



THE ACADEMY  
OF APPLIED STUDIES  
POLYTECHNIC



International Scientific  
and Professional Conference

Politehnika  
2025

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PROCEEDINGS

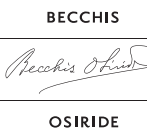
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International Scientific  
and Professional Conference

**Politehnika  
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# Conference Proceedings

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Environment and  
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and Safety and Fire Safety

Smart Management Systems

Graphic Engineering

Design

Traffic Engineering

Biotechnology, Pharmacy  
and Healthcare

Mechanical Engineering

Ecotourism and  
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## Foreword

The International Scientific and Professional Conference POLITEHNIKA 2025 represents the eighth edition of the POLITEHNIKA scientific and professional events, occurring biannually since its inaugural event in 2011. POLITEHNIKA 2025 upholds a distinguished tradition and commitment to integrating higher education and practical application across a diverse spectrum of disciplines represented by defined thematic scopes.

Organized with the patronage of the Ministry of Education of the Republic of Serbia, the Ministry of Science, Technological Development and Innovation of the Republic of Serbia, the Directorate for Occupational Safety and Health, the Office for Dual Education and National Qualifications Framework, the Chamber of Commerce of Belgrade, the Institute for Standardization of Serbia, Serbian Automotive Cluster - AC Serbia, Center for the Promotion of Science, Engineering Academy of Serbia and the Development Agency of Serbia, POLITEHNIKA 2025 stands as a collaborative platform at the intersection of academia, governmental institutions and industry.

Proudly holding its international status, the Conference POLITEHNIKA 2025 encompasses 10 thematic domains: Environment and Sustainable Development, Occupational Safety and Health and Fire Safety, Smart Management Systems, Graphic Engineering, Design, Traffic Engineering, Biotechnology, Pharmacy and Healthcare, Mechanical Engineering, Ecotourism and Rural development, and Mechatronics. By engaging experts, emerging professionals, and practitioners from these domains, the conference unifies fields of study programs of the Academy of Applied Studies Polytechnic. The thematic scopes, coupled with the structure of the compiled papers in this Proceedings, exhibit a rich diversity and multidisciplinary approach, fundamentally contributing to a holistic examination and resolution of societal and scientific challenges.

Comprising over 200 peer-reviewed contributions, the Proceedings represent a substantial intellectual asset, aligning with the conference's overarching objective of fostering the exchange of knowledge, research findings, and professional experiences among experts from industry, research institutions, and higher education establishments.

The Proceedings of the International Scientific and Professional Conference POLITEHNIKA 2025 serve as a comprehensive snapshot of the current landscape within the thematic realms of the conference, offering both insights and directives for ongoing scientific and professional development. Moreover, it offers concrete solutions to practical challenges grounded in contemporary trends and pertinent insights.

The Academy of Applied Studies Polytechnic extends its sincere appreciation to all conference supporters whose financial contributions played a pivotal role in its successful realization. Special acknowledgment is reserved for the authors of the papers, whose diligence and eagerness to present their work to a wider audience, alongside the reviewers and members of the International Scientific Committee, Program Committee and Organizational Committee, have collectively contributed to the triumph of the International Scientific and Professional Conference POLITEHNIKA 2025.

Belgrade, November 2025  
EDITORS



# TABLE OF CONTENTS

## SCOPE 1. ENVIRONMENT AND SUSTAINABLE DEVELOPMENT

|   |     |
|---|-----|
| <b>Srećko Stopić, Zixi Gao, Hanwen Chung, Bernd Friedrich, Mulbah Forkpayea, Duško Kostić, Nenad Nikolić, Vladimir Damjanović, Dragana Životić</b><br><i>The importance of using hydrometallurgical treatment of different raw materials at high pressures for environmental protection and sustainable development</i> | 25  |
| <b>Dorđe Ogrizović, Milica Delić, Maja Đolić, Ivana Matić Bujagić</b><br><i>Recent advances in removal of emerging contaminants from wastewaters</i>  | 31  |
| <b>Ljiljana Tolić Stojadinović, Radmila Novaković, Dušan Kekić, Ina Gajić, Svetlana Grujić</b><br><i>Determination of selected antibiotics in hospital and urban wastewater using liquid chromatography-tandem mass spectrometry</i>  | 36  |
| <b>Natalija Nedić, Tamara Tadić, Sandra Bulatović, Bojana Marković, Aleksandra Nastasović</b><br><i>Optimization of orange G sorption using GMA-based polymer through response surface methodology and Box-Behnken design</i>   | 42  |
| <b>Natalija Nedić, Tamara Tadić, Sandra Bulatović, Aleksandra Nastasović, Bojana Marković</b><br><i>Efficient removal of aniline from aqueous solution using a hydroxyl methacrylate-based sorbent</i>  | 47  |
| <b>Jelena Vesković, Milica Lučić, Andrijana Miletić, Marija Vesković, Antonije Onjia</b><br><i>Identifying groundwater heavy metal(loid) pollution sources in the Požarevac area using principal component analysis</i>   | 52  |
| <b>Nataša Palić, Marina Maletić, Ana Kalijadis, Anita Lazić, Katarina Trivunac, Marija Vukčević</b><br><i>Comparative analysis of chemically and thermally modified potato starch for the adsorption of brilliant green dye</i>   | 57  |
| <b>Tijana Radojičić, Nataša Palić, Marina Maletić, Nataša Mladenović Nikolić, Daniela Popović, Marija Vukčević, Katarina Trivunac</b><br><i>Alkali-activated material: A sustainable approach for adsorbing heavy metals and rare earth elements from water</i>   | 63  |
| <b>Miodrag Stanisavljević, Ana Stojković, Ivan Krstić</b><br><i>Comparative analysis of conventional and non-conventional systems for electroplating wastewater treatment</i>   | 69  |
| <b>Marija Vesković, Jelena Vesković, Antonije Onjia</b><br><i>Hydrogeochemical characterization of groundwater in the Northeastern Serbia</i>   | 75  |
| <b>Dragana Popović, Jovana Savanović, Andrija Vučetić, Tatjana Ćurčić, Dragana Despot</b><br><i>Optimization of solid-phase extraction for the determination of quaternary ammonium compounds in water by UHPLC–MS/MS</i>   | 80  |
| <b>Tijana Spasojević, Marina Maletić, Ana Kalijadis, Nataša Mladenović, Katarina Trivunac, Marija Vukčević</b><br><i>Carbonization and activation of flax fibers for the removal of bromazepam from water</i>   | 85  |
| <b>Tijana Spasojević, Marina Maletić, Dušan Trajković, Isabel Gria, Mirjana Ćujić, Nevena Prlainović, Maja Đolić</b><br><i>Enhanced arsenic removal using an iron-modified sandy clay and biochar</i>   | 91  |
| <b>Andrijana Miletić, Jelena Vesković, Milica Lučić, Antonije Onjia</b><br><i>Chemometric analysis of trace elements in sediments near an industrial ship dock</i>  | 97  |
| <b>Grozdana Bogdanović, Dragan Radulović, Dragana Marilović, Jovica Stojanović, Sanja Petrović, Vladimir Simić</b><br><i>From waste to resource: Leaching metals from flotation tailings at the “Rudnik” mine for sustainable development</i>   | 103 |

|  |     |
|--|-----|
| <b>Anja Bubik, Klara Hohkraut</b><br><i>From isolation to detection of microplastics in natural and industrially processed honey</i>   | 107 |
| <b>Milica Vlahović, Miljan Vlahović, Nenad Vušović, Darja Žarković</b><br><i>Radium contamination of groundwater and remediation approaches</i>  | 113 |
| <b>Marija Prosheva, Teodora Stojanovska, Andrea Petanova, Jadranka Blazhevska Gilev</b><br><i>Degradation behavior of lignin/TiO<sub>2</sub> waterborne polymers</i>   | 119 |
| <b>Dorđe Ogrizović, Milica Delić, Ivana Matić Bujagić, Maja Đolić</b><br><i>Adaptive water management and pathways toward urban resilience</i>   | 125 |
| <b>Andrea Petanova, Marija Prosheva, Jadranka Blazhevska Gilev</b><br><i>Towards sustainable carbon nanomaterials: Pulsed laser-assisted synthesis approach</i>  | 130 |
| <b>Milica Rančić, Jelena Gržetić, Tamara Tešić, Ivana Gavrilović-Grmuša</b><br><i>Development and applications of bioepoxies for green materials</i>   | 136 |
| <b>Milica Rančić, Mlađan Popović, Ivana Gavrilović-Grmuša</b><br><i>Green innovation in materials: Eco-panels made from hemp shives and starch</i>   | 142 |
| <b>Nevena Purić, Marija Popović, Darko Đorđević, Maja Đolić</b><br><i>Biowaste as a resource: Challenges and opportunities for biowaste management and sustainable infrastructure in Serbia</i>  | 147 |
| <b>Jelena Gligorijević-Sokolović, Vesna Krstić, Ana Petrović, Zoran Štirbanović, Jovica Sokolović</b><br><i>The role of solid recovered fuel (SRF) in waste reduction, resource management and carbon footprint mitigation within the circular economy</i> | 153 |
| <b>Darja Žarković, Ana Aleksić, Milica Vlahović, Nenad Vušović</b><br><i>Information technologies in municipal solid waste management – from public participation to powerful software tools</i>   | 159 |
| <b>Darja Žarković, Milica Vlahović, Žaklina Todorović, Miljan Vlahović, Milica Prelić</b><br><i>Application of information systems in water resources monitoring and management</i>  | 165 |
| <b>Vesna Alivojvodić, Niko Samec, Filip Kokalj</b><br><i>Standards-based value creation for modern waste-to-energy facilities</i>  | 171 |
| <b>Vesna Alivojvodić, Aleksandra Vučinić, Nela Vujović</b><br><i>Bridging policy gaps through ISO 59000 standards in European waste management transitions</i>   | 177 |
| <b>Lea Komerički Kotnik, Katrin Školnik Škrabe, Anja Bubik</b><br><i>Erasmus+ projects as the opportunity to improve youth awareness on microplastics</i>  | 183 |
| <b>Nataša Radić, Andreja Stojić, Mirjana Perišić</b><br><i>Analysis of the effects of social and industrial changes on air quality during the Covid-19 pandemic in Belgrade</i>  | 189 |
| <b>Jasmina Bašić, Dragana Dragaš Milovanović, Mila Filipovć, Marina Ivanović, Bojana Luković, Danijela Pecarski</b><br><i>Air pollutant levels in the first half of 2025 and their health effects in the Republic of Serbia</i>                            | 195 |
| <b>Aleksandar Petković, Jovan Ilić</b><br><i>Numerical simulations of transient operation of SHPPs with pelton turbines and selection of protective measures. Case study of SHPP Velika Ploca</i>  | 202 |
| <b>Slavica Mihajlović, Nataša Đorđević, Vladan Kašić, Srđan Matijašević</b><br><i>The significance of the circular economy in solid waste management</i>   | 208 |
| <b>Jelena Andrić</b><br><i>Towards sustainable development in infrastructure projects</i>  | 214 |
| <b>Nataša Radić, Ana Popović, Vesna Alivojvodić</b><br><i>Practices and attitudes toward food waste in the Republic of Serbia - pilot survey</i>   | 219 |
| <b>Radule Tošović</b><br><i>Managerial-economic aspects of the participation of environmental costs in the cost price of mineral raw materials in the mineral sector</i>   | 224 |
| <b>Ana Popović, Nebojša Ćurčić, Aleksandra Božić</b><br><i>Managing environmental disasters: The role of environmental risk assessment</i>   | 230 |

|   |     |
|---|-----|
| <b>Miloš Tošović</b><br><i>Copenhagen school of security in the light of analysis of environmental security and environmental risk management</i>   | 236 |
| <b>Suzana Radojković</b><br><i>Microbiological pollution in the Toplica River: Impact and Solutions</i>   | 242 |
| <b>Tatjana Mitrović, Marija Perović, Darija Obradović, Saša Lazović</b><br><i>Soil remediation: Perspectives and risks</i>  | 248 |
| <b>Tatjana Mitrović, Marija Perović, Darija Obradović, Saša Lazović</b><br><i>Ecological risks of urban soils in Belgrade</i>   | 254 |
| <b>Aleksandra Pavlović, Andrea Ivanišević</b><br><i>Is Serbia becoming a pollution haven? The impact of FDI on air pollution and public health</i>  | 260 |
| <b>Dragan Ugrinov, Magdalena Nikolić</b><br><i>A model of successful medical waste management in Pančevo municipality – system analysis and development perspectives</i>  | 266 |
| <b>Dragan Ugrinov, Magdalena Nikolić</b><br><i>Ecological and political dimensions of sustainable natural resource management in the context of climate change</i>  | 271 |
| <b>Magdalena Nikolić, Dragan Ugrinov</b><br><i>Ecotourism as a mechanism for biodiversity conservation in the protected natural areas of Serbia</i>   | 277 |
| <b>Marija Tasić, Milica Petković, Sofija Miljković, Žarko Vranjanac</b><br><i>Application of the Serbian water quality index in the assessment of the Jerma, Gaberska River, and Great Timok (2019–2023)</i>  | 283 |
| <b>Aleksandar Petković, Jovan Ilić</b><br><i>Numerical simulations of long-term annual energy generation of SHPP Kresaja</i>  | 289 |
| <b>Zorica Baroš, Olivera Jovanović</b><br><i>Monitoring ionizing radiation in the Republic of Serbia</i>  | 293 |
| <b>Sara Stanić Jovanović, Marica Milošević, Ana Urošević, Božo Ilić</b><br><i>The importance of environmental sustainability in hotel operations: A case study of Hotel 'Iver'</i>  | 299 |
| <b>Jovana Vukanić, Bojana Sterniša Staničić</b><br><i>Urban ecology in architecture: Ecological potential of public spaces and strategies for improving biodiversity</i>  | 306 |
| <b>Vaishnavi Khedulkar, Ana Popović</b><br><i>The evolution of sustainability: From cultural roots to future generations</i>  | 312 |
| <b>Ivana Rvović, Aleksandra Davidović</b><br><i>Forest fires in Serbia – spatial analysis of the impact of forest ownership and prevention measures</i>   | 317 |
| <b>Bensedira Noureddine, Milles Abdessmad, Aggoune Mohammed-Salah</b><br><i>Photovoltaic supplied MHD desalination system for agricultural uses</i>   | 323 |
| <b>Nevenka Galečić, Đurđa Petrov, Dejan Skočajić, Jelena Čukanović, Sara Đorđević, Radenka Kolarov, Mirjana Ocokoljić</b><br><i>The influence of light and air temperature on the visual perception of <i>Photinia x fraseri</i> 'Red Robin' in the parterre composition of Savski Square in Belgrade</i>                                       | 329 |
| <b>Đurđa Petrov, Nevenka Galečić, Dejan Skočajić, Jelena Čukanović, Dragan Vujičić, Sara Đorđević, Mirjana Ocokoljić</b><br><i>Secondary flowering and fruiting of <i>Laburnum anagyroides</i> Medik. and their importance in urban landscape design</i>  | 335 |
| <b>Mirjana Ocokoljić, Jelena Čukanović, Sara Đorđević, Nevenka Galečić, Dejan Skočajić, Radenka Kolarov, Đurđa Petrov</b><br><i><i>Amorpha fruticosa</i> L. in the alluvial habitats of Belgrade and Novi Sad: Morphological and phenological characteristics of inflorescences, flowers, and flowering in the context of ecosystem service</i> | 341 |

|  |     |
|--|-----|
| <b>Nevenka Galečić, Đurđa Petrov, Dejan Skočajić, Jelena Čukanović, Radenka Kolarov, Sara Đorđević Mirjana Ocokoljić</b><br><i>Adaptation of flowering phenology and flower longevity of <i>Philadelphus coronarius</i> L. in landscape design under climate change conditions</i> | 347 |
| <b>Mirjana Ocokoljić, Nevenka Galečić, Dejan Skočajić, Jelena Čukanović, Sara Đorđević, Radenka Kolarov, Đurđa Petrov</b><br><i>Viburnum tinus</i> L.: Mediterranean floral element in the urban and suburban landscape of Belgrade  | 353 |
| <b>Mirjana Ocokoljić, Radenka Kolarov, Jelena Čukanović, Nevenka Galečić, Dejan Skočajić, Sara Đorđević, Đurđa Petrov</b><br><i>Morphological and biochemical characteristics of the fruits of <i>Malus hupehensis</i> var. <i>Pinyensis</i> n.g. Jiang in Belgrade</i>            | 359 |
| <b>Đurđa Petrov, Nevenka Galečić, Dejan Skočajić, Jelena Čukanović, Dragan Vujičić, Radenka Kolarov, Mirjana Ocokoljić</b><br><i>Punica granatum</i> L. in garden design in Serbia   | 365 |
| <b>Mirjana Ocokoljić, Nevenka Galečić, Jelena Čukanović, Sara Đorđević, Radenka Kolarov, Đurđa Petrov</b><br><i>Ornamental cherry trees in the open urban spaces in front of the temple of Saint Sava in Belgrade: Identification and significance</i>                             | 372 |

## STUDENT PAPERS

|   |     |
|---|-----|
| <b>Nikola Stojković</b><br><i>Determination of heavy metal content in river fish</i>  | 378 |
| <b>Marija Perkunić, Ana Popović</b><br><i>Integrating phytoremediation into sustainable development strategies: Lead removal potential of <i>Mentha</i> sp.</i> | 384 |
| <b>Nikola Stojković</b><br><i>Digital ecology and the environmental impact of digital platforms</i>   | 390 |
| <b>Lav Leskur</b><br><i>Environmental risk assessment for Pambukovica Dam project in Serbia – a case study</i>  | 395 |

## SCOPE 2. OCCUPATIONAL HEALTH AND SAFETY AND FIRE SAFETY

|  |     |
|--|-----|
| <b>Dragan Jovanović</b><br><i>The role of experts in court proceedings of the Republic of Serbia</i>   | 402 |
| <b>Jelena Andrić, Xi'an Jiaotong</b><br><i>The analysis of occupational accidents on construction sites in Hong Kong</i>   | 408 |
| <b>Branka Bursać Vranješ, Svetozar Sofijanić</b><br><i>Specific features of occupational safety and health organization in bridge construction</i>                                   | 413 |
| <b>Dragan Živanić, Nikola Ilanković, Tanasije Jojić</b><br><i>Integration of sensor systems for enhancing escalator safety and reliability</i>                                       | 419 |
| <b>Dragan Živanić, Nikola Ilanković, Tanasije Jojić</b><br><i>Design and analysis of a conveyor system for removing floating waste from river surfaces</i>                           | 425 |
| <b>Marko Miletić, Aleksandar Pantović, Marko Milošević, Marko Đapan, Ivan Mačužić</b><br><i>The improvement of lockout/tagout compliance in manufacturing through digitalization</i> | 431 |
| <b>Daniela Ristić, Ognjen Ristić</b><br><i>The impact of work stress on employees' performance and job satisfaction</i>  | 437 |

|  |     |
|--|-----|
| <b>Snežana Knežević, Snežana Milanović, Marijana Jandrić Kočić, Tamara Gajić</b><br><i>Work-life balance among higher education employees</i>  | 442 |
| <b>Maja Đikić</b><br><i>From paper to practice: How employees use personal protective equipment and perceive occupational health and safety training</i>   | 448 |
| <b>Nebojša Ćurčić, Novak Milošević</b><br><i>Real-time monitoring of workplace environmental factors using smart devices – an overview on vibration exposure evaluation</i>  | 454 |
| <b>Darko Marković, Nebojša Ćurčić, Novak Milošević</b><br><i>Research on impact of cultural diversity on occupational safety and health culture in multinationals teams based on Hofstede's cultural dimensions theory</i> | 461 |
| <b>Dejan Kožović, Dragan Đurđević, Mirko Dinulović, Marta Trninić</b><br><i>ADS-B aviation system: Analysis of real time flight data</i>   | 470 |
| <b>Nataša Ćirović, Nebojša Bošnjaković</b><br><i>Fire risk level of a residential business object</i>  | 476 |
| <b>Petar Simonović, Marijola Božović</b><br><i>Training fires as high-risk events: Rethinking safety in simulated environments</i>   | 484 |
| <b>Ana Aleksić, Darja Žarković</b><br><i>Application of GIS technology in the education of engineers of fire protection</i>  | 490 |
| <b>Nikola Tanasić, Radenko Rajić, Ivan Arandjelović</b><br><i>A novel tabular method for estimation of heat extraction factor</i>  | 496 |
| <b>Milivoje Filipović, Marina Milovanović Arandjelović</b><br><i>An extended tabular method for estimation of water flow rate at the hydrant nozzle</i>  | 500 |
| <b>Barbara Vidaković Ristić</b><br><i>Understanding intentional fires: From 'how' to 'why' through an interdisciplinary lens</i>   | 504 |
| <b>Barbara Vidaković Ristić</b><br><i>Fire risk management in nightclubs: Regulatory framework, practice and recommendations</i>   | 509 |

## STUDENT PAPER

|  |     |
|--|-----|
| <b>Lav Leskur</b><br><i>How to prevent workplace accidents and save workers' lives? Tackling the invisible trio of depression, anxiety and insomnia before it's too late</i> | 515 |
|--|-----|

## SCOPE 3. SMART MANAGEMENT SYSTEMS

|   |     |
|---|-----|
| <b>Dragana Gardašević, Koviljka Banjević, Milanka Gardašević-Filipović, Vladan Radivojević</b><br><i>AHP and PROMETHEE II methods in selecting candidate for the position of strategic planning manager</i> | 522 |
| <b>Brankica Pažun, Zlatko Langović, Milena Cvjetković</b><br><i>Quantum computing in business decision-making</i>   | 528 |
| <b>Dragana Gardašević, Aleksandra Božić, Ana Popović, Vladana Ilijin</b><br><i>Application of control charts in the internal control of chemical oxygen demand determination method</i>                     | 535 |
| <b>Dušan Trajković, Nevena Purić, Aleksandar Kojović, Dragana Živojinović</b><br><i>Global market and standardization in biofuel industry</i>   | 540 |
| <b>Saša Marković, Marko Pavlović</b><br><i>Possibilities of improving business processes and business efficiency in the automotive industry</i>   | 546 |

|   |     |
|---|-----|
| <b>Dragana Rošulj, Aleksandra Nastasić, Dejan Petrović</b><br><i>The culture of knowledge management and its impact on the implementation of knowledge management processes</i>       | 552 |
| <b>Biljana Ljubanović, Koviljka Banjević, Zoran Sekulić</b><br><i>Change scenario: Control of documented information</i>  | 559 |
| <b>Goran Nestorović</b><br><i>Development of teaching staff through the introduction of professional doctoral studies</i>   | 565 |
| <b>Predrag Janković, Dragan Miletić, Suzana Pavlović</b><br><i>The place and perspectives of the development of dual education in the higher education the Republic of Serbia</i>     | 572 |
| <b>Vana Colić</b><br><i>The role of mathematical education and digital competencies in preparing workforce for Industry 4.0</i>   | 578 |
| <b>Ivan Mačužić, Marko Milošević, Nikola Tonić, Marija Savković, Đorđe Milojević</b><br><i>Demo-didactic systems for practical training in Industry 4.0</i>                           | 583 |
| <b>Đorđe Dihovični, Dragan Kreculj, Nada Ratković Kovačević, Goran Vorotović</b><br><i>XML approach to the creation of a database for the alumni project</i>                          | 589 |
| <b>Goran Vojnović</b><br><i>Augmented reality in academic libraries: Implementing affordable tools</i>  | 594 |
| <b>Marija Mićanović</b><br><i>The analysis of writing style and the application of tools for academic writing</i>   | 600 |
| <b>Aleksandra Nastasić, Dragana Rošulj, Aleksandra Božović</b><br><i>Influence of artificial intelligence on organisational culture</i>   | 606 |
| <b>Marija Simonović, Snežana Tadić, Mladen Krstić, Miloš Veljović</b><br><i>Space logistics: How to get into space?</i>   | 612 |
| <b>Saša Marković, Marko Pavlović</b><br><i>Strategic forms of business internationalization</i>   | 618 |
| <b>Bosiljka Srebro, Marija Perić, Stevica Dedanski</b><br><i>The impact of digital technologies on enterprise e-commerce export strategies</i>  | 623 |
| <b>Jasmina Đurašković, Ana Slavković, Brankica Pažun</b><br><i>Web transparency of CSR activities in Belgrade municipalities: A content analysis of official websites</i>             | 629 |
| <b>Aleksandra Pavlović</b><br><i>Economic growth in Serbia - Does inflation matter?</i>   | 634 |
| <b>Brankica Pažun, Zlatko Langović, Jasmina Đurašković</b><br><i>Processor technologies and their impact on global economic trends</i>  | 639 |
| <b>Srdan Barzut, Dragana Sajfert, Ana Bašić, Milica Jevremović</b><br><i>The main cyber treats in modern e-business</i>   | 643 |
| <b>Marko Pavlović, Dragana Đurić, Miloš Lučić</b><br><i>The role of CRM systems in the revitalization of an artistic brand: A study on consumer perception of the Naslikati brand</i> | 650 |
| <b>Đorđe Dihovični</b><br><i>Programs and their applications in web design and web management</i>   | 656 |

## STUDENT PAPER

|   |     |
|---|-----|
| <b>Lav Leskur</b><br><i>Is personality the missing key for boosting sales? A fresh perspective for marketing strategists on Serbian consumers' organic food attitudes</i> | 662 |
|---|-----|

## SCOPE 4. GRAPHIC ENGINEERING

- Adrijana Đorđević, Danijela Kovačević, Nenad Đorđević, Aleksandra Krstić** 669  
*An investigation into the mechanical properties of corrugated fiberboard packaging boxes*
- Dejan Miljković, Danijela Kovačević, Adrijana Đorđević, Nenad Đorđević, Aleksandra Krstić** 675  
*Comparative analysis of transport packaging manufactured using flat and rotary die-cutting tools*

## SCOPE 5. DESIGN

- Predrag Maksić** 682  
*Foundations and principles of interdisciplinary design: Towards a holistic approach to creative practice*
- Ljubomir Maširević** 688  
*The video game industry and globalization*
- Ljubomir Maširević** 694  
*Video games in culture*
- Dušanka Komnenić** 701  
*AI and the aesthetic of imperfection: Defining the visual signature of machine-made art*
- Danica Glođović** 705  
*Visual codes and cultural narratives: Rethinking graphic design as semiotics*
- El Hadj Mimoune Arezki, Khattabi Lahcene, Berkani Dalila** 710  
*Eternal geometry: Zellij as a bridge between Islamic heritage and modern design*
- Maja Milinić Bogdanović** 716  
*How additive manufacturing can enhance contemporary fashion and footwear design*
- Jelena Zdravković** 723  
*Contemporary fashion and interdisciplinary approach to design: Zero waste fashion design*
- Jelena Zdravković, Igor Ponti** 730  
*Fashion design and digital technology: Ready-to-wear collections and the modern textile industry in Serbia*
- Jasna Jelić Obradović** 738  
*The influence of art theory in the field of design*
- Željko Zdravković** 743  
*Designing the future: How AI platforms are transforming industrial design in our world today*
- Duško Radaković, Nebojša Andrijević, Dragana Gardašević, Nenad Živanović** 750  
*An assessment of diverse generative AI applications*
- Duško Radaković, Danijela Živojinović** 757  
*Implicit modeling and the future of next gen CAD*
- Fedor Rakić** 765  
*Will artificial intelligence ever replace the UX designer?*
- Fedor Rakić** 770  
*Real vs. synthetic users: The future of UX testing*
- Dragica Nikodinović** 776  
*Poster design in the society of the spectacle*
- Jelena Jocić, Maja Milinić Bogdanović** 782  
*Contemporary creative approaches and technological tendencies in graphic art and fashion design communication*

|  |     |
|--|-----|
| <b>Katarina Nikolić</b><br><i>Oblique strategies and projector cards – fostering creativity in design through randomness and material engagement</i>             | 788 |
| <b>Natalija Đukić</b><br><i>Space as the third teacher: Architecture of preschool institutions based on the Reggio Emilia approach – case study analysis</i>     | 795 |
| <b>Dejan Vračarević</b><br><i>The Future of 3D additive technologies in an artificial intelligence environment for industrial designers and artists</i>          | 801 |
| <b>Milica Matović</b><br><i>Digital aesthetics and contemporary painting: The transformations of visual form in post-media art</i>                               | 805 |
| <b>Duško Trifunović</b><br><i>Werner Jeker — photography, typography, and grid in poster design</i>  | 811 |
| <b>Sandra DePalo</b><br><i>The colour of light: Influence of James Turrell’s work on contemporary interior lighting design</i>                                   | 816 |
| <b>Sandra DePalo</b><br><i>Light narratives: Adaptive museum lighting as a medium of artistic expression and communication</i>                                   | 823 |
| <b>Natalija Gaković</b><br><i>Selection of contemporary synthetic polymeric organic materials for application in sustainable interior design</i>                 | 830 |
| <b>Jelena Ivanović Vojvodić, Goran Vojvodić</b><br><i>Reconstruction of the Building Palace of Science in Belgrade – The Miodrag Kostić Foundation Endowment</i> | 836 |
| <b>Ivan Erkić</b><br><i>The power of the new 3D material in visual merchandising</i>   | 842 |

## SCOPE 6. TRAFFIC ENGINEERING

|  |     |
|--|-----|
| <b>Biljana Ranković Plazinić, Željko Ranković, Nemanja Deretić</b><br><i>A methodology to determine parking zone boundaries</i>  | 848 |
| <b>Nebojša Andrijević, Zoran Lovreković, Bojan Jovanović, Vlada Jevtić, Branko Petrović</b><br><i>IoTarchitecture for a smart modular traffic intersection control with real-time multi-sensor adaptation</i>  | 854 |
| <b>Dejan Jovanov, Daniel Pavleski, Kosta Jovanov</b><br><i>Road safety action plan: Data driven decision making approach</i>   | 862 |
| <b>Željko Ranković, Biljana Ranković Plazinić, Nemanja Deretić</b><br><i>Comparison of road safety level on the “Miloš Veliki” motorway and two-lane state road IB No. 22 following the construction of the “Miloš Veliki” motorway</i>  | 868 |
| <b>David Rilak, Boris Antić, Nenad Marković, Emir Smailović</b><br><i>Identification of characteristic road problems and deficiencies at locations, sections, and streets of increased pedestrian risk in the territory of the Belgrade police department, through the application of independent assessment</i> | 874 |
| <b>Denis Lukač, Mirsad Velju, Jasmin Hodžić</b><br><i>Analysis of traffic safety at level crossings in Montenegro</i>  | 880 |
| <b>Aleksandra Obradović, Biljana Ranković Plazinić</b><br><i>The impact of signalization of pedestrian crossings on pedestrian safety</i>  | 886 |
| <b>Jaime Vite Solares, Iran Guerrero Andrade</b><br><i>Pedestrian mobility and urban policy in Pachuca: Inequality, risks, and the right to the city</i>   | 893 |

|   |     |
|---|-----|
| <b>Dragana Velimirović, Milan Marković, Milan Velimirović</b><br><i>Novelties in automotive industry sector in European countries</i>                           | 899 |
| <b>Danijela Miloradović, Jasna Glišović, Jovanka Lukić</b><br><i>Measuring instruments for vehicle technical inspection in technical regulations – a review</i> | 905 |
| <b>Dobrovoje Ćatić, Vladimir Ćatić</b><br><i>Analysis of brake drum damage in motor vehicle braking systems</i>   | 911 |
| <b>Nemanja Deretić, Saša Kukolj</b><br><i>Human resource management and digital transformation in transport companies</i>                                       | 917 |
| <b>Slavka Durlević</b><br><i>The role of logistics center in the supply chain – a case study</i>  | 923 |
| <b>Filip Marković, Miroljub Nikolić, Maja Stošković</b><br><i>Financial aspects of supply chain optimization in freight forwarding</i>                          | 929 |

## SCOPE 7. BIOTECHNOLOGY, PHARMACY AND HEALTHCARE

|   |     |
|---|-----|
| <b>Dragana Ilić Udovičić, Jelena Đuričić Milanković, Aleksandra Vasić Popović, Ivana Jevtić, Jelena Makević</b><br><i>Allergens as a parameter of food quality and safety control: Attitudes and awareness of medical school students</i> | 935 |
| <b>Dubravka Mandušić</b><br><i>Artificial intelligence in the animal world</i>  | 941 |
| <b>Tatjana Marinković, Dragan Marinković, Jovana Pavlović</b><br><i>Physical activity and microbiota: An overlooked link to health</i>  | 945 |
| <b>Snežana Knežević, Snežana Milanović, Slavica Đorđević, Marijana Jandrić Kočić</b><br><i>Preventive medicine and healthy aging: Addressing population frailty prevention</i>  | 951 |
| <b>Snežana Knežević, Aleksandar Stevanović, Snežana Milanović, Slavica Đorđević</b><br><i>Climate change impacts on bacterial foodborne infections and food safety</i>  | 957 |
| <b>Tanja Krunić</b><br><i>Reusing and improving food industry waste</i>   | 963 |
| <b>Višnja Sikimić, Slavica Čabrilo, Nada Jelić</b><br><i>Formulations of gluten free biscuits with improved nutritional and functional properties</i>   | 969 |
| <b>Marina Ivanović, Jasmina Bašić, Mila Filipović, Dragana Dragaš Milovanović, Bojana Luković</b><br><i>Utilization of lactic acid bacteria in food technology from bioprotection to sensory quality enhancement</i>                      | 977 |
| <b>Dragana Dragaš Milovanović, Jasmina Bašić, Mila Filipović, Marina Ivanović, Bojana Luković</b><br><i>Dose-response relationship between chronic exposure to trihalomethanes and haloacetic acids and adverse health outcomes</i>       | 982 |
| <b>Dragana Dragaš, Jasmina Bašić, Danijela Pecarski</b><br><i>Current pharmacogenetics trends in depression treatment</i>   | 985 |
| <b>Nebojša Andrijević, Zoran Lovreković, Vladan Radivojević, Mihajlo Manojlović, Milica Velkovski</b><br><i>Implementation of IoT systems in modern agriculture: Optimization and automation of smart greenhouse functionality</i>        | 989 |
| <b>Miloš Purić</b><br><i>Apricot kernel oil as a new edible products processed from biowaste</i>  | 996 |

|   |      |
|---|------|
| <b>Eleonora Gvozdić, Danijela Prokić, Marija Bajović, Svetlana Grujić, Tatjana Đurkić</b><br><i>Fungicide residues in apples: Analysis and health risk assessment</i>   | 1002 |
| <b>Marija Bajović, Eleonora Gvozdić, Tatjana Đurkić</b><br><i>Validation of a GC-MS/MS method for determining 200 pesticides in herbal tea infusions</i>  | 1008 |
| <b>Milica Jevtić, Goran Nestorović, Darko Stojićević</b><br><i>The rise of data-driven agriculture: Transforming farming through digital intelligence</i>   | 1013 |
| <b>Vladanka Stupar, Milica Jevtić</b><br><i>Sustainable innovation in plant production</i>  | 1018 |
| <b>Melita Zec Vojinović, Kristijan Jurišić, Slavica Dudaš, Martina Peršić, Marin Tomičić</b><br><i>The inhibitory potential of thyme essential oil (<i>Thymus vulgaris</i> L. against the phytopathogenic fungus <i>Colletotrichum acutatum</i></i> | 1024 |
| <b>Milica Lučić, Andrijana Miletić, Jelena Vesković, Antonije Onjia</b><br><i>LC-MS/MS analysis of imazalil in lemons</i>   | 1030 |
| <b>Ana-Marija Valland, Tatjana Golubović</b><br><i>Exposure to antineoplastic pharmaceuticals and associated health effects</i>   | 1036 |
| <b>Tatjana Sekulić, Vladanka Stupar, Zlata Živković, Milica Blažić</b><br><i>Microbial bioremediation strategies of environmental pollutants</i>  | 1041 |
| <b>Slavica Čabrilo, Višnja Sikimić, Nada Jelić</b><br><i>The role of antimicrobial packaging in the protection cheese</i>   | 1047 |
| <b>Milica Ivanović, Predrag Rajković, Aleksandra Janković, Sandra Stanković</b><br><i>Optimization of the mixture composition and initial process parameters for composting grape pomace and co-substrates: Selection of an appropriate method</i>  | 1054 |
| <b>Markola Saulić, Aleksandar Stevanović, Marko Kovačević, Snežana Knežević</b><br><i>Integrated digital systems in pesticide control for safe food and agroecosystem conservation</i>  | 1061 |
| <b>Tanja Krunić</b><br><i>Impact of carrier composition and gastrointestinal digestion on the hydrogel sphericity and diameter</i>  | 1067 |
| <b>Danijela Pecarski, Dragana Dragaš Milovanović, Jasmina Bašić</b><br><i>Mycotoxin contamination in Serbia: Health implications and food safety challenges</i>   | 1073 |
| <b>Jasmina Rajić, Tanja Petrović, Aleksandra Stojićević, Dragana Mihajlović</b><br><i>Functional food: Concept, regulation, and public health significance</i>  | 1079 |
| <b>Jasna Savić, Aleksandra Božić, Dominik Brkić, Biljana Simić Polić</b><br><i>HDL functionality as a biomarker and therapeutic target in the era of new dyslipidemic drugs – a biochemical perspective</i>   | 1085 |
| <b>Maja Antanasković</b><br><i>Treatment and management of medical waste in the Health Center Prokuplje</i>   | 1092 |
| <b>Jasmina Rajić, Tanja Petrović, Aleksandra Stojićević, Dragana Mihajlović</b><br><i>Technological challenges and innovations in the formulation of functional food products</i>   | 1098 |
| <b>Aleksandra Stojićević, Ana Alimpić Aradski, Smiljana Janković, Jasmina Rajić, Marko Jauković, Aleksandar Stevanović, Milica Blažić</b><br><i>The essential oil of <i>Satureja</i> species as a promising food ingredient</i>                     | 1103 |

## STUDENT PAPER

|  |      |
|--|------|
| <b>Tijana Pavlović, Aleksandra Stojićević, Marko Jauković</b><br><i>Influence of the storage conditions on the chemical composition and shelf life of potato tuber</i> | 1109 |
|--|------|

## SCOPE 8. MECHANICAL ENGINEERING

- Kuznetsov Yu. A., Yakovlev D.D., Dobychin A.V., Gribakin A.A., Pichev V.S., Kravchenko I. N., Kalashnikova L.V.** 1115  
*Formation of protective coatings by high-velocity oxygen-fuel spraying*
- Milica Timotijević, Olivera Erić Cekić, Petar Janjatović, Stojko Biočanin, Dragan Rajnović** 1120  
*Quantification of niobium-rich and chromium-rich carbides in HP40Nb alloy after overheating*
- Manuel Vite-Torres, Juan Laguna-Camacho, Ezequiel Gallardo-Hernández, Javier Frias-Flores** 1129  
*The contribution on solid particle erosion (SPE) of two tribology labs in Mexico*
- Do Duc Trung, Hoang Tien Dung, Siniša Škrbić, Aleksandar Ašonja** 1135  
*Applying the depart method for material selection in mechanical engineering*
- Aleksandar Cvetković, Žaklina Tasić, Marija Petrović Mihajlović, Milan Radovanović, Ana Simonović, Milan Antonijević, Snežana Milić** 1141  
*Carbon paste electrodes and ZnO/CPE sensors: A short review*
- Đorđe Đurđević, Nikola Tanasić, Andrijana Đurđević, Nina Anđelić** 1147  
*Static calculation of smoke exhaust duct construction in fire conditions using FEM*
- Milan Marković, Dragana Velimirović** 1153  
*Moment of inertia as a cause of loss of stability in a front forklift*
- Bojan Ivljanin, Uroš Kovačević, Vladeta Milenković** 1160  
*Comparative analysis of new systems for determining ratio and phase displacement errors on high-voltage current transformers without power interruption*
- Goran Pavlović, Mile Savković, Nebojša Zdravković, Marko Todorović, Goran Marković, Predrag Mladenović** 1166  
*Weight minimization of the hydraulic press frame with metaheuristic algorithms*
- Andrijana Đurđević, Đorđe Đurđević** 1172  
*Static calculation of the tank wall*
- Strahinja Đurović, Nikolaj Velikinac, Milan Mišić, Aleksandra Kokić Arsić, Goran Maksimović, Ivan Šarkoćević, Andjela Baščarević** 1177  
*Artificial intelligence in fused deposition modeling*
- Milanka Plavšić** 1182  
*Design of polymeric materials in function of unit (technological) operations for new industrial production methods*
- Predrag Drobňjak, Đorđe Đurđević, Andrijana Đurđević** 1188  
*Analysis of the problem of deformation of the guides and rearing of the guide console from the wall of the passenger lift drive shaft*
- Miloš Milovančević, Marija Stevanović** 1193  
*ANFIS-based prediction of surface roughness and material removal rate in plasma arc cutting of Quard-400*
- Obrad Aničić** 1200  
*Integration of modern technologies and artificial intelligence into CNC manufacturing systems: From 3D modeling to the application of neural networks*
- Milan Milutinović, Nikola Matić, Uroš Ugrinić** 1204  
*Tool life of CBN cutting inserts during hard turning of 60WCrV7 steel*
- Milan Mišić, Nikolaj Velikinac, Strahinja Đurović, Dragan Lazarević, Bojan Stojčević, Martina Petković, Aleksandra Kokić Arsić** 1210  
*Influence of feed rate on surface roughness of 3D printed PLA parts after milling process*

|  |      |
|--|------|
| <b>Nada Ratković Kovačević, Miloš Jakovljević, Đorđe Dihovični, Milica Ivanović, Petar Jakovljević</b><br><i>Project based learning - building a scaled operating CNC mill model using 3D printed parts</i>  | 1215 |
| <b>Milan Vasić, Mirko Blagojević, Milan Banić, Miloš Josimović, Goran Nestorović</b><br><i>Investigation of the influence of lubricant type on the efficiency of a cycloidal reducer</i>   | 1221 |
| <b>Nataša Soldat, Ivana Atanasovska</b><br><i>Step-by-step approach of rolling bearings modelling for efficient FEA contact analysis</i>   | 1227 |
| <b>Marko Tasić, Žarko Mišković, Radivoje Mitrović</b><br><i>Appliance of the polymer material for construction of the conveyor belt carrying idler's shell</i>   | 1233 |
| <b>Marko Milošević, Dragan Džunić, Živana Jovanović Pešić, Marko Miletić, Vladimir Kočović, Slobodan Mitrović</b><br><i>Tribo-mechanical characterization of epoxy-based composites reinforced with abaca fibers: A scratch test study</i>   | 1239 |
| <b>Milanka Plavšić</b><br><i>Some applications of polymer system scaling theory in design of processing industrial equipment</i>   | 1246 |
| <b>Blanka Škipina, Biljana Pećanin, Aleksandar Savić, Ljiljana Topalić-Trivunović, Branka Ružičić, Slavica Maletić, Mitja Kolar, Manja Kurečić, Andreja Rudolf, Dragana Grujić</b><br><i>Enhancing electrical conductivity of polypropylene nonwoven textiles via Cu/Zn-modified bentonite: FTIR, XRD and dielectric study</i> | 1252 |
| <b>Milica Timotijević, Stojko Biočanin, Željko Bulatović</b><br><i>Reliability model of the CNC hydraulic press DAGGT</i>  | 1257 |
| <b>Đorđe Karić, Mirko Komatina, Goran Vorotović</b><br><i>Machine learning methods for predicting energy savings in building retrofits</i>   | 1266 |
| <b>Andela Vasović, Nebojša Denić, Nikolaj Velikinac, Aleksandar Marković, Marko Smilić</b><br><i>The impact of batch size on the performance of the ResNet-18 model on the CIFAR-10 dataset</i>  | 1271 |
| <b>Nebojša Petrović, Goran Vorotović, Aleksandar Bengin, Miloš Januzović, Jela Burazer, Dejan Blagojević</b><br><i>High-resolution UAV analysis of urban heat islands</i>  | 1275 |
| <b>Milan Travica, Danilo Miljković, Nenad Mitrović</b><br><i>Application of a mobile digital image correlation system for on-site structural integrity assessment</i>  | 1281 |
| <b>Marija Stevanović, Miloš Milovančević</b><br><i>Identification of key influential parameters for economic optimization of wastewater treatment systems using ANFIS</i>  | 1286 |
| <b>Ioannis Filippou Kyriakidis, Savvas Koltsakidis, Konstantinos Tsongas, Michel Theodor Mansour, Apostolos Korlos, Konstantinos David, Dimitrios Tzetzis</b><br><i>Mechanical and dynamic behaviour of thermoplastic polyurethane-based composites produced via fused filament fabrication for machine mount applications</i> | 1294 |

## SCOPE 9. ECOTOURISM AND RURAL DEVELOPMENT

|  |      |
|--|------|
| <b>Radomir Stojanović</b><br><i>Tourism destination management in Serbia - selecting new management model</i>  | 1301 |
| <b>Jelena Anđelković Grašar, Rokšana Chowaniec, Emilija Nikolić, Marija Jović, Ljubomir Jevtović, Stefan Stančić</b><br><i>Green heritage - archaeological parks as living labs for achieving sustainability</i> | 1307 |
| <b>Slobodanka Stankov, Radomir Stojanović, Branko Radeljić</b><br><i>Digitalisation of cultural heritage and its impact on tourism development in Serbia</i>   | 1314 |

|  |      |
|--|------|
| <b>Valentina Radoičić, Ivo Županović</b><br><i>Assessment of sustainable tourism development in Durmitor National Park</i>   | 1320 |
| <b>Marko Pavlović, Dragana Đurić, Saša Marković, Marija Perić, Ben Mladenović</b><br><i>Belgrade as a tourist brand - opportunities and development strategies</i> | 1326 |
| <b>Biljana Ranković Plazinić, Svetlana Lekić</b><br><i>Transport accessibility as a driver of rural development</i>  | 1332 |
| <b>Aleksandar Todorović, Darko Dimitrovski</b><br><i>Field trip as educational instrument in rediscovering rurality</i>  | 1338 |

## SCOPE 10. MECHATRONICS

|  |      |
|--|------|
| <b>Goran Zajić, Milan Pavlović, Marija Zajeganović</b><br><i>Case study on generating configuration parameters for network devices and computers using generative AI agents</i>  | 1346 |
| <b>Dorđe Lazarević, Jovan Ćirić</b><br><i>Multisensor IoT system for detection and measurement of physical parameters of the work environment</i>  | 1352 |
| <b>Nebojša Andrijević, Zoran Lovreković, Vladan Radivojević, Milan Milanović, Milica Stojičević</b><br><i>Cost-efficient smart building IoT architecture: Integration of Arduino Mega, ESP32 and real-time web control</i> | 1358 |
| <b>Aleksa Turudić, Siniša Škrbić, Uroš Ilić</b><br><i>Impact of small distributed energy resources on voltage profiles and power flow in distribution networks</i>   | 1365 |
| <b>Nikola Slavković, Mirjana Tomić, Dejan Đukic, Goran Zajić</b><br><i>Human - machine interrelationship: Automatic sentence generation by rule-based systems</i>  | 1371 |
| <b>Nastasija Nikolić, Marko Đapan, Ivan Mačuzić, Carlo Caiazzo, Petar Todorović, Arso Vukičević</b><br><i>Identification of parameters affecting the implementation of robotic solutions in lean industrial systems</i>    | 1378 |
| <b>Nada Ratković Kovačević, Goran Vojnović, Đorđe Dihovični, Dragan Kreculj, Petar Jakovljević</b><br><i>Programming Arduino to drive a stepper motor for positioning a scanner in a library automation system</i>         | 1384 |
| <b>Đorđe Dihovični, Aleksandra Mitrović, Nada Ratković Kovačević, Dragan Kreculj</b><br><i>Advances in 3D printing of electronics</i>  | 1390 |
| <b>Nela Vujović, Jelena Zarić Kovačević, Vesna Alivojvodić</b><br><i>AI-driven resource efficiency balancing opportunities and constraints in mining</i>   | 1396 |
| <b>Dragan Kreculj, Đorđe Dihovični, Aleksandra Mitrović, Nada Ratković Kovačević, Miloš Vorkapić</b><br><i>Artificial intelligence in digital twins</i>  | 1401 |

## STUDENT PAPER

|  |      |
|--|------|
| <b>Alper Şanlı, Alim Rüstem Aslan, Tuncay Yunus Erkeç, Musa Şen</b><br><i>Misalignment effects on optical payload performance for small satellites</i> | 1407 |
|--|------|



## SOIL REMEDIATION: PERSPECTIVES AND RISKS

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**Abstract:** Elevated levels of heavy metals (cadmium (Cd), copper (Cu), aluminium (Al), nickel (Ni), chromium (Cr), mercury (Hg), lead (Pb), and zinc (Zn)), lead to harmful changes in soil quality which must be taken out of agricultural production and can compromise groundwater quality and safety. It is essential to adopt cost-effective, environmentally friendly, sustainable, and reliable remediation strategies for contaminated soils. A review of various soil remediation studies has been analysed herein. Techniques, such as soil excavation, deep plowing, solidification, stabilization, soil washing, and phytoremediation, are frequently employed to address metal pollution in soils. Their sustainability can be limited by effectiveness in addressing the presence of multiple metals with different geochemical behaviours, environmental impacts, and cost constraints. Phytoextraction is recognized as an environmentally and economically advantageous method, but its slow remediation rates may require several decades to even centuries to effectively clean heavily contaminated sites. Soil washing is a cost-effective method but the treatment for purifying and reusing eluents still remains. Dissolved organic matter (DOM) derived from waste biomass and its modified by-products show promise as eco-friendly, low-cost alternatives for treating both soil and eluents. This review also consolidates global advancements in innovative nano and electrokinetic (EK) remediation technologies.

**Keywords:** Soil Pollution, Heavy Metals, Remediation

### 1. INTRODUCTION

The contamination of soils with heavy metals and their pervasive accumulation has intensified as a consequence of human activities, including industrial atmospheric emissions and waste process effluents, mining, fossil fuel combustion, waste disposal, agricultural activities, fertilizer usage, sludge farming etc. [1, 2]. These contaminants readily enter ecological pathway via bioaccumulation and transfer, thereby posing profound threats to both ecosystem integrity and human health. Heavy metal contaminated soils are widespread worldwide, necessitating remediation or stringent management to mitigate detrimental effects on living organisms [3].

The heavy metal contaminants commonly found in soils include Cd, Cu, Al, Ni, Cr, Hg, Pb, and Zn [2]. These elements are characterized by their persistence in the environment, non-biodegradability, high toxicity, environmental mobility and significant bioavailability for crop uptake, thereby posing serious risks to global food security and human health [4]. The excessive accumulation of these pollutants in soils adversely impacts crop yield and safety, while also presenting substantial health hazards to humans through the food chain. These health risks include increased susceptibility to cardiovascular diseases, cancer, cognitive impairment, chronic anaemia, and damage to critical

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organs such as the kidneys, nervous system, brain, skin, and bones [5, 6]. Elevated concentrations of heavy metals in soil, particularly in the presence of multiple metal contaminants, can lead to significant degradation of soil quality. This deterioration is likely to adversely affect agricultural productivity as well as the quality and safety of groundwater resources [2]. Therefore, it is crucial to implement appropriate remediation strategies for contaminated soils to mitigate the risk of heavy metal pollution. The continued presence of dangerous heavy metals in soil environments highlights the importance of remediation technologies to be low-cost, green, sustainable and effective.

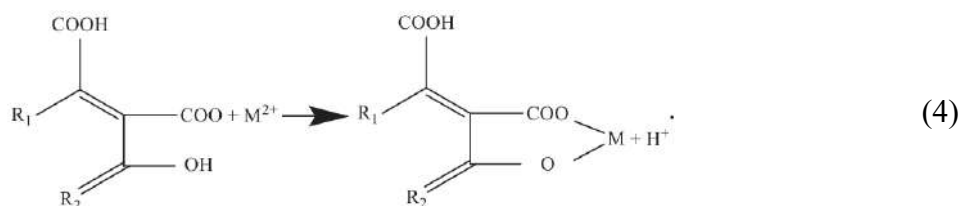
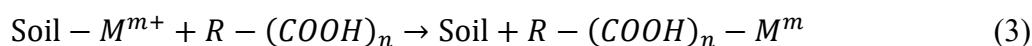
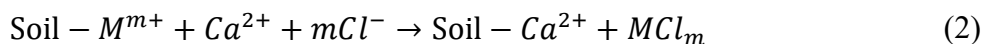
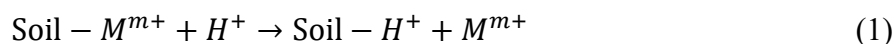
The present study summarized published studies about soil remediation techniques, their efficiencies, conditions, long-term sustainability potentials and advantages but also limitations and environmental risks. Traditional and innovative methods are analysed and discussed.

## 2. RESULTS AND DISCUSSION

Traditional techniques, including soil excavation, deep plowing, solidification, stabilization, soil washing, and phytoremediation, are commonly used to remediate soil metal pollutants [3]. However, excavation and deep plowing are costly and challenging at large scales and solidification carries reactivation risks. Stabilization is a widely employed technique aimed at preventing the leaching of bioavailable metals from contaminated soils by utilizing adsorptions or the formation of precipitates with stabilizers. Though, the simultaneous presence of the anionic species such as metalloids As and all the others cationic metals, which display different geochemical behaviours (changes soil pH and redox conditions (Eh)), make it difficult to concurrently reduce the availability of both in the soil [7]. Cheng et al. examined the organic-inorganic composite of iron-manganese oxides with polyacrylamide, modified as a stabilizing amendment for As and Cd contaminated soil. This innovative amendment effectively reconciles the previously opposing stabilization mechanisms for anionic and cationic metals. It provides dual benefits by not only remediating contaminated soil but also facilitating waste disposal, thereby offering a great solution for environmental management [7]. Organic nitrogen was also tested as amendment for Cd toxicity using cucumber as model plant [8]. Phytoextraction and soil washing are currently viewed as some of the most appealing remediation strategies. On-site phytoextraction, in particular, stands out as an environmentally and economically beneficial approach. It relies on the gradual release of heavy metals to maintain moderate concentrations in the soil solution, aligning with plant uptake while preventing their leaching and subsequent contamination of receiving waters [9].

Still, phytoextraction has its limitations, including slow remediation rates that may take several decades to centuries for cleaning heavy metal-polluted sites [9]. Moreover, the results from phytoextraction have been inconclusive so far, due to a lack of convincing large-scale field tests. Additionally, this method can only be applied to moderately contaminated soils where plant growth is largely unrestricted. After phytoextraction, incinerating the plant material can yield valuable bioenergy, and heavy metals can ultimately be recovered from the resulting ash. Soils that are excessively contaminated and unsuitable for phytoextraction can be remediated through soil washing or soil flushing, both of which are cost-effective and efficient methods, which permanently remove metals [9]. Soil washing is a practical and cost-efficient approach for large-scale remediation of farmland. It employs agents that facilitate the transfer of heavy metals from solid materials to a liquid phase through processes such as desorption, dissolution, and complexation [3]. The process involves chemical agent diffusion into soil, heavy metal dissolution, and their migration to the fluid phase. Soil washing can be performed either on-site using mobile washing systems or off-site at centralized soil washing facilities. To enhance the dissolution of heavy metals and improve the efficiency of soil washing remediation, various chemical agents have been studied. These include natural and synthetic organic and inorganic acids, complexing agents, and surfactants [3, 5]. Since the goal of soil washing is to effectively maximize the removal of pollutants, the selected agents strive to achieve the highest concentrations of dissolved heavy metals while reducing potential damage to the soil. Moreover, the selected agents must not introduce significant risks to human health or disrupt ecosystem functionality.

Consequently, selecting the right soil washing agent is a vital component of the process. Conventional washing agents comprise inorganic acids, chelating agents, alkalis, inorganic salts, aminopolycarboxylic acids and surfactants (chemical and biosurfactants) [10]. Inorganic agents (HCl, HNO<sub>3</sub>, H<sub>2</sub>SO<sub>4</sub>), along with salts (NaCl, FeCl<sub>3</sub>, CaCl<sub>2</sub>), are both cost-effective and efficient in extracting heavy metals (e.g., Cd, Cu, Ni) from soil [2]. Inorganic acids use H<sup>+</sup> ions to break down metal-soil complexes (soil-M) through acid digestion, facilitating elution (Eq. (1)). On the other hand, inorganic salts improve metal desorption via ion exchange, wherein Cl<sup>-</sup> ions form soluble metal compounds, or cations (Ca<sup>2+</sup>, Mg<sup>2+</sup>) replace the metal ions (Eq. (2)) [3].



Soil chelating agents can be categorized into synthetic agents (such as EDDS, GLDA, and EDTA) and natural agents (like citric, oxalic, and tartaric acids). These chelators are environmentally friendly, working by desorbing heavy metal ions (M<sup>m+</sup>) through chelation with functional groups (e.g., carboxyl groups (R-(COOH)<sub>n</sub>)) to create stable, water-soluble organic-heavy metal complexes. These complexes are then transported along with washing agents from the soil to the liquid-phase elution solution for leaching, as illustrated in Eq. (3).

Soil surfactants encompass both biosurfactants (including rhamnolipids, saponins, and humic acids) and chemical surfactants (such as sodium dodecyl sulfate (SDS), sodium dodecyl benzene sulfonate (SDBS), sodium lauryl ether sulfate (SLS), and polysorbate). Biosurfactants reduce the adhesion of heavy metal ions to soil particles by decreasing surface tension, facilitating their complexation and detachment. Conversely, abiotic surfactants, which utilize carboxyl functional groups, enhance ion exchange by transferring heavy metals from the solid phase to the liquid phase, as depicted in Eq. (4) [3]. While all these agents demonstrate high removal efficiency, most are costly and prone to secondary pollution and environmental damage [3]. Although traditional agents such as ferric chloride (FeCl<sub>3</sub>), ethylenediaminetetraacetic acid (EDTA), S, S-ethylenediaminedisuccinic acid (EDDS), N, N-bis (carboxymethyl)-l-glutamic acid (GLDA) [11], and biosurfactants (like rhamnolipids and saponins) have demonstrated high efficiency in removing heavy metals there are still some limitations and possible ecological risks. For example, FeCl<sub>3</sub> can negatively impact soil structure, lead to acidification, reduce nutrient levels, and harm soil microorganisms. Although biosurfactants like rhamnolipids are effective, biodegradable, and environmentally friendly, they are costly and not yet appropriate for large-scale use. Similarly, while EDTA is an economical option with high efficacy in metal removal, its persistence can change soil chemical properties, affect enzyme activities [12]. There is also the question about the untreated waste eluent which may cause secondary pollution to soil and groundwater and most studies focus only on metal removal efficiency while neglecting eluent treatment and eventual reuse. Waste eluent typically contains soluble metal chelates and free metal ions, requiring tailored post-treatment to separate heavy metals and recover the eluent. Current methods for treating heavy metal-polluted waste eluent include water evaporation, precipitation, electrolysis, chemical precipitation, ion exchange, membrane technology, adsorption, and other industrial waste- water treatments.

Adsorption is the most widely studied technology for effectively removing heavy metals from wastewater, using inexpensive, widely available, and environmentally friendly innovative biomass

materials [3]. However, despite advancements in researching different adsorbents, challenges such as cost and the risk of secondary pollution continue to persist. In comparison to the previously mentioned chemical agents, such as nitrilotriacetic acid (NTA) ethylenediaminetetraacetic acid (EDTA), and other synthetic aminopolycarboxylic acids which are non-degradable and toxic to various organisms, naturally occurring dissolved organic matter (DOM) presents an innovative, more environmentally friendly and cost-effective option [10]. DOM is rich in active functional groups and is highly responsive to its surroundings. It can interact with metal ions, forming stable, water-soluble complexes through chelation or complexation, which alters the chemical speciation and bioavailability of heavy metals [13].

Soil DOM is a simply defined term consisting of a complex mixture of a great number of different only partly known water-soluble organic molecules, functional groups, originating from wastewater treatment, food or wine processing [10], root exudates and partial decomposed plant materials [9]. Despite the limited number of published investigations, the potential of DOM as extractant of cationic and anionic heavy metals has been clearly demonstrated for soils polluted with As, Cd and, in particular, with Cu, and strongly indicated for Co, Cr, Ni, Pb and Zn polluted soils. While the divalent Cd, Co, Cu, Ni, Pb and Zn cations are dissolved because of binding to DOM functionalities, mainly carboxylate and phenolate groups, anionic As and Cr are extracted because DOM dissolves their sorbents, mainly Al and Fe oxides. It also forms highly stable and soluble organo-metallic complexes with heavy metals, a beneficial characteristic for washing reagents employed in soil washing technology [10]. Moreover, DOM application to soils can increase soil nutrient contents and mitigate negative effects on soil pH and cation exchange capacity. However, the considerable complexity of the DOM-heavy metal-soil system depend on many variables such as solution:soil ratio, extraction time and extraction mode and strictly controlled environmental conditions [9]. DOM can also be used for waste eluent treatment. Yang et al. highlighted that DOM sourced from waste biomass and its modified residues has potential as an eco-friendly, affordable treatment for soil and eluents [3]. Concretely, they focus on the potential of agricultural and forestry waste biomass as new adsorbents for waste eluent treatment.

Lately, nanomaterials have shown great potential for remediating heavy metals in soil. Their distinctive physicochemical properties, nanoscale size, extensive specific surface area, and increased reactivity facilitate several immobilization pathways, including adsorption, precipitation, redox transformations, and surface complexation, which together significantly lower heavy metal mobility and bioavailability [14]. Wang et al. analysed four principal classes of nanomaterials and demonstrated their great remediation applications efficiencies [6]. These are:

- Nanometal-based materials: nano iron-base (nano-FeS) and nano calcium-based (nano-CaCO<sub>3</sub>, nano-CaSiO<sub>3</sub>, nano CaO) materials, highly effective at immobilizing and detoxifying heavy metals in soil through adsorption and chemical transformation. By facilitating redox reactions, they reduce heavy metal ions to less reactive or inert forms, thereby substantially decreasing their bioavailability. Moreover, their large specific surface area and abundant active sites promote the formation of stable precipitates with heavy metals via chemical interactions, further mitigating their mobility and toxicity in the soil environment.
- Nano non-metallic materials (e.g., thiol-functionalized nano-SiO<sub>2</sub>, nano-selenium particles (SeNPs)): employ tailored surface chemistries to enhance adsorption affinity and specificity.
- Nanoclays and mineral nanomaterials (e.g., montmorillonite, sepiolite, diatomaceous earth, etc): exploit intrinsic layered or porous architectures to promote ion sequestration and precipitation processes. However, their limited porosity restricts accessibility to embedded contaminants within aggregated soil structures.
- Nanomodified biochar composites: integrate the high adsorption capacity of biochar (BC) with the reactivity of nanoscale metals (BC/nZVI, Fe–Mn co-modified (FMBC)) to produce cost-effective, multifunctional remediation platforms.

Despite their transformative potential, the long-term environmental stability, ecological safety, and economic scalability of nanomaterials remain critical challenges. This has led to advances in nanotechnology and microbial-electrochemical systems (METS), which integrate multiple scientific

fields. Nanotechnology is transforming environmental research by creating materials and instruments with superior qualities. Nanomaterials such as nanoscale zero-valent iron (nZVI), carbon-based compounds, and metal oxides offer large surface areas, adjustable reactivity, and good contaminant-targeting properties. They are employed in agriculture [14].

Wen et al. proved that novel electrokinetic (EK) remediation has potential for in situ removal of a broad spectrum of organic contaminants and heavy metals coexisting in low-permeability soils [15]. EK encompasses the application of a low direct-current voltage across two or more electrodes embedded in the contaminated soil, driving two principal transport mechanisms: electromigration (EM) and electroosmotic flow (EOF). EM pertains to the migration of ionic species (e.g., heavy metals, radionuclides) within the pore medium, whereas EOF describes the convective transport of soil pore fluid, carrying dissolved species (e.g., organic pollutants) with it. Like other remediation modalities, EK efficacy is governed by the adsorption–desorption dynamics of contaminants in the soil, and removal is contingent upon desorption into the aqueous phase. Heavy metals dissolve in the acidic regions of the soil and accumulate near the cathode [16]. To mitigate adsorption limitations, several enhancement strategies have been proposed, including the use of chemical oxidants (persulfate) with ultrasound, surfactants, chelates, and complexing agents to desorb pollutants from particle surfaces and maintain them in solution.

Nonetheless, delivering chelating agents and surfactants into low-permeability zones presents additional logistical and economic challenges. Moreover, the transport of contaminants can be impeded by secondary electrokinetic phenomena such as the focusing effect and potential flattening, which may attenuate remediation efficiency [15].

### 3. CONCLUSION

Soil remediation is essential for promoting sustainable land use and maintaining ecosystem health, as it encourages plant growth and improves nutrient cycling. Effective remediation efforts need to save the biological and nutritional properties of the soil to sustain plant life, necessitating the implementation of comprehensive techniques that strike a balance between efficiency, environmental compatibility, and time-scalability. Soil excavation, deep plowing, solidification, stabilization, soil washing, and phytoremediation, are commonly used to remediate soil metal pollutants, but they are costly and challenging at large scales. Still, the use of innovative modified organic-inorganic composite amendment as stabilizing agent, such as iron-manganese oxides with polyacrylamide, effectively reconciles the previously opposing stabilization mechanisms for anionic and cationic metals. There are researches about naturally occurring dissolved organic matter (DOM) as an option not only for soil washing but for waste eluent treatment as well. It presents an innovative, more environmentally friendly and cost-effective agent.

Recently, nanomaterials (metal-based materials, non-metallic materials, clays and mineral materials nanomodified biochar composites) have demonstrated significant potential for the remediation of heavy metals in soil. Yet, the long-term environmental stability, ecological safety, and economic scalability of nanomaterials remain critical challenges. Next to nanotechnologies there is also novel electrokinetic (EK) remediation technology which has potential for in situ removal of a broad spectrum of organic contaminants and heavy metals coexisting in low-permeability soils. It is based on the application of a low direct-current voltage across two or more electrodes embedded in the contaminated soil, the migration of ionic species (e.g., heavy metals, radionuclides) within the pore medium, and transport of soil pore fluid, carrying dissolved species (e.g., organic pollutants) with it. Although the studied remediation technologies provide good efficiencies in removing heavy metals from soils but challenges such as cost and the ecological risk of secondary pollution continue to persist.

## LITERATURE

- [1] Yang, J. et al. (2024): Neglected pathways of heavy metal input into agricultural soil: Water–land migration of heavy metals due to flooding events, *Water Res.*, Vol. 267, pp. 122469, ISSN: 1879-2448.
- [2] Gusiatin, Z. M., Kulikowska, D., & Klik, B. (2020): New-Generation Washing Agents in Remediation of Metal-Polluted Soils and Methods for Washing Effluent Treatment: A Review, *International Journal of Environmental Research and Public Health*, Vol.17 No.17, pp. 6220, ISSN: 1660-4601.
- [3] Yang, S., Tu, C., Liu, G. et al. (2025): Waste biomass-derived organic matter for sustainable soil remediation: Enhancing heavy metal removal and eluent reuse in agricultural application, *Bioresource Technology*, Vol. 435, pp. 132876, ISSN 0960-8524.
- [4] Liu, H., Lv, J., Yang, Y. (2024): Recyclable water-modified deep eutectic solvents for removal of multiple heavy metals from soil, *Chemosphere*, Vol. 350, pp. 141141, ISSN: 0045-6535.
- [5] Yang, S., Tu, C., Liu, G., et al. (2025): Synergistic enhancement of heavy metals removal and soil nutrients for agricultural soils using novel agro-waste biomass derived washing agents, *Environmental Technology and Innovation*, Vol. 39, pp. 104336, ISSN 2352-1864.
- [6] Wang, M., Zheng, X., Oba, B. T. et al. (2025): Innovations in nanomaterials for remediation of heavy metal–polluted soil: Advances, mechanistic insights, and future prospects, *Nano Materials Science*, ISSN 2589-9651.
- [7] Cheng, F., Guo, S., Cheng, Z. (2024): Stabilization of arsenic-cadmium co-contaminated soil with the iron-manganese sludge derived amendment: Effects and mechanisms. *Journal of Environmental Management*, Vol. 370, pp. 122570, ISSN 0301-4797.
- [8] Dresler, S., Hawrylak-Nowak, B., Kováčik, J., Woźniak, M., Gałązka, A., Staniak, M., Wójciak, M., Sowa, I. (2021): Organic nitrogen modulates not only cadmium toxicity but also microbial activity in plants, *Journal of Hazardous Materials*, Vol. 402, pp. 123887, ISSN 0304-3894.
- [9] Borggaard, O. K., Holm, P. E., Strobel, B. W. (2019): Potential of dissolved organic matter (DOM) to extract As, Cd, Co, Cr, Cu, Ni, Pb and Zn from polluted soils: A review, *Geoderma*, Vol. 343, pp. 235–246, ISSN 0016-7061.
- [10] Zhang, H., Xu, Y., Kanyerere, T., Wang, Y., Sun, M. (2022): Washing Reagents for Remediating Heavy-Metal-Contaminated Soil: A Review, *Frontiers: Earth Science*, Vol. 10, ISSN 2296-6463.
- [11] Wang, G., Zhang, S., Xu, X. et al. (2016): Heavy metal removal by GLDA washing: Optimization, redistribution, recycling, and changes in soil fertility, *Science of The Total Environment*, Vol. 569–570, pp. 557–568, ISSN 0048-9697.
- [12] Gluhar, S., Kaurin, A., Finžgar, N. et al. (2021): Demonstrational gardens with EDTA-washed soil. Part I: Remediation efficiency, effect on soil properties and toxicity hazards, *Science of The Total Environment*, Vol. 792, pp. 149060, ISSN 0048-9697.
- [13] Fan, C., Zhang, Y. (2018): Environmentally friendly remediation of lead/cadmium co-contaminated loess soil in northwestern China using a humificated straw solution. *Environmental Science and Pollution Research*, Vol. 25, No. 25, pp. 25243–25254, ISSN: 0944-1344.
- [14] Upadhyay, S. K., Kumar, P., Jain, D., Zhao, X. (2025): Convergence of nanotechnology and microbial-electrochemical systems for next-generation of toxic heavy metal and organic pollutant soil removal, *Journal of Environmental Chemical Engineering*, Vol. 13, No. 5, pp. 118272, ISSN 2213-3437.
- [15] Wen, D., Gao, C., Zhang, Y. et al. (2024): Simultaneous removal of PAHs and heavy metals from soil by combining electrokinetic-assisted delivery of persulfate and ultrasound activation, *Journal of Hazardous Materials*, Vol. 480, pp. 136315, ISSN: 0304-3894.
- [16] Hamdi, F. M., Altaee, A., Aedan, Y. et al. (2025): Decontamination of Heavy Metals from Soil by Electrokinetic Combined with Reactive Filter Media from Industrial Wastes, *Water, Air, and Soil Pollution*, Vol. 236, No. 9, ISSN: 1573-2932.



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ENVIPACK d.o.o. je specijalizovani operater sa integralnom dozvolom za sakupljanje i transport opasnog i neopasnog otpada, osnovan od strane kompanije Galenika Fitofarmacija ad prevashodno sa ciljem da se uspostavi sistem za sakupljanje i zbrinjavanje otpadne ambalaže od sredstava za zaštitu bilja na teritoriji Republike Srbije. Osnovna namera je da se smanje količine generisanog otpada, očuvaju prirodni resursi i uspostavi optimalno upravljanje ambalažnim otpadom u skladu sa najboljim iskustvima zemalja EU i sveta.

Pored usluga sakupljanja, transporta i organizacije finalnog zbrinjavanja ambalažnog otpada, ENVIPACK d.o.o. Beograd svim zainteresovanim stranama iz različitih grana industrije, nudi konsalting u oblasti upravljanja otpadom i mogućnost sistematskog preuzimanja i organizaciju finalnog zbrinjavanja velikog broja opasnih i neopasnih otpada, uključujući i otpadna ulja, emulzije, robu sa isteklim rokom trajanja, otpadne filterske materijale, apsorbente, kertridže itd).

Razvijeni model sakupljanja i zbrinjavanja otpada je primenjen i organizovan po sistemu „zagađivač plaća“ u skladu sa Zakonom o upravljanju otpadom, a veliki broj renomiranih klijenata iz različitih grana industrije je tokom prethodnih 13 godina postojanja ENVIPACK doo, postalo deo ENVIPACK sistema koji uspešno rešava probleme upravljanja otpadom iz poljoprivrede, farmaceutske industrije, građevinske industrije, grafičke industrije, metaloprerađivačke industrije, drvnoprerađivačke industrije i iz drugih grana privrede.

Za sve dodatne informacije možete nas kontaktirati na jedan od kontakt brojeva telefona ili putem e-pošte.



**ENVIPACK d.o.o. Beograd (Zemun)**

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