili mangan, pretvarajući ih u manje štetne spojeve ili spojeve koje je lakše ukloniti iz vode. Iako su navedeni oksidansi vrlo učinkoviti, njihova proizvodnja obično podrazumijeva značajnu potrošnju energije, dok primjena navedenih oksidanasa uzrokuje nastanak nepoželjnih nusproizvoda dezinfekcije (DBP)s. Stoga se istražuju i testiraju nove tehnike oksidacije kojima bi se postigla visoka učinkovitost bez stvaranja štetnih nusprodukata za čije uklanjanje je potrebno dodatno obrađivati vodu. U ovom radu biti će prikazani rezultati nedavno provedenih istraživanja s ciljem testiranja učinkovitosti oksidacije primjenom visoko reaktivnih spojeva kisika (ROS): hidroksilnih radikala (HO•), superoksidnih radikala (O_2•−) i singletnog kisika ($1O_2$).
Ključne riječi: prerada vode, oksidacija, reaktivne vrste kisika

Integrated treatment of industrial wastewater by improved ferritization technology

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Abstract: Environmental protection problems are substantively associated with the treatment of industrial wastewater flows. The hydrophase ferritization is a promising cost-efficient method of processing for exhausted technological solutions with synthesis magnetic materials from iron-containing liquid waste. The technology was improved by the use of variable magnetic fields to activate the processing of the spent etching solutions at ambient temperatures instead of the thermal one at 75°C. The efficiency of the energy-saving application of magnetic activation with amplitude of magnetic induction of 0.3 T and frequency from 0.5 to 10 Hz was established. Electric power consumption for magnetic activation in comparison with the thermal one is reduced by 60%. Application of magnetic activation does not reduce both the degree of removal of heavy metal ions and the crystalline structure of the sediments. A chemically stable phase of magnetite is obtained in the sediments with the initial concentration of iron ions of 16.6 g/dm^3, pH of 11.5, and the process duration of 15 min. The qualitative and quantitative composition of the sediments was investigated using x-ray diffraction and electron microscopy. The phases of magnetite, iron monohydrate, and heavy metal ferrites with magnetic properties were detected. The study results demonstrated the feasibility of integrated "green" technology for industrial waste processing with the production of materials with ferromagnetic and sorption properties.

Keywords: wastewater treatment, ferritisation, energy-saving, green technology

Guidelines for Circular Wastewater Management

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Abstract: It is becoming increasingly necessary to consider new elements in water management, during which it is important to stress that competent institutions have begun searching for harmonized quality solutions that are sustainable for all components of the water system in line with sustainable development and biodiversity conservation, without inequalities that put social cohesion, equity and safety at risk. In such a circular economy, the water cycle is also viewed through the contribution of wastewater treated at wastewater treatment plants of larger agglomerations or urban zones. The concept of circular economy replaces the former and - according to indicators -an unsustainable linear model of resource exploitation, manufacture and use of products, and waste disposal, in which the water sector was not systematically included. The review of the Directive concerning urban wastewater treatment (91/271/EEC) will contribute to awareness raising about the removal of nutrients from wastewater and preparation of treated wastewater and sludge for reuse, thus supporting circular water management with less pollution. Stricter requirements for urban wastewater treatment and measures for better monitoring, control and reduction of pollution at source will affect the quality of treated urban wastewater, thus encouraging water reuse. The purpose of Regulation 2020/741 of the European Parliament and of the Council of 25 May 2020 on minimum requirements for water reuse is to facilitate the uptake of water reuse whenever it is appropriate and cost-efficient. The Regulation guarantees that reclaimed water is safe for agricultural irrigation, ensuring a high level of protection of the environment and of human and animal health, encouraging a circular economy, thus also contributing to the efficient functioning of the internal market. Member States should also strive to develop new infrastructure, giving priority to green and blue infrastructure.

Keywords: wastewater, circular economy, sustainable development, directive, water reuse

Smjernice za kružno upravljanje otpadnim vodama

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Sažetak: Sve više je potrebno razmotriti nove elemente u upravljanju vodama, pri čemu je važno naglasiti da su se nadležne institucije pokrenule iznalaženje kvalitetnih i usklađenih rješenja koja su održiva za sve dijelove vodnog sustava u skladu s održivim razvojem, očuvanjem biološke raznolikosti, bez nejednakosti koje ugrožavaju socijalnu koheziju, pravdu i sigurnost. U tom kružnom gospodarstvu ciklus vode promatra se i kroz doprinos otpadne vode koja se pročišćava na uređajima za obradu otpadnih voda većih aglomeracija, odnosno urbanih zona. Pojam kružnog gospodarstva zamjenjuje dosadašnji, a prema pokazateljima i neodrživi, linearni model crpljenja resursa, izrade proizvoda, upotrebe istih te odbacivanja otpada, u koji vodni sektor nije bio sustavno uključen. Preispitivanjem Direktive o pročišćavanju komunalnih otpadnih voda (91/271/EEZ) pridonijet će se podizanju razine svijesti za uklanjanje hranjivih tvari iz otpadnih voda te pripremu pročišćenih voda i mulja za ponovnu upotrebu, čime se podupire kružno upravljanje vodama s manje onečišćenja. Stroži zahtjevi za pročišćavanje komunalnih otpadnih voda i mjera za bolje praćenje, nadzor i smanjenje onečišćenja na izvoru utjecat će na kvalitetu pročišćenih komunalnih otpadnih voda pa će se time podupirati ponovna upotreba vode. Svrha Uredbe 2020/741 Europskog parlamenta i vijeća od 25. svibnja 2020. o minimalnim zahtjevima za ponovnu upotrebu vode je olakšati primjenu ponovne upotrebe vode kada god je to primjereno i troškovno učinkovito. Uredba osigurava da je obrađena voda sigurna za navodnjavanje poljoprivrednih površina, čime se osigurava visoka razina zaštite okoliša te zdravlja ljudi i životinja, promiče kružno gospodarstvo, a time i doprinosi učinkovitom funkcioniranju unutarnjeg tržišta. Države članice također bi trebale nastojati razviti novu infrastrukturu, pri čemu bi prednost trebale dati zelenoj i plavoj infrastrukturi.
Ključne riječi: otpadne vode, kružno gospodarstvo, održivi razvoj, direktiva, ponovna upotreba vode

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