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BOOK OF ABSTRACTS

Knjiga sažetaka



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UVODNA RIJEČ

3. Studentski kongres o održivoj kemiji i inženjerstvu je treći u nizu studentski kongres ove tematike u organizaciji Studentske sekcije HDKI-ja. SKOKI kongresi održavaju se još od 2023. godine s velikim uspjehom, s obzirom na rastuću popularnost održive tematike u današnjem svijetu. Zbog porasta zahtjeva brzo rastućih industrija, eksponencijalnog rasta broja stanovništva te povećanja potreba za boljim životnim standardom istog, ova tematika postaje sve zastupljenija u našoj svakodnevnicima.

Upravo zbog toga održavamo SKOKI, čiji je cilj približiti koncepte održivosti i njihove primjene studentima kemijskog inženjerstva, kemije, strojarstva i srodnih struka. Održive prakse u ovim su industrijama od velike važnosti, ali ne samo za dobrobit okoliša, već i za optimizaciju tehnoloških procesa, poboljšanje kvalitete proizvoda te maksimizaciju ekonomičnosti rada u tim industrijama. Cilj kongresa je uputiti i motivirati studente kako bi i oni sami primijenili održive prakse u svojim budućim karijerama te u svom svakodnevnom životu.

SKOKI se svake godine sastoji od plenarnih i pozvanih predavanja profesora, znanstvenika i stručnjaka iz raznih industrija koji obogaćuju kongres edukativnim i aktualnim sadržajem, jednostavno i razumljivo predstavljenim kako bi ih studenti mogli pratiti s razumijevanjem. Osim predavanja, ove godine su se na SKOKI-ju održale i interaktivne radionice: „*Application of Microorganisms for Biopolymer Synthesis*“, „*The Great Fuel Mystery: Investigating Biofuel's Secret Identity*“ i „*Achieving Circularity Equilibrium with a Focus on Waste & Wastewater*“ koje su dale priliku sudionicima da praktičnim i samostalnim radom, uz prethodno predstavljene teorijske osnove nauče i kreiraju nešto novo. Uz navedeno, na SKOKI-ju su se također održale posterska sekcija, panel rasprava u obliku *Q&A*-a naziva „*Teorija vs. praksa - Stvarni izazovi održivosti u industriji*“ gdje su studenti mogli uživo, putem QR koda anonimno postavljati pitanja stručnjacima koji iza sebe imaju godine iskustva rada u industriji te razriješiti sve svoje nedoumice vezane uz rad i zaposlenje u industriji.

Zahvaljujući našim znanstvenim suradnicima i naravno svim članovima organizacijskog odbora koji su uložili trud, rad i vrijeme ovaj se kongres kontinuirano održava na visokom standardu. Također uz pokroviteljstvo Hrvatskog kemijskog društva te Europskog kemijskog društva (*European Chemical Society*) kongres je prvi puta dobio međunarodni status, koji je potvrdio suradnjom sa stranim znanstvenim suradnicima te izvedbom na engleskom i hrvatskom jeziku.

Paul Šimunić, voditeljica organizacijskog odbora 3. SKOKI-ja

FOREWORD

The 3rd Student Congress on Sustainable Chemistry and Engineering is the third edition of student congresses on this topic, organized by the Student Section of HDKI. SKOKI congresses have been held successfully since 2023, driven by the growing focus on sustainability worldwide. This rise comes from the needs of fast-growing industries, rapid population growth, and demands for better living standards, making it a highly represented part of everyday life.

This is exactly why we organize SKOKI which's main goal is to introduce the concepts of sustainable practices to chemical engineering, chemistry, mechanical engineering students and students from related fields. Sustainable practices in these industries are of great importance, but not only for protection of the environment, but also for the optimization of technological processes, improvement of product quality and maximization of the economy of work in these industries. The goal of the congress is to guide and motivate students so that they themselves apply sustainable practices in their future careers and in their daily lives.

Every year SKOKI consists of plenary and invited lectures by professors, scientists and experts from various industries that enrich the congress with educational and current content, simply and comprehensibly presented so that students can follow them with understanding. Apart from lectures, interactive workshops were also held at SKOKI this year: *"Application of Microorganisms for Biopolymer Synthesis"*, *"The Great Fuel Mystery: Investigating Biofuel's Secret Identity"* and *"Achieving Circularity Equilibrium with a Focus on Waste & Wastewater"*, which gave participants the opportunity to learn and create something new through practical and independent work with previously explained theoretical foundations. In addition to these, SKOKI also featured a poster section, a panel discussion in the form of Q&A called *"Theory vs. Practice - Real Challenges of Sustainability in Industry"* where students could anonymously ask questions live, via QR code, to experts who have years of experience in industry and resolve all their doubts related to work and employment in industry.

Thanks to our scientific associates and of course all members of the organizing committee who invested effort, work and time, this congress is continuously held at a high standard. Also under the patronage of the *Croatian Chemical Society* and the *European Chemical Society*, the congress for the first time received international status, which was confirmed by cooperation with foreign scientific associates and performance in English and Croatian.

Paula Šimunić, chair of the 3rd SKOKI organization committee

UVODNA RIJEČ PREDSEDNIKA STUDENTSKE SEKCIJE Hrvatskog društva kemijskih inženjera i tehnologa

Kao predsjednika Studentske sekcije HDKI-ja, veseli me vidjeti su se na ovogodišnjem SKOKI-ju skupili prijatelji i kolege iz raznih niša, raznih stadija karijere, znanosti i industrije, studenti i profesori, jer upravo ta interdisciplinarna i sveobuhvatna povezanost je ono čemu SSHDKI teži i u što vjeruje da je temelj društva i tehnologije budućnosti.

Na SKOKI-ju smo se okupili oko održivosti. Teme o kojima smo slušali, raspravljali i učili su iznimno bitne, ne samo za nas nego za cjelokupno šire društvo. Na nama je da osiguramo svojoj djeci i njihovoj djeci da im životni standard samo raste, naša težnja prema održivim tehnologijama je oružje koje se bori za to, šira javnost često nema perspektivu kako prepoznati opasnosti koje nas mogu sustići i još manje kako popraviti štetu, jedino što je sigurno, bilo to sprječavanje ili popravljanje, mi smo ti na kojima leži taj teret. Smatram da je to plemenita zadaća i vjerujem da svi mi taj teret nosimo bez imalo sumnje u značaj našeg djelovanja. Samo kroz interdisciplinarnu suradnju i potpunu umreženost između područja i generacija inženjera možemo osigurati razvoj i primjenu tehnologije koja čini život lakšim, sigurnijim i sretnijim ne samo za nas nego za nebrojene generacije koje će nas naslijediti.

Vilim M. Boroša, predsjednik Studentske sekcije HDKI-ja.

FOREWORD FROM THE PRESIDENT OF STUDENT SECTION OF HDKI

As the president of the Student Section of the Croatian Society of Chemical Engineers, I am pleased to see that SKOKI has gathered colleagues from various niches, various career stages, science and industry, students and professors, because it is precisely this interdisciplinary and comprehensive connectivity that SSCSCE strives for, and believes is the foundation of the society and technology of the future.

We have gathered around sustainability. I think it is clear to everyone how important the topics we listened, talked and discussed about are, not only for us but for the entire wider society. It is up to us to ensure the standard of living for our children and their children, our aspiration towards sustainable technologies is a weapon that fights for this, the general public often has no perspective on how to recognize the dangers that can catch up with us and even less how to repair the damage, the only thing that is certain, whether it is prevention or repair, we are the ones on whom that burden lies. I believe that this is a noble task and I believe that all of us carry this burden without any doubt about the significance of our actions. Only through interdisciplinary cooperation and complete cooperation between fields and generations of engineers can we ensure the development and application of technology that makes life easier, safer and happier not only for us but for countless generations that will succeed us.

Vilim M. Boroša, President of the Student Section of HDKI.

3. Studentski kongres o održivoj kemiji i inženjerstvu, Zagreb, 6. i 7. ožujka 2026.

SADRŽAJ

CONTENTS

PLENARNA PREDAVANJA / PLENARY LECTURES

Srećko Herceg

GREEN HYDROGEN PRODUCTION: CHALLENGES, CONTROL STRATEGIES, AND INDUSTRIAL PERSPECTIVES.....1

Dragana Tomašević Pilipović, Đurda Kerkez, Anita Leovac Maćerak, Vesna Pešić, Milena Bečelić-Tomin

WASTEWATER AS A RESOURCE – CIRCULAR ECONOMY IN FOCUS.....2

POZVANA PREDAVANJA / INVITED LECTURES

Toni Alar

THE ROLE OF HYDROGEN IN THE ENERGY TRANSITION.....4

Barbara Bertović, Monika Šabić Runjavec, Marija Vuković Domanovac

RECOVERY OF SOIL CONTAMINATED WITH PETROLEUM HYDROCARBONS INTO A FUNCTIONAL NATURAL RESOURCE THROUGH BIOREMEDIATION.....5

Silvija Petković, Eugen Milan Maršić

CIRCULAR VALORISATION OF POLYMERIC WASTE SLUDGE FOR SUSTAINABLE ASPHALT PRODUCTION.....6

Monika Šabić Runjavec, Marija Vuković Domanovac

ADVANCING SUSTAINABLE WASTEWATER TREATMENT THROUGH BIOREMEDIATION OF PHARMACEUTICALS.....7

Davor Dolar, Iva Ćurić

CLOSED WATER CYCLE IN TEXTILE INDUSTRY: REUSE OF TEXTILE WASTEWATER IN TEXTILE PROCESSES BY MEMBRANE SEPARATION PROCESSES.....8

Natalija Velić, Marija Stjepanović

UPCYCLING FOOD INDUSTRY BY-PRODUCTS INTO FUNCTIONAL BIOSORBENTS.....9

Ivana Ćosić

AIR QUALITY AND WASTE: FROM SOURCE TO AIR QUALITY FORECAST.....10

Danica Maljković

NOTHING 2 WASTE.....11

POSTERSKA IZLAGANJA / POSTER PRESENTATIONS

Vanja Perković, Nera Bebek, Renata Vičević

THE INFLUENCE OF RECOMBINANT [Ni-Fe]-HYDROGENASE OBTAINED BY EXPRESSION OF DIFFERENT PLASMIDS IN ESCHERICHIA COLI ON BIOHYDROGEN REDUCTION.....13

Klara Štingl, Monika Šabić Runjavec, Marija Vuković Domanovac

EFFICIENCY OF MICROBIAL ANTIBIOTIC REMOVAL AND MORPHOLOGICAL RESPONSE OF A BACTERIAL ISOLATE.....14

Andrijana Vuković, Petra Kovač, Monika Šabić Runjavec, Marija Vuković Domanovac

BIOPOTENTIAL ASSESSMENT OF URBAN GREEN WASTE.....15

Farah Subašić, Marija Vuković Domanovac

MICROORGANISMS AS A SUSTAINABLE ALTERNATIVE FOR BIOFUEL PRODUCTION.....16

Antonija Karakaš, Marko Robić, Davor Margetić

ECO-FRIENDLY IRON-BASED DESULFURIZATION REAGENTS FOR SUSTAINABLE GUANIDINE SYNTHESIS.....17

3. Studentski kongres o održivoj kemiji i inženjerstvu, Zagreb, 6. i 7. ožujka 2026.

Karla Kuzman, Marta Blažek, Petra Popović, Donna Danijela Dragun, Iva Rezić Meštrović, Ernest Meštrović <i>SUSTAINABLE ELECTROSPINNING OF NANOFIBERS USING SOLVENT SYSTEMS BASED ON ACETIC AND FORMIC ACID</i>	18
Laura Čavec, Ivana Glavaš, Erza Stajku, Andrea Špoljarić, Elvira Vidović <i>STUDY OF THE CONTENT OF REACTIVE PHOSPHORUS USING THE DIFFUSION GRADIENT TECHNIQUE WITH THIN FILMS</i>	19
Tea Lažeta, Marija Labudović, Mustapha EL Cadiri, Suresh Kumar Pandey, Sandra Romac, Hrvoje Kušić, Marijana Kraljić Roković <i>ELECTROCHEMICAL SYNTHESIS AND DOPING OF WO₃</i>	20
Dora Lastovčić, Ivona Zirn, Kristina Bule Možar, Luka Večenaj, Matija Cvetnić, Marinko Markić, Tomislav Bolanča, Dajana Kučić Grgić, Šime Ukić <i>OPTIMISATION OF THE BIODEGRADATION OF THE ANTIVIRAL DRUG REMDESIVIR USING ACTIVATED SLUDGE</i>	21
Mirela Volf, Monika Šabić Runjavec, Marija Vuković Domanovac <i>INCREASING THE EFFICIENCY OF BIOLOGICAL LEACHATE TREATMENT USING TARGETED BIOAUGMENTATION</i>	22
Jakov Gugić, Barbara Bertović, Monika Šabić Runjavec, Marija Vuković Domanovac <i>ENVIRONMENTAL ROLE AND ENZYMATIC CAPACITY OF AN INDIGENOUS SOIL ISOLATE</i>	23
Katarina Kordej, Vilma Lovrinčević, Dragana Vuk, Monika Šabić Runjavec, Marija Vuković Domanovac, Ines Despotović <i>SYNTHESIS AND ANTIMICROBIAL ACTIVITY OF NEW ARYL-SUBSTITUTED INDENE DERIVATIVES</i>	24
Stela Relota, Klara Krajnović, Tomislav Domanovac, Monika Šabić Runjavec, Marija Vuković Domanovac <i>ASSESSMENT OF THE BIOSORPTION CAPACITY OF ACTIVATED SLUDGE FOR LEACHATE</i>	25
Barbara Vukas, Laura Šugić, Nino Drpić, Viktor Gaal, Matija Cepanec, Marko Rogošić <i>DETERMINATION OF SOLID-LIQUID EQUILIBRIUM IN HYDROPHOBIC EUTECTIC SOLVENT SYSTEMS BY DIFFERENTIAL SCANNING CALORIMETRY</i>	26
Iva Pinušić, Mihaela Gašpar, Petra Santro, Dora Paponja, Iva Blažević, Aleksandra Sander <i>THE INFLUENCE OF PIPERINE AND CURCUMIN ON THE SOLUBILITY AND GRANULOMETRIC CHARACTERISTICS OF SULFAMETHOXAZOLE</i>	27

3. Studentski kongres o održivoj kemiji i inženjerstvu, Zagreb, 6. i 7. ožujka 2026.

PLENARNA PREDAVANJA

PLENARY LECTURES

GREEN HYDROGEN PRODUCTION: CHALLENGES, CONTROL STRATEGIES, AND INDUSTRIAL PERSPECTIVES

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Green hydrogen is widely recognized as a key element in the global energy transition. However, despite its promising sustainability narrative, significant technical, economic, and operational challenges remain. This presentation analyzes green hydrogen production, focusing on water electrolysis technologies and their integration into current energy systems. The presentation will highlight efficiency limitations, material degradation, dynamic operation under fluctuating renewable energy inputs, and scale-up considerations. It will address process control strategies that enable stable and efficient operation under variable loads, a critical requirement in renewable energy systems.

Based on industrial experience and applied research, the lecture will discuss how advanced process control and soft sensing can enhance performance and reduce operational costs. The discussion will also cover practical constraints, safety considerations, and the gap between laboratory-scale demonstrations and industrial implementation. [1] [2]

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WASTEWATER AS A RESOURCE – CIRCULAR ECONOMY IN FOCUS

Dragana Tomašević Pilipović, Đurđa Kerkez, Anita Leovac Maćerak, Vesna Pešić, Milena Bečelić-Tomin

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Wastewater management is facing increasing pressure due to population growth, urbanization, climate change, and escalating water scarcity, rendering conventional linear approaches based solely on treatment and discharge insufficient for long-term sustainability. In response, a transition toward circular economy (CE) principles is gaining importance, where wastewater is recognized as a valuable resource rather than a waste stream. This approach enables the recovery and reuse of water, energy, and materials, contributing to enhanced water security and environmental protection. A key element of circular wastewater management is the implementation of fit-for-purpose treatment concepts, which allow safe and efficient water reuse for agricultural, industrial, urban, and environmental applications. Beyond water reuse, wastewater represents a significant source of recoverable resources, including nutrients such as nitrogen and phosphorus, energy in the form of biogas, and other high value-added products. Advances in treatment technologies, coupled with risk-based management frameworks, provide the foundation for the development of integrated circular water systems. [1] [2]

The “waste-to-resource” paradigm provides a conceptual framework for transforming wastewater and sewage sludge management into a driver of sustainable development. By minimizing negative environmental externalities, reducing pressure on natural resources, and restoring aquatic ecosystems, circular wastewater management represents a strategic tool for accelerating the transition of the water sector toward a resilient and sustainable circular economy. [3] [4]

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3. Studentski kongres o održivoj kemiji i inženjerstvu, Zagreb, 6. i 7. ožujka 2026.

POZVANA PREDAVANJA

INVITED LECTURES

THE ROLE OF HYDROGEN IN THE ENERGY TRANSITION

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Hydrogen has become one of the central technological components of global, as well as EU decarbonization strategies, offering an energy carrier capable of supporting climate neutral energy systems. Its importance has grown rapidly due to increase in renewable energy deployment, tightening climate policies, and the need to decarbonize hard-to-abate sectors.

Recent assessments show that there are many sectors where hydrogen could play a crucial role including heavy industry, heating, transport etc. The key feature is in its versatile nature: it can be transported, stored, used as a fuel or used as an energy feedstock. This broad spectrum is the main reason why many countries opt to invest, develop and expand hydrogen production and storage technologies. Beyond its environmental benefits, which primarily refers to CO₂ reduction, hydrogen is expected to influence future global economic and industry trends. The integration of hydrogen into the broader energy transition is also shaped by policy frameworks and the expansion of renewable capacity.

However, large-scale adoption of hydrogen still faces structural challenges. Green hydrogen production remains more expensive than fossil-based alternatives, infrastructure for transport and storage is limited, and energy conversion losses reduce overall system efficiency. Physical properties of hydrogen such as low volumetric density require intensive compression or liquefaction, leading to logistical complexity and higher costs. Nonetheless, global initiatives and national hydrogen strategies increasingly view hydrogen as indispensable for meeting net-zero targets and a step toward reaching climate neutrality.

Hydrogen's role in the energy transition is defined by its unique ability to bridge the gap between renewable energy expansion and the decarbonization of energy-intensive sector as renewable energy becomes the dominant global energy source.

References:

No references were used for the purpose of writing this abstract.

RECOVERY OF SOIL CONTAMINATED WITH PETROLEUM HYDROCARBONS INTO A FUNCTIONAL NATURAL RESOURCE THROUGH BIOREMEDIATION

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Soil contaminated with petroleum hydrocarbons is often classified as hazardous waste due to its toxicity, persistence, and potential risks to ecosystems and human health. [1] Conventional remediation methods typically rely on intensive physical or chemical treatments that may generate secondary waste streams, require high energy consumption, and alter soil properties to such an extent that further use becomes limited. [2] Bioremediation offers an alternative approach based on natural biological processes, aiming not only to reduce contamination but also to restore soil functionality and enable safe reuse. [3] This study investigates the potential of autochthonous microorganisms isolated from petroleum-contaminated soil as tools for hazardous waste recovery. Autochthonous bacterial strains, including the genera *Bacillus* and *Pseudomonas*, were isolated from crude oil-contaminated soil and selected for their ability to survive in contaminated environments. The metabolic activity of these strains enables the transformation of petroleum hydrocarbons into less harmful compounds, contributing to the gradual recovery of contaminated soil and its potential return to the environment as a functional natural resource. The research highlights the essential role of autochthonous microbial communities in hazardous waste management and demonstrates how bioremediation can support the principles of the circular economy by reducing the need for waste disposal and promoting the sustainable reuse of contaminated land.

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CIRCULAR VALORISATION OF POLYMERIC WASTE SLUDGE FOR SUSTAINABLE ASPHALT PRODUCTION

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This study investigates the application of circular economy principles in the development of a novel asphalt additive derived from polymeric waste sludge generated during solvent regeneration processes. The central scientific question is whether such hazardous industrial waste can be chemically and physically modified into a stable, homogeneous, and technically suitable material for use in asphalt mixtures, while simultaneously reducing environmental burden and dependence on virgin petrochemical resources. [1]

A multi-stage experimental methodology was employed. Initial activities included a review of current asphalt production practices, relevant European and national regulations, and standard laboratory characterisation methods for asphalt and asphalt mixtures. Chemical and physical analyses of polymeric fractions were conducted to identify critical parameters affecting performance, such as particle size distribution, viscosity, and volatile content. Identified challenges were addressed through filtration, controlled dehydration, and viscosity adjustment, resulting in a homogenised polymeric fraction suitable for use as an asphalt additive.

Subsequent laboratory-scale testing involved incorporation of selected polymeric fractions into asphalt mixtures at varying mass ratios, followed by evaluation of viscosity, density, volatile content, and compositional characteristics. The results indicate that polymeric fractions with lower viscosity and reduced volatile content exhibit superior compatibility with bitumen and asphalt matrices, while fully dehydrated polymeric fractions showed the most favourable compatibility. Pilot-scale and preliminary industrial mixing trials further confirmed the technical feasibility of the developed additive. Ongoing work includes industrial-scale validation and real-road testing to assess performance under operational conditions.

The results obtained to date demonstrate that polymeric waste sludge can be successfully valorised into a functional asphalt additive without compromising key material properties. This approach offers a promising pathway for reducing hazardous waste, lowering the environmental footprint of asphalt production, and advancing circular economy implementation in the construction sector. The findings provide a basis for further industrial validation and future commercialisation strategies.

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ADVANCING SUSTAINABLE WASTEWATER TREATMENT THROUGH BIOREMEDIATION OF PHARMACEUTICALS

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The continuous discharge of pharmaceutical wastewater from hospitals, households, veterinary practices, agricultural activities and industrial production has been recognized as an emerging environmental issue. This type of wastewater contains a wide range of biologically active compounds, particularly antibiotics, which are not efficiently eliminated during the conventional wastewater treatment process and may consequently remain in receiving aquatic environments. Such persistence presents ecological risks and accelerates the emergence and spread of antimicrobial resistance. A key scientific question is whether microbial processes can be effectively exploited to remove pharmaceutical contaminants from wastewater in a sustainable manner. Bioremediation represents a promising approach consistent with the principles of sustainable chemistry and engineering. It relies on the metabolic capabilities of microorganisms to degrade, transform, or remove pharmaceutical compounds from contaminated water systems. Indigenous microorganisms, naturally adapted to polluted environments, often demonstrate higher degradation efficiencies and greater resilience under variable operational conditions. These findings suggest that microbial-based treatment systems can significantly reduce antibiotic concentrations and their associated biological activity in wastewater. The application of bioremediation provides a low-energy, cost-effective, and environmentally friendly alternative to conventional wastewater treatment technologies, supporting the development of sustainable treatment strategies. Integrating microbial processes into existing treatment frameworks may contribute to improved removal of pharmaceutical residues and reduced environmental and public health risks.

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CLOSED WATER CYCLE IN TEXTILE INDUSTRY: REUSE OF TEXTILE WASTEWATER IN TEXTILE PROCESSES BY MEMBRANE SEPARATION PROCESSES

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One of the major problems in the world today is water scarcity, which leads to increased costs. By reusing water in industry, water cycles can be closed, helping to reduce water scarcity. Drinking water and groundwater have become scarce natural resources due to population growth and economic industrialization. [1] In the economic sector, the textile industry is one of the largest consumers of drinking water and groundwater for its processes. These processes such as pretreatment, bleaching, dyeing, washing, and finishing consume 0.06-0.40 m³ of water per kg of finished textile product. [2] As a result, large amounts of wastewater are generated. It is estimated that a factory producing 2-16 t of product per day can generate between 150 and 2700 m³ of wastewater. [3] In addition, textile wastewater (TWW) is extremely toxic due to its composition. It mainly contains acids, alkalis, auxiliaries, salts, dyes, and other substances, resulting in high levels of chemical oxygen demand, biological oxygen demand, suspended solids, total organic carbon, color, electrical conductivity, and turbidity. [2] If released into the environment without treatment, it can have mutagenic, carcinogenic, and toxic effects on flora, fauna, and humans. Therefore, it is necessary to find a wastewater treatment method that is feasible, efficient, reliable, and environmentally beneficial. Such methods, defined by the concept of "Best Available Techniques" (BAT), include membrane separation processes for wastewater treatment. In this presentation, membrane separation processes will be introduced as a solution to achieve a closed water cycle in the textile industry. This approach will include the application of membrane bioreactor, ultrafiltration, nanofiltration, and reverse osmosis for TWW treatment and reuse in wet textile processes (dyeing, bleaching, washing, and finishing). Additionally, to achieve a closed water cycle, the reuse of reverse osmosis retentate for irrigation of basil and beans will be demonstrated. [4] [5]

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UPCYCLING FOOD INDUSTRY BY-PRODUCTS INTO FUNCTIONAL BIOSORBENTS

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Food industry residues, including by-products and waste streams, represent a significant opportunity for resource valorisation. [1] Strategic European frameworks, such as the European Green Deal, the Circular Economy Action Plan, the European Bioeconomy Strategy, and the “Zero Pollution” Action Plan, promote sustainable resource use, emission reduction, and the development of innovative circular economy models. [2] These strategies support the transformation of production residues into valuable resources, contributing to environmental protection and enhanced sustainability. Within this context, food industry by-products have been explored as low-cost, environmentally friendly biosorbents for the removal of different pollutants (e.g. synthetic dyes, nutrients, and pharmaceuticals) from aquatic systems. [3] Various modification techniques have been employed to enhance their adsorption capacity, while regeneration potential and desorption efficiency have also been assessed to ensure reusability. [4] Overall, the development and application of biosorbents derived from food industry residues will be discussed, as they exemplify an innovative and practical approach to integrating waste valorisation into sustainable wastewater treatment strategies.

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AIR QUALITY AND WASTE: FROM SOURCE TO AIR QUALITY FORECAST

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Waste is any substance or object which the holder discards or intends or is required to discard. [1] [2] Waste is typically categorized based on its properties, origin, and chemical composition, which determines the risk it poses to the environment. [2] [3] Following classification based on its origin and hazardous properties, waste is managed according to the waste hierarchy, including recycling, energy recovery such as incineration, or disposal. [1] [2] Although the incineration process is controlled and designed to minimize emissions, it still releases a variety of dangerous chemicals into the environment, including dioxins, particulate matter, toxic materials, and furans. Uncontrolled waste burning, such as accidental fires, releases the same harmful substances, often in larger quantities. Due to the intense heat present during a fire, the smoke that is released rises quickly and spreads well above ground level. Sulphur dioxide (SO₂) and nitrogen dioxide (NO₂) from waste burning contribute to acid rain, which harms ecosystems, soils, and buildings. [4] Furthermore, ground-level ozone is formed through photochemical reactions between nitrogen oxides (NO_x) and volatile organic compounds (VOCs) in the presence of sunlight. Additionally, significant volumes of greenhouse gases are released into the atmosphere during open waste burning; including methane (CH₄), carbon dioxide (CO₂), as well as particulate matter of different sizes (PM_{2.5} and PM₁₀), which are frequently associated with poor air quality and can cause serious respiratory illnesses. [5] Therefore, it is essential to continuously monitor air pollutant concentrations. Regular monitoring enables an accurate assessment of population exposure, providing a basis for effective environmental protection measures and stronger public health policies.

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NOTHING 2 WASTE

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The presentation introduces LOOPER[®], a waste-to-hydrogen system developed by a Croatian company (an internal start-up of DOK-ING) to address two related challenges: managing non-recyclable waste and producing affordable low-carbon hydrogen. LOOPER[®] employs a two-stage thermochemical process to convert hydrocarbon-containing wastes (such as plastics, sewage sludge, and textiles) into syngas, from which high-purity hydrogen is separated using membrane technology, then stored and used in transport and industry. Solid residues and ash are valorised in construction, including brick trials demonstrating properties comparable to conventional materials. The presentation positions the solution as CO₂-negative compared to landfilling or incineration, requiring about half the renewable electricity of electrolyzers, and highlights a compact, modular design suitable for diverse end users, enabling energy self-sufficiency and reducing waste management costs. It also outlines progress milestones (2022–2025) and external validation through major funded projects, including the Innovation Fund S2H2 (targeting 25 t/day sludge to approximately 1 t/day hydrogen, with operation planned for 2026), as well as Horizon Europe and European Defence Fund initiatives.

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POSTERSKA IZLAGANJA

POSTER PRESENTATIONS

THE INFLUENCE OF RECOMBINANT [Ni-Fe]-HYDROGENASE OBTAINED BY EXPRESSION OF DIFFERENT PLASMIDS IN *Escherichia coli* ON BIOHYDROGEN PRODUCTION

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The enzyme [NiFe]-hydrogenase is a key biocatalyst for hydrogen-based bioprocesses, as it catalyzes the reversible interconversion of molecular hydrogen (H_2) and protons/electrons. This enzyme can be isolated from natural hosts such as *Cupriavidus necator* H16, which contains four oxygen-tolerant [NiFe]-hydrogenases. [1] However, isolation from natural hosts is often limited by low enzyme abundance, activity losses due to limited stability during handling, and labour-intensive downstream processing. Consequently, heterologous expression in *Escherichia coli* has become an alternative, enabling higher production levels and streamlined purification through affinity-tagged constructs. Transitioning from crude extract to purified preparations can further improve reproducibility by removing contaminating biomolecules, reducing side reactions, and enhancing overall operational control of the biocatalyst. [2] The objective of this research is to compare four plasmid designs for recombinant [NiFe]-hydrogenase expression in *E. coli* and to determine how vector architecture affects expression efficiency, catalytic activity, enzyme stability, and hydrogen-process performance in a batch reactor. The study will use standardized cultivation of recombinant strains, controlled enzyme recovery and purification, and determination of specific activity under consistent assay conditions. The outcomes will identify the most effective plasmid configuration for producing active, stable oxygen-tolerant [NiFe]-hydrogenase, providing a foundation for scalable and efficient biohydrogen bioprocesses aligned with renewable feedstock and sustainability goals.

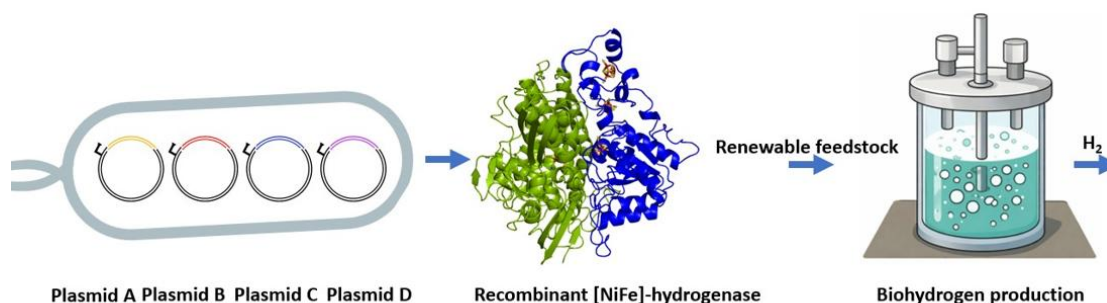


Figure 1 – Biohydrogen production

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EFFICIENCY OF MICROBIAL ANTIBIOTIC REMOVAL AND MORPHOLOGICAL RESPONSE OF A BACTERIAL ISOLATE

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Antibiotics are widely used in human and veterinary medicine; however, their extensive use and incomplete metabolism result in their release into the environment via wastewater, agricultural runoff, and improper disposal. [1] Their persistence can disrupt microbial communities and promote antimicrobial resistance, as conventional wastewater treatment often fails to remove them fully. Bacterial biodegradation presents a promising sustainable solution, as certain strains can metabolise antibiotics. [2] In this study, the ability of a Gram-negative bacterial isolate to degrade antibiotics was investigated. The experiment was conducted under submerged batch conditions with different initial concentrations of antibiotic dissolved in mineral medium. During the experiments, the concentration of antibiotic as substrate, biomass concentration, pH, dissolved oxygen concentration, and electrical conductivity were monitored. Microscopic analysis was performed to assess any morphological changes in bacterial cells. The antibiotic removal efficiency was $23.4 \pm 4.0\%$ on the fifth day of the experiment at the highest tested antibiotic concentrations. Morphological analysis revealed that, despite antibiotic removal, changes in cell size occurred. These findings suggest that such bacteria could be utilised in future bioremediation strategies.

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BIOPOTENTIAL ASSESSMENT OF URBAN GREEN WASTE

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Green waste is a significant source of biomass in urban areas and includes fallen leaves, grass clippings, tree and shrub trimmings, wilted flowers, and other plant residues resulting from natural decomposition processes or anthropogenic activities. [1] Although rich in organic matter, it is often disposed of in landfills, neglecting its potential within a circular economy. Due to its high content of biodegradable components, green waste is a valuable substrate with considerable biopotential. In this study, maple leaves and cherry laurel were characterised as representative fractions of urban green waste. The results showed a high organic matter content of $92.8 \pm 1.0\%$. In maple leaves, higher concentrations of viable bacterial cells and fungi were found, at 7.1×10^7 cfu/mL and 1.9×10^4 cfu/mL, respectively. A bacterial culture of the genus *Pantoea* was isolated from the eluate, indicating the presence of indigenous microbial populations involved in biodegradation processes. The results obtained provide insight into the physicochemical and microbiological properties of the tested materials and confirm their significant biopotential for the valorisation of green waste.

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MICROORGANISMS AS A SUSTAINABLE ALTERNATIVE FOR BIOFUEL PRODUCTION

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The continuous growth of the global population and rising living standards have increased energy demand, with fossil fuels remaining the dominant source. Their limited availability, non-renewable nature, and negative effects on the environment and socio-economic stability underscore the need to develop sustainable alternative solutions. Biofuels are among the most promising options, particularly those produced using microorganisms, due to their metabolic diversity and ability to convert various substrates into energy [1] [2]. This work highlights the importance of developing biofuels, with particular emphasis on the microbial processes that enable their production. The advantages and limitations of these technologies are discussed, as well as the need for innovative approaches to increase efficiency and reduce costs, ensuring production is sufficient to meet global needs. Given the rapid depletion of fossil resources, the development of microbial-based biofuels is a crucial step towards a sustainable energy system for the future.

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ECO-FRIENDLY IRON-BASED DESULFURIZATION REAGENTS FOR SUSTAINABLE GUANIDINE SYNTHESIS

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This investigation employs two sustainable approaches: the development of novel desulfurization reagents in guanilation reaction and the application of mechanochemical organic synthesis. Specifically, the chemical synthesis of guanidine compounds is achieved through the desulfurization of aromatic thioureas using innovative iron-based reagents, such as FeOCl and α -Fe₂O₃. Novel guanidine derivatives were successfully prepared using ball milling, a mechanochemical technique well-regarded for its ability to reduce solvent consumption and minimize toxic waste, thereby aligning with green chemistry principles. [1-4]

These novel guanidine derivatives were fully characterized using FTIR, HRMS, ¹H NMR, and ¹³C NMR spectroscopy. This approach represents an excellent alternative to traditional methods that often rely on hazardous solvents. In this work, environmentally friendly iron-based reagents replace conventional mercury-based desulfurization agents like yellow HgO and HgCl₂.

To gain a deeper understanding of the mechanochemical process with iron-based desulfurization reagents, ⁵⁷Fe Mössbauer spectroscopy, FE-SEM (Field Emission - Scanning Electron Microscopy) and XRPD (X-ray Powder Diffraction) were utilized to characterize both the reaction mixture and the precipitate obtained after filtration [5] [6].

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SUSTAINABLE ELECTROSPINNING OF NANOFIBERS USING SOLVENT SYSTEMS BASED ON ACETIC AND FORMIC ACID

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The development of environmentally responsible manufacturing strategies has become a critical priority in contemporary nanomaterials engineering [1]. Electrospinning, despite its widespread application in the fabrication of nanofibrous materials for biomedicine, filtration, advanced functional coatings, and membrane platforms for organ-on-a-chip systems, continues to rely predominantly on organic solvents that are toxic and environmentally hazardous. This issue is particularly significant as organ-on-a-chip technologies are increasingly emerging as viable alternatives to animal studies in preclinical research [2]. The transition toward cell-based microphysiological systems requires the fabrication of membranes that are free from residual toxic solvents, as even trace contaminants may adversely affect cell viability, differentiation, and functional response within these platforms. Consequently, the selection of safer solvent systems is not only an environmental and regulatory concern but also a critical factor in ensuring biological compatibility and experimental reliability in next-generation in vitro models.

In this study, we explore acetic acid and formic acid as green, economically viable solvent systems for the sustainable production of polymeric nanofibers. Polymer solutions of polycaprolactone were prepared using mixed solvent systems based on acetic and formic acid, followed by electrospinning under controlled processing conditions. The influence of solvent composition on solution properties (viscosity, conductivity), fiber morphology, and structural uniformity was systematically investigated. Scanning electron microscopy confirmed the formation of continuous nanofibers, and FTIR spectroscopy confirmed the identity of the materials. A rapid semi-quantitative screening of potential leachables will be conducted by immersing the membranes in water and analyzing the morphology of coffee-ring patterns formed from evaporated droplets of the extract. The results demonstrate that organic acid-based systems enable stable jet formation and reproducible fibers while significantly reducing the environmental and safety concerns associated with conventional halogenated solvents. Beyond morphological control, the use of low-toxicity, readily available solvents supports scalable and cost-effective manufacturing. This work highlights the potential of acid-based solvent platforms as a sustainable alternative for nanofiber production and contributes to the broader transition toward greener electrospinning technologies.

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STUDY OF THE CONTENT OF REACTIVE PHOSPHORUS USING THE DIFFUSION GRADIENT TECHNIQUE WITH THIN FILMS

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Phosphorus is an essential element for life, but its elevated content in aquatic systems can cause eutrophication and disruption of the ecological balance. Therefore, the development of reliable methods for monitoring and removing reactive phosphorus is of great importance. In this work, the diffusion gradient technique with thin films (DGT) was applied to quantitatively monitor the diffusion of orthophosphate through a three-layer hydrogel system. Binding hydrogels based on cellulose grafted with poly(dimethylaminoethyl methacrylate) (PDMAEMA) were prepared in ratios of 1:1, 1:3 and 1:5. Ferrihydrite was mixed into the prepared hydrogels as an adsorption component. The adsorption efficiency of ferrihydrite and the kinetics of phosphate diffusion through the diffusion and binding layers were tested. The experiments were conducted in vertical and horizontal system configurations, with the horizontal position providing more stable diffusion conditions. Continuous monitoring and sampling yielded results indicating the ability of phosphate binding to ferrihydrite and confirming the potential of the DGT method and the suitability of hydrogels for analytical monitoring and removal of phosphate from aqueous systems, with the possibility of further optimization of the material for environmental applications. [1] [2]

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ELECTROCHEMICAL SYNTHESIS AND DOPING OF WO₃

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Photoelectrochemical processes (PEC) attract increasing attention because they find application in degradation of target pollutants, hydrogen generation and synthesis of organic molecules. Various semiconductor materials, such as UV-responsive TiO₂ and ZnO₂, or visible light-responsive SnS₂, BiVO₄, Fe₂O₃, and WO₃, have been used for this purpose. The aim of this study was to synthesize WO₃ layers at fluorine-doped tin oxide (FTO) glass, by cathodic electrodeposition, using a peroxotungstic acid precursor. In addition to WO₃, Co-doped WO₃ layer and layer modified by spent battery materials (black mass) were prepared by adding Co-salts or black mass solution (black mass / deep eutectic solvent) to the peroxotungstic acid precursor. The Co-doping process is usually conducted during synthesis by hydrothermal/solvothermal, co-precipitation or sol-gel methods. In this work, electrochemical method was used due to the simplicity of synthesis, possibility to conduct process at low temperatures and possibility to apply photoactive material directly on the conductive surface. The direct application avoids subsequent steps and ensures good adhesion at conductive support, which is necessary for good electrochemical response of active material. Therefore, it was expected for materials prepared in this work to show high photoelectrochemical activity. The photoelectrochemical response of the obtained materials was characterized by linear sweep voltammetry (Figure 1), electrochemical impedance spectroscopy, chronoamperometry, open circuit potential monitoring and UV/Vis spectroscopy. To confirm that doping had indeed occurred, the prepared samples were also analyzed using X-ray diffraction (XRD).

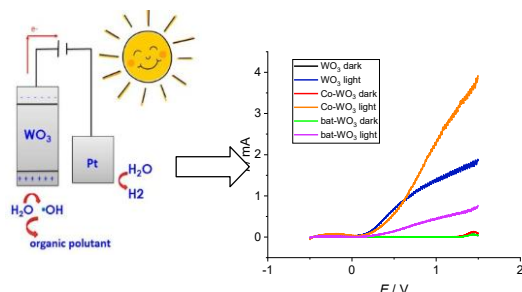


Figure 1 - Characterisation of WO₃ and doped WO₃ (Co-WO₃, bat-WO₃) by linear polarization.

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No references were used for the purpose of writing this abstract.

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OPTIMISATION OF THE BIODEGRADATION OF THE ANTIVIRAL DRUG REMDESIVIR USING ACTIVATED SLUDGE

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One consequence of the coronavirus pandemic, in addition to the increased number of infected individuals and fatalities, the burden on healthcare systems, and the economic crisis, is the occurrence of elevated concentrations of antiviral drugs in wastewater. Wastewater treatment is a complex process that includes mechanical, chemical, and biological stages. The biological phase involves microorganisms that degrade organic matter, nitrogen and phosphorus compounds, detergents, and various micropollutants, including antiviral drugs. In this process, activated sludge plays a key role as the carrier of biological degradation. The aim of this study was to optimize the biodegradation conditions for the SARS-CoV-2 antiviral drug remdesivir using activated sludge.

This study investigated the conditions under which activated sludge achieves maximum efficiency in the biodegradation of remdesivir. The influence of pH (5.5, 7.0, and 8.5), sludge biomass concentration (1, 3, and 5 g/L), and temperature (10, 30, and 45 °C) was analyzed to determine the optimal process conditions. Parameters monitored over a 24-hour period included antiviral concentration, dissolved oxygen concentration, conductivity, pH, MLSS (mixed liquor suspended solids), MLVSS (mixed liquor volatile suspended solids), MLNVSS (mixed liquor non-volatile suspended solids), and microscopic analysis. Additionally, the ecotoxicity of the antiviral solution was evaluated using the bacterium *Aliivibrio fischeri*, while antiviral concentrations were determined by ultra-high-performance liquid chromatography (UHPLC) with a UV detector.

Using the developed UHPLC method, the dynamics of antiviral concentration changes were monitored throughout the experimental period. In most experimental conditions, a removal efficiency of at least 99.3735% was achieved after 24 hours. According to the Design-Expert software optimization analysis, the predicted optimal conditions for remdesivir biodegradation were a temperature of 45 °C, a pH value of 7.0 and an activated sludge concentration of 1 g/L. The results indicate very high efficiency of antiviral removal using this biological treatment process.

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INCREASING THE EFFICIENCY OF BIOLOGICAL LEACHATE TREATMENT USING TARGETED BIOAUGMENTATION

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In the current era of rapid technological advancement, human activities are causing increasingly severe pollution of water resources. Leachate from the organic fraction of mixed municipal waste has a high organic load and requires appropriate treatment before discharge. Bioremediation represents a sustainable and efficient approach based on the metabolic and enzymatic activity of microorganisms that convert pollutants into less toxic products. To improve its efficiency, strategies such as biostimulation and bioaugmentation are applied. This study examined the potential of bioaugmentation with *Pseudomonas putida* to enhance leachate bioremediation. Experiments were conducted in a batch reactor under submerged aerobic conditions for 8 days. The system achieved an average organic load removal efficiency of 89%, demonstrating the potential of targeted bioaugmentation for treating highly loaded leachate. The findings support further development of integrated biological wastewater treatment strategies. [1] [2]

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ENVIRONMENTAL ROLE AND ENZYMATIC CAPACITY OF AN INDIGENOUS SOIL ISOLATE

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Soil is a dynamic and selective ecosystem in which microorganisms develop metabolic adaptations in response to environmental conditions. In this study, the environmental and biotechnological potential of a *Bacillus mycoides* isolate from soil was investigated to assess its enzymatic capacity. The isolate was identified by biochemical tests and MALDI-TOF analysis, followed by detailed characterization of its enzymatic activity. Biochemical analysis confirmed the presence of hydrolytic enzymes, including amylase, α -glucosidase, trehalase, N-acetylglucosaminidase, and gelatinase. These enzymes enable the degradation of polysaccharides, disaccharides, structural biopolymers, and protein substrates into simpler metabolites. In addition, the detected kinases (hexokinase, fructokinase, and ribokinase) facilitate the efficient entry of these metabolites into central metabolic pathways for energy production and biosynthesis. This combination of hydrolytic and metabolic activities indicates the isolate's ability to efficiently utilize complex organic substrates present in soil, representing a significant ecological advantage. The results highlight the importance of soil as a reservoir of indigenous microorganisms with functionally relevant enzymatic potential for application in organic load decomposition and sustainable biotechnological processes.

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SYNTHESIS AND ANTIMICROBIAL ACTIVITY OF NEW ARYL-SUBSTITUTED INDENE DERIVATIVES

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The emergence of bacterial and fungal strains resistant to common antimicrobial drugs creates a need for the development of new effective compounds, with indene derivatives occupying an important place due to their structural diversity and favorable biological profile. This work describes the synthesis of new aryl-substituted indene derivatives and the testing of their antimicrobial activity on selected microbial species.

The synthetic approach is based on a two-step procedure. In the first step, the condensation of indene with various aromatic aldehydes in ethanolic potassium hydroxide solution at reflux temperature is carried out, which affords aryl-substituted indene intermediates. In the second step, these compounds are reduced with lithium aluminum hydride in dry tetrahydrofuran, resulting in the corresponding alcohols. The obtained products are purified by column chromatography, and their structures are confirmed by ¹H and ¹³C NMR spectroscopy.

The antimicrobial activity of the synthesized compounds was tested in vitro using the disk diffusion method on strains *Bacillus subtilis* 3020, *Pseudomonas aeruginosa* 3011, *Candida lipolytica* 59 and *Aspergillus niger* 405. The diameters of the inhibition zones were used to qualitatively assess the susceptibility of individual microorganisms. Several compounds showed pronounced inhibition of the growth of the Gram-positive bacterium *Bacillus subtilis* 3020 and strains *Candida lipolytica* 59 and *Aspergillus niger* 405, while no activity was observed against the Gram-negative bacterium *Pseudomonas aeruginosa* 3011, indicating differences in susceptibility between the tested microorganisms.

The obtained results indicate that aryl-substituted indene derivatives can serve as promising starting structures for further optimization of potential antimicrobial drugs targeting Gram-positive bacteria and selected microbial species.

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ASSESSMENT OF THE BIOSORPTION CAPACITY OF ACTIVATED SLUDGE FOR LEACHATE

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Biosorption is an important process for removing pollutants from the environment, particularly due to its efficiency, low cost, and suitability for various types of wastewater. As an environmentally friendly technology, biosorption employs biological materials or microbial biomass to bind and remove pollutants, making it a valuable tool in sustainable water resource management. [1] With the increasing burden on water systems from industrial and municipal wastewater, there is a growing need for methods that can effectively reduce pollutant concentrations without high energy or chemical requirements. For this reason, biosorption is attracting increasing attention as a technique that enables fast, selective, and renewable treatment of complex waste streams. [2] In this study, a biosorption experiment was carried out under batch conditions using leachate and activated sludge with initial concentrations of 15.9 ± 0.7 g/L and 2.74 ± 0.21 g/L, respectively. The estimated Freundlich isotherm parameters, K_f and n_f , were 10.91 L/g and 2.90. The R^2 value of 0.904 indicates a good model fit. These results confirm that the tested system demonstrates a significant biosorption capacity of $15.2 \pm 2.2\%$.

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DETERMINATION OF SOLID–LIQUID EQUILIBRIUM IN HYDROPHOBIC EUTECTIC SOLVENT SYSTEMS BY DIFFERENTIAL SCANNING CALORIMETRY

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Nonaqueous deep eutectic solvents (DES) are usually hydrophilic which directs them to application in analytical, medical and biochemical fields. They are easy to prepare and environmentally friendly. They give consistent data in scientific research and therefore are supportive of research. Their counterparts, hydrophobic DESs, are starting to get more attention in a field of science. The starting point from which physical and chemical analyses in DES research are further developed is constructing a solid-liquid equilibrium phase diagram. Hydrophobic DESs usually consist of molecules that come in racemic mixtures which may make their phase diagrams difficult to analyze. [1] In this study three hydrophobic systems were studied: L-menthol – dodecanoic acid, thymol – dodecanoic acid and thymol – L-menthol. Unlike the standard method of DES preparing (melt mixing), DESs were prepared by dissolving in common solvents (acetone, dichloromethane and methanol) and evaporating solvents in vacuum dryer. Prepared DES systems were further analyzed by the differential scanning calorimetry method (DSC). Constructed phase diagrams were compared with COSMO-RS model predictions. [2] The advantages and drawbacks are presented in light of the experimental dataset and the possibilities for further improvements are discussed.

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THE INFLUENCE OF PIPERINE AND CURCUMIN ON THE SOLUBILITY AND GRANULOMETRIC CHARACTERISTICS OF SULFAMETHOXAZOLE

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Although oral administration is the most common route, low bioavailability caused by poor solubility and permeability remains a major challenge in drug formulation. [1] An example is sulfamethoxazole (BCS class IV), which is most often combined with trimethoprim due to its synergistic effect. [2] To further improve the bioavailability of the active substance, the use of bioactive compounds such as piperine, curcumin, and allicin is being investigated, as they affect intestinal absorption and enzymatic activity, thereby increasing drug efficacy. [3]

To further enhance pharmacokinetic properties, this study investigates the influence of binary solvent systems (ethanol/water and methanol/water; 40:60, w/w), the state of the feed mixture (suspension or solution), and bioactive components (piperine and curcumin) on the solubility of sulfamethoxazole (SMX) and the granulometric characteristics of powders obtained by spray drying. Drying was carried out at 140 and 160 °C. In addition to the active substance (SMX) and the bioactive component, the formulation included the polymer carrier hydroxypropyl methylcellulose (HPMC), gum arabic (GA), and Tween 80 to stabilize the system and further improve the solubility of SMX and the bioactive components. The concentration of SMX in the obtained products was determined using the Bratton–Marshall method, a classical colorimetric method for measuring the concentration of sulfonamides and other primary aromatic amines in biological samples through a chemical reaction that forms a characteristic-colored compound, the intensity of which is measured by spectrophotometer. [4] Characterization of the obtained powder systems was performed using ¹H NMR and FTIR spectroscopy, as well as SEM and XRD analysis.

The mentioned spectroscopic methods confirmed the presence of characteristic peaks of all components in the obtained powders. SEM analysis results indicate that process conditions influence granulometric characteristics and the homogeneity of the final product. Spray drying of suspensions at both temperatures resulted in powders of non-uniform composition. Drying temperature and solvent type significantly affect powder properties: the methanol/water system at 140 °C resulted in the smallest particles, while drying at 160 °C in the same medium produced the powder with the highest solubility. The solubility of the formulation containing curcumin was 40% higher than that prepared with the addition of piperine under the same drying conditions. XRD analysis results indicate a partially amorphous structure of all formulations obtained from solutions, which explains the improved solubility compared to pure SMX. Moreover, in formulations obtained by spray drying of solutions, form II of SMX predominates, which has higher water solubility.

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