

University of Ss. Cyril and Methodius in Trnava

Faculty of Natural Sciences

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Book of abstracts

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2. Biology and Biotechnology
3. Environmental Sciences
4. Chemistry
5. Young Scientists

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## FOREWORD

Dear Colleagues, Dear Guests,

It is my great pleasure to welcome you to the **9th International Scientific Conference Applied Natural Sciences 2025**. Over the past years, this conference has become an important forum for scientists, researchers, and students to exchange ideas, present new findings, and strengthen collaborations across disciplines.

This year, we are honored to host participants from many countries, whose contributions span a wide range of fields – from biology and biotechnology to chemistry, environmental sciences, and informatics. The diversity and quality of the submitted abstracts reflect not only the progress made in applied natural sciences, but also the enthusiasm and dedication of the scientific community to address current and future challenges.

I would like to extend my sincere thanks to all authors for their contributions, to the keynote speakers for sharing their expertise and vision, and to the Organising Committee for their tireless work in making this event possible. My gratitude also goes to our partners and supporters, without whom this conference would not be possible.

I believe that the *Book of Abstracts* you now hold in your hands will serve not only as a record of the scientific discussions held here in **Štrbské Pleso**, but also as an inspiration for future research and cooperation.

I wish you a fruitful conference, stimulating discussions, and many enjoyable moments during your stay in the High Tatras.

With best regards,

**Assoc. Prof. Iveta Dirgová Luptáková, PhD.**  
Dean  
Faculty of Natural Sciences  
University of Ss. Cyril and Methodius in Trnava

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**Applied Informatics**

# Resilience of multi-model NoSQL databases to transport-layer DDoS attacks

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**Abstract:** This study analyzes the resilience of selected multi-model NoSQL database systems - specifically MongoDB, ArangoDB, CosmosDB, and TerminusDB - against distributed denial-of-service (DDoS) attacks targeting the transport layer. The experiments were conducted in a controlled distributed environment simulating both volumetric and stateful TCP-based attacks. Key performance metrics such as service availability, response latency, and system recovery capability were monitored throughout the tests. The results reveal significant differences among the evaluated databases in their ability to handle TCP-level stress. The study also assesses the effectiveness of selected mitigation techniques, including connection limiting, TCP backlog parameter tuning, and the deployment of reverse proxy services. The findings provide practical recommendations for system architects and administrators seeking to enhance the resilience of NoSQL infrastructures against transport-layer threats.

**Acknowledgement:** The work was funded by the grant KEGA 010TTU-4/2025 *Development of pupils' computational and algorithmic thinking through the effective integration of modern technologies into the teaching of computer science and mathematics.*

**Keywords:** multi-model databases, non-relational databases, transport-layer DDoS, system resilience

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# Artificial intelligence in recruitment: ethical, decision-making and security implications of AI-based systems in human resources

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**Abstract:** The integration of artificial intelligence (AI) into human resource management, particularly recruitment, is fundamentally transforming traditional hiring practices. While AI-based systems offer enhanced efficiency, objectivity, and scalability, they simultaneously introduce complex ethical, decision-making, and security challenges. The aim of this paper is to analyse the key risks and challenges associated with the use of AI in recruitment processes and to propose a conceptual framework for its ethical, transparent, and secure implementation. The paper explores the impact of AI technologies on recruitment through the lens of applied informatics and responsible digital transformation. Particular attention is given to algorithmic bias, the opacity of decision-making (“black-box” systems), and the risk of overreliance on automated outputs. The study emphasises the importance of human oversight (human-in-the-loop), explainability (XAI), and the protection of personal and biometric data under legal frameworks such as the GDPR and the AI Act. Using system modelling and selected case studies, the research identifies critical vulnerabilities and offers a multi-layered proposal for ensuring trustworthy AI deployment in e-recruitment systems. The findings contribute to the current discourse on trustworthy AI and highlight the need for interdisciplinary collaboration across informatics, ethics, law, and human resource management in the development of responsible AI-based hiring technologies.

**Keywords:** s automated decision-making, artificial intelligence, e-recruitment, trustworthy AI, algorithmic bias, human-in-the-loop

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## Code generation with large language models

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**Abstract:** Large Language Models (LLMs) have emerged as powerful tools for code generation, offering new ways to automate and enhance software development while transforming how developers write, debug, and inspect code. This article provides an overview of the current capabilities of LLMs in code generation workflows. It covers model architectures, examples of usage, common use cases, and important limitations. The article also emphasizes the need of human oversight in LLM-based code generation, particularly due to concerns regarding reliability and security. Finally, article explores future directions in integrating LLMs into development tools and workflows.

**Acknowledgement:** The work was funded by the grant KEGA 014UCM-4/2025 Interactive modules for developing AI literacy.

**Keywords:** LLM, code generation, microservices

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# Real-time rendering of glittery materials: Photorealistic visualizations for interactive applications

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**Abstract:** The demand for photorealistic graphics in applications like video games, films, virtual reality, and industrial visualization is rapidly growing, driving the need for accurate rendering of glittery materials caused by small flakes within the surface paint. The automotive industry particularly relies on realistic coat paint simulations to showcase vehicle finishes under varied lighting conditions. These materials, with their intricate microstructures, require precise light interaction modelling for visually compelling results. This paper presents a novel method for real-time rendering of glittery materials.

Using the Unity engine and its High Definition Render Pipeline (HDRP), we implemented a custom shader solution. Building on state-of-the-art techniques, our method introduces improvements including multiple generated grids, dynamic glint scaling based on camera distance, and light color dependency. Our implementation involved modifying HLSL shader programs and developing a custom material editor for intuitive parameter control.

We rigorously evaluated the method against existing techniques, considering usability, complexity, performance, and visual quality. Results show our approach creates dense, rich glitter effects without artifacts, proving especially effective from a distance. However, it demands higher computational resources in complex scenarios.

This work highlights the importance of realistic rendering in industries like automotive design and identifies future optimization paths, such as exploring deferred rendering, transitioning to 3D noise textures, and addressing GPU branching improvements, to enhance real-time graphics performance.

**Keywords:** glitter, perception, unity 3D, High Definition Render Pipeline

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# Using artificial intelligence to optimize performance and autonomously manage relational database systems

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**Abstract:** The complexity of database systems and the dynamic nature of the load on these systems create the need for intelligent tools for analyzing and optimizing SQL queries. Traditional query tuning techniques, based on static heuristics and manual intervention, are often no longer sufficient. In this paper, we present the design and implementation of a module that uses machine learning methods to predict the performance requirements of SQL queries. Using the Random Forest algorithm, we classify queries as "slow" or "fast" based on data obtained in PostgreSQL. Input features include, for example, the number of calls, the number of processed rows, the number of reads from the cache memory, the duration of the query, or the occurrence in the list of the most demanding queries. As part of the experimental part, tests were performed on generated and real workloads. The entire solution is implemented as a containerized application with a connected PostgreSQL database, ensuring easy replication, scalability, and integration. The results point to the practical benefits of using AI in the area of predictive analysis of database queries. The proposed module can serve as a basis for autonomous workload management systems, automatic query planner optimization, or real-time monitoring of performance anomalies.

**Acknowledgement:** The work was funded by the grant KEGA 011UCM-4/2024 Teaching and training IoT security using modern technologies.

**Keywords:** database, optimization, machine learning

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# Experimental verification of the performance of the iEDF scheduling algorithm for IoT tasks in an Edge cloud system

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**Abstract:** The aim of this paper is to verify the performance of the iEDF (improved Earliest Deadline First) algorithm that we designed and implemented. It is the algorithm that schedules IoT tasks in an Edge cloud system. We verify the performance of the algorithm based on 2 key criteria: makespan (the completion time of the last task in the schedule) and deadline fulfilment (the latest required completion time) of each task. We designed experiments, implemented 3 scheduling algorithms in the CloudSimPlus simulator environment: our iEDF, the original EDF and a Greedy-based algorithm and used 33 scaled datasets of IoT tasks. Together we obtained 99 pseudo-optimal schedules for various scaled datasets of tasks using the whole set of microclouds and by applying all 3 scheduling algorithms. This provided us with a detailed picture of the behaviour of the scheduling system when using different input sets. On the base of performed complex experiments and by mutual comparing of algorithms, we found that our algorithm iEDF achieves the shortest (best) makespan and 100% deadline fulfilment for all scheduled tasks. The Greedy-based algorithm had slightly worse makespan results and insufficient deadline fulfilment. The EDF algorithm had slightly worse deadlines (83 to 100%) and the worst makespans among the compared algorithms.

**Acknowledgement:** This paper was supported by the VEGA 1/0192/24 project - Developing and applying advanced techniques for efficient processing of large-scale data in the intelligent transport systems environment. Computing was performed in the High-Performance Computing Center of the Matej Bel University in Banska Bystrica using the HPC infrastructure acquired in project ITMS26230120002 and 26210120002 (Slovak infrastructure for high-performance computing) supported by the Research & Development Operational Programme funded by the ERDF.

**Keywords:** IoT, Edge computing, task scheduling, Earliest Deadline First algorithm, improved Earliest Deadline First algorithm

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# Virtual reality as a tool for simulation of land degradation and reclamation scenarios – user experience test and satisfaction

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**Abstract:** According to the United Nations Convention to Combat Desertification (UNCCD), land degradation is occurring worldwide due to human activities. This results in a reduction of its use value, biodiversity, and fertility. The UNCCD's goal of land degradation neutrality (LDN) can halt and then reverse this alarming state of affairs in the future. Consequently, it is imperative to direct attention toward the types of soil degradation and the methodologies for the remediation of degraded soils. The objective of this paper is to present the design and development procedures of a simulation in a virtual reality environment, focusing on selected types of soil degradation and ways to remove them according to the current established methods. Furthermore, the present study offers the comparative results of an investigation into the user acceptance experiences and satisfaction with the simulation, which was designed in this manner for use in virtual reality.

**Acknowledgement:** The work was funded by the grant Soil in the Mirror of InterDisciplinary Science (PIDVE).

**Keywords:** virtual reality, design, programming, UX testing, participants

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# An analysis of SSH attack frequency based on standard vs. non-standard port usage

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**Abstract:** Our paper focuses on analysing the number of attacks targeting the SSH service exposed to the public internet. In this study, we used the Cowrie honeypot, which we deployed with various SSH port configurations to evaluate the impact of port selection on the frequency of attacks. The experiment lasted for one month, during which we monitored three devices running an active SSH honeypot. The first device operated on the standard TCP port 22, the second used the commonly known alternative TCP port 2222, which is frequently recommended in the literature, and the third device ran on a non-standard, unprivileged TCP port 65100. The main motivation behind our paper was to investigate and highlight whether the number and nature of attacks on the SSH service vary depending on the selected port. In the final part of the paper, we present the results of our measurements and assess the effectiveness of the “security through obscurity” strategy, specifically the use of a non-standard port for a service that remains publicly accessible from the internet.

**Acknowledgement:** The work was funded by the grant KEGA 010TTU-4/2025 *Development of pupils' computational and algorithmic thinking through the effective integration of modern technologies into the teaching of computer science and mathematics.*

**Keywords:** SSH security, honeypot, port obfuscation, cyberattack metrics

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# Design of an interactive tool for enhancing algorithmic thinking and programming skills

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**Abstract:** The current development of information technologies requires that students and professionals in computer science possess not only theoretical knowledge of algorithms but also practical skills in effectively working with data structures. However, traditional teaching methods often fail to adequately address the need for interactivity, visual clarity, and direct application of knowledge. This highlights the necessity for modern educational tools and instructional approaches that better reflect contemporary educational demands. The introductory section analyses existing tools for teaching dynamic data structures, identifying their advantages and limitations in the context of fostering algorithmic thinking and programming skills. The core contribution is an original interactive application integrated into a broader e-learning course. The application visualises a selected data structure, a doubly linked list, and serves as an effective instructional aid in teaching algorithm design and programming. The visualisation enables a clear and graphical representation of complex structures and processes, thereby facilitating comprehension. Beyond the development of technical competencies, working with the application also supports the cultivation of so-called soft skills, such as analytical thinking and problem-solving in both independent and collaborative contexts. The findings of this paper may prove valuable for educational institutions aiming to modernise and enhance the quality of computer science instruction.

**Acknowledgement:** The work was funded by the grant KEGA 011UCM-4/2024 Teaching and training IoT security using modern technologies.

**Keywords:** visualisation, interactivity, data structures, hard skills, soft skills, quality of education

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## Air pollution data analysis in Prague

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**Abstract:** There is a variety of emissions data available that is being collected across the Czech Republic. One of the providers of these data is the Czech Hydrometeorological Institute, which has been collecting these data from 1969 to the present. Our aim is to analyse a selected part of these data and identify possible relationships between the observed variables as well as visualization of the data itself.

Our primary objective was to find correlations between the values of monitored emissions in the Prague area. Since information on emissions is available for the whole territory of the Czech Republic, we focused on the comparison of air pollution directly in Prague and in the surrounding areas. On the basis of this analysis it is possible to conclude to what extent emissions are generated directly in the city (traffic, industry) or are caused by external influences (Saharan sands, volcanic eruptions). The amount of emissions generated directly in the city can often be influenced e.g. by intelligent traffic management, which is the subject of our long-term research.

**Acknowledgement:** Part of the research results was obtained using the computational resources procured in the national project National competence center for high performance computing (project code: 311070AKF2) funded by European Regional Development Fund, EU Structural Funds Informatization of society, and Operational Program Integrated Infrastructure. This work was co-funded by the Slovak Grant Agency VEGA (contract No. 1/0779/25) and the High Performance Computing Center of the Matej Bel University in Banská Bystrica using the supercomputing infrastructure acquired in project ITMS 26230120002 and 26210120002 (Slovak infrastructure for high-performance computing) and supported by the Research & Development Operational Programme funded by the ERDF.

**Keywords:** smart city, emissions, air pollution, environment, data analysis

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# An analysis of semantic similarity detection methods for automated assessment of open-ended questions

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**Abstract:** Automated short-answer grading (ASAG) presents challenges when grading open-ended questions due to the complexities of syntax and semantics in natural language processing. This often results in inconsistent evaluations. Commonly used platforms such as LMS Moodle, Socrative, Google Forms, and MS Teams Testportal interpret data differently. However, alternative methods exist for more accurate assessments. This study compares semantic similarity algorithms and large language models (LLMs) for digital assessments, including all-MiniLM-L6-v2, SlovakBert, MPNet, GPT\_trained, and Groq API's LLaMa 3 (70B), which achieved an impressive 98% success rate (49/50 responses correct). These models have unique strengths: SlovakBert has native language expertise, and LLaMa 3 has deep contextual understanding. While automation provides speed and efficiency, human oversight is essential to ensure evaluation reliability. The nuances of student responses often require manual validation to ensure fairness. A combined strategy, merging the strength of state-of-the-art models with professional analysis, might open the door to more precise and reliable digital evaluations in learning environments.

**Acknowledgement:** The work was funded by the grant KEGA 010TTU-4/2025 *Development of pupils' computational and algorithmic thinking through the effective integration of modern technologies into the teaching of computer science and mathematics.*

**Keywords:** semantic similarity, large language models, sentence transformer

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# Hacking the mind of AI

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**Abstract:** Large language models (LLMs) are AI systems used in content generation, chatbots, and decision-making. By "jailbreaking" attackers bypass safety features to make them produce harmful or restricted content or stealing sensitive data.

Jailbreaks are grouped into three main types:

- **Prompt Engineering:** This involves crafting tricky inputs, like asking the model to act as an "unrestricted AI" (role playing, contextual misleading) or adding noise to hide harmful requests (token manipulation), with recent methods like FlipAttack achieving up to 98% success rates.
- **Adversarial Attacks:** Token-Level Perturbations, i.e. modifying input tokens to create adversarial examples that preserve semantic meaning while bypassing safety filters; Gradient-Based Attacks; Weak-to-Strong Jailbreaking, which uses two smaller models (one safe and one unsafe) to adversarially modify the decoding probabilities of a significantly larger safe model.
- **Model Manipulation:** This means changing the model's training data or settings to weaken safety, like fine-tuning on bad data or inserting hidden triggers.

Apart from malicious intent, jailbreaking LLMs may have legitimate reasons, like testing against attacks, or exploring how the model handles controversial topics.

To fight jailbreaking, developers can train models with tricky examples, filter inputs to block bad prompts, use red-teaming with ethical hackers and tests and explainability techniques.

**Acknowledgement:** This research was supported by the grant KEGA 014UCM-4/2025.

**Keywords:** jailbreaking, large language models, prompt engineering, adversarial attacks, model manipulation

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## The use of artificial intelligence in e-learning systems

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**Abstract:** The use of artificial intelligence (AI) in e-learning platforms is a dynamically developing area that is transforming the architecture and functionality of e-learning. This article focuses on the technical possibilities of integrating AI components into modern educational systems, particularly in terms of architectural design, data flow, APIs, and scalability. Attention is given to functionalities such as adaptive learning, predictive analytics for student performance, automated assessment, and personalized content recommendation.

The analysis evaluates different types of platforms in terms of support for the integration of external AI services, availability of machine learning (ML) modules, compatibility with cloud deployment, and the ability to process real-time data. The possibilities of interfacing with authoring tools and the level of technical openness of the systems are also considered.

The results show that the choice of a suitable system depends on the specific type of institution, its technical background, and the requirements for the level of teaching personalization. Based on the findings, it is recommended that universities deploy open-source platforms that offer broad possibilities for integrating artificial intelligence. Corporate environments prefer compact SaaS solutions with integrated analytical tools, while platforms with native support for adaptive learning are best suited for language and vocational education.

**Acknowledgement:** The work was funded by the grant KEGA 011UCM-4/2024 Teaching and training IoT security using modern technologies.

**Keywords:** artificial intelligence, e-learning platforms, adaptive learning, AI integration, machine learning, personalized learning

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## Cybersecurity by design: Modeling processes first

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**Abstract:** Universities are increasingly exposed to cybersecurity threats focused on personal data, research information, and IT service availability. Their open, decentralized environment, characterized by academic freedom, also increases vulnerability to cyber-attacks and internal security weaknesses. Effective cybersecurity management in this context requires structured, transparent, and coordinated processes that respect the specific characteristics of academic life. Business process modeling (BPM) can serve as a practical tool to document, improve, and communicate key security-related activities. This contribution explores how BPM tools can support cybersecurity process management in universities. Specifically, it compares two modeling tools OpenBPM and ADONIS, in terms of their usability and effectiveness for visualizing selected processes related to university cybersecurity. The focus is not on the tools themselves, but on whether process clarity plays a more significant role than the tool choice. This contribution aims to share practical experience by comparing the usability of BPM tools in supporting university cybersecurity managers in balancing academic freedom with effective security management.

**Keywords:** cybersecurity, BPMS, OpenBPMN, Adonis, process modeling, higher education

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## Model design for data acquisition from heterogeneous sensors that produce lysimeter station data

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**Abstract:** The lysimeter station is a complex experimental facility designed for long-term monitoring of the impact of various agricultural technologies on soil water dynamics and material flows. The station generates a high volume of data from several types of sensors, including meteorological sensors, which are designed to measure weight, soil moisture. These data are heterogeneous and generated at different frequencies, formats, and structures. This study presents a data extraction, transformation, and storage model design that would enable the efficient processing of complex data flows. The lysimeter weighs and serves as a reference object with a permanently grassed surface. Three non-weighable lysimeter containers were placed in experimental fields with different soil cultivation methods, namely, no-till, minimization, and conventional technology. Each lysimeter generates different hydrological and physical parameters. The proposed model assumes data collection from all available sources transformation and adjustment into a standardized structure, time-synchronized, and stored in a timeseries database. This study aims to ensure data integrity during transfer and transformation and to prepare a basis for easy reporting and visualization. The proposed system is sufficiently scalable and ready for future measurement expansion or integration with environmental analysis platforms.

**Acknowledgement:** The work was funded by the grant VEGA 1/0175/25 Applying machine learning and digital fingerprinting to improve detection and mitigation of DDoS attacks.

**Keywords:** data acquisition, ETL process, timeseries database, flow base, BIG DATA

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**Biology and Biotechnology**

## Bacterial inhabitants of wood-decay fungi basidiocarps

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**Abstract:** Various bacteria were isolated from 14 basidiocarps of wood-decay fungi collected from June to September 2023 in selected locations in Slovakia (Oravské Veselé village, Banská Bystrica city, and a mixed forest in Vrútky city). Fungi were identified by combination of morphological traits and ITS spacer region sequence analysis, bacteria were identified by MALDI-TOF MS. To detect the cellulolytic ability of bacterial isolates, the Congo-Red Staining method with carboxymethyl cellulose medium was used. Highly variable populations of bacteria were detected in all basidiocarps with predominance of *Pseudomonas* spp. Most basidiocarps (9) were identified as *Phellinus igniarius*, from which multiple *Pseudomonas* spp. including *P. extremorientalis*, *P. synxantha*, two *Achromobacter* spp., *Bacillus pumilus*, *B. subtilis*, *Enterobacter asburiae*, *E. bugandensis*, *Ewingella americana*, *Lelliottia amnigena*, *Serratia liquefaciens*, and *Stenotrophomonas* sp. were isolated. From *Trametes versicolor* basidiocarps, *Ochrobactrum* sp. and *Lelliottia amnigena* were isolated; from *Trametes gibbosa*, *Bacillus* sp., *Bacillus subtilis*, *Lysinibacillus fusiformis*, two *Pseudomonas* spp., and *Stenotrophomonas* sp.; from *Trametes hirsuta*, three different *Pseudomonas* species and *Raoultella terrigena* were isolated. In *Fomitopsis betulina*, two *Bacillus* spp. and *Sporosarcina* sp. were detected. Cellulolytic activity was observed in bacteria belonging to the *Pseudomonas*, *Bacillus*, and *Achromobacter* genera. The possible role of fungi-bacteria symbiosis in wood-decay is discussed.

**Acknowledgement:** This work was funded by KEGA Grant No. 015UMB-4/2025 and VEGA Grants No. 1/0694/21, 1/0508/25.

**Keywords:** basidiocarps, cellulolytic bacteria, ITS, MALDI-TOF MS, *Pseudomonas* spp., wood-decay fungi

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## Plant cell, tissue, and organ cultures: research and application perspectives

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**Abstract:** The research program of the "Plant In Vitro Culture Systems" team focuses on plant *in vitro* organ, tissue, and cell cultures. It includes micropropagation, callus formation, cell suspension and root cultures, and the establishment of plant stem cells. The scope of research encompasses a variety of medicinal, aromatic, ornamental, and industrial plant species, such as *Datura stramonium* L., *Calendula officinalis* L., *Chelidonium majus* L., *Lavandula* spp., *Sida* spp., *Tagetes* spp., *Sempervivum tectorum* L., and *Cannabis sativa* L. These species have been selected for their content of metabolites with pharmacological and biocidal activities. The aim is to produce plant cell biomass and bioactive secondary metabolites *in vitro*, also using a spectrum of biotic and abiotic elicitors, both conventional and unconventional, to enhance the biosynthesis and production of targeted secondary metabolites. An important objective of the program is to develop specialized *in vitro* culture platforms, customized for each species, that can produce consistent biomass yields and specific phytochemicals for applications in the pharmaceutical, cosmetic, and nutraceutical industries, as well as in agriculture.

**Keywords:** plant, callus, cell suspension culture, root culture, stem cells, secondary metabolite

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## Effect of silicon on pigments in grain amaranth under abiotic stress

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**Abstract:** The most detrimental impact of abiotic stress on photosynthesis is the reduction in the levels of photosynthetic pigments. Decreased pigment content directly leads to the plant's diminished ability to photosynthesize. In addition, oxidative stress damages the structure of chloroplasts, which further reduces the vitality and yield of crops. In recent decades, the positive influences of beneficial silicon (Si) on the pigment content and antioxidant activity in plants under stress have been extensively researched. However, the effectiveness of Si varies considerably depending on several factors, including species, genotype, phenological stage, and the plant's ability to accumulate Si.

In our experiments, we investigated the effect of Si ( $\text{Na}_2\text{SiO}_3$ ; 3 mM) on the concentrations of photosynthetic and protective pigments in grain amaranth (*Amaranthus cruentus* L.) grown in soil contaminated with cadmium (Cd; 200  $\mu\text{M}$ ) and sodium chloride (NaCl; 200 mM). We observed the highest chlorophyll and carotenoid content in the leaves of plants exposed to Cd in combination with Si or NaCl. Both chlorophyll *a* and *b* contributed to the increase in total chlorophyll content. We also observed a decline in the content of strong antioxidant betalains in all treated plants, primarily due to a reduction in betacyanin concentration.

**Keywords:** grain amaranth, pigments, silicon, soil stress

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## Swiss similarity – public web tool for searching of new, anti-bacterially effective Nitroxoline™ structural analogues

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**Abstract:** There is currently a persistent need for new pharmaceuticals across various therapeutic areas, due to high cost of drugs development. Therefore, there is a clear effort to implement *in silico* prediction methods to eliminate unsuccessful drug candidates. SwissSimilarity is one of the modern tools used to identify potential structural analogues of successful drugs (or bioactive compounds) based on 2D or 3D similarity, loading from multiple databases. The subject of this study was the parametrization and identification of structural analogues of Nitroxoline™, along with 18 additional compounds from a training subset. As a pilot calculation was chosen the following SwissSimilarity tool in “bioactive compounds” mode with 2D/3D projection and the ChEBI database as the standard calculation for comparing with others. The aim of this study was to demonstrate a correlation between molecular similarity and antibacterial efficacy against two bacterial taxa *in vitro*: the Gram-negative bacterium *Escherichia coli* CCM 7929 and the Gram-positive taxon *Micrococcus luteus* CCM 732. This first (pilot) calculation revealed a correlation between structural similarity of 2,4-quinolinediol and 8-hydroxy-5-nitroquinoline-2-carbaldehyde to Nitroxoline™, and their antibacterial efficiency.

**Keywords:** Nitroxoline™, structural analogues, Swiss similarity web tool

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## The balance of plant extracts potency to scavenge model radical and to reduce ferric ion in model complex

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**Abstract:** Fifty randomly selected plant extracts were evaluated for their ability to scavenge a model radical and to reduce ferric ions in a model complex. Both methods were applied simultaneously using microplate assays. The DPPH method simulates the capacity of a plant extract to scavenge the model radical DPPH, which can be broadly interpreted as a manifestation of antioxidant potential. The FRAP method assesses the ability of compounds to reduce the oxidation state of transition metal ions, specifically the reduction of Fe<sup>3+</sup> in complex with TPTZ (2,4,6-tris(2-pyridyl)-s-triazine). This indicates antioxidant activity, but also under certain conditions, it reflects the potential to create more reactive pro-oxidant metal ion species. The ratio of these two distinct activities is expressed as the Pro-oxidant/Antioxidant Balance Index (PABI). Most plant extracts demonstrated higher activity in the FRAP assay, suggesting a greater potential for pro-oxidant metal ion formation compared to radical scavenging antioxidant capacity. However, some extracts showed surprisingly predominant radical scavenging activity, including those from the following taxa: *Aesculus hippocastanum* L., *Clematis vitalba* L., *Mespilus germanica* L., and *Piper nigrum* L. This study presents the achieved results and their statistical processing.

**Keywords:** balance, plant extracts, radical scavenging, ferric ion reduction, study *in silico*

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## The prediction of DPPH radical scavenging potency and ability to reduce ferric ion in model complex for selected compounds *in silico*

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**Abstract:** A preliminary screening of 22 selected compounds with known antioxidant activity, and the standard TROLOX, was conducted to evaluate their capacity to scavenge the model radical DPPH and to reduce ferric ions in a model complex system. These properties were assessed using the parameters DPPH<sub>50</sub>, FRAP<sub>50</sub>, and the Pro-oxidant/Antioxidant Balance Index (PABI), revealing significant differences in antioxidant performance among the individual compounds. To support and explain these observations, a complementary *in silico* study was conducted to calculate structural parameters of the tested compounds. This analysis combined molecular mechanics simulations using the AMBER force field with semi-empirical quantum chemical calculations using the AM1 method. The computational study revealed a causal relationship between the presence and nature of heteroatoms in the molecules, their partial charges, and their antioxidant activities. These partial charges reflect the mesomeric and inductive effects within the molecules, influencing both their ability to scavenge the DPPH radical and their capacity to reduce the oxidation state of transition metals, exemplified by the reduction of Fe<sup>3+</sup> in the TPTZ complex. The computational results were further complemented by physicochemical parameters available from the PubChem database for all evaluated compounds. The obtained results were processed using advanced statistical methods.

**Keywords:** antioxidants, radical scavenging, ferric ion reduction, study *in silico*

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## Biocidal effect of lichen extract on selected phytopathogens

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**Abstract:** Phytopathogens cause huge losses in global plant production annually, with these damages reaching billions of dollars. One solution to their elimination is the use of synthetic pesticides, which, however, have a negative impact on the environment. An alternative to such pesticides are biopesticides. Such substances are generally safer for the environment. In our work, we deal with the effect of an extract derived from lichens on reducing the production of tobamoviruses in infected tomato plants, *Solanum lycopersicum* L., genotype ANAHU. Secondary metabolites of lichens are compounds that usually have a low molecular weight. The aim of the work was to investigate the biocidal potential of an extract derived from lichens. We determined the biocidal effect of the extract by proteomic analysis. Higher concentration of the extract showed a more significant inhibitory potential for the presence of the virus coat protein. The distribution of *tomato mosaic virus* (ToMV) in individual organs of these plants after application of the metabolite was monitored. The results indicate that the lichen extract can significantly reduce the concentration of virus particles in infected plants and limit the spread of the virus to individual organs.

**Acknowledgement:** This research was supported by the projects: APVV-24-0042 and APVV-21-0289.

**Keywords:** lichens, extract, tobamoviruses, inhibition, biopesticides

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## Training of future biology teachers in summer science schools

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**Abstract:** In 2023, the Sumy State Pedagogical University named after A. Makarenko organized and held the first international school “Natural Science Research School.” This school was implemented jointly by the University of St. Cyril and Methodius in Trnava. The school's program included a chemical and ecological training workshop. In 2024, together with the Faculty of Natural Sciences and the Faculty of Biology and Biotechnology at St. Cyril and Methodius University in Trnava, two international grants were prepared and won with the financial support of the International Visegrad Fund's Visegrad+. The V4 Generation Mobility Mini-Grant project aims to improve sustainable development research skills and promote environmental thinking among young scientists. As part of this project, an international scientific school “Youth for sustainable environment” was held in December 2024. Future teachers had a unique opportunity to work under the guidance of leading European experts, conduct research in modern laboratories of the Biological Institute of the Pomeranian University in Słupsk (Poland) and develop their own environmental projects. As part of the international grant project “Enhancing Eco-Skills Through Cross-Border Collaboration between V4 and Ukraine” No. 22420189, an international summer science school “Best Practices of V4 Countries and Ukraine in Developing Eco-Skills” was held in June 2025.

**Keywords:** skills formation, summer school, future biology teacher, educational and professional program, research skills

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## Plant-mediated green synthesis of silver nanoparticles and their characterization

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**Abstract:** Green synthesis represents an eco-friendly approach to the production of metal nanoparticles, typically utilizing biological systems such as plants, fungi, or bacteria. Silver nanoparticles were prepared via green synthesis using leaf extracts from *Ocimum basilicum* L. as the reducing and stabilizing agents, with silver nitrate serving as the precursor. Various parameters, including temperature, pH, and extract: precursor ratio, were varied to optimize the synthesis. Characterization of the silver nanoparticles was performed using UV-Vis spectroscopy, dynamic light scattering (DLS), scanning electron microscopy (SEM), and Fourier-transform infrared spectroscopy (FT-IR). The synthesized nanoparticles exhibited an average size of  $8.54 \pm 1.79$  d.nm and showed prooxidant activity.

**Acknowledgement:** The work was supported by the project VEGA 1/0230/24.

**Keywords:** nanoparticles, plant extract, silver nitrate

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## Laccase production by *Pleurotus ostreatus* in repeated solid-state cultivation

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**Abstract:** Laccases, which belong to the group of multicopper oxidoreductases, have significant potential for removing pollutants from the environment. These effective enzymes are mainly produced by white-rot fungi, known for their high redox potential. However, their use is often limited by high production costs and relatively long cultivation times. These drawbacks can be addressed by selecting fast-growing white-rot fungi and optimizing cultivation conditions. From this perspective, solid-state cultivation appears to be a promising approach. The aim of this study was to evaluate the feasibility of reusing the cultivation medium under solid-state conditions for effective laccase production over several weeks without the need to restart the culture of *Pleurotus ostreatus* DSM 1833. Our results showed that, depending on the type of lignocellulosic waste used, laccases could be produced continuously for up to five weeks, with weekly extractions (every 7 days). The best results were achieved using hardwood waste (bark of *Prunus avium* L. or bark of *Aesculus hippocastanum* L.) and softwood waste (bark of *Tilia cordata* Mill.) rich in lignin and phenolic compounds. This process not only enables the efficient production of laccases but also promotes the valorization of lignocellulosic waste, contributing to cost reduction and environmental sustainability.

**Keywords:** laccase, production, repeated solid-state cultivation, white-rot fungi, *Pleurotus ostreatus*

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## Brine over gold – bioprospecting of halophilic microbiota from Miocene salt deposits

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**Abstract:** Hypersaline environments are extreme habitats with limited biodiversity due to the combined effects of several environmental factors; on the other hand, such environments could serve as biodiversity hotspots and extreme conditions naturally select microorganisms with modified biochemistry giving opportunity for new compounds, genes, and processes discoveries. In our experiments, halophilic microbiota from three Miocene salt deposit brines in Solivar near Prešov in Slovakia, the Solotvyno salt-lake in Ukraine, and the Salina Turda mine in Romania, were isolated and analysed for the presence of biotechnologically interesting activities. While microbiota of all brines was dominated by halophilic Proteobacteria, a very limited overlap of population composition was observed with the highest diversity seen in Solotvyno salt-lake. Observed differences between microbial populations indicate that spatial isolation possibly contributed to speciation. The only common bacterial genus found in samples from all three brines was the genus *Idiomarina*, but each site contained different species. In the analysed bacteria unique sets of biotechnologically interesting activities were detected including numerous hydrolases (proteases, cellulases, azoreductases) and high level of PHA production was observed in some isolates. The data obtained contributes significantly to the knowledge of halophilic microbiota and highlights the protection of these microbial resources for future biotechnological advancements.

**Acknowledgement:** This work was supported by the VEGA grant No. 1/0508/25 and the VVGS-2025-3508 grant.

**Keywords:** Miocene salt deposits, brine, microbiota diversity, biotechnology

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## Salinity-induced changes in photosynthetic pigments and proline levels in *Euglena gracilis*

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**Abstract:** *Euglena gracilis* is a unicellular freshwater eukaryote, known for its metabolic flexibility and ability to adapt to various forms of abiotic stress. In our work, we aimed to monitor the effect of increasing the concentration of sodium chloride in the CMM medium for growth of *E. gracilis*. Cells were grown in CMM medium statically for 7 days under continuous illumination at 25°C. Growth was monitored by manual cell counting. The concentration of chlorophylls, carotenoids and proline was determined spectrophotometrically. The results proved that higher NaCl concentrations led to a reduction in growth rate, a decrease in chlorophyll content, and a significant decline in carotenoids. We also observed a decreasing trend in proline content, which did not prove its significant role in osmotic adaptation under the specific conditions. These findings support the ability of *E. gracilis* to effectively modulate its metabolism in response to stress induced by elevated salinity.

**Acknowledgement:** This work was supported by the KEGA 012UCM-4/2025 project.

**Keywords:** *Euglena gracilis*, NaCl, salinity stress, proline, carotenoids, chlorophylls

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## Comparison of the antibacterial effect of biogenic silver and copper nanoparticles

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**Abstract:** Silver nanoparticles (Ag-NPs) and copper oxides nanoparticles (CuO-NPs) are characterized by unique antimicrobial properties. The antimicrobial effect of nanoparticles against bacterial cells is induced by a combination of mechanisms that affect the cell at multiple levels from the cell wall to the genome, which potentially leading to cell death. In this work, we determined the antibacterial activity of Ag-NPs and CuO-NPs on two Gram-positive bacteria and three Gram-negative bacteria. Antibacterial effects were confirmed for all tested bacteria. The highest antibacterial efficacy of the nanoparticles was on *Micrococcus luteus*. In the disk diffusion method, we measured inhibition zones of 16.7±0.6 mm for Ag-NPs (1 mg DM/ml) and 17.0±1.4 mm for CuO-NPs (45 mg DM/ml). In the microdilution method, we observed significant differences in the effect of Ag-NPs and CuO-NPs on *M. luteus*. With Ag-NPs, the MIC<sub>90</sub> was 0.063 mg DM/ml, while with CuO-NPs, the MIC<sub>90</sub> was 2.8 mg DM/ml. Based on the results, it was not determined the higher efficiency of NPs against bacteria depended on Gram-positivity or Gram-negativity. Ag-NPs showed more effective and at the same time broad-spectrum antimicrobial activity against the tested bacterial strains.

**Acknowledgement:** This work was supported by the VEGA 1/0230/24 project.

**Keywords:** nanoparticles, antibacterial effect, MIC, disk-diffusion test

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# Bioinformatic identification of genetic variants in primary lymphedema

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**Abstract:** Primary lymphedema is a rare genetic disorder resulting from impaired lymphatic function, leading to chronic swelling of the limbs. Despite advances in genetic research, the majority of cases still lack a clear molecular diagnosis. This study focuses on the identification of novel genetic variants in 408 patients with clinically diagnosed primary lymphedema using a targeted next-generation sequencing panel comprising 99 genes, including key genes of the VEGF-C/VEGFR3 and PI3K/AKT pathways. Bioinformatic tools such as MutationTaster2, VEP, GnomAD, and VarSome were used to interpret the pathogenicity of the variants. We identified 22 potentially disease-associated variants across eight genes (*RELN*, *CDH5*, *ARAP3*, *KIF11*, *PTPN14*, *FLT4*, *ADAMTS3*, *CCBE1*), of which 17 have not been previously linked to primary lymphedema. Protein interaction analysis confirmed the functional relevance of these variants in lymphangiogenesis. Our findings expand the understanding of the genetic heterogeneity of lymphedema and suggest new candidate genes for future diagnostics and personalized treatment strategies.

**Acknowledgement:** This work was supported by the European Union – NextGenerationEU via the Recovery and Resilience Plan of the Slovak Republic, project no. 09I03-03-V05-00004.

**Keywords:** primary lymphedema, bioinformatics, genetic variants, VEGF-C/VEGFR3, PI3K/AKT pathway, molecular diagnostics

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**Environmental sciences**

## Effect of inoculation with arbuscular mycorrhizal fungi on metal (Zn and Cu) or radionuclide ( $^{137}\text{Cs}$ ) uptake in tomato plants

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**Abstract:** The aim of the work was to evaluate the effect of tomato (*Solanum lycopersicum* L.) plants inoculation with a mixture of arbuscular mycorrhizal fungi (AMF: *Rhizoglyphus irregularis*, *Funneliformis mosseae*, and *Funneliformis caledonium*) on the uptake and translocation of metals (Cu and Zn) or radionuclide ( $^{137}\text{Cs}$ ) under laboratory conditions. Determination of Cu and Zn in soil and plant biomass was conducted using AES-ICP, and the presence of  $^{137}\text{Cs}$  in these samples was analysed by scintillation gamma-spectrometry. We found that AMF inoculation had no clear effect on total Cu and Zn uptake by tomato plants and the calculated values,  $[M]_{\text{plant}}/[M]_{\text{soil}} \approx 0.4$ . However, the obtained results indicate a significant relationship between AMF inoculation and changes in the distribution of metals, where more than 2-fold reduction in their translocation to the aerial parts compared to the control (tomato plants without AMF inoculation) was observed. In the case of  $^{137}\text{Cs}$  uptake, up to an 18-fold reduction in  $^{137}\text{Cs}$  translocation was observed in AMF-treated plants when compared to the control. A commercial microPET system was also employed to image and quantify Cu uptake and translocation in tomato plants, and the radioisotope  $^{64}\text{Cu}$  was used as a positron emitter.

**Acknowledgement:** This work was supported under the APVV project “*Interakcie arbuskulárnych mykoríznych húb s rastlinami v stresových podmienkach a ich potenciál pri fytoremediačných metódach*”, No. APVV-17-0150.

**Keywords:** arbuscular mycorrhizal fungi, heavy metals,  $^{137}\text{Cs}$ , translocation, *Solanum lycopersicum*, phytoremediation

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## Impact of mercury contamination on soil chemical properties in the historical mining area of Gelnica

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**Abstract:** This study focused on evaluating the impact of mercury contamination on selected soil characteristics (pH, total nitrogen, total carbon, and soil organic carbon content) in the historical mining area of Gelnica. Mercury concentrations in all analyzed soil samples significantly exceeded the permitted limit values, indicating a high level of environmental contamination. Soil pH values ranged from 3.34 to 6.8, corresponding to acidic to neutral soil conditions. Total nitrogen content ranged from 0.08% to 0.54%, while total carbon content varied between 1.27% and 10%. Total carbon was determined by dry combustion using the Multi N/C 3100 analyzer (Analytik Jena), total nitrogen was measured by the Kjeldahl method, and soil organic carbon content was calculated. Correlation analysis revealed significant positive correlations between total nitrogen, total carbon, and soil organic carbon content. In contrast, total nitrogen showed a negative correlation with both pH and total mercury content. Total carbon was negatively correlated with total nitrogen. The results suggest that mercury has an indirect negative impact on soil nutrients and the chemical balance of the environment, which may affect soil fertility and the ecological stability of the area.

**Acknowledgement:** This research was supported by the VEGA project No. 1/0213/22.

**Keywords:** soil chemistry, soil pollution, former mining area, mercury

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## Microbial activity of Cu-mining heap in Central Slovakia before and after application of natural sorbents

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**Abstract:** Mine waste poses significant environmental hazards due to high concentrations of potentially toxic elements. One method of waste heap reclamation involves introducing mineral-organic fertilisers and sorbents. Since microbiological activity is a sensitive indicator of environmental changes, this study, which was based on pot experiment, investigated the effect of chicken manure, biochar and bentonite (1%, 20% and 10% of technosol weight, respectively), as well as an organo-zeolite sorbent i.e. a mixture of chicken manure, perlite and CaCO<sub>3</sub> (1%, 5% and 3%, respectively) on the number of microorganisms and enzymatic activity in and around the Maximilián heap in Špania Dolina. Each pot was also sown with a grass mixture of *Agrostis capillaris*, *A. stolonifera*, *Festuca rubra* and *Poa pratensis* was sown in each pot. Compared with untreated technosol, chicken manure, organo-zeolite sorbent and biochar significantly increased the total number of bacteria, copiotrophs, cellulolytic bacteria, proteolytic microorganisms and oligotrophs. The addition of bentonite increased the number of oligotrophs and cellulolytic fungi. The highest biochemical activity was observed after organo-zeolite application but the lowest after addition of bentonite.

**Acknowledgement:** This work was supported by the Scientific Grant Agency of the Ministry of Education, Research, Development and Youth of the Slovak Republic (grants VEGA 1/0220/23 and VEGA 2/0062/25).

**Keywords:** Cu mining heap, number of microorganisms, enzymatic activity, natural sorbents, plants

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## Soil contamination by mercury in the vicinity of abandoned mines: A case study from Gelnica, Slovakia

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**Abstract:** This study focuses on the assessment of soil contamination by mercury in the historical mining region of Gelnica, a former center of ore mining, including mercury-bearing minerals. A total of 30 soil samples were collected from mining bodies and their immediate surroundings. Mercury concentrations were determined using the AMA-254 analyzer, followed by the calculation of the contamination factor (Cf) and the geoaccumulation index (Igeo). Mercury concentrations ranged from 0.15 to 6.68 mg/kg. More than 83% of the samples exceeded the limit values for mercury in soil, indicating a significant environmental concern. The contamination factor values indicated very high contamination in all evaluated samples. The geoaccumulation index ranged from 0.38 to 5.79, reflecting moderate to extreme contamination levels. The results highlight the considerable impact of historical mining activity on soil quality in the area and emphasize the need for further monitoring and the development of appropriate remediation strategies.

**Acknowledgement:** This research was supported by the VEGA project No. 1/0213/22.

**Keywords:** former mining area, contamination factor, soil pollution, geoaccumulation index

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## Energetic trade-offs in two wheat cultivars under metal stress in different nitrogen conditions

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**Abstract:** Wheat as a staple crop has been thoroughly studied in terms of agricultural production. It is well known that toxic metal contamination of agricultural fields poses a serious threat, as wheat can accumulate these metals in organs and grain, potentially introducing toxic metals into the food chain. In our experiment, we took a closer look on stress response of young wheat plants under metal stress (Cd), grown hydroponically in media with optimal, absent and excessive nitrogen concentrations. By evaluating growth, light harvesting capabilities, activity of selected pathogenesis related proteins with enzymatic activity and Cd accumulation in different parts of plants, we could observe that energetic trade-off strategies of wheat differ significantly between individual cultivars, and that these differences in stress coping mechanisms were largely dependent on nitrogen conditions. Our results provide an insight on growth-defence trade-offs and Cd stress coping strategies of wheat, by comparing a modern semi-dwarf cultivar and an older tall cultivar. The differences in above ground Cd concentration showed that the older tall cultivar accumulated highest Cd concentrations under nitrogen deficit conditions, while the modern cultivar accumulated highest Cd concentrations in nitrogen surplus. This could be critical information for food safety and should be considered in agricultural practices.

**Acknowledgement:** This research was supported by projects FPPV-54-2025 and APPV-21-0504.

**Keywords:** metal stress, cadmium, trade-offs, wheat, PR proteins

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## Valorization of *Miscanthus × giganteus* biomass ash for soil improvement and plant growth support

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**Abstract:** The increasing generation of biomass ash (BA) from energy crops calls for sustainable reuse strategies in line with circular economy principles. This study investigates the potential of *Miscanthus × giganteus* (*M×g*) biomass ash, derived from thermally treated *M×g* grown on trace element-contaminated soil, as a soil amendment in subsequent *M×g* cultivation. Under controlled conditions, BA was applied at 1%, 3%, and 7% (w/w) to assess impacts on soil properties, nutrient dynamics, and plant performance. BA significantly increased soil pH, electrical conductivity, and total organic carbon (from 0.81 to 0.96 mg kg<sup>-1</sup>), but reduced microbial carbon mineralization by 64% at the highest dose. Key nutrients such as P (77 to 2,167 mg kg<sup>-1</sup>) and K (6 to 460 mg kg<sup>-1</sup>) were enriched, while Ca declined. Plant growth improved at 1% BA but decreased at higher doses. Chlorophyll content declined and carotenoids increased, suggesting physiological stress responses. Antioxidant activity was reduced, and elemental uptake patterns shifted, with stems accumulating more K and Ni but less Mg and Ca. These findings support the use of *M×g* BA as a regenerative amendment to enhance soil quality and resource efficiency. However, optimized application rates are crucial to maximize benefits while minimizing stress effects.

**Keywords:** *Miscanthus × giganteus*, biomass ash, soil amendment, nutrient dynamics, soil-plant system, waste valorization

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## Organic carbon amendments in livestock feeds reduce rumen methane emissions and improve manure quality and soil carbon stability

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**Abstract:** The cattle feed amended with stabilized organic carbon materials provides health and nutritional benefits to livestock. It enhances nutrient utilization by reduced carbon (and nitrogen) volatilization from rumen. While rumen methane emissions decreased, nutrient retention in dung increased. This may form manure with enhanced fertilization value and soil conditioning potential. A stable experiment was done, involving cows (groups of eight animals) fed for 30 day with either biochar, humic leonardite derivate (commercial product Humac), or with both amendments. Animal daily methane production was reduced by feeding mix biochar + Humac compared to the control group without feed supplement. The manures from various feed treatments did not differ significantly in total carbon content; all amendments' diets increased manure pH compared to the control. Both biochar or Humac supplementation increased manure potassium content. The impact of manure on soil was evaluated in 12-week pot experiment with maize (*Zea mays*). The manure from Humac-fed group increased D-glucose- and other substrate-induced respirations in amended soil. The manure from biochar-fed group reduced respiration potential, indicating a tendency to stabilize soil organic carbon. The tested feed supplementations reduced greenhouse gas emissions in cattle production, increased manure quality and long-term soil organic carbon stabilization.

**Acknowledgement:** This research was supported by the Technology agency of the Czech Republic project No. SQ01010201- Valorization of carbonaceous materials for reducing greenhouse gas emissions in livestock production and supporting primary production and carbon sequestration in soil.

**Keywords:** biochar, humic acids, methane, pH, soil microbial activity

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## Human stem cells radiolabeling with unconventional positron emitting metals for theranostic applications

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**Abstract:** The aim of the work was to evaluate the possibility of human mesenchymal stem cells (MSC) radiolabeling with <sup>64</sup>Cu, <sup>62</sup>Zn, and <sup>107</sup>Cd as positron emitters, through bioaccumulation processes, that could be applied in theranostic applications. <sup>64</sup>Cu, <sup>65</sup>Zn, and <sup>109</sup>Cd radioisotopes were used with scintillation gamma-spectrometry to evaluate the bioaccumulation processes. We found that the highest Cu bioaccumulation (17.3 %) was observed when the MSC were cultivated in MEM : 0.9 % (w/w) NaCl = 1 : 1 medium. After 8 h of exposure, <sup>65</sup>Zn and <sup>109</sup>Cd bioaccumulation did not exceed the efficiency 0.85 % and 1.6 %, respectively. Overall, the highest specific bioaccumulation (in nmol/10 000 MSC) was confirmed for Cd and at the highest applied CdCl<sub>2</sub> concentration, whereby this value decreased in the order: 40 μmol/dm<sup>3</sup> CdCl<sub>2</sub> (0.0289) > 30 μmol/dm<sup>3</sup> CdCl<sub>2</sub> (0.02275) > 20 μmol/dm<sup>3</sup> CdCl<sub>2</sub> (0.0175) > 40 μmol/dm<sup>3</sup> ZnCl<sub>2</sub> (0.0116) > 30 μmol/dm<sup>3</sup> ZnCl<sub>2</sub> (0.0093) > 20 μmol/dm<sup>3</sup> ZnCl<sub>2</sub> (0.0061) > 0.5 μmol/dm<sup>3</sup> CuCl<sub>2</sub> (0.0033).

The pre-cultivation of MSC in the presence of Cu, Zn, and Cd on the bioaccumulation of <sup>64</sup>Cu, <sup>65</sup>Zn or <sup>109</sup>Cd showed that MSC pre-exposure in the presence of Cd had a positive effect on the efficiency of <sup>64</sup>Cu and <sup>65</sup>Zn bioaccumulation.

**Keywords:** human mesenchymal stem cells, positron emitters, heavy metals, radiolabelling, bioaccumulation, positron emission tomography

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## Exploring the potential of spelt (*Triticum spelta* L.) wheat lines in Czech Republic: Growth, yield and quality characterization

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**Abstract:** Spelt (*Triticum spelta* L.), an ancient wheat species, has gained renewed interest due to its nutritional properties and adaptability to organic and low-input farming systems. A diverse set of spelt genotypes was evaluated under field conditions with a detailed analysis of morphological characteristics and grain quality parameters. The objectives of this experiment are to (1) evaluate the influence of morphological and grain quality traits of spelt wheat (2) investigate the relationship between growth and quality indices. Significant variation was observed among the lines, indicating substantial genetic diversity and adaptability. Several lines demonstrated competitive yields and superior quality characteristics, making them suitable for food processing, particularly in organic and low-input systems. Our findings support the inclusion of spelt in regional breeding programs and highlight its value as a resilient crop under changing climatic conditions. The study found that (1) Strong positive correlations exist between SC (starch content), CP (crude protein), TGW (1000 grain mass), and ZST (Zeleny sedimentation test) (2) Strong correlations exist among traits like HTF (heading till flowering), FTM (flowering till maturity), SL (spike length), TGW, and ZST (3) PCA (principle component analysis) explains 34.7% of the variance and PC2 explains 24.8%, together accounting for 59.5% of total variation. This research contributes to the broader understanding of spelt's agronomic potential and its role in crop diversification and in Europe.

**Keywords:** spelt wheat, sustainable agriculture, genotype evaluation, breeding potential, protein content

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## Efficiency of using digestate in growing intercrops

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**Abstract:** Intercropping is an important tool for protection of agricultural land. This paper deals with the efficiency of using digestate, as organic fertilizer in growing various kinds of intercrops. The aim was to assess the influence of different digestate doses on the biomass production of seven intercrop species: Safflower, Buckwheat, Purple tansy, Radish, White mustard, Garden cress and Millet.

Results showed that the application of digestate at 20 t/ha had a generally positive influence on the yield of both fresh and dry biomass in most of the monitored species when compared with the control without digestate application. The highest biomass growth was recorded in Radish, White mustard and Millet in which the yields of fresh matter increased by 116 %, 78 % and 75 % as compared with the control that was not fertilized. However, the application of 40 t/ha resulted in some species in the decreased effectiveness and no statistically significant biomass yield increase was on average recorded as compared with the dose of 20 t/ha. The yield of dry matter even exhibited a mild decrease. This points to limited efficiency of high digestate doses and emphasizes the necessity to optimize the fertilization.

An optimum dose of digestate is about 20 t/ha; higher doses are inefficient.

**Acknowledgement:** This research was funded by the Ministry of Agriculture of the Czech Republic – National Agency for Agricultural Research (NAZV), Project: Importance of ligno-cellulose complex from the biomass of inter-crops for improvement of soil environment, Registration no. QK21010161 and by institutional support MZE-RO1225.

**Keywords:** digestate, biomass yield, fertilization

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## Biochar from grape pomace: Agronomic and environmental applications

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**Abstract:** Grape pomace, a major type of agri-food waste generated during wine production, represents a significant biomass residue with currently limited options for high-value utilization. In line with the principles of the circular economy and European policy objectives (e.g., the Green Deal), the potential of pyrolytic conversion of grape pomace and the subsequent application of the resulting biochar were evaluated. The biochar was characterized in terms of its physico-chemical composition and properties. In an agronomic experiment, it was incorporated into a soil substrate used for the cultivation of *Lactuca sativa*, with biometric and physiological plant parameters being monitored. Soil composition and biological activity were also assessed, with a particular focus on microbial communities to evaluate microbial biomass and community structure. In parallel, a sorption study was conducted to assess the removal efficiency of selected organic pollutants. The results demonstrated a positive effect of the grape pomace-derived biochar on plant growth, soil quality, and microbial dynamics, as well as an effective sorption capacity. The study confirms that pyrolysis of agri-food waste such as grape pomace represents a promising strategy for converting underutilized residues into functional materials with applications in both agronomy and environmental engineering.

**Keywords:** biochar, grape pomace, pyrolysis, agri-food waste, soil amendment, adsorption

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## Isolation and characterization of copper-tolerant *Arthrobacter* sp. from a former gold/copper mine

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**Abstract:** A copper-tolerant *Arthrobacter* sp., a member of the family *Microbacteriaceae* (*Actinobacteria*), was isolated from an iron-rich crust at a former gold and copper mine in Zlaté Hory, Czech Republic. This study aimed to investigate the strain's resistance to copper and its potential for bioprecipitation. To assess the copper tolerance, minimum biofilm inhibitory concentration (MBIC) was determined using Nutrient agar (Himedia, India) supplemented with copper nitrate trihydrate [Cu(NO<sub>3</sub>)<sub>2</sub>·3H<sub>2</sub>O]. The MBIC for *Arthrobacter* sp. was <4 mM. Interestingly no growth inhibition was observed when the strain was cultivated in nutrient broth with copper concentrations of 1, 2, and 4 mM, indicating a minimum inhibitory concentration (MIC) of ≥4 mM for this copper salt. The morphology of bacterial cells and the copper bioprecipitation were examined using scanning electron microscopy (SEM), scanning transmission electron microscopy (STEM), and energy-dispersive X-ray spectroscopy (EDX). Microscopy analysis revealed the formation of intracellular copper nanoparticles with irregular, round, and elongated shapes, ranging in size from 10 to 100 nm. EDX analysis confirmed the presence of copper within the cells, with an approximate copper content of 34.9 wt%. The *Arthrobacter* sp. demonstrates significant copper resistance and exhibits promising potential for bioprecipitation, which could be valuable for environmental remediation or copper recovery processes.

**Acknowledgement:** This work was supported by SURRI project GA No 101079345, provided by HORIZON Twinning in 2024 and Student Grant Competition SGS-2024-3490 at the Technical University of Liberec.

**Keywords:** Actinobacteria, Minimum biofilm inhibitory concentration (MBIC), Minimum inhibitory concentration (MIC), Heavy metal resistance, STEM

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## Flying sensors: Honey bees (*Apis mellifera*) as indicators of trace contamination in the landscape

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**Abstract:** Honey bees (*Apis mellifera*) have proven to be effective bioindicators of environmental contamination due to their broad foraging range and interaction with various landscape features. In this study, we analysed the concentration of 17 trace elements (e.g., Ba, Mn, Cd, Hg, Zn) in bees collected from 82 locations across Slovakia and assessed their spatial and seasonal variability in relation to landscape characteristics such as altitude, ecological stability, anthropogenic pressure, and land cover types. Generalized linear mixed models revealed a significant seasonal increase in barium and magnesium concentrations, with Ba rising from 0.094 µg/kg in May to 0.193 µg/kg in July, and Mg from 30.5 to 47.2 µg/kg. Mercury concentrations exhibited high spatial variability, reaching up to 1166.7 µg/kg. Spearman's correlation showed strong positive associations between elevation and Ba, Mn, and Mg, suggesting a link between orographic and ecological conditions and trace element accumulation. Principal component and factor analysis further supported the role of landscape gradients in shaping contaminant profiles. Our findings are consistent with recent Slovak studies demonstrating the seasonal and spatial patterns of mercury and pesticide residues in bee matrices (Demková et al., 2024; Staroň et al., 2024), as well as with landscape-related patterns in parasite prevalence (Oboňa et al., 2022), underscoring the broader relevance of honey bees in environmental monitoring frameworks.

**Acknowledgement:** This research was supported by the Slovak Research and Development Agency under the project APVV-20-0140 and by the Scientific Grant Agency of the Ministry of Education, Science, Research and Sport of the Slovak Republic under the project VEGA project 1/0213/22.

**Keywords:** bioaccumulation, pollinators, environmental chemistry, spatial analysis, ecotoxicology, biomonitoring

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## ***In situ* electrically enhanced mobilisation, oxidation and bioremediation of extremely high organic contamination**

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**Abstract:** The research aims to develop and validate an innovative technology for remediating sites contaminated with LNAPL (light non-aqueous phase liquid) through remotely monitored and controlled *in situ* electrically enhanced chemical and biological oxidation. The technology employs advanced survey methods, followed by online monitoring and control of remediation activities, including heating and mobilising the light phase, oxidising it with sodium persulfate, and final bioremediation through the anaerobic oxidation of petroleum hydrocarbons by sulphate-reducing bacteria. Bioremediation is monitored with molecular genetic methods that determine the quantity of functional genes encoding enzymes for the anaerobic oxidation of petroleum hydrocarbons in the contaminated groundwater. The research is conducted at the Ostramo site, a former refinery located in the centre of Ostrava. Since the late 19th century, kerosene and fuel were produced there; from the 1960s, it was primarily used for refining used motor oils until it ceased operations in 1995. This activity left behind one of the most severe environmental burdens in Czechia, with groundwater heavily contaminated with LNAPL composed of petroleum substances, benzene, and 1,2-dichloromethane. The developed multi-stage technology optimises costs, reduces remediation time, and minimises the environmental impacts of the remediation process. It could also be applied in other LNAPL-contaminated localities in Czechia or abroad.

**Acknowledgement:** The authors acknowledge the assistance provided by project No. FW12010141, supported by the Technology Agency of the Czech Republic

**Keywords:** petroleum hydrocarbons, electromobilisation, *in situ* chemical oxidation, biodegradation

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## Comparative cadmium tolerance in flax: Screening cultivars for in-situ phytoremediation feasibility

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**Abstract:** Toxic metal pollutants such as Cd threaten agro-ecosystems worldwide and demand cost-effective remediation strategies. Phytoremediation—using plants to extract or stabilize contaminants—offers a low-cost alternative to physicochemical methods because it generates minimal secondary waste and can be deployed over large areas without soil excavation. Flax (*Linum usitatissimum* L.) is particularly attractive since tolerates high Cd loads, produces harvestable biomass and fits easily into existing crop rotations. We screened 31 commercial flax cultivars under a sub-lethal Cd dose (20 mg kg<sup>-1</sup>) and analysed growth, chlorophyll fluorescence, and gas-exchange traits by principal-component analysis. Six cultivars: Belinka, Diana, Laura, Marina, Flanders and Jitka showed superior vigour and similar shoot Cd translocation;  $\gamma$ -spectrometry confirmed uptake efficiencies comparable with known hyperaccumulators. Cultivar Jitka combined the highest metal removal with negligible metabolic penalty, corroborating earlier field reports and identifying it as the prime candidate for remediation programmes. Our results refine within-species selection criteria and illustrate how cultivar choice complements broader decision frameworks. The given cultivars are obsolete cultivars; therefore, the commercially utilised cultivar ‘Merkúr’ was tested for in-situ phytoremediation, and this study presents preliminary results on how soil contaminated with Cd, Cu, Zn and Cr affects its growth and physiological parameters.

**Acknowledgement:** This work was supported by research grants APVV-21-0504 and by the UCM Research Support Fund number FPPV-54-2025

**Keywords:** cadmium, cell fractionalization, flax, metal tolerance, phytoremediation

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## Biomass of intercrops as a source of lignin as a precursor for the formation of humus substances in the soil

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**Abstract:** Disintegrating plant residues rich in cellulose and lignin which are substances naturally resistant to microbial decomposition form an important part of soil organic matter (SOM). Yet, the degradation of lignin can start already in the initial stages of decomposition if the soil contains a sufficient amount of readily available saccharides that serve as an immediate source of energy for microorganisms to which they allow to produce enzymes necessary for lignin decomposition.

The aim of this study was to monitor changes in the content of simple sugars and lignin in the biomass of intercrops during their vegetation of the ten intercrop species: Watercress, Oil radish, White mustard, Purple tansy, Crimson clover, Millet, Safflower, Buckwheat, Fenugreek and Hungarian vetch.

The highest sugar to lignin ratio was recorded in Oil radish (7.20% DM) and Watercress (3.97% DM). For comparison - traditionally used farm fertilizers contain significantly more lignin: 15.03 % DM in cattle manure and 13.05 % DM in horse manure.

Results show that the biomass of intercrops markedly differs in its degradability among the individual species. A key factor affecting this degradability is the ratio of sugars and lignin in the plant mass, which is changing in dependence on advanced phenological development according to BBCH scale.

**Acknowledgement:** This research was funded by the Ministry of Agriculture of the Czech Republic – National Agency for Agricultural Research (NAZV), Project: Importance of ligno-cellulose complex from the biomass of inter-crops for improvement of soil environment, Registration no. QK21010161 and by institutional support MZE-RO1225.

**Keywords:** decomposition, lignin, microorganisms, soil organic matter, sugar

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## **Bokashi composting as an alternative method of processing biodegradable kitchen waste in households**

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**Abstract:** The study focuses on the application of Bokashi composting as an alternative method of biodegradable kitchen waste (BKW) management in households. A questionnaire survey conducted in the Lučenec district aimed to assess residents' willingness to separate BKW and their interest in alternative processing methods. The Bokashi composter uses anaerobic fermentation to transform waste into solid residues and fermentation liquid. The effectiveness of this liquid was tested via a phytotoxicity test using garden cress seeds (*Lepidium sativum L.*), observing germination effects at various dilutions over 48 hours. Results showed that 38.9% of respondents would prefer home composting with provided composters, and 61.1% consider it the most efficient method of BKW management. While 50% had not heard of the Bokashi method, 22.2% expressed interest in further information. Findings suggest a significant potential for domestic composting, especially when proper technical support and education are provided. The phytotoxicity test confirmed that the fermentation liquid is suitable for gardening use when adequately diluted.

**Acknowledgement:** The contribution was supported by the Cultural and Educational Grant Agency Slovak Republic KEGA, Project No. 015UMB-4/2025 and of Project UGA-12-DS-2025.

**Keywords:** Bokashi composting, biodegradable kitchen waste, fermentation, phytotoxicity, waste management

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## Tracking pathogenic amoebae in water: Molecular insights into emerging health risks

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**Abstract:** Free-living amoebae (FLA) are protozoa widely distributed in both natural (lakes, rivers, hot springs) and artificial environments (swimming pools, water distribution systems). They can survive host-independent and play a crucial role in microbial ecosystems by regulating bacterial populations. Some genera, however, are pathogenic and can cause infections in humans and animals. Moreover, FLA can act as reservoirs and vectors for other clinically significant microorganisms.

This study focused on detecting potentially pathogenic FLA in water distribution systems and recreational water sources. A total of 55 samples, primarily from European countries, were analyzed using cultivation, microscopy, and molecular techniques. Amoebae were detected in 83% of the samples. Molecular characterization identified *Vermamoeba vermiformis*, *Acanthamoeba lenticulata*, and *Acanthamoeba* spp., all associated with diseases such as granulomatous amoebic encephalitis and *Acanthamoeba* keratitis.

The amoebae strains were isolated from both engineered and natural water systems used for recreational or everyday human activities. These results underscore the importance of continuous monitoring and raise public health concerns regarding the potential risks posed by FLA. A phylogenetic analysis will be conducted to further characterize the genetic relationships of the isolated strains.

**Keywords:** *Acanthamoeba*, *Vermamoeba vermiformis*, genotyping, water distribution systems, swimming, public health

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## Sorption separation and solidification of heavy metals from metal mine tailings water using synthetic zeolites and geopolymers

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**Abstract:** The aim of the work was to evaluate the possibilities of solidification of hazardous wastes such as sludge and water from tailings and old mines into geopolymer waste forms, which could be subsequently used as "grey" building materials. In the first step, the physico-chemical characterization of the obtained samples of sludge and water from the Sedem žien tailings pond in Banská Bela (Slovak Republic) was carried out. Recipes for the preparation of geopolymer waste forms (commercially available mixture Geocem) containing different weight content of synthetic zeolite with heavy metals Zn and Cd separated from tailings sludge and water, which was additionally radiolabeled with radioisotopes of <sup>65</sup>Zn and <sup>109</sup>Cd, were proposed and applied. The prepared geopolymer waste forms fulfilled characteristics, such as Zn and Cd leachability test carried out according to ANSI/ANS-16.1-1986, but did not achieve the required properties in terms of compressive strength (required limit > 5 MPa). The pressure value at which the destruction of the geopolymer waste form was occurred decreased linearly from a value of less than 14 MPa measured for the sample with 0 wt.% of synthetic zeolite (control) to a value of 2 MPa observed for the geopolymer waste form with 35 wt.% of sorbent.

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**Keywords:** Zn, Cd, synthetic zeolites, geopolymers, metals leachability, compressive strength

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## Restoring soil health through *Lactuca sativa* phytoremediation of hospital wastewater contaminated soil

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**Abstract:** The use of hospital wastewater for irrigation introduces heavy metals and pharmaceutical compounds (PhACs) into agricultural soils, posing significant risks to microbial activity, soil quality, and food safety. This study aimed to assess the phytoremediation potential of lettuce (*Lactuca sativa*) in restoring soil health impacted by such contamination. A controlled greenhouse experiment was conducted with five treatment levels, ranging from 100% distilled water (T1, control) to increasing concentrations of hospital wastewater (T2–T5). Treatments were applied every 10 days to both lettuce-planted and unplanted soils, with five replicates per treatment. Key soil biochemical parameters, total soil carbon, soil nitrogen content, and enzyme activities (acid phosphatase, glucosidase, protease, and arylsulfatase) were measured to evaluate changes in soil health. Results revealed that lettuce cultivation in wastewater-amended soils significantly enhanced enzyme activity and nutrient levels compared to unplanted soils, indicating improved biological function and soil fertility. These findings underscore the effectiveness of lettuce in remediating hospital wastewater-contaminated soils and promoting ecological recovery through phytoremediation. Ongoing research is focused on quantifying the uptake and accumulation of PhACs in lettuce tissues, identifying physiological stress markers, and conducting comprehensive risk assessments to ensure environmental safety and protect human health within the food production system

**Keywords:** hospital wastewater, pharmaceutical compounds, enzyme activities, phyto management, lettuce

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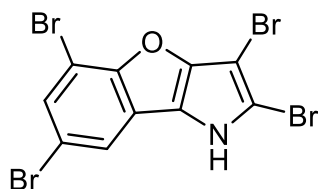
**Chemistry**

# The use of selected *in silico* methods in the investigation of 2,3,5,7-tetrabromobenzofuro[3,2-*b*]pyrrole as a potential antibacterial drug

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**Abstract:** Furo[3,2-*b*]pyrrole-derived heterocycles are important isosteres for the indole scaffold and are of great interest due to their significant biological activity. A model structure, 2,3,5,7-tetrabromobenzofuro[3,2-*b*]pyrrole (TBBFP), extracted from a marine *Pseudoalteromonas* sp. has exhibited significant antimicrobial activity against methicillin-resistant *Staphylococcus aureus* (MRSA).



Various *in silico* methods have been developed to rapidly estimate the potential biological activity and pharmacokinetic properties of new compounds. The main issue with synthetic drugs is their possible side effects. An ideal drug should have strong biological activity, good pharmacokinetic properties and non-toxicity.

The properties of the model compound TBBFP were calculated using the Molinspiration web tool. The results showed that TBBFP has one violation of Lipinski's rule, which is acceptable for antibacterial substances. AntiBac-pred tool calculated a confidence value defined as the probable inhibitory/non-inhibitory effect of TBBFP against resistant *Staphylococcus aureus* which is 0.422. SwissADME software shows that TBBFP has high gastrointestinal absorption, does not penetrate the blood-brain barrier and is substrate for P-glycoprotein. Finally, ProTox 3.0 software was used to estimate the toxicity of TBBFP and showed that TBBFP should be slightly neurotoxic with a 0.56 probability. Future research should be directed toward derivatization of the TBBFP skeleton with more favorable properties without losing activity.

**Keywords:** furo[3,2-*b*]pyrrole, *in silico*, antibacterial activity, toxicity, properties

# Green transformation of analytical methods in environmental pollution monitoring

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**Abstract:** Environmental analysis plays a key task in terms of screening and monitoring emerging pollutants and their presence in various compartments of the environment. In analytical practice, several methods are used for the detection and quantification of various pesticides, drugs, and perfluoroalkyl substances in the aquatic environment. Since these are multi-component mixtures, separation techniques in combination with spectral detection techniques are currently used for this purpose. Sample preparation is the important step of the analytical method and is crucial for the accurate and precise determination of analytes. Suitable pretreatment methods are selected for different analytes in various environmental samples based on the physicochemical properties of the substances. The result of sample preparation is the reduction of matrix interferences and the concentration of the analyte. The development and validation of a simple and fast analytical methods for the determination of variety micropollutants in water and sediments employing innovative ways of green transformations to sample preparation procedures or its omitting will be presented.

**Acknowledgement:** This work was supported by the Slovak Research and Development Agency under the Contract no. SK-TW-24-0002, by the Scientific Grant Agency VEGA project No. 1/0332/24, and by the ZSE Foundation.

**Keywords:** green analytical chemistry, ground water, sediments, pollutants, sample preparation, mass spectrometry

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## Electrochemical determination of DMST in water samples

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**Abstract:** N,N-dimethyl-4-methylbenzenesulfonamide (DMST), a hydrolysis product of the fungicide tolylfluanid, represents a potentially relevant contaminant in surface waters. Despite its expected environmental occurrence, no electrochemical method for its detection has been reported to date. This study presents the first voltammetric investigation of DMST using a glassy carbon electrode (GCE) under controlled pH conditions.

The electrochemical behavior of DMST was systematically evaluated using cyclic voltammetry (CV), square-wave voltammetry (SWV), and differential pulse voltammetry (DPV). The strongest and most stable anodic signal was observed at pH 9, where oxidation occurred irreversibly with a peak potential around +0.56 V (vs. Ag|AgCl, KCl 0.1 M). Among the tested techniques, DPV provided superior sensitivity, yielding a detection limit (LOD) of 1.22  $\mu\text{M}$  and a quantification limit (LOQ) of 1.75  $\mu\text{M}$  in the linear range of 1–50  $\mu\text{M}$ .

The applicability of the method was verified in model matrices and surface water samples (rivers Morava and Bystrička), achieving recoveries between 92–98% without significant matrix interference. Furthermore, by incorporating a solid-phase extraction (SPE) step, DMST was successfully quantified in the Morava river sample at a concentration level of 75 nM. These results demonstrate the potential of electrochemical detection as a promising alternative for routine environmental monitoring of pesticide transformation products.

**Keywords:** DMST, electrochemical detection, voltammetry, SPE, environmental monitoring

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## Development and optimization of a microplate-based assay for phytic acid analysis in cereals

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**Abstract:** Phytic acid (inositol hexaphosphate) is the primary storage form of phosphorus in cereal seeds. However, from a human nutritional perspective, it is considered an antinutrient. Its chemical structure allows it to form chelates (phytates) with essential micronutrients such as zinc, calcium, and magnesium during digestion, potentially leading to health issues such as anaemia or osteoporosis. The ability of phytic acid to form specific phytates is also exploited in its analytical determination, mostly by UV-VIS spectrophotometric methods.

Quantification of phytic acid in wheat grain samples requires complete extraction into acidified water, followed by a specific reaction with a reagent containing  $\text{Fe}^{3+}$  ions. The subsequent decrease in iron concentration is measured spectrophotometrically.

The assay was optimized using wheat samples, focusing on reagent composition, a reagent-to-sample volume ratio of 3:1, extraction time (1 hour), sample-to-solvent ratio, and reaction mixture conditions. The optimal detection wavelength was 505 nm. Calibration parameters were established as:

$$c = \frac{A - 0.588}{-6.59 \cdot 10^{-4}}$$

with a linear range of 50–500  $\mu\text{g/mL}$ ,  $R^2 = 0.998$ , and reproducibility (RMSE < 3%).

Following the successful optimization of the assay for a standard cuvette-based setup, the method was adapted for use with a microplate reader. This adaptation enables high-throughput screening of a large number of samples.

**Keywords:** phytic acid, cereal grains, spectrophotometric microplate assay, high-throughput screening

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## Using an azo coupling reaction to determine 3-chloro 2,6-diethylaniline by HPLC method

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**Abstract:** 3-chloro 2,6-diethylaniline (CDEA) is used to produce pesticides, triazine herbicides, dyes, antioxidants, pharmaceuticals, synthetic resins, fragrances, and other products.

Used a derivatization reaction of CDEA with 4-nitrophenyldiazonium cation, leading to the formation of the azo compound CDEA. The effect of hydrogen ion concentrations on the formation of the azo derivative was carried out in the pH range from 3.3 to 13.6. The maximum yield of the azo derivative is observed in the pH range of 4.5 - 6.5. The effect of the concentration of 4-nitrobenzenediazonium cation on the formation of the azo coupling product was studied. The maximum yield of the reaction is observed already at a 15-fold amount of the reagent relative to the concentration of CDEA. The most effective extractants were chloroform and dichloroethylene.

Liquid chromatography was performed on a Waters chromatograph (USA) with a PDA detector. The method of reverse-phase chromatography. The retention time of the CDEA azo derivative is 9.4 min. Based on the data obtained, a method for determining CDEA as an azo derivative by HPLC was developed. A linear dependence of the chromatographic peak area on the CDEA concentration is observed in the range of 30-450 µg/mL.

**Keywords:** 3-chloro 2,6-diethylaniline, azo-derivate reaction, HPLC, method of determination

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# Technique for single-shot time-resolved spectroscopy of irreversible chemical processes utilizing specialty dual-core optical fibers

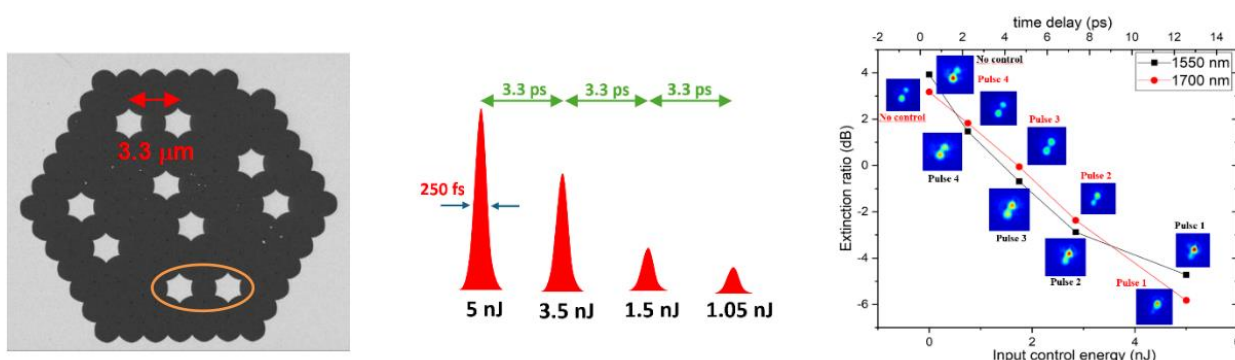
Sarah Pulikottil Alex<sup>1</sup>, Edgar Kaksis<sup>1</sup>, Ryszard Buczynski<sup>2</sup>, Audrius Pugžlys<sup>1</sup>,  
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**Abstract:** When photo-induced irreversible chemical transformations are repeatedly triggered by short laser pulses during time-resolved measurements, they can distort the observed dynamics. For instance, in studies involving microscopic biological samples, repeated exposure to intense optical pulses in pump-probe sequences may lead to sample degradation. To mitigate this issue, single-shot spectroscopy techniques employing sequences of short probe pulses have been developed to minimize sample damage and preserve measurement integrity.



The left panel of the figure shows the cross-section of an optical fiber containing five dual-core units, designed for all-optical cross-switching (the employed dual-core unit is marked). The middle panel illustrates a sequence of four femtosecond control pulses at 1030 nm, used to switch a single signal pulse by applying appropriate time delays. The right panel presents experimental results showing the dual-core extinction ratio versus control pulse energy, recorded by a camera for all four control pulses using signal wavelengths of 1550 nm and 1700 nm. The observed monotonic dependence demonstrates that by recording a sequence of switched signal energies, it is possible to retrospectively determine the energies of the control pulses responsible for the all-optical cross-switching. Consequently, single-shot registration of the signal sequence reveals the time-resolved decay of the control pulse sequence.

**Keywords:** irreversible chemical processes, ultrafast time-resolved optical spectroscopy, single-shot registration, all-optical switching, dual-core optical fibers

## Electrochemical determination of selected biologically active substances

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**Abstract:** Civilization diseases, specifically cardiovascular diseases and cancer, still represent a global problem of society, which has a negative impact on the socio-economic aspect of society. Seemingly different diseases are connected by oxidative stress, which participates in their pathogenesis. Prevention may include supplementation with appropriate substances with antioxidant effects. Several natural substances are known or assumed to have antioxidant effects. A selected group of avenanthramides and carnosine may act as potential nutraceuticals. There are a large number of avenanthramide derivatives, and it has been found that avenanthramide C has the most favorable properties suitable for therapeutic purposes among the derivatives. With the majority of avenanthramides (A, B, C) in oats, the antioxidant effect prevails over the pro-oxidant effect. Avenanthramides A, B, C as well as carnosine have a DNA protective effect. Several electrochemical methods were used to optimize selected parameters and for the electroanalytical determination of selected avenanthramides and carnosine.

**Acknowledgement:** This research was funded by KEGA No. 022UCM-4/2023.

**Keywords:** electroanalytical chemistry, carnosine, avenanthramides, determination

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## Biogenic amines in foods and HPLC methods for their determination.

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**Abstract:** Biogenic amines (BA) represent a group of nitrogenous organic substances that contain an amino group. Their structure can be aliphatic, aromatic or heterocyclic. Most of them have a significant physiological effect and serve as a source of nitrogen and precursors for the synthesis of hormones and nucleic acids and proteins. Many of them are commonly found in small quantities in foods of plant and animal origin, especially in fermented foods and beverages. Their presence in elevated concentrations in foods can pose a risk to human health from both a physiological and toxicological point of view. Therefore, their analysis is of interest not only to researchers, but also to food safety control authorities.

In our work, we focused on optimizing the HPLC method for the detection and determination of eight biogenic amines, namely tryptamine, phenylethylamine, histamine, cadaverine, putrescine, tyramine, spermidine and spermine. The determinations were performed in various biological matrices, such as meat, meat products, fish, cheeses, fruits and vegetables and wines. For the extraction of BA samples was used 10% trichloroacetic acid. The samples were then filtered through a filter paper and a membrane filter. For the derivatization of the samples, dansyl chloride dissolved in acetone was used, 0.5 ml, which was added to 1 ml of the sample extract and 0.5 ml of sodium carbonate solution. After mixing, the samples were incubated at 60°C for 15 minutes. Subsequently, they were evaporated and dissolved in acetonitrile. HPLC analysis was performed on a C18 reversed-phase column. The mobile phase consisted of 0.02 M acetic acid, methanol and acetonitrile. The samples were detected with a UV-VIS DAD detector. In the samples we determined (vegetables, baby food, sauerkraut, wine), only some of the biogenic amines were detected. However, their values were low, which does not pose a risk to consumer health. Importantly, none of the concentrations detected exceeded toxic levels, which does not pose a risk to consumer health.

**Acknowledgement:** Supported by the Kega project 009UCM-4/2024.

**Keywords:** biogenic amines, food safety, determination, HPLC method, fermented foods, beverages

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# (Un)revealed proceeding of Suzuki-Miyaura cross-coupling of thienyl-thiazolo[5,4-*d*]thiazole halides and spirobifluorenyl boranes

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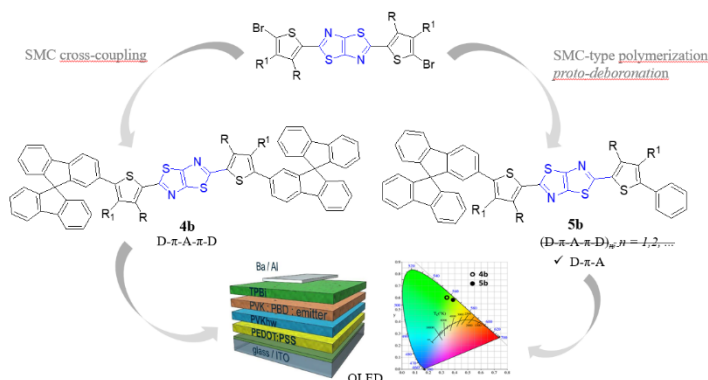
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**Abstract:** The Suzuki-Miyaura cross-coupling reaction (SMC) represents a straightforward synthetic approach to substituted biaryls and biheteroaryls via C-C covalent bond formation. This palladium-catalyzed reaction employs aryl or heteroaryl halides and organo-*mono*-boranes as substrates [1]. By replacing organo-*mono*-boranes with symmetric aryl or heteroaryl organo-*bis*-boranes, the reaction is conducted as SMC-type polymerization to produce oligo- and polymers with a well-defined structure [2]. Depending on the reaction conditions, *proto-deboronation* can occur spontaneously, leading to the formation of unexpected compounds [3]. Particularly, high reaction temperatures and prolonged reaction periods favor such accompanying processes. In our approach, the symmetric D- $\pi$ -A- $\pi$ -D chromophore **4b** was achieved under the conditions of simple Suzuki-Miyaura cross-coupling. In contrast, the SMC-type polymerization toward the oligomer with at least two repeating (D- $\pi$ -A- $\pi$ -D)<sub>*n*</sub> structural motifs {*n* = 1, 2...} has apparently aborted at the first stage. As a consequence of *proto-deboronation* in combination with insufficient solubility of compounds in the reaction mixture, the monomer **5b** possessing the D- $\pi$ -A molecular scaffold has been predominantly achieved. Surprisingly, the unique green-yellow luminescence of the OLED (organic light-emitting diode) for both **4b** (D- $\pi$ -A- $\pi$ -D) and **5b** (D- $\pi$ -A), when employed as part of the emitting layer, is observed [4]. Despite the success of obtaining a sufficient electroluminescent device, our current research issues focus on *proto-deboronation* proceeding either as accompanying or replacing the SMC-type polymerization.



**Acknowledgement:** Financial support from the Ministry of Education, Research, Development, and Youth of the Slovak Republic, KEGA 009UCM-4/2024, and VEGA 2/0137/23 is acknowledged.

**Keywords:** Suzuki-Miyaura cross-coupling (SMC), SMC-type polymerization, *proto-deboronation*

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## Molecular properties of amino acids in water

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**Abstract:** Amino acids have been studied by quantum chemical ab initio and DFT methods including the solvent effect in order to get electronic structure and molecular descriptors, such as ionisation energy, electron affinity, molecular electronegativity, chemical hardness, electrophilicity index, dipole moment, quadrupole moment and dipole polarizability. Thermodynamic functions (zero-point energy, inner energy, enthalpy, entropy, and the Gibbs energy) were evaluated after the complete vibrational analysis at the true energy minimum provided by the full geometry optimization. Reaction Gibbs energy allows evaluating the absolute redox potentials on reduction and/or oxidation. The non-local non-additive molecular descriptors were compared along the series showing which of them behave as extensive, varying in match with the molar mass and/or separation of the carboxyl and amino groups. Amino acidic forms and zwitterionic forms of the substances were studied in parallel in order to compare their relative stability and redox properties.

**Acknowledgement:** The Slovak grant agency KEGA (KEGA no. 009UCM-4/2024) is acknowledged for the financial support.

**Keywords:** Ab initio calculations, DFT calculations, molecular descriptors

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**Young Scientists**

## 7,000 years of environmental change in the Eastern Carpathians: A palynological record from Lake Vinderel

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**Abstract:** Lake Vinderel, located in the high-altitude Maramureş Mountains of the Romanian Carpathians, provides a valuable archive of paleoecological and climatic changes. This study aimed to reconstruct the lake's paleoecological history over the past ~7,000 years and to identify the onset and development of anthropogenic influence in the surrounding landscape. A sediment core was extracted using a Uwitec Piston Corer, and palynological analysis was performed on 66 samples (0.5 cm<sup>3</sup> each) using standard acetolysis and light microscopy at 400× magnification. The resulting pollen diagram includes 53 identified taxa and reveals several key phases in vegetation dynamics. In the earliest period, the region was dominated by forest vegetation composed mainly of *Pinus*, *Abies*, *Betula*, and *Corylus*, indicating stable mid-Holocene climatic conditions. A continuous and abundant presence of *Alnus* and grass taxa (*Gramineae*) suggests a wetter phase, potentially marking the onset of human influence. In later stages, a significant increase in non-arboreal taxa such as *Gramineae*, *Artemisia*, and *Aster*-type points to intensified anthropogenic impact, including deforestation and land-use changes. This study enhances understanding of long-term interactions between climate, vegetation, and human activity in the Carpathians and enriches the palynological record of rare and ecologically sensitive mountain taxa.

**Keywords:** paleoecology, palynology, anthropogenic influence, vegetation dynamics, Carpathians

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# Reproducible testing of query performance in MongoDB, ArangoDB, CosmosDB, and TerminusDB

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**Abstract:** This article investigates the performance of modern non-relational databases, with particular emphasis on multi-model systems that integrate diverse data models specifically document and graph-based representations. The primary objective of the study is to assess the efficiency of query execution across different models within a single database platform and to identify scenarios where the application of a specific model yields performance advantages. The evaluation was conducted on a set of selected non-relational database systems, including MongoDB, ArangoDB, CosmosDB, and TerminusDB. The testing methodology was carefully designed to ensure objective, reproducible, and comparable performance assessment through the execution of semantically equivalent queries. For the experimental evaluation, the Twitter Social Circles dataset from the Stanford Network Analysis Project (SNAP) was utilized. The results of the study provide valuable insights into the performance characteristics and practical applicability of multi-model databases. The findings are intended to support developers in selecting appropriate query strategies and database models for different types of applications, contributing to more efficient and informed design decisions in the development of data-intensive systems.

**Acknowledgement:** The work was funded by the grant KEGA 010TTU-4/2025 *Development of pupils' computational and algorithmic thinking through the effective integration of modern technologies into the teaching of computer science and mathematics.*

**Keywords:** Multi-model databases, Non-relational databases, Database benchmarking

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## Classification of motor imagery EEG data: Attribution of high-impact electrodes to associated brain regions

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**Abstract:** This study implements multiple classification models for a binary classification of motor imagery EEG data using the 2009 Physionet dataset consisting of recordings from 109 subjects. Features were extracted using Common Spatial Patterns (CSP), and SHAP analysis was conducted to identify electrodes that contributed most significantly to classification accuracy across subjects. The accuracy achieved by some models approached state-of-the-art performance. Additionally, the underlying brain structures associated with these high-performing electrodes are discussed.

**Keywords:** EEG, BCI, SHAP, Common Spatial Patterns

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# The impact of calcium ions on the expression of transmembrane calpains in unicellular flagellate *Euglena gracilis*

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**Abstract:** Calpains are calcium-dependent cysteine proteases that are involved in various cellular processes, including cytoskeletal remodelling, cell signalling and programmed cell death. A distinct subgroup of these enzymes – transmembrane calpains – contains membrane-anchoring domains in addition to conserved CysPC catalytic motif. Transmembrane calpains are not present in animals or bacteria but are specific to plants. They were recently found also in some unicellular eukaryotes, yet their role in protists remains largely unexplored. Therefore, *Euglena gracilis* provides a unique model to study calpain function and regulation in a basal eukaryotic lineage of unicellular flagellates.

In this study, we focus on the expression patterns of genes encoding transmembrane calpains in *E. gracilis* under varying extracellular calcium concentrations. Using *in silico* analyses, we identified two calpain homologs in the transcriptome of *E. gracilis* with predicted transmembrane localization. The expression of selected calpain genes was measured by quantitative PCR. Our findings suggest that calcium ions modulate calpain expression in *E. gracilis*, highlighting the evolutionary conservation of calcium-regulated calpain systems in eukaryotes. Further research will investigate the functional roles of these calpains in cellular physiology.

**Acknowledgement:** This research was funded by the EU NextGenerationEU through the Recovery and Resilience Plan of the Slovak Republic under project No. 09I03-03-V05-00004.

**Keywords:** calcium ions, cysteine proteases, *Euglena gracilis*, gene expression, quantitative PCR, transmembrane calpains

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## Data analysis to support decision-making processes

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**Abstract:** This study focuses on the analysis of network activity data to support decision-making processes in network management and security. Several machine learning methods were designed, implemented, and evaluated with the goal of detecting anomalies in network traffic. The approaches included classification, clustering, and anomaly detection techniques, employing algorithms such as logistic regression, neural networks, and support vector machines SVM. The models were first trained on a custom-collected dataset and later on the publicly available NSL-KDD dataset, which provided richer structure and significantly improved the results.

The best-performing models, SVM and neural networks, achieved prediction accuracies of approximately 85%, demonstrating their potential for identifying network threats. However, these models remain computationally demanding, and their current performance is not yet sufficient for direct deployment in real-time operations. Despite this limitation, they can already serve as a supplementary tool for monitoring network traffic or enhancing firewall configuration.

The results confirm that machine learning-based anomaly detection can substantially contribute to improving cybersecurity. Future research will focus on large-scale training using distributed computing clusters, benchmarking against professional security tools, and exploring threat detection in encrypted communications.

**Acknowledgement:** The work was funded by the grant KEGA 010TTU-4/2025 *Development of pupils' computational and algorithmic thinking through the effective integration of modern technologies into the teaching of computer science and mathematics.*

**Keywords:** machine learning, PySpark, big data, data analysis, network security, anomaly detection

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## ***In vitro* micropropagation of Country mallow (*Sida cordifolia* L.)**

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**Abstract:** Country mallow (*Sida cordifolia* L.) is a medicinal plant of significant therapeutic value, traditionally used in Ayurvedic medicine for the treatment of various conditions, including inflammation, pain, respiratory disorders, and neurological ailments. Its pharmacological activity is attributed to the presence of bioactive constituents such as alkaloids, flavonoids, and sterols. Despite its medicinal importance, large-scale cultivation of *S. cordifolia* is limited by poor seed germination rates. This study aimed to develop an efficient *in vitro* micropropagation protocol for *S. cordifolia*, to facilitate clonal multiplication and long-term conservation under controlled *in vitro* conditions. Nodal segments were used as the primary explants, obtained from donor plants germinated aseptically from scarified and surface-sterilized seeds. The most effective medium for shoot proliferation was Murashige and Skoog (MS) medium at half-strength, supplemented with 170 mg/dm<sup>3</sup> KH<sub>2</sub>PO<sub>4</sub>. The highest shoot production (4.40 ± 0.48 shoots per explant) was obtained after eight weeks of cultivation on half-strength MS medium supplemented with 85 mg/dm<sup>3</sup> KH<sub>2</sub>PO<sub>4</sub> and 0.1 mg/dm<sup>3</sup> thidiazuron. The developed protocol provides a reliable method for the rapid micropropagation of *S. cordifolia*, contributing to its sustainable medicinal use and the conservation of its genetic resource.

**Keywords:** *Sida cordifolia* L., Country mallow, micropropagation, *in vitro* culture

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## Case study on UI migration in iOS: Adapting a radio streaming application to liquid glass design

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**Abstract:** This paper presents a case study focused on the development and adaptation of a native iOS application for streaming Slovak radio stations, specifically addressing its transition to the recent Liquid Glass interface paradigm. The study provides a systematic analysis of both standard system-provided UI components and custom-built interface elements, identifying the necessary technical and design modifications to ensure full visual and functional integration with the new design language. Special attention is devoted to developer decision-making within Apple's evolving platform guidelines, with emphasis on animation handling, layout restructuring, and component responsiveness. The case study further includes the collection and analysis of real user feedback to evaluate how end-users perceive and adapt to significant visual and interaction changes. As part of the design considerations, accessibility support is addressed, laying the groundwork for future work on inclusive design in upcoming projects such as a music-focused application. Drawing on the expected large user base, inferred from the success of the Android counterpart, this work aims to establish practical best practices for migrating both native and custom components in iOS applications. The study contributes to the broader understanding of platform-driven UI transitions and user experience continuity in mobile development.

**Acknowledgement:** The work was funded by the grant FPPV-56-2025 project "Extension of the assistance capabilities of the mobile application", co-financed by the University of Ss. Cyril and Methodius in Trnava.

**Keywords:** iOS application development, user interface adaptation, liquid glass design, custom UI components, user experience evaluation, accessibility

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# Shaping zinc-rich wheat: The phenotyping frontier in biofortification

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**Abstract:** Zinc biofortification of wheat represents a method for eliminating micronutrient deficiency in the global population. Optimization of the nutritional profile of durum wheat therefore represents a priority goal in modern breeding strategies. Within our research, we analyze a collection of 13 durum wheat cultivars (*Triticum durum*) in terms of Zn tolerance and accumulation in grain. Comprehensive phenotypic evaluation plays a key role in our research approach, enabling the identification of genotypes with optimal characteristics for biofortification programs. Phenotypic profiling includes detailed characterization of morphometric parameters, physiological status, and metabolomic signatures of individual cultivars. Part of the research involves the extent of influence of arbuscular mycorrhizal fungi (AMF) on Zn absorption and accumulation in the tested genotypes. Mycorrhizal symbiosis represents a key factor affecting mineral nutrition of plants, while its modulatory effect on biofortification processes requires detailed phenotypic characterizations. Photosynthetic apparatus parameters evaluated during phenotyping reflect the tolerance of varieties to Zn toxicity as a fundamental prerequisite for successful biofortification. Phenotypic data provide us with valuable information for optimizing biofortification strategies and identifying promising genotypes for further breeding applications. We also evaluate agronomic grain parameters - the amount of zinc and other metals and antioxidant enzymes in wheat.

**Acknowledgment:** This work is supported by the Slovak Research and Development Agency under grant No. APV 21-0504.

**Keywords:** biofortification, zinc, durum wheat, phenotyping

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# Utilisation of mycorrhizal fungi in the degradation of microplastics from soil

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**Abstract:** Microplastics (MP) are a new and still poorly understood environmental threat to terrestrial ecosystems. Not only do they negatively affect the soil microbiome, but their surfaces serve as vectors for heavy metals and other contaminants that can subsequently affect soil-plant systems. A little-studied area is the interaction of MPs with arbuscular mycorrhizal fungi (AMF), which form the basis of a healthy soil microbiome and influence plant micronutrient uptake. In this study we investigated the degradation potential of AMF for polystyrene MPs and their translocation patterns in wheat using fluorescently labelled MPs and related microscopic methods. Fluorescently labelled amine-modified MPs (0.2 µm Invitrogen by Thermo Fisher Scientific, Slovakia) were used as a model system, selected for their optimal size for fungal enzyme accessibility and positive surface charge, which allows electrostatic interactions with the negatively charged cell walls of AMF. The experimental design included different concentrations of microplastics (0.5–1.0 ml per pot, approximately 0.8–1.6% of soil weight) in combination with AMF inoculation and experimental wheat varieties. Degradation assessment was performed using confocal laser scanning microscopy. The positively charged surface of amine-modified microspheres is expected to enhance interactions with AMF through electrostatic attraction, as fungal cell walls carry a negative charge. Our multi-level approach investigated MPs degradation via AMF in soil, MPs accumulation at the root interface, and translocation into wheat tissues. This research thus contributes to the development of more effective sustainable strategies for mitigating plastic pollution.

**Acknowledgement:** The research is supported by the projects FPPV-29-2025.

**Keywords:** microplastics, arbuscular mycorrhizal fungi, biodegradation, remediation

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## Virtual laboratories for network technologies: An analysis of selected tools

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**Abstract:** This paper focuses on a comprehensive analysis of available tools for teaching network technologies. The evaluation is conducted from the instructor's perspective, with particular attention given to centralized management capabilities, project-based work, and the implementation of multiple virtual appliances. The study includes both commercial and open-source solutions, specifically GNS3 version 3.0.5, EVE-NG Community Edition version 6.2.0-4, and Cisco Packet Tracer. The primary motivation behind this work is the growing demand for hybrid teaching methods and the need to virtualize large-scale laboratory environments into a digital format accessible to both students and instructors without requiring physical presence. Virtualization also addresses issues such as limited hardware availability and high power consumption.

**Acknowledgement:** The work was funded by the grant KEGA 010TTU-4/2025 *Development of pupils' computational and algorithmic thinking through the effective integration of modern technologies into the teaching of computer science and mathematics.*

**Keywords:** virtual LAB, GNS3, EVE-GN, Cisco oacket Tracer

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# Production of polyhydroxyalkanoates from molasses by bacteria *Cupriavidus necator*

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**Abstract:** Polyhydroxyalkanoates (PHAs) are a group of biodegradable biopolymers that, due to their favorable technological and utility properties, have the potential to complementarily replace petroleum-based synthetic plastics. These polymers are produced by various types of microorganisms as intracellular storage compounds for carbon and energy. The bacterial species *Cupriavidus necator* is a key producer, capable of accumulating PHAs up to 80% (w/w) of the dry weight of its biomass. However, the main obstacle to the widespread use of PHAs is their high production cost, primarily due to the cost of raw materials, which accounts for nearly 50% of total production expenses, and the complex process of isolating and purifying the target PHAs. To make PHAs more economically viable, secondary raw materials and waste generated in various sectors of the national economy can be used for their fermentation-based production. One particularly promising substrate for fermentation is molasses, a by-product of sugar beet or sugar cane processing in the sugar industry. However, the fermentation of molasses into PHAs by *C. necator* is limited by the inability of this bacterial species to utilize the disaccharides present in molasses. Therefore, the aim of this work was to explore the possibilities of implementing biological pretreatment methods of the selected raw material based on enzymatic hydrolysis and/or microbial conversion prior to PHAs production by *C. necator*. These strategies may also open up new opportunities for producing PHAs from other complex carbon sources, whose conversion into a usable form is even more complicated.

**Acknowledgement:** Funded by the EU NextGenerationEU through the Recovery and Resilience Plan for Slovakia under the projects no. 09I03-03-V05-00004 and 09I03-03-V04-00499.

**Keywords:** bacteria, *Cupriavidus necator*, fermentation, molasses, pretreatment, polyhydroxyalkanoates

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## Application of high-throughput sequencing for the analysis of grapevine virome

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**Abstract:** Viral diseases represent a significant challenge in viticulture, as they can severely impact both yield and grapevine quality. The grapevine virome is highly complex and includes a wide range of viruses and viroids, sometimes acting in synergy or antagonism. High-Throughput Sequencing (HTS) has emerged as a modern and efficient tool for in-depth virome analysis. In our study, we applied HTS methods to identify pathogens present in several grapevine samples from Slovakia. The analysis of sequencing data enabled us not only to detect various viruses in a complex infection, but also to reconstruct complete genome sequences, such as that of Grapevine Pinot Gris Virus. Furthermore, in the case of Grapevine Rupestris Stem Pitting-Associated Virus, we were able to identify intra-species genetic variants, contributing to a better understanding of viral diversity, population polymorphism and evolution. Using HTS, we also detected subviral agents, including viroids and grapevine satellite viruses. Our results highlight the strong potential of HTS for diagnostics and research in grapevine virology, and its applicability in the development of strategies for vineyard health management.

**Acknowledgement:** This work was funded by the EU NextGenerationEU through the Recovery and Resilience Plan for Slovakia under the project No. 09I03-03-V05-00004 and APVV-22-0067.

**Keywords:** genome, grapevine, massive parallel sequencing, virome, virus isolate

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## Understanding $\beta$ -1,3-glucan synthase specificity and evolution in *Euglena gracilis*

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**Abstract:** Bioactive  $\beta$ -glucans became popular commercially used pharmaceutical supplements with substantial clinical interest, mostly due to their immunomodulatory and immunostimulatory effect. Storage  $\beta$ -1,3-glucan from *Euglena gracilis* is called paramylon and possesses some special features that make it a lucrative type of  $\beta$ -glucan for various commercial applications. A high level of accumulation and easy isolation of paramylon from *Euglena*, as well as a linear type of polysaccharide chain and insolubility under hydro-/lipophilic conditions, are the most significant features. The process of paramylon synthesis is mediated by  $\beta$ -1,3-glucan synthase which represents a large transmembrane protein. It is classified in the CAZy database into glycosyltransferase family 48 (GT48) together with synthases that form structural  $\beta$ -glucans of plant and fungal cell walls. There is a new accessibility status of genomic data from *E. gracilis* and also the first crystallographic 3D structure of  $\beta$ -1,3-glucan synthase from the GT48 family. This information enabled us to provide a prediction of important structural and functional characteristics of paramylon synthase. Moreover, the tertiary structure of protein is better conserved than the primary structure, which made it possible for us to study critical, well-conserved catalytic regions of the enzyme specificity and also structural differences between individual enzymes. Phylogenetic analyses of  $\beta$ -1,3-glucan synthases of products with diverse function within the distinct organisms contributed to a better understanding of evolutionary aspects that determined  $\beta$ -1,3-glucan as a storage polysaccharide in *Euglena*.

**Keywords:**  $\beta$ -1,3-glucan synthase, 3D structure, characteristics, evolution

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# Modification of solid phase extraction procedure for the determination of 20 selected phenolics in plant material by liquid chromatography

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**Abstract:** Plants produce a variety of secondary metabolites, among which phenolic compounds play a key role in adaptation to stress conditions. Although they are present in lower concentrations, their accumulation correlates with plant tolerance to environmental stress, which makes the determination of phenolic compounds highly important. Proper sample preparation and extraction are the key steps before the chromatographic analysis.

This work focuses on the modification of the solid phase extraction procedure, an essential part of preparing plant extracts for 20 selected phenolic compound analysis, which enables effective purification and preconcentration of analytes and significantly enhancing the applicability of this procedure. The modification is based on our previously published research, with an emphasis on modification of extraction conditions compatible with a new developed liquid chromatography method for determining 20 selected analytes. Changes were made in conditioning and elution solvent composition and volume, sorbent weight to achieve average recovery over 95 % and reproducibility (RSD ~ 3 %, n = 3) for all 20 selected phenolics.

The result of this work is an efficient evaporation of methanol from the plant extract, followed by solid phase extraction purification. The main advantage of this method is its compatibility with a newly developed high-performance liquid chromatography method for the determination of phenolic compounds in plant matrices.

**Acknowledgment:** The authors express their gratitude for the financial support of the project FPPV-32-2025.

**Keywords:** phenolic compounds, plant samples, solid phase extraction, liquid chromatography

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# Analysis and evaluation of SQL tests using generative artificial intelligence models

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**Abstract:** The project focuses on the development and application of generative artificial intelligence methods for the automated assessment of SQL language tests. The main goal is to create a system capable of analysing student's responses, evaluating their correctness, and providing personalized feedback including error explanations. The core methodology involves the integration of advanced generative language models, which are capable of understanding the structure and semantics of SQL commands and evaluating them based on defined criteria. Emphasis is placed on the accuracy and reliability of the evaluation process, with the aim of comparing the results of automated assessment with those of human instructors and identifying the potential of AI to minimize subjective discrepancies. The project will deliver a user interface design, the development of a functional prototype of the assessment system, and its pilot deployment in real educational settings. Experiments will be conducted with a sample of students and teachers to analyse the system's impact on the quality of teaching, assessment efficiency, and user satisfaction. Current research aims to develop systems that can deliver evaluation with the accuracy and depth of feedback comparable to that of experienced educators.

**Acknowledgement:** The work was funded by the grant KEGA 014UCM-4/2025 "Interactive modules for developing AI literacy" and the FPPV-48-2026 project "Analysis and Evaluation of SQL Tests Using Generative Artificial Intelligence Models, co-financed by the University of Ss. Cyril and Methodius in Trnava.

**Keywords:** large language model, SQL, assessment

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## Determination of microbial isolates from two different composts and the evaluation of their potency to stimulate the growth of tomato

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**Abstract:** Composting is an aerobic process consisting of several phases, producing a stable and mature fertiliser. The first compost analysed in this study originates from the municipal composting plant, which serves for decomposition of kitchen waste, while the second compost is being commercially sold. The aim of this study was to isolate bacteria promoting plant growth from both composts. Samples from composts were incubated at 25 °C in various liquid cultivation media. Subsequently, selected colonies were inoculated onto fresh solid media and the bacterial composition of both composts was analyzed by MALDI TOF-MS after protein extraction. We were able to isolate several interesting bacterial species including *Lysinibacillus xylanilyticus* and *Solibacillus silvestris* from municipal compost. *Pseudomonas citronellolis* and *Pseudomonas stutzeri* were isolated from the commercially sold compost. These isolates have traits that are specific for plant-growth promoting bacteria or they can serve as biocontrol agents against infections causing many plant diseases. Isolates with these traits can thus significantly facilitate the growth, development or immunodefence of tomato (*Solanum lycopersicum* L.).

**Acknowledgement:** This research was supported by the University Grant Agency (UGA) of Matej Bel University in Banská Bystrica, Slovakia, Project No. UGA-12-DS-2025.

**Keywords:** compost, bacterial isolates, MALDI TOF-MS, tomato

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## Biosorption of Li<sup>+</sup> ions from aqueous solutions using modified cyanobacterial biomass

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**Abstract:** In this work, dried biomass of the cyanobacteria *Synechococcus bigranulatus* (BSB), an environmentally friendly and cost-effective biosorbent, was chemically modified with K<sub>4</sub>[Fe(CN)<sub>6</sub>] solution (BFCN) and by phosphorylation reaction (BF) for biosorption separation of Li<sup>+</sup> ions from aqueous solutions. The effect of biosorbent concentration, pH value, and initial Li concentration on the Li biosorption was studied in the individual experiments. We observed 100 % removal of Li<sup>+</sup> ions in the case of BFCN and at initial concentrations of Li ranging from 0.5 to 5 mg/dm<sup>3</sup>. On the contrary, the specific biosorption (mg/g; d.w.) gradually increased with increasing initial Li concentration in the solution, when the maximum biosorption capacity  $Q = 3.06 \pm 0.16$  mg/g was calculated at the highest initial Li concentration 10 mg/dm<sup>3</sup>. The process of Li biosorption by BF biosorbent was better described by the Freundlich isotherm ( $R^2 = 0.999$ ) than the Langmuir isotherm model ( $R^2 = 0.775$ ), whereby  $Q$  reached  $0.32 \pm 0.02$  mg/g (d.w.). We found that the highest efficiency removal of Li from geothermal water sample containing 0.88 mg/dm<sup>3</sup> Li (pH = 7.2) was determined in the case of BFCN biosorbent, and this efficiency decreased in the order: BFCN – 58.3 % > BSB (unmodified biosorbent) – 25.7 % > BF – 12.6 %.

**Acknowledgement:** This work was supported under the Interreg VI-A SK-AT Programme and project “Využitie biouhlia z čistiarenských kalov v zelených technológiách a obehovom hospodárstve”, No. 404201DPF8, co-financed by the European Regional Development Fund, and under institutional project No. FPPV-50-2025.

**Keywords:** lithium, separation, biosorption, *Synechococcus bigranulatus*, chemical modification, geothermal wastewater

# Effects of superabsorbent polymer on the activity of antioxidant enzymes and defensive PR-proteins in agricultural crops grown under drought conditions

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**Abstract:** Global warming has intensified the impact of abiotic stresses, particularly drought, which disrupts plant physiology by inducing oxidative stress through the accumulation of reactive oxygen species (ROS). In response, plants activate antioxidant enzymes – catalase (CAT) and ascorbate peroxidase (APX), and pathogenesis-related (PR) proteins, including  $\beta$ -1,3-glucanase and chitinase, which contribute to defence and adaptation mechanisms. Superabsorbent polymers (SAPs), such as AquaHolder (PeWas s.r.o.), offer a promising strategy to mitigate drought effects by retaining large volumes of water in the soil. This study investigated the influence of AquaHolder, applied as a seed treatment, on the activity of CAT, APX, and selected PR-proteins under drought stress. *Zea mays L. cv. Alombo*, *Hordeum vulgare L. cv. Bojos*, and *Triticum aestivum L. cv. PS Luana* were grown under four treatment conditions (control, fungicide only, AquaHolder only, and combined treatment). Samples were collected in Slovakia (Borovce) and the Czech Republic (Žabčice) (2021-2022). Spectrophotometric analysis showed reduced CAT and APX activity in AquaHolder-treated plants in 2021, with no consistent effects in 2022. SDS-PAGE revealed five chitinase and three  $\beta$ -1,3-glucanase isoforms, with generally increased band intensity in AquaHolder-treated groups. Results suggest AquaHolder may enhance PR-protein synthesis and partially modulate antioxidant responses under drought.

**Acknowledgement:** This work was supported by Interreg V-A SK-CZ 304011Y185 and KEGA 013UCM-4/2025.

**Keywords:** drought stress, antioxidant enzymes, chitinase,  $\beta$ -1,3-glucanase, superabsorbent polymer.

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# Biochar and bioaugmentation applied to soil mitigate impacts of combined stress with potentially toxic elements and drought on red fescue

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**Abstract:** Potentially toxic elements (PTE) in soil hamper plant growth. Grasses can better sustain PTE-induced stress but in case of combined toxicity stress with other stresses, e.g. due to drought, grass growth is more deteriorated. Under such conditions, amendment of biochar or/and bioaugmentation could alleviate adverse effects of both stresses. This hypothesis was tested in a pot experiment with soil contaminated with PTEs, using red fescue (*Festuca rubra* L.) inoculated with bacteria (*Pseudomonas* + *Bacillus*) and amended with biochar. Uncontaminated soil was used as a control for subjecting the grass only to single drought stress. After 7 weeks, grass was drought-stressed for 2 weeks with 1/3 watering compared to the control variant, then watering rate was restored to unreduced for next 3 weeks. Regularly-watered control was supplied with unreduced access of water during the whole trial duration. Dry aboveground plant biomass (AGB<sub>dry</sub>) was harvested and the soil was sampled after 12-week cultivation. The results showed that under dry conditions, soil treatment with either by biochar or inoculum tended to increased yield of AGB<sub>dry</sub> in comparison to the untreated control, in gradual increment toward the significantly highest AGB<sub>dry</sub> under treatment with biochar combined with inoculum. Such effect was not found in regularly-watered pots, though. There was not found any significant difference in soil microbial activity (indicated by dehydrogenase) but in conclusion, different yields of plant biomass were i.a. ascribed to changes in soil biologic properties, driven by drought, PTE content, biochar-sorption, or helper microbes, among which the combined effect of drought and PTE toxicity played key role and was efficiently mitigated by both tested protective tools (biochar and bioaugmentation).

**Acknowledgement:** This research was supported by the project IGA25-AF-IP-026 and by the Ministry of Agriculture of the Czech Republic, institutional support MZE-RO1225.

**Keywords:** soil amendment, plant growth-promoting rhizobacteria, plant biomass, grass, osmotic stress, dehydrogenase

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## Biochar/eggshell-based mechanochemically activated adsorbents for efficient phosphate recovery

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**Abstract:** The rapid expansion of industrial sectors has contributed to the decline in clean and safe water availability, making effective treatment of polluted water sources increasingly important. Adsorption has emerged as a promising method for removing contaminants like phosphate from water. In this study, two innovative adsorbents were prepared via mechanochemical treatment (high-energy ball milling) of cherry pit biochar (CPB) or walnut shell biochar (WSB) with eggshell waste (ESM) to enhance phosphate removal. Both CPB+ESM and WSB+ESM demonstrated rapid phosphate adsorption within the first 60 minutes, reaching equilibrium after 360 minutes. The kinetics of CPB+ESM followed a pseudo-second-order model, suggesting chemisorption, while intra-particle diffusion modeling indicated a two-stage process: fast surface adsorption followed by slower internal diffusion. Maximum Langmuir adsorption capacities were 12.5 mg/g for CPB+ESM and 6.7 mg/g for WSB+ESM. Optimal phosphate removal occurred at pH 9 (CPB+ESM) and pH 5 (WSB+ESM). In real water samples (pH ~7.5) from green roof runoff, removal efficiencies ranged from 46.4–64.8 % (WSB+ESM) and 28.6–57.0 % (CPB+ESM). These findings suggest that mechanochemically modified biochar-eggshell materials are effective, sustainable adsorbents for phosphate removal and can potentially reduce eutrophication while spent adsorbents could serve as phosphorus-rich components of roofing substrates.

**Acknowledgment:** This work was supported by the Scientific Grant Agency of the Ministry of Education, Science, Research, and Sport of the Slovak Republic (project number VEGA 1/0399/24) and the Slovak Research and Development Agency under the contract number SK-CN-23-0023.

**Keywords:** mechanochemical activation, biochar/eggshell adsorbent, phosphate, water treatment, green roof runoff

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