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BOOK OF ABSTRACTS

Novi Sad, Serbia, October 31, 2025

SafeLi Conference 2025

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*It is our great pleasure to welcome you to the **SafeLi Conference 2025**, organized within the framework of the project "New Ionic Additives for Safer and Durable Electrolytes in Lithium-Ion Batteries (SafeLi)", supported by the Science Fund of the Republic of Serbia.*

The SafeLi project addresses one of the key challenges in modern energy storage — enhancing the safety, stability, and lifetime of lithium-ion batteries. The project focuses on the development of innovative ionic additives for advanced electrolytes, aiming to improve both the thermal and electrochemical performance of next-generation batteries. By combining experimental research, computational modeling, and artificial intelligence methods, SafeLi explores new pathways for designing safer, more reliable, and durable electrolyte systems.

*The **SafeLi Conference 2025** provides a platform for researchers, students, and industry representatives to share their findings, exchange knowledge, and foster collaboration in the field of advanced battery technologies. The program includes oral and poster sessions covering a wide range of topics such as electrolyte design, battery safety, materials characterization, and intelligent approaches for materials optimization.*

*This **Book of Abstracts** brings together the contributions presented at the conference, showcasing the diversity and innovation within the SafeLi project and its broader research community. We hope it will serve as a useful reference and an inspiration for future scientific and technological advancements toward safer and more sustainable energy storage solutions.*

We extend our sincere gratitude to the Science Fund of the Republic of Serbia for its support, to all contributors for their valuable work, and to the organizing committee for their efforts in realizing this event.

We wish all participants a successful and inspiring conference.

SafeLi Conference 2025 team

SafeLi   Science Fund of the Republic of Serbia

Local Organizing Committee

1. Dr. Snežana Papović, University of Novi Sad, Serbia

2. Dr. Gorana Mrđan, University of Novi Sad, Serbia

3. MSc Teona Teodora Borović, University of Novi Sad, Serbia

4. MSc Dragana Mekić, University of Novi Sad, Serbia

Conference partners

Conference program

9:00-9:30	**Registration**
09:30-9:40	Opening ceremony
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10:00-10:20	**Presenter: Slobodan Gadžurić** Securing the EU's Green Future: FREECOVER's Circular Solution to the Rare Earth Supply Challenge
10:20-10:40	**Presenter: Jelena Beljin** Phytoremediation of Multi-Contaminated Soils Using Hemp and Sorghum with Microbial Amendments: Assessment of Metal Bioavailability and Organic Pollutant Degradation in POT Experiments
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11:00-11:20	Coffee break
11:20-11:40	**Presenter: Gordana Gajica** Geochemical characterisation of peloids and ecosystem services of peloids-rich areas in Serbia - insights from the PELAS project
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12:00-12:20	**Presenter: Jelena Bogosavljević Lipovac** Application of a β-Diketo Ester Stabilizing Agent for Immobilization of Heavy Metals in Sewage Sludge: ICP-OES Assessment and Environmental Safety Evaluation
12:20-13:00	Lunch
13:00-13:20	**Presenter: Tijana Marjanović Srebro** pH-dependent degradation of triazine herbicides by biochar-persulfate systems
13:20-13:40	**Closing ceremony**

LECTURES

Securing the EU's Green Future: FREECOVER's Circular Solution to the Rare Earth Supply Challenge

Slododan Gadžurić,[1] Andrea Melchior,[2] Fabio Piccinelli,[3] Tatjana Trtić-Petrović,[4] Gustavo Perez,[5] Bojan Šarac,[6] Oscar Prado,[7] Leonardo Piccinetti,[8] Enita Kurtanović,[9] Markel Luaces[10]

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Rare Earth Elements (REEs) are critical for the EU's green transition but face high supply risks. The FREECOVER project addresses this challenge by developing a sustainable, closed-loop recycling process for REEs from end-of-life permanent magnets (Figure 1). The innovative approach utilizes eco-friendly materials derived from natural resources: natural acids for leaching, novel bio-based ionic liquids for separation, and low-cost minerals for adsorption. This hydrometallurgical process aims to minimize environmental impact by recycling water and valorizing waste streams, such as repurposing metal-loaded adsorbents as catalysts. Through international and interdisciplinary collaboration, FREECOVER seeks to secure a sustainable REE supply chain, enhance EU competitiveness in green technologies, and advance the circular economy.

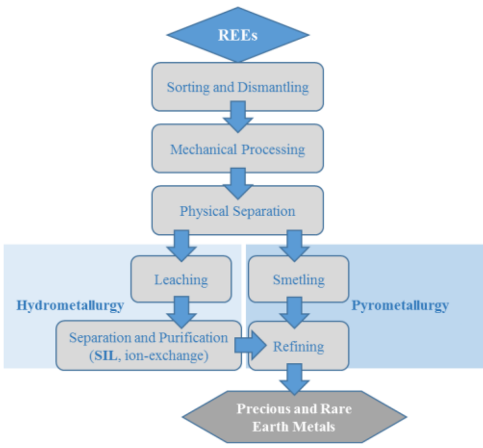

Figure 1. Flowchart of REEs recovery.

Acknowledgments: This research is supported by the FREECOVER project (grant agreement #101182579) under the European Community's Horizon Europe Program HORIZON-MSCA-2023-SE-01.

Phytoremediation of Multi-Contaminated Soils Using Hemp and Sorghum with Microbial Amendments: Assessment of Metal Bioavailability and Organic Pollutant Degradation in POT Experiments

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This study evaluated the effectiveness of phytoremediation strategies in reducing contamination from heavy metals and persistent organic pollutants (POPs) in soils treated with diesel, sewage sludge, and heavy metal mixtures. POT experiments were conducted using hemp and sorghum, combined with microbial plant growth-promoting rhizobacteria (PGPR) and fungi, to assess their impact on pollutant stabilization, bioavailability, and degradation. Soils were characterized for total and bioavailable fractions of metals (Cr, Cu, Zn, Pb, Cd, As, Ni) and organic contaminants, including total petroleum hydrocarbons (TPHs) and polycyclic aromatic hydrocarbons (PAHs), at the start and end of the experiments.

Results indicated that heavy metal contents were highest in HM treatments (e.g., Zn up to 300 mg/kg, Cu up to 160 mg/kg), whereas sewage sludge treatments showed significantly lower levels. PGPR amendments had limited effects on metal reduction, although hemp exhibited greater uptake potential for Cu and Cr compared to sorghum. Sequential extraction (BCR) revealed that most metals, particularly Pb and Cr, remained in immobile fractions, while Zn and Cu demonstrated higher availability in HM treatments. Notably, cadmium bioavailability decreased across all treatments due to plant uptake.

For organic contaminants, TPH concentrations decreased by up to 83% in diesel-contaminated soils, with greater remediation observed at higher initial contamination levels. PAH concentrations also showed significant reductions, particularly in diesel and heavy metal treatments, with fungal PGPR enhancing the degradation of persistent compounds such as benzo(a)pyrene and pyrene. Metabolite analysis confirmed the transformation of hydrocarbons into secondary compounds like benzoic acid and n-hexadecanoic acid. Bioavailability assessments revealed that the proportion of degradable hydrocarbons and PAHs declined during remediation, highlighting the role of plant–microbe interactions in pollutant sequestration and transformation.

Microbial community analysis showed overall increases in heterotrophic and nitrogen-fixing bacteria, with successful isolation of 36 diesel-degrading and 9 phenanthrene-degrading strains. Enzyme activities varied, with dehydrogenase and alkaline phosphatase increasing by experiment end, indicating improved microbial function. Overall, this study underscores the potential of integrated phytoremediation strategies—particularly hemp combined with microbial inoculants—for mitigating soil contamination under multi-stress conditions, while emphasizing the importance of bioavailability as a metric for assessing remediation efficiency.

Acknowledgements: This research was supported by the Science Fund of the Republic of Serbia, #GRANT No 6769, Natural based efficient solution for remediation and revitalization of contaminated locations using energy crops – ReNBES.

Enhance solubility of bioactive compounds via addition of polymers or ionic liquids

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One of the major challenges in the isolation and utilization of bioactive compounds (BACs) is their poor solubility in water. Increasing solubility, and thereby enhancing their extraction efficiency from biomass, is often achieved through the addition of chemical agents such as organic solvents and surfactants. However, these agents are frequently toxic, which drives the need for alternative, less harmful or non-toxic solutions.

The aim of this work was to improve the solubility of two groups of BACs—parthenolide and phenolic compounds from Tanacetum parthenium flowers, by adding polymers, and ellagic acid and phenolic compounds from raspberry pomace, by adding ionic liquids. Our results demonstrate that the extraction yield strongly depends on both the biomass particle size and the use of selected additives. Smaller particles, due to improved contact with the solvent, provided significantly higher yields.

To enhance the yield of parthenolide, a hydrophobic compound, we employed the polymer PPG 400. Increasing the PPG 400 concentration from 1 to 15% raised the parthenolide yield from 2.6 to 4.6 mg/g (Figure 1). Figure 1 demonstrates that the maximum yield of parthenolide is achieved through extraction with ethanol; however, the concentration of total phenols is five times higher when using 15% PPG 4000 compared to ethanol. The most pronounced effect on ellagic acid extraction was observed with surface-active ionic liquids, which increased the yield up to fivefold compared to water.

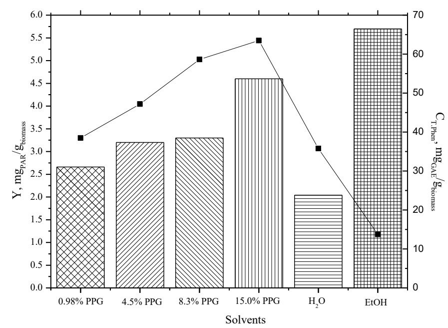

Figure 1. The effect of polymer concentration on the extraction yield of Parthenolide and total phenolic compounds.

These findings highlight the potential of polymers and ionic liquids as green and efficient alternatives for improving the solubility and extraction of poorly water-soluble bioactive compounds. Such approaches open new perspectives for sustainable isolation of natural products with enhanced applicability in pharmaceuticals and functional foods.

Acknowledgements: This research was supported by the Science Fund of the Republic of Serbia, Grant No 17475, Green Innovation: Unlocking the Bioactive Potential of Biomass for Enhanced Pharmaceuticals and Foods through Eco-Friendly Sustainable Technologies – VIVENDI, and the Ministry of Science, Technological Development, and Innovation of the Republic of Serbia (451-03-136/2025-03/200017).

Geochemical characterisation of peloids and ecosystem services of peloids-rich areas in Serbia - insights from the PELAS project

Tijana Mutić[1], Emilija Vukićević[2], Jovana Roganović[2], Nikola Burazer[1], Tijana Milićević[3], Gorica Veselinović[1] and Gordana Gajica[1]

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Peloids, or healing muds, represent "mature" mud, which consists of a complex mixture of fine-grained natural materials of geological and/or biological origin and mineral water. They are considered economically valuable natural resources that are used for therapeutic, cosmetic and relaxation purposes. Their therapeutic properties are influenced by their mineralogical, geochemical, and thermophysical characteristics. Furthermore, the quality of peloid and its potential application in pelotherapy depend on its thermal, chemical and mechanical properties. The specifics arise from the composition and interaction of the inorganic and organic parts with mineral water during the maturation processes, as well as from the conditions in the sedimentation environment. These processes are accompanied by biological activity, which further alters the composition of the organic and inorganic components of the peloid. Peloids can form in lakes, wetlands, seashores and floodplains, as a result of volcanic and hydrothermal activity.

In Serbia, there are over 50 spas with more than 1000 sources of different mineral waters, the differences of which result from variations in geological compositions and hydrogeological and geothermal characteristics. Some spas, in addition to healing waters, also have healing mud and gas, and some are air spas, thanks to their geographical location. Although peloids have been used for therapeutic purposes in Serbia since ancient times, they have not been sufficiently investigated. There is no systematic and comprehensive peloid database with its physicochemical, geochemical and ecochemical characterisation.

The main goals of the project "*Peloids in Serbia: geochemical characterisation, quality assessment and ecosystem services of peloid-rich areas* - PELAS" are to determine: (*i*) the geological history and conditions of the sedimentation environment that contributed to their formation; (*ii*) the composition of the peloids and to assess their suitability for use, (*iii*) the assessment of the ecosystem services of areas rich in peloids, and (*iv*) to form systematic and comprehensive Data-point map. Within the PELAS project, healing mud from 15 spas covering all regions of Serbia will be analysed [1].

Through an integrated multidisciplinary approach, the findings of this research will provide a robust scientific basis for the safe and effective use of Serbian peloids in pelotherapy, as well as for fundamental research, by understanding the conditions that contribute to their formation. The expected outcomes of the PELAS project include a detailed characterisation of peloids to guide their practical applications, insights into geological conditions for identifying new peloid deposits, and an assessment of ecosystem services to support sustainable management strategies. The Data-point map will serve as a valuable resource for stakeholders, facilitating sustainable exploitation of natural resources through avenues such as ecotourism. Ultimately, the results contribute to the sustainable development of Serbia's spa tourism sector and the promotion of natural therapeutic resources.

Acknowledgments
This research has been financially supported by the Science Fund of the Republic of Serbia, #GRANT No. 11015, Peloids in Serbia: Geochemical characterization, quality assessment and ecosystem services of peloid-rich areas – PELAS. and the Ministry of Science, Technological Development and Innovation of Republic of Serbia (Contract No: 451-03-136/2025-03/200168, and 451-03-136/2025-03/200026).

[1] www.pelas.rs

pH-dependent degradation of triazine herbicides by biochar-persulfate systems

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Triazine herbicides such as atrazine and simazine are frequently reported in aquatic environments due to their extensive use and high persistence. Conventional treatment processes are often inefficient in removing these compounds, which raises concerns regarding ecological and human health risks. Advanced oxidation processes (AOPs) based on persulfate activation by biochar (BC/PS) represent a promising and sustainable alternative. However, the influence of pH, one of the most critical operational parameters, remains poorly understood.

In this study, the role of pH in the degradation of atrazine and simazine in BC/PS systems was investigated. Batch experiments were carried out at three pH values (5.00, 7.02, and 9.50) using biochars derived from hardwood, corn cob, and wheat straw (pyrolyzed at 700 °C). Atrazine and simazine were tested at an initial concentration of 100 µg/L, using a persulfate dose of 3 mM previously identified as optimal. Contact times of 0.5, 1, 2, and 4 h were applied to assess the degradation dynamics, since prior experiments at pH 7.02 demonstrated that equilibrium was typically achieved within 4 h.

Both atrazine and simazine exhibited high degradation efficiencies (>80% at all contact times, 0.5-4 h) under acidic and neutral conditions across all biochar types. Hardwood biochar showed the most robust performance, achieving nearly complete removal at pH 7.02. In contrast, degradation was strongly inhibited under alkaline conditions (pH 9.50). Hardwood biochar retained moderate activity (~50% for atrazine and ~78% for simazine after 4 h), while corn cob and wheat straw biochars showed efficiencies below 20%. The inhibition observed under alkaline conditions may be related to reduced persulfate activation and a possible shift in the dominant oxidative pathways. Acidic and neutral conditions are likely to favor sulfate radical ($SO_4^{\bullet -}$) formation, while alkaline media may promote hydroxyl radicals ($HO^{\bullet}$), which tend to be less selective toward triazines. These results suggest that triazine herbicides are particularly sensitive to pH, with substantially reduced removal under alkaline conditions. To place these findings in a broader context, it may be useful to compare them with chlorinated pesticides previously investigated in our group. Unlike triazines, lindane and β-endosulfan showed consistently high degradation efficiencies in BC/PS systems, achieving >90% removal within 4 h across acidic and neutral pH conditions, while maintaining high stability even under alkaline conditions [1]. The contrasting behaviors of triazine and chlorinated pesticides could be associated with their distinct molecular structures. Triazines contain heteroaromatic rings with protonable functional groups, making their reactivity more sensitive to radical speciation and solution pH. In contrast, chlorinated pesticides are hydrophobic and non-ionizable, which may favor non-radical pathways (e.g., singlet oxygen, ${}_1O^2$) and support consistently high removal efficiencies under different pH conditions.

Overall, these results suggest that the role of pH in BC/PS systems is highly pollutant-specific and influenced by the chemical structure of the contaminant. Such insights contribute to a better understanding of the underlying reaction mechanisms and may provide practical guidance for optimizing BC/PS systems in real-world water treatment applications.

Acknowledgements: This research was supported by the Science Fund of the Republic of Serbia, #10810, Sustainable solutions in environmental chemistry: exploring biochar potential-EnviroChar.

[1] T. Simetić, T. Marjanović Srebro, T. Apostolović, J. Anojčić, N. Đukanović, S. Mutić, J. Molnar Jazić and J. Beljin, *Processes*, 2025, **13**, 1856.

ZnO-Nanostructured Electrochemical Sensor for Efficient Detection of Glyphosate in Water

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Glyphosate is one of the most widely applied herbicides in modern agriculture, but its excessive and uncontrolled use has raised serious environmental and health concerns due to persistence in water resources [1]. The development of simple, rapid, and cost-effective methods for glyphosate detection is therefore of great importance for ensuring water quality and food safety. In this study, we report on the design and application of a ZnO-nanostructured electrochemical sensor for efficient glyphosate detection. The sensor was fabricated by modifying a carbon electrode with ZnO nanostructures, synthesized to provide high surface area and abundant reactive sites for molecular interaction. ZnO is particularly attractive for this application because of its low toxicity, high electron mobility, biocompatibility, and strong affinity toward functional groups present in glyphosate molecules. Surface modification with ZnO was achieved through a controlled deposition procedure, resulting in uniform coverage and stable adherence of nanostructures to the electrode surface.

Electrochemical characterization was carried out using cyclic voltammetry, differential pulse voltammetry, and electrochemical impedance spectroscopy. The results demonstrated a clear interaction between glyphosate molecules and the ZnO-modified surface, manifested as a decrease in charge-transfer resistance and a pronounced increase in faradaic current. This behavior is attributed to the chelation of glyphosate's phosphonate and carboxylate groups with Zn^{2+} sites on the nanostructure surface, which facilitates electron transfer between the analyte and the electrode. Importantly, the sensor exhibited a linear response across a wide concentration range, with a low limit of detection suitable for environmental applications.

In addition to sensitivity, the ZnO-based platform demonstrated good reproducibility and stability under repeated measurements, confirming its robustness for real-world applications. Selectivity studies revealed that the sensor could discriminate glyphosate from structurally related compounds, further highlighting its analytical potential. Given the simplicity of fabrication and good electrochemical performance, the presented ZnO-nanostructured sensor represents a promising alternative to conventional chromatographic or spectroscopic methods, which often require expensive instrumentation and complex sample preparation [2].

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References:

[1] Benbrook, C. M. (2016). Trends in glyphosate herbicide use in the United States and globally. *Environmental Sciences Europe*, *28*(1), 3.

[2] Zambrano-Intriago, L. A., Amorim, C. G., Rodríguez-Díaz, J. M., Araújo, A. N., & Montenegro, M. C. (2021). Challenges in the design of electrochemical sensor for glyphosate-based on new materials and biological recognition. *Science of The Total Environment*, *793*, 148496.

Probiotic immobilization on flaxseed

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Lactobacillus gasseri has gained considerable attention for its potential roles in modulating gut microbiota and enhancing host immune function. To exert health-promoting effects, probiotics must retain high viability, which can be improved by incorporating them into protective delivery matrices [1]. Flaxseed cake, a byproduct of cold-pressed oil production, is rich in fiber, protein, and bioactive compounds, making it a promising substrate for probiotic immobilization.

In this study, the flaxseed cake was ground, sieved to a particle size below 600 µm, sterilized, and suspended in distilled water at 10 % (w/v). Following L. gasseri inoculation, one sample underwent fermentation, incubation at 4 °C for 1 h, freezing, and subsequent freeze-drying, while the other was processed identically without fermentation. The resulting lyophilized powders were evaluated for probiotic survival and antioxidant activity.

High viability of *L. gasseri* was maintained in both preparations. Fermentation prior to lyophilization decreased survival by approximately 5 % yet significantly enhanced the antioxidant capacity of the probiotic powder. These findings demonstrate that flaxseed cake is an effective carrier matrix for *L. gasseri,* supporting both microbial stability and functional bioactivity.

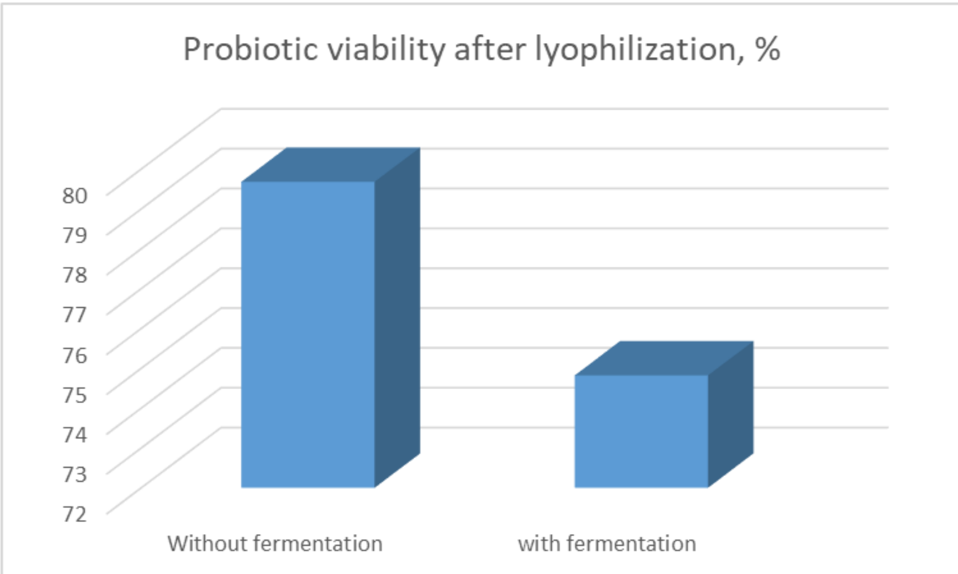

Figure 1. Viability of *Lactobacilus gasseri* after 24h of lyophilization.

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References:
[1] T. Z. Krunic, N. S. Obradovic, M. B. Rakin, *Food Chemistry*, 2019, **293**, 74–82

Application of a β-Diketo Ester Stabilizing Agent for Immobilization of Heavy Metals in Sewage Sludge: ICP-OES Assessment and Environmental Safety Evaluation

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The agricultural recycling of sewage sludge is limited by the risk of heavy metal contamination, necessitating the development of safe and sustainable stabilization strategies [1]. In this study, a β-diketo ester compound was synthesized and investigated as a chemical agent for immobilizing toxic metals in sewage sludge, with emphasis on quantitative elemental analysis and environmental risk reduction. The target compound was synthesized through a base-catalyzed condensation of diethyl oxalate with a methyl ketone in ethanol using sodium ethoxide, an approach consistent with green chemistry principles [2]. The synthesis pathway is shown in Figure 1.

The compound was incorporated into sewage sludge at defined treatment concentrations to evaluate its metal-chelating efficiency. Following incubation, sludge samples, treated soils, and plant tissues were subjected to inductively coupled plasma-optical emission spectrometry (ICP-OES) to determine total concentrations of Cu, Ni, Pb, Cd, Zn, Cr, and Co. Treatment with 50 mg/L of the β-diketo ester resulted in a marked reduction of metal solubility and mobility, indicating strong chelation and immobilization effects. Bioaccumulation studies using *Capsicum annuum* L. demonstrated significantly lower metal uptake in root, stem, leaf, and fruit tissues compared to untreated sludge, with concentrations falling below internationally accepted safety thresholds for agricultural amendments. Metal stabilization occurred without altering essential nutrient balance (Fe, Mn, Mg, Ca), and soil pH remained within neutral agronomic limits, demonstrating the chemical compatibility of the treatment. Microbial activity assays and germination bioassays confirmed that the compound did not negatively impact soil biota, supporting its ecological safety.

This work provides evidence that β-diketo esters offer a selective and efficient strategy for heavy metal risk mitigation in wastewater-derived biosolids, enhancing their potential for safe reuse in sustainable agriculture.

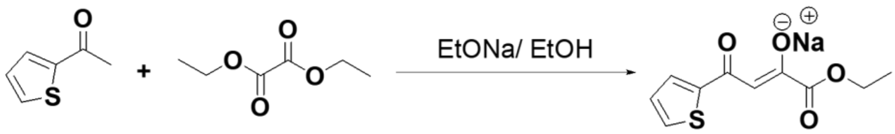

Figure 1. Procedure for synthesis of β-diketo ester sodium salt.

Acknowledgements: This research was supported by the Science Fund of the Republic of Serbia, 14866, New method of inactivation of sewage sludge using biocompatible 2,4-diketo esters and its potential use in agriculture – ***BETAgro***.

References:

[1] N. Nunes, C. Ragonezi, C.S. Gouveia and M.Â. Pinheiro de Carvalho, *Sustainability*, 2021, **13**, 2317.

[2] S. Branković, M. Bugarčić, F. Bugarčić, A. Ostojić, J. Petronijević, G. Rosić, I. Radojević, D. Selaković, Z. Simić and N. Joksimović, *Envir. Sci. Poll. Res.*, 2022, **29**, 58703.