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DISC 2021 by DIFENEW

1st DIFENEW INTERNATIONAL STUDENT CONFERENCE

ABSTRACT BOOK

1st DIFENEW INTERNATIONAL STUDENT CONFERENCE

Faculty of Technical Sciences,
University of Novi Sad
Online event
16th December, 2021
Novi Sad, Serbia

Organizers:

Department of Environmental Engineering and Occupational Safety and Health,
Faculty of Technical Sciences, University of Novi Sad, Serbia
Institute of Analytical Chemistry, Faculty of Chemical and Food Technology,
Slovak University of Technology in Bratislava, Slovakia

The 1st DIFENEW International Student Conference - DISC2021 is the part of the project activities within the Serbian-Slovak Bilateral Project "*Development and Implementation of Field and Laboratory Methodologies for Environmental Evaluation of wetlands - DIFENEW*" supported by Ministry of Education, Science and Technological Development of Serbia and Slovak Research and Development Agency.

CIP - Каталогизација у публикацији
Библиотеке Матице српске, Нови Сад

502(048.3)

DIFENEW International Student Conference – DISC2021 (1 ; 2021 ; Novi Sad)
Abstract book [Elektronski izvor] / 1st DIFENEW International Student Conference – DISC2021 ; [editors Maja Petrović, Ivan Špánik, Nevena Živančev]. - Novi Sad : Faculty of Technical Sciences, 2021

Način pristupa (URL):
https://www.izzs.uns.ac.rs/uploads/files/shares/DISC2021%20Abstract%20book.pdf. - Opis zasnovan na stanju na dan 26.1.2022. - Nasl. s naslovnog ekrana.

ISBN 978-86-6022-383-0

a) Заштита животне средине -- Апстракти

COBISS.SR-ID 56827401

Abstract Book

1st DIFENEW INTERNATIONAL STUDENT CONFERENCE DISC2021

Publisher
Faculty of Technical Sciences
Trg Dositeja Obradovića 6, Novi Sad, Republic of Serbia

Editors
Maja Petrović
Ivan Špánik
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Design and prepress

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Maja Sremački
Maja Petrović

Cover page photo
Maja Sremački

ISBN
978-86-6022-383-0

Year
2021

PREFACE

On behalf of the Scientific and Organizing Committees, it is my pleasure to present to you the Abstract book of the 1st DIFENEW International Student Conference DISC2021, which was held in hybrid mode on 16th December 2021. The 1st DIFENEW International Student Conference DISC2021 was organized by the Department of Environmental Engineering and Occupational Safety and Health, Faculty of Technical Sciences, University of Novi Sad, Serbia and Institute of Analytical Chemistry, Faculty of Chemical and Food Technology, Slovak University of Technology in Bratislava, Slovakia as the part of the activities realized under the Serbian-Slovak Bilateral Project "*Development and Implementation of Field and Laboratory Methodologies for Environmental Evaluation of wetlands - DIFENEW*". The Project is supported by the Ministry of Education, Science and Technological Development of Serbia and Slovak Research and Development Agency.

The DISC2021 conference was an interdisciplinary forum where the research results in the field of Environmental Engineering, Environmental Monitoring, Occupational Safety and Health and Civil Engineering were shared between PhD students and their professors from the entire world. At the same time, the event was the place for the promotion of the DIFENEW results to a wider audience.

I would like to express my sincere thanks to all session chairs, presenters, Scientific and Organizing committees, as well as to many others who contributed to the success of the DISC2021.

We are confident that the solid foundation created by the DIFENEW project will continue to build up and strengthen the unique international network.

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Dr. Maja Petrović

In Novi Sad, December 2021

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ABSTRACT BOOK

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DEVELOPMENT OF DATA INFRASTRUCTURE FOR THE SYSTEMATISATION OF LEACHATE SCREENING DATA IN SERBIA

Adamov T.[1], *Španik I.*[2], *Koljančić N.*[2], *Petrović M.*[1]

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Abstract: Sustainable municipal solid waste management in Serbia presents a significant social and environmental concern since landfilling is the oldest and most used disposing method. Landfills are final depositories and many synthetic chemicals, used in industrial and agricultural activities, return to the environment via landfill leachate in form of the complex mixtures. Some of these chemicals have significant potential to interfere with normal biological functions and cause adverse health effects. By virtue of living in a VUCA world and being under daily exposure, it is extremely difficult to determine the link between specific hazardous compounds and their harmful effects. The main objective at this level is to develop the database of substances with unique identifiers which will allow intercomparison at the global scale. The preliminary screening analysis of leachate from one of the biggest unsanitary landfill sites in Serbia, was performed. The occurrence of organic compounds found in consumer products such as pharmaceuticals, flavourings, preservatives, plasticizers and additives used in plastic production has been confirmed. The major organic compound groups were organochlorine and organophosphate pesticides, alkylphenols, triazines, phthalates, polycyclic aromatic hydrocarbons and bisphenol A. The results confirmed the importance of organic pollutants' life-cycles assessment and associated risks. Moreover, a data infrastructure which will enable the prioritisation of hazardous chemicals causing adverse environmental and health effects at the national scale in support of the European water, chemicals and waste management policy, has been proposed.

Keywords: *Landfill leachate; Screening data infrastructure; Hazardous compunds, Waste management.*

Acknowledgement

The project is co-financed by the Governments of Czechia, Hungary, Poland and Slovakia through Visegrad Grants from International Visegrad Fund. The mission of the fund is to advance ideas for sustainable regional cooperation in Central Europe. Part of this work was carried out within the financial support from the Bilateral project funded by the Ministry of Education, Science and Technological Development under contract 337-00-107/2019-09/16 and Slovak Research and Development Agency under contract SK-SRB-18-0020, the Ministry of Education, Science and Technological Development through the project no. 451-03-68/2020-14/200156: "Innovative scientific and artistic research from the FTS (activity) domain" and the Slovak Research and Development Agency under Contract No. APVV-19-0149.

THE INFLUENCE OF INORGANIC ANIONS ON THE PHOTOCATALYTIC DEGRADATION OF PHARMACEUTICALS

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Abstract: Pharmaceuticals, as one of dominant group of emerging substances, are present in the environment in very low concentrations (from ng/L to μg/L) and are known as pseudo-persistent, toxic and bioaccumulative pollutants. Since conventional wastewater treatments are not designed for the removal of pharmaceuticals, the future solution may be found in advanced oxidation processes. Photocatalytic treatment is based on reactive species which can decompose organic pollutants to simpler molecules such as water and carbon dioxide. In order to determine the optimal parameters of photocatalysis, it is necessary to be familiar with the other wastewater constituents that could affect the process. Within this paper, the impact of inorganic anions (chlorides, sulfates, phosphates, and nitrates) on photocatalytic degradation was studied. Effects of inorganic anions on photocatalytic degradation of naproxen, ibuprofen, ketoprofen, and diclofenac are experimentally examined with various concentrations of selected anions and a nanostructural mixture of ZnO/SnO_2 as a photocatalyst. Taking in consideration the nature of analyzed pharmaceuticals, each of the anions has shown either improved or inhibitory effects. The maximum concentration of chlorides (100 mg/L) has slowed down the photocatalytic degradation of ketoprofen by 88 % relative to the rate at zero ion concentration (from 0.542 min^{-1} to 0.067 min^{-1}). In contrast, they increased the degradation rate constant by 133,33 % (from 0.117 min^{-1} to 0.273 min^{-1}), under the identical conditions. The highest concentration of nitrates (20 mg/L) has reduced the degradation rate of ibuprofen from 0,04 min^{-1} (at 0 mg/L of nitrates) to 0.006 min^{-1}. Anions could bind to active centers and reduce the adsorption of pharmaceuticals, which is assumed for anions at the highest oxidation state - sulfates and phosphates. They could react with positive holes and affect to photocatalysis, which is presumably the mechanism of inhibition caused by nitrates and chlorides.

Keywords: *Photocatalysis; Pharmaceuticals; Anions; Wastewater; Treatment*

Acknowledgement

This work was supported by the Government of Vojvodina (Project no. 142-451- 2387/2018-01/01) and by Ministry of Education, Science and Technological Development, Republic of Serbia, through the project no. 451-03-68/2020-14/200156: “Innovative scientific and artistic research from the FTS domain”.

CARBON-BASED MATERIALS AS AN ADSORBENT FOR DIMETHOATE REMOVAL FROM WATER

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Abstract: Dimethoate (DMT), one of the major organophosphorus pesticides, is widely used in agriculture. DMT is highly toxic for mammals. Its harmful effects are related to the irreversible inhibition of the enzyme acetylcholinesterase. The high stability of DMT, poor biodegradability and extensive usage led to its accumulation in the environment. Excessive use of DMT also leads to residues accumulating in the human body through the food chain. Therefore, efficient procedures for its elimination from the environment are crucial. The main strategy for the removal of pesticides from water is the adsorption. Numerous studies in the literature reporting DMT adsorption on mineral surfaces, carbon-based materials, and nanoparticles can be found. Special attention is given to application activated carbons produced from waste or biomass because it positively impacts the environment. Various graphene derivatives have also been applied in environmental protection. In our investigation, we used graphene oxide and carbon material derived from viscose fibers as adsorbents for DMT from water. It was shown that 1 g of graphene oxide is capable of adsorbing $8.8 \cdot 10^{-3}$ mol of DMT. A satisfactory agreement of experimental results with the Langmuir isotherm model suggests the monolayer adsorption on the homogenous surface. We also used activated carbon material derived from viscose fibers for DMT removal from water. It was shown that 1 g of the investigated material is capable of adsorbing $2.5 \cdot 10^{-4}$ mol of DMT. The adsorbent in the concentration of 1 g/dm^3 was able to eliminate 93.12 % of $5 \cdot 10^{-4}$ mol/dm^3 DMT under the given experimental conditions. Our study showed that both carbon materials are good adsorbents for DMT. Still, it is obvious that graphene-oxide exerts higher efficiency in removing DMT from water. Nevertheless, the difference in price between investigated materials and the possible impact on the environment have to be considered when choosing the best candidate.

Keywords: *Dimethoate; Adsorption; Carbon-based materials; Graphene oxide.*

Acknowledgment

This work was partially supported by the Ministry for Science of the Republic of Serbia (Grant no. 451–03–9/2021–14/200017).

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EFFECTS OF ORGANOPHOSPHATE POISONING ON HUMAN ORGANS – AN OVERVIEW

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Abstract: Organophosphates belong to the most toxic compounds ever known due to their ability to irreversibly inhibit the enzyme acetylcholinesterase (AChE), which enables the transmission of signals in cholinergic neurons. AChE has a role in the fast degradation of the neurotransmitter acetylcholine (ACh), thus being responsible for the repolarization of the synapses. ACh, a mainly excitatory neurotransmitter, is present in both peripheral (PNS) and central (CNS) nervous system. The systemic loss of function of cholinergic neurons affects practically all human organs. The overall effect of organophosphate poisoning in a particular organ depends on the type of innervation (sympathetic PNS, parasympathetic PNS or CNS), i.e., the type (nicotinic or muscarinic), subtype (N1, N2 or M1-M5) and location (pre-ganglionic or post-ganglionic) of cholinergic receptors. This contribution summarizes the expected effects of organophosphate poisoning from the aspect of human organs and systems of organs, based on the known cholinergic innervation. Besides the most obvious effects on peripheral innervation of internal organs and, rather more complex, impact on CNS features, attention will also be paid to the second-order effects on indirectly involved organs (e.g., liver and kidneys). Finally, the possible effects of organophosphates on the function of other human enzymes (besides irreversible AChE inhibition) will also be discussed.

Keywords: *Organophosphates; Acetylcholinesterase (AChE); Poisoning; Toxins.*

Acknowledgment

This work was supported by the Ministry for Science of the Republic of Serbia (Grant no. 451–03–9/2021–14/200017).

COMPARISON OF CONVENTIONAL AND NOVEL EXTRACTION TECHNIQUES OF PHENOLIC COMPOUNDS FROM PLANTS

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Abstract: Phenolic compounds are the most common secondary metabolites in vascular plants with enormous structural diversities. Many phenolic compounds occur constitutively and determine the basic life processes of plants, but some stress factors contribute to increases in or *de novo* synthesis of phenolics, such as infection, plant tissue damage, UV radiation and elevated temperature. The interest in the extraction of phenolic compounds has been growing, due to their importance and possible positive effect on human health. Also, determination of phenolic compounds can be very helpful in estimation of pharmacological activity of medicinal plants. The recovery of these phenolic compounds from plants is mainly dependent on the method of extraction. The most utilized conventional methods are *maceration*, *decoction*, *percolation*, *infusion*, *digestion*, *serial exhaustive extraction (SEE)*, and *solid-liquid extraction (SLE)* or *Soxhlet extraction*. These methods are mostly designated by utilizing larger volume of extraction solvents and manual procedures that are labor-intensive and mostly dependent on the investigator. Prolonged exposure to high temperatures during conventional solvent extraction may cause degradation of the phenolic compounds in plant cells and thus reduce the maximum recovery yields of the compounds. According to some studies, greener novel extraction methods have been generated with the purpose of filling the missing gaps of conventional methods. Novel extraction technologies like *accelerated solvent extraction (ASE)*, *ultrasound-assisted extraction (UAE)*, *supercritical fluid extraction (SFE)*, *microwave-assisted extraction (MAE)*, *shock wave-assisted extraction*, *pressurized liquid extraction (PLE)*, *supercritical CO_2 extraction (SC–CO_2)*, and *enzyme-assisted extraction (EAE)* are getting more attention because of their shorter time and lower energy consumption, and higher extraction efficiency. These methods are also known to be environmentally friendly since they use smaller volumes of extraction solvents. The demand for new bioactive compounds will continue to encourage the search for innovative extraction techniques to achieve appreciable recovery yields from the plant materials.

Keywords: *Phenolic compounds; Conventional extraction methods; Novel extraction methods.*

Acknowledgement

This paper has been supported by the Ministry of Education, Science and Technological Development through the project no. 451-03-68/2020-14/200156: "Innovative scientific and artistic research from the FTS (activity) domain".

PATTERN OF HAZARDS, SAFETY PRACTICES, KNOWLEDGE AND ATTITUDE AMONG LABORATORY TECHNOLOGISTS IN THE UNIVERSITY OF IBADAN

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Abstract: The workers in laboratories generally are faced with many occupational risks at work which compromises health and safety. These hazards can be physical, chemical, biological, ergonomic, and psychosocial. Poor laboratory safety practices can cause laboratory accidents and severe injuries. This study was aimed to assess the level of knowledge, practice, and attitude to laboratory safety among the study participant, and document prevalent health conditions among technologists in the selected laboratories and determine types of hazards associated with the selected laboratories. The study utilized a descriptive cross-sectional design and proportionate sampling technique was used. A total of 248 respondents were allocated proportionately. While a total of 38 departments were used based on having laboratories, questionnaire was administered to laboratory technologists, observational checklist was used to assess safety practices. The mean age of the respondent was age 57.7 ± 18.6 and 65.5 % of the respondents were males while the remaining 34.5 % were females. The result reveals that more than half of the respondents 154 (68.1 %) had poor knowledge about laboratory safety hazards, while majority 136 (60.2 %) of the respondents had positive attitude towards laboratory safety practices, Also, most of the respondents 138 (61.1 %) had good practice towards laboratory safety, 94 (41.6 %) had excellent state of health. In this study, most hazards reported were from medical laboratories. The statistical analysis showed a significant association between the age and level of knowledge, attitude and practice ($P<0.05$).

Keyword: *Hazard pattern; Knowledge, attitude and practice; Laboratory safety.*

IMPACT OF TURBINE IMPELLER SPEED ON COPPER ION SORPTION ON ZEOLITE

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Abstract: Hydrodynamic conditions in the batch reactor are affected by reactor design, e.g. by the reactor size, impeller type and size, its position in the reactor and mixing speed. The influence of the mixing speed of two different turbine impellers, one with straight blades (SBT) and one with the inclination of the blades of 45° (PBT) on the sorption kinetics of copper ions on zeolite NaX has been studied. The experiment was conducted at constant suspension temperature in a batch reactor with baffles at four different impeller speeds and constant turbine impeller off-bottom clearance. The Ritchie model and Weber-Morris model were used to estimate the slowest process step and the models' parameters. The kinetic analysis of the obtained kinetic experimental data showed that that the mixing speed, of both impellers, influence the process. According to the good matching of Ritchie's model and obtained data and AARD values can be stated that the reaction of copper ion sorption on zeolite NaX is kinetic controlled and follows the second-order kinetics.

Keywords: *sorption kinetic; turbine impeller; kinetic models*

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CONSTRUCTED WETLANDS SYSTEMS FOR TREATMENT AND REUSE OF DOMESTIC WASTEWATER - PROJECT FIT4REUSE

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Abstract: Due to the depletion of water resources caused by climate change, pollution and anthropic activities, many technologies have been implemented to treat and recover wastewater. Since traditional centralised wastewater treatment plants require high energy input and expert maintenance, the research has pointed towards greener and more sustainable alternatives. More economically and environmentally compatible, constructed wetlands (CWs) are simple nature-based solutions recognised as less demanding, less costly and decentralised technologies for wastewater treatment, that allow water and nutrients recycle, favouring the closure of their life cycle. As part of the FIT4REUSE project, the present study aims to recover and treat municipal wastewater with CWs, to render it suitable for agricultural irrigation. A CW pilot plant was established in Granarolo dell'Emilia (Italy) to study the CWs treatment capacity and to reach an effluent quality needed for wastewater reuse. Three subsurface horizontal and three vertical flow constructed wetlands were built and have been studied to investigate six different substrates, namely gravel, pumice, agriperlite, sand, vermiculite and cork, and were planted by two species, *i.e. Phragmites australis* and *Iris pseudacorus*. The performance analyses have been based on the capability of the systems to reduce different pollutants characteristic of domestic wastewater. In comparison to the influent, the preliminary results indicated removals in the range 54 – 85 % for COD, 14 – 44 % for TN, 39 – 79 for NH_4^+-N, 89 – 100 % for Total coliforms and 84 – 100 % for *E. coli*. While further investigations are required, e.g. to evaluate aeration influence on the performance, the pilot plant have already presented the potential to treat wastewater accordingly to the aims of the project.

Keywords: *Wastewater treatment; Wastewater reuse; Nature-Based Solutions; Constructed wetlands.*

Acknowledgement

This work was supported by the project "Safe and Sustainable Solutions for the Integrated Use of Non-Conventional Water Resources in the Mediterranean Agricultural Sector (FIT4REUSE)" which has received funding from the Partnership on Research and Innovation in the Mediterranean Area (PRIMA) under grant agreement No 1823. PRIMA is supported by the European Union's Horizon 2020 research and innovation program.

SUSTAINABILITY, NUCLEAR INDUSTRY AND CLIMATE CHANGE

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Abstract: The global effort to reduce greenhouse gas emissions had received increased attention. Even though the uncertainty that surrounds the world's nuclear energy situation, nuclear power is continuing to be a strategic option that can address climate change. This paper aims to answer the following question: What conditions would nuclear energy be considered as a feasible option to provide energy services in a sustainable manner? Also, is it true or not, that if the concept of sustainable development applies to the nuclear energy industry, then a global large-scale sustainable system of nuclear energy would require major technological and economic changes to minimize risks? This paper presents a literature review to analyze the various sources related to the topic of this study. The researcher who support nuclear energy point out its advantages as environmentally friendly (clean energy, producing no carbon emissions with low fuel demand) and a safe energy source that supplies electricity at a stable expense. Other scientists point out that the key reasons for the fate of nuclear power generation being so gloomy are the rigid safety requirements and hazards involved in reactor construction, functioning, dismantling and, in specific, nuclear waste storage, and potential nuclear disasters. The topic is examined under various concerns such as the safety risks associated with nuclear fuel cycles, the accumulation of nuclear waste, nuclear security risks, and the cost of nuclear energy.

Keywords: Sustainable development, Nuclear industry, Climate change, Sustainability, Risks.

Acknowledgement

This work was supported by the Ministry of Education, Science and Technological Development of the Republic of Serbia

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SAMPLING OF PARTICULATE MATTER IN VARIOUS ENVIRONMENTS OF NOVI SAD

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Abstract: Particle pollution levels vary significantly both at regional and local levels. The most common methods for measuring particulate matter (PM) are by their concentration or size distribution. Nowadays, PMs are measured by low or high-volume samplers, instruments that use gravimetric method (GM) as the most accurate measurement type, and by real-time monitoring. GM involves careful pre- and post-conditioning of the microfiber filters. Completely manual process and high operating costs of such instruments limit their applications and cause usually sparse measuring networks. Real-time measurements of PMs are usually conducted by low-cost optical particle counters (LC_{OPC}) which measures either light scattering, light absorption, or light extinction caused by PM. LC sensors (LCS) are integrated with Internet of Things technology, which enables wireless communication systems and the ability to use a range of sensor networks to measure air quality with high spatial resolution in near real-time. LCS have greater mobility, maintenance costs are relatively low, and can be installed at a large number of locations, on roofs, terraces, trees, etc., utilizing the existing infrastructure across the cities. The biggest obstacle is the quality of LCS measurements. Many methods and algorithms are developing to overcome these obstacles especially in field conditions, which are also under great influence of significant diurnal and seasonal timescales variations of humidity and ambient temperature. In Novi Sad, during heating and non-heating season (2020/2021), fine PM ($PM_{2.5}$) sampling campaign was conducted by applying low-volume gravimetric instruments and LC_{OPC}. During heating and non-heating season, most of $PM_{2.5}$ concentrations exceeded WHO regulation. Despite many limitations of LCS, PMs data collected by the LC_{OPC} make LCS suitable for PM research in various environments. This study aimed to share sampling campaign experiences and present indicative LCS $PM_{2.5}$ measurement results at 21 urban and industrial locations in Novi Sad.

Keywords: *Active sampling; Low-cost sensors; $PM_{2.5}$; Urban and industrial environment.*

Acknowledgement

This work was supported by the Ministry of Education, Science and Technological Development, Project number 451 03 68 2020 14 200156: “Innovative scientific and artistic research from the FTS (activity) domain” and H2020 project VIDIS (GA 952433).

ASSESSMENT OF GROUNDWATER QUALITY IN CROSS BORDERS PROTECTED AREAS IN SERBIA AND CROATIA

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Abstract: Monitoring is carried out in order to determine the physic-chemical status of groundwater and determining long-term exposure to pollutants from anthropogenic sources. Chemicalization of soil with pesticides and fertilizers represents diffuse sources of contamination that are not easy to identify and register, which makes it difficult to assess and determine their overall contribution to water pollution. Due to the great similarities of cross border protected area (around the lakes and wetlands were agricultural land with narrow and wider vegetation belts and the same types of crops are grown), Zobnatica lake in Serbia and Wetlands of Tompojevci in Croatia, it is possible to evaluate cumulative pollution in compared regions. During two-year monitoring program, eighteen physic-chemical parameters were analyzed at eight locations in Serbia and eight locations in Croatia. The results of the independent sample t test indicate that there is a statistically significant increased concentration of nitrite, nitrite, total nitrogen and sulfate ($p<0.05$) in Zobnatica lake compared to Wetlands of Tompojevci. Based on the conducted research, it could be conclude that the protected area from Serbia is more contaminated by agricultural activities. The results obtained within the two-year monitoring are highly essential for achieving a quality database that could be used for groundwater management in the future with the aim of minimizing environmental pollution, especially water medium.

Keywords: *Monitoring; t test; Groundwater; Anthropogenic activities.*

Acknowledgement

This work was supported in part by Active Sensor Monitoring Network and Environmental Evaluation for Protection and Wise use of Wetlands and Other Surface Waters project (acronym SeNs Wetlands, grant agreement no 2017HR-RS135) within Interreg IPA CBC Croatia-Serbia Programme.

TAILORING TITANIUM DIOXIDE NANOPARTICLES FOR WATER PURIFICATION APPLICATIONS

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Abstract: Photocatalytic degradation is an increasingly popular solution to the problem of water pollution due to its effectiveness and versatility. Different structural modifications are used to enhance the performance of the photocatalyst such as doping and formation of composites. In this work, we study the potential of modification of the properties of known and cheap semiconductor TiO_2, by the introduction of dopants. Potential dopants are nonmetals (N, B) in combination with various metals (Pt, Pd, Ni...). Experimental study of the synthesized co-doped TiO_2 nanoparticles included XRD, UV-VIS spectroscopy, XPS, and indicate significant enhancement of optical properties and significant decrease of the bandgap in the material. To understand the mechanism of such enhancement, DFT calculations are done for selected systems. DOS reveals the primary effect of the nonmetal dopant in bandgap reduction, while additional features related to co-doping with nonmetal and noble metal are shown to lead to the expected tailoring of these materials for degradation of various pollutants. To achieve a comprehensive picture of potential dopant pairs, a machine learning model for the prediction of bandgap in doped TiO_2 anatase systems based on the graph neural networks is tested, revealing potential pairs of dopants which could provide suitable bandgap values for application with visible light.

Keywords: *TiO_2; Noble metal; DFT; Machine learning;*

Acknowledgment

This work was supported by the Ministry of Education, Science, and Technological Development of the Republic of Serbia.

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Online event
16th December 2021

STRENGTHENING OF MASTER CURRICULA IN WATER RESOURCES MANAGEMENT FOR THE WESTERN BALKANS REGION

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Abstract: Water is more and more significant resource, and there is increasing need nowadays for maximum usage of the water resource. This need has emerged after it was clear that water quality has a decreasing trend, because of constant and raising pollution, climatic changes, and extreme space/time misbalance. Maximum water resource usage efficiency involves its efficient management, maximum efficiency of the hydrological potential of the water bodies (construction of the accumulations in a series), while the other sectors i.e. tourism, water supply, agriculture, energy, with optimal management of these system can achieve sustainability and safety regarding certain parameters. In order to educate experts for water management resources in Western Balkans countries, in line with national and EU Policy, SWARM project for the master curriculum development in water resource management in Western Balkans HEIs, has been launched within ERASMUS+ Program of the European Union. Project included several key activities such as: Analysis of water resources management in the Western Balkan region, Development of competence-based curricula aligned with EU trends, Development of trainings for professionals in water sector and Implementation of developed master curricula and trainings. Finally, project is currently promoted through dissemination and exploitation of results, winter schools and symposiums for promotion of water resources management for the Western Balkans Region.

Keywords: *Strengthening; Water Resources; Western Balkan; Master Curricula.*

Acknowledgement

This work was supported by SWARM project from ERASMUS+ Program of the European Union, Project number: 597888-EPP-1-2018-1-RS-EPPKA2-CBHE-JP, and with the support from Ministry of Education, Science and Technological Development Project no. 451-03-68/2020-14/200156: "Innovative scientific and artistic research from the FTS (activity) domain".

ELECTROTHERMAL PERFORMANCE OF COMPOSITE HONEYCOMB MONOLITH AS THE ADSORBENT IN ESA PROCESS

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Abstract: The technologies for CO_2 removal from industrial flue gases, competitive to commercial amine adsorption, beside Pressure (PSA) and Temperature (TSA) include *ESA – Electric Swing Adsorption*. Up-to-date research is focused on development of hybrid adsorbents (composite materials or Metal Organic Frameworks – MOFs): to be selective towards CO_2 and to be electro conductive – the lower the specific electrical resistivity, the faster the heating with the electric current during the adsorbent regeneration, which ensure economic viability of the process. This research was aimed to determine the specific electrical resistivity of a honeycomb monoliths made of ZSM-5 zeolite (78 wt. %) and carbon black (22 wt. %), produced by Corning (France), and to realize how the installation of the sample into the column affects it. Two samples were used: the length of 5 cm and 20 cm, both with square cross section of 400 cells per square inch. The specific electrical resistivity ρ (Ohm·m) was calculated from the measured resistance R (Ohm) using the equation $\rho = R \cdot \frac{A}{L}$, where A is the area of the cross section, and L is length of the sample. The samples were electrically heated to a constant temperature by applying different voltages (up to 25 V) while the electric current was measured. The resistance R was calculated from Ohm law. A QPX600DP Dual 600 Watt DC Power Supply (Power Flex+, Thurlby Instruments Limited, England) was used as the power source, and the temperature was measured with a type K thermocouple. Silver ink was used for fixing the samples into the column. The results showed the expected linear dependence of resistivity on temperature which can be fitted in well known form $\rho(T) = \rho_R \cdot \left(1 + \alpha_R (T - T_R)\right)$, where T_R is a reference temperature. Rated resistivity of the installed samples was lower than the non-installed ones, indicating the overall ESA unit performance can be strongly influenced by column design.

Keywords: *Electric Swing Adsorption; Honeycomb monolith; Specific Electrical Resistivity.*

Acknowledgement

This work was supported by Faculty of Technology and Metallurgy, FP7 – ENERGY – 2013 – 1. The authors acknowledge their gratitude to the Ministry of Education, Science and Technological Development of the Republic of Serbia.

DISC2021
1st DIFENEW International Student Conference
Online event
16th December 2021

ADSORPTION OF CHLORPYRIFOS ON BIOWASTE-BASED CARBON MATERIALS

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Abstract: Organophosphorus pesticides are widely used for pest control and the prevention of diseases in agriculture and households. However, the growing use of these pesticides makes them some of the major contaminants of the environment. Therefore, it is necessary to develop effective removal techniques of pesticides from the environment. Adsorption is one of the most commonly applied methods for the removal of pesticides from water due to its efficiency, capacity, and applicability on a large scale. With an aim to develop an efficient and economical adsorbent for pesticide removal, we prepared two activated carbons derived from biowaste and assessed them for adsorption of one of the commonly used organophosphorus pesticides chlorpyrifos (CPS). Used rabbit litter was employed as a precursor for low-cost activated carbon. The precursor was treated with phosphoric acid or sodium hydroxide as a chemical reagent added during the activation process and then converted into carbon material in a chamber furnace under a nitrogen atmosphere by heating for 60 min at 900 °C. After washing with 0.1 M HCl, 0.1 M NaOH, and 50 % ethanol solution, obtained products (RL-H_3PO_4 and RL-NaOH) were dispersed in 50 % ethanol solution and evaluated for the removal of CPS from the aqueous systems containing 10^{-5} – $5 \cdot 10^{-4}$ M. The results indicate about 20 % removal CPS with RL-H_3PO_4, and about 30 % uptake of CPS with RL-NaOH from an initial concentration of $5 \cdot 10^{-4}$ M. Removal efficacy decreases rapidly with the increase in the initial CPS concentration. The maximum adsorption capacity of $10.2 \cdot 10^{-3}$ mol/g and $14.5 \cdot 10^{-3}$ mol/g for RL-H_3PO_4 and RL-NaOH, respectively, were obtained within 30 min, at 25 °C, with adsorbent concentrations of 1 mg/mL and initial CPS concentration of $5 \cdot 10^{-4}$ M. The isotherm models were evaluated, and the Freundlich model represented equilibrium data best.

Keywords: *Chlorpyrifos; Adsorption; Activated carbon; Biowaste; Pesticides.*

Acknowledgement

This work was supported by the Ministry for Science of the Republic of Serbia, Grant no. 451–03–9/2021–14/200017

DISC2021
1st DIFENEW International Student Conference
Online event
16th December 2021

LC-MS/MS METHOD FOR DETERMINATION OF SELECTED PHARMACEUTICALS IN UNDERGROUND WATER

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Abstract: The occurrence and fate of pharmaceutical residues in the aquatic environment have attracted considerable attention in recent years. Nowadays, wide range of pharmaceutical compounds and products are used daily as prescription of medicaments by patients, such as analgetic, antibiotics, antiepileptics, β-blockers, lipid regulators and steroid drugs. The residues of these compounds can enter the environment in different ways: for example, during their manufacture, during the disposal of unused or expired drugs, and with human and animal excretion. It goes without saying that monitoring of pharmaceuticals, which can remain in widely various matrices in various compartments of the environment, requires highly sensitive, highly selective, and accurate analytical methods. The performance of analytical instruments has improved dramatically during the last 20 years. Regarding development of analytical methods for pharmaceuticals residues, high performance liquid chromatography with a mass spectrometry (MS) or tandem MS (MS/MS) has also been used extensively. In this study, the high-performance liquid chromatography tandem with mass spectrometry (LC-MS/MS) method for determination of 11 pharmaceuticals in ground water such as: β-blocker: atenolol, lipid regulators: bezafibrate and fenofibrate, analgetics and antipyretics: diclofenac, ketoprofen and ibuprofen, antibiotics: sulfamethoxazole and sulfadiazine, antiepileptics: primidone, carbamazepine was developed. For separation of analytes, gradient elution was applied. Mobile phase was composed of acetonitrile and deionized water acidified with formic acid or acetic acid. Direct injection of the sample was selected with the benefit of fast and simple arrangement with no complicated sample preparation. The MS was operated in positive or negative ionization mode, with at least two transitions for each compound. The proposed method includes the addition of stable isotopically labeled compound to increase accuracy and precision. The developed method was optimized and validated.

Keywords: *Pharmaceuticals; LC-MS/MS; Underground water; Drinking water.*

Acknowledgement

This work was supported by the Slovak Research and Development Agency under the Contract No. APVV-19-0149. The work was supported by the Scientific Grant Agency of the Ministry of Education of the Slovak Republic (VEGA project No. 1/0412/20).

INVESTIGATION OF KEY OPERATIONAL FACTORS IMPACTING PHOSPHORUS REMOVAL AND RECOVERY FROM WWTP

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Abstract: Nutrient and micropollutant removal, as well as resource recovery, are some of the major current concerns in the wastewater treatment field. WWTPs need solutions to quickly tackle these emerging problems and operate as sustainably as possible. Therefore, this research focused on providing insight into some of the major challenges in these fields. Enhanced biological phosphorus removal (EBPR) is a complex process where specific polyphosphate accumulating organisms (PAOs), such as "*Candidatus* Accumulibacter phosphatis", are used for phosphorus removal. A reactor enriched with *Accumulibacter* (>85 %) was operated for over a one-year period, and identification at the sub-clade level was necessary to correlate the specific identity of the *Accumulibacter* group with the observed reactor performance. This work showed that some organisms commonly recognised as PAOs do not promote efficient phosphorus removal and their recharacterization might be needed. Removal of micropollutants is another emerging concern, as some micropollutants such as diclofenac have been shown to be near-recalcitrant in conventional WWTPs and some physical/chemical processes can produce more toxic products than the parent compound. Diclofenac biotransformation, metabolic pathway and toxicity of by-products were investigated in the EBPR process. Although *Accumulibacter* did not appear to transform diclofenac efficiently, it was found to still contribute towards its detoxification. Finally, resource recovery is one of the major initiatives in the wastewater treatment field. WWTPs are no longer seen as just treatment facilities, but also as opportunities to provide other added-value products and more sustainable solutions. Phosphorus is an irreplaceable nutrient and a scarce resource that must be recovered from phosphorus rich waste streams. Biological acidification was tested as an additional step within conventional WWTPs and was shown to have great potential to recover phosphorus and carbon that could be used in subsequent processes to produce phosphorus rich fertilizers or bioplastics, respectively.

Keywords: *Phosphorus removal and recovery, Enhanced Biological Phosphorus Removal (EBPR), Micropollutants, Diclofenac, Waste valorisation.*

Acknowledgement

This work was supported by the Sigma Agile Erasmus scholarship, The WATINTECH international project, The PhosForce international project and the EIT Raw materials Funmat Inno scholarship.

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16th December 2021

DISTRIBUTION TREND OF HYDROCARBON BIOMARKERS IN SEDIMENT AND SOIL SAMPLES: A CASE STUDY OF THE CITY AREA OF BANJA LUKA (BOSNIA AND HERZEGOVINA)

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Abstract: Hydrocarbon pollution is one of the leading global problems with fossil fuels and crude oils, as main sources. Hydrocarbon comopounds that reach the environment undergo through certain transformation and degradation processes, creating relatively thermodynamically stable isomers, known as geological biomarkers or biological markers. In addition, these isomers can be used to determine certain sediment quality parameters. In this study, 12 soil and sediment samples were analyzed fromVrbas river near the city area of Banja Luka, Bosnia and Herzegovina. The focus of this study was to compare the presence and corelation of individual hydrocarbon biomarkers and to determine the source, intensity and degree of possible pollution from samples taken in the city area with sediment samples from the city heating plant. Assisted solvent extraction was used to isolate the total petroleum hydrocarbons (TPH) from all twelve samples. The extracts were fractionated on saturated and aromatic hydrocarbon groups by column chromatography. The fractions were analyzed by gas chromatography – mass spectrometry (GC-MS) equipped with non-polar HP-1ms stationary phase. The GC-MS method identified the presence of *n*-alkanes (*m*/*z* 71), terpanes (*m*/*z* 191) and steranes (*m*/*z* 217) as well as aromatic hydrocarbons (alkylated phenanthrenes and alkylated anthracenes). In order to determine the origin and distribution of hydrocarbons in the samples as well as the degree of microbiological degradation, the following parameters were calculated based on GC-MS results: carbone preference index (CPI) values, pristane/phytane (Pr/Ph) ratios, *n*-C_{17}/Pr ratios and *n*-C_{18}/Ph ratios. Calculated values for CPI ranged from 1.3981 to 2.6383, for Pr/Ph from 0.9601 to 1.2771, for *n*-C_{17}/Pr, from 1.1449 to 3.8451, and for *n*-C_{18}/Pr from 1.1695 to 4.3249. The overall values of the mentioned parameters as well as the dominance of hydrocarbons with odd number of carbon atoms suggest the terrestrial and anthropogenic origin of the pollution. Furthermore, it can be concluded that the microbiological degradation of the organic compouns has occurred, due to the reduced intensity of the peaks for individual hydrocarbons homologous members. Another parameter which indicates the microbiological degradation is the presence of the unresolved complex mixture (UCM) on the chromarograms.

Keywords: *Sediments, Hydrocarbon pollution, Gas chromatography – mass spectrometry, Biomarker analysis.*

Acknowledgement

This work was supported by Slovak Research and Development Agency under contract SK-SRB-18-0020.

BIOMASS CARBON MATERIAL FOR REMOVAL OF CHLORPYRIFOS FROM WATER SAMPLES

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Abstract: Industries using biomaterial produce a lot of biowaste, which pollutes surrounding soil and water. That biowaste can be chemically and physically treated to be converted into carbon material that can be used in environmental protection. This work aimed to synthesize and physically activate carbon material from viscose fibers with desirable properties for the adsorption of chlorpyrifos from water. Viscose fibers were carbonized and physically activated in CO_2 flow. Synthesized material was characterized using: Raman spectroscopy, BET analysis of the material surface, SEM and EDX. The concentration of chlorpyrifos was determined by UPLC analysis. Different concentrations of the carbon material were used to examine its efficiency and potential application in chlorpyrifos remediation. Adsorption of chlorpyrifos in real samples was also investigated. The optimal incubation time required to reach adsorption equilibrium was determined by recording UPLC chromatograms after different chlorpyrifos and carbon material contact periods. The adsorption rate constant was determined using the Guggenheim method. To examine whether more toxic products are formed during the process, a toxicity assessment was performed by measuring the acetylcholinesterase activity in samples with and without carbon material in the presence of chlorpyrifos. Synthesized carbon material showed a high level of graphitization and a significantly ordered structure with a relatively large specific surface area and total pore volume. Despite carbonization, viscose fibers retained their primary structure. The increase of adsorbed concentration of chlorpyrifos with the increase of the concentration of carbon material has been noted. Furthermore, the toxicological analysis showed a decrease in the toxicity of treated aqueous solutions compared to non-treated samples. Thus, it confirms that there was no formation of more toxic products. The investigated material showed the best adsorption efficiency for chlorpyrifos concentration $1 gdm^{-3}$. The adsorption was also efficient in real samples.

Keywords: *Biowaste; Chlorpyrifos; Adsorption; Water remediation*

Acknowledgement

This work was supported by the Ministry for Science of the Republic of Serbia, Grant no. 451–03–9/2021–14/200017.

DISC2021
1st DIFENEW International Student Conference
Online event
16th December 2021

CIRCULAR ECONOMY IN ARCHITECTURE

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Abstract: The emergence of the industrial revolution in the 19th century and the introduction of new technologies left far-reaching consequences on all segments of society (economic, political, cultural and others). Faced with the effects of his way of life-mass production and consumption, uncontrolled consumption of energy and fossil fuels, man begins to change his habits. Once launched, the creative process and technological shift towards sustainable development has unstoppably continued to permeate all spheres of humanity. That is how architecture came next. The construction of facilities has been proven to harm the environment. About 30 % of all raw materials used by mankind go to processes related to the use of construction materials. It is not only a task, but also a responsibility for the architect to contribute to the reduction of such negative influences that come from construction materials through his work through practice. At the global level, the circular economy and its application in architecture are recognized as important determinants whose respect and application determines the path to sustainable development. In the circular economy, products are designed for easy reuse, disassembly or adaptation and recycling, with the understanding that reusing already used materials, rather than extracting new resources, is the foundation of economic growth. By researching the architectural world practice that integrates the principles of circular economy, two basic paths can be noticed that start from completely opposite starting points, and give the same or similar results. Circular architecture can be found in both developed and underdeveloped parts of the world as: modern architecture – which seeks to reduce waste by dividing materials-related processes into technical and biological cycles; and traditional architecture – which does not know technology, so it easily fits into natural trends. This paper explains the concept of circular economy, principles and the way of application in architecture through the analysis of concrete examples from the world architectural practice.

Keywords: *Circular economy; Architecture; Recycling; Materials; World architectural practice.*

THE PERFORMANCE OF NEWLY SYNTHESIZED NANOMATERIAL FOR DECOMPOSITION OF PHARMACEUTICAL MIXTURE

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Abstract: Residues of active pharmaceutical ingredients are continuously introduced into environmental compartments through various pathways due to extensive use for human and veterinary purposes. Advanced oxidation processes (AOPs) are specifically explored and applied to remove pollutants that are highly chemically stable or resistant to complete mineralization in conventional treatments, such as biological treatments. Evaluation of the effect of individual pharmaceutical components is very complex in the presence of other pharmaceutical compounds. Organic microcontaminants are always present in the mixture in aquatic recipients. The complex nature of pharmaceuticals poses a danger to aquatic organisms. Long-term exposure to pharmaceutically active components can lead to various types of anomalies for non-target species. To assay efficiency of photocatalytic treatment, the mixture of four non-steroidal anti-inflammatory drugs (ketoprofen, diclofenac, naproxen, and ibuprofen) was selected. To provide a new nanomaterial mixture, the starting precursors zinc oxide and indium oxide (ZnO/In_2O_3) were synthesized in three simple steps in molar ratio 2:1. The synthesis involved the application of an eco-friendly mechanochemical solid-state method without demanding the usage of toxic chemicals. The variation in pharmaceutical concentration (from 2 mg/L to 10 mg/L) with 0,40 mg/mL of photocatalyst was examined under laboratory conditions. As a source of irradiation, the 125 W high-pressure mercury lamp (Philips, HPL-N, emission bands in the UV region at 304, 314, 335, and 366 nm, with maximum emission at 366 nm) was used. In the case of application of the highest concentrations (from 8 to 10 mg/L), the percentage decrease in degradation rate (k) for naproxen was 80 % and 81 % for individual values (from k~ 0,041(4) to 0,0080(4) min^{-1} and from 0,027(0,00237) to 0,0050(3) min^{-1} for 8 and 10 mg/L, respectively). By assessing the degradation efficiency of individual pharmaceuticals in the mixture, ibuprofen proved to be the most resistant pollutant.

Keywords: *Photocatalysis; Pharmaceuticals; Wastewater; Cocktail effect; Nanomaterials.*

Acknowledgement

This work was supported by the Government of Vojvodina (Project no. 142-451- 2387/2018-01/01) and by the Ministry of Education, Science and Technological Development (contract no. 337-00-107/2019-09/16) and Slovak Research and Development Agency (contract no. SK-SRB-18-0020).

MANGANESE REMOVAL FROM WATER USING COMBINATION OF DIFFERENT COST-EFFECTIVE METHODS

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Abstract: Natural renewable water resources are endangered on a daily basis by anthropogenic activities, especially industry, mining and agriculture. In order to preserve natural waters as well as to ensure sufficient quantities of healthy water for human consumption, and for industrial use, increasingly strict criteria for water quality are being set. Although the manganese and iron are naturally present in aquatic environment, their increased concentrations in water can cause serious problems. They significantly influence the organoleptic properties of water, tint industrial products, and cause a number of technological problems due to formation of slimy and gelatinous biomass. Therefore, to meet certain quality requirements of water, an effective and environmentally friendly methods of water purification are necessary. A number of methods are used to remove manganese and iron from water such as oxidation, chemical precipitation followed by filtration, and adsorption/ion exchange which are often limited by high costs. However, the use of low-cost sorbents such as natural zeolites makes their use more cost-effective. Current research is focused on manganese removal from an aqueous solution of concentration 19.91 mg/L by a combination of aeration, chemical precipitation with lime at pH = 8.5, coagulation/flocculation followed by filtration, and sorption on the natural zeolite clinoptilolite by batch process. By applying combination of cost-effective methods, the overall manganese removal up to ≈ 50 % was achieved, with a residual concentration in the range 5.02 - 9.78 mg/L. Optimal results were achieved by 1 h aeration with chemical precipitation, and subsequent 40 min sorption onto natural zeolite at solid/liquid ratio of 2 g/50 mL. For reducing manganese concentration below the required level of 0.05 mg/L in water for human consumption, future studies should be focused onto aeration with alkalinisation at pH ≥ 9.5 and subsequent multistage sorption on the natural zeolite by batch and/or column method.

Keywords: *Manganese; Aeration; Chemical precipitation; Sorption; Natural zeolite clinoptilolite.*

DEVELOPMENT OF DIGITAL APPROACH FOR OCCUPATIONAL HEALTH AND SAFETY SYSTEMS IN HIGHER EDUCATION COURSES – PROJECT OVERVIEW

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Abstract: Professional entering the workforce need to develop the necessary occupational health and safety (OHS) skills, knowledge and attitudes. This need is even more evident for OHS engineers and analytical chemists who will have legal duties regarding the design, planning and execution of different workplaces and working conditions. As there has been less activity regarding the development and implementation of education courses in the field of OHS at university-level and because it presents some special challenges, and the types of teaching methods traditionally used, the sharing of experiences and resources at the university level is particularly important. The overall objective of Project DOHASS is developing digital capacities of higher education institutions in the field of occupational safety and health in order to provide high quality online and distance learning lessons and practical exercises. The Project will result in openly accessible educational resources, textbooks and online educational platform, which will contain lessons, laboratory and field exercises in different languages (Serbian, Slovak, Czech, and English). Moreover, the DOHASS is designed to develop and modernize courses, which could be used after the pandemic crisis, providing high quality, digital content and multilingual learning material needed for developing the competences of future occupational health and safety experts. The transnational implementation of the Project will bring harmonization of the teaching approach in partner universities and will support the strengthening of organizational and internal institutional capacities, sharing knowledge among partners and promote innovate solutions in higher education of occupational health and safety.

Keywords: *occupational safety and health; digital capacities; distance learnig; educational platform*

Acknowledgement

Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or European Education and Culture Executive Agency (EACEA). Neither the European Union nor the EACEA can be held responsible for them. Grant agreement number 2020-1-RS01-KA226-HE-094562. The work was partially supported by the Ministry of Education, Science and Technological Development through the project no. 451-03-68/2020-14/200156: "Innovative scientific and artistic research from the FTS (activity) domain".

USING OF LEMNA MINOR FOR POLLUTED WATER TREATMENT

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Abstract: Aquatic macrophytes are considered to be promising biological objects for wastewater treatment from heavy metal ions, in particular iron, nitrates and phosphates, due to their high ability to remove these contaminants. The most promising aquatic macrophyte is *Lemna minor*, which can effectively remove iron ions from water, resistant to temperatures below 10 °C, is a free-floating plant with one of the fastest growth rates and doubling time every 5 – 6 days. The aim of the work is to improve the biotechnology of wastewater treatment using *Lemna minor* to increase the efficiency of removal of iron ions. Duckweed is considered as a biological agent for surface and wastewater treatment, capable of high accumulation of iron compared to other aquatic plants up to 7.5 mg/g of dry biomass. Based on theoretical analysis, the mechanisms of removal of iron ions from aqueous solutions by higher plants is based on the enzymatic reduction of trivalent iron to divalent and its transport into the cell by a carrier protein. Stimulating factors of the mechanism of transport and accumulation of iron ions by duckweed were revealed: duration of daylight 12 h and more; illumination from 3000 lux, while the accumulation of iron ions increases by 30 % compared to conditions without illumination. Sulfates in concentrations above 80 mg/dm^3 have a stimulating effect on the expression of genes that affect the synthesis of transport proteins in plants, which increases the accumulation of iron ions in plant tissues. From the obtained results it is possible to recommend the value of duckweed biomass in the development of wastewater treatment technology from iron compounds – 25 ± 1 g/dm^3, because at a rational duration of 8 h, for such biomass the concentration of iron ions in treated water was the lowest – 1.9 mg/dm^3.

Keywords: *Duckweed; Lemna minor; Wastewater; Metal ions.*

RISK ASSESMENT OF DANUBE WATERCOURSE POLLUTION BY WRASTIC METHOD

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Abstract: Emerging substances, EmS, are pollutants that can potentially adversely affect health and are not currently included in routine monitoring programs within the European Union as well as biomonitoring programs. According to the development of modern analytical methods, numerous EmS have been detected in aqueous media in concentrations ranging from a few nanograms per liter to a few micrograms per liter over the past few decades. Due to the different effects of EmS on the environment and the human health, it was necessary to establish methodologies for prioritizing EmS both in the risk assessment of EmS on environmental media and in the selection of substances in monitoring plans. The WRASTIC method was used in this research with the aim to assess the susceptibility to pollution of the surface water basin of the Danube River under the influence of municipal wastewater in Novi Sad. The calculation of the parameters of the WRASTIC method is initially based on the knowledge of the main characteristics of the basin as well as the way of using the land of the observed watercourse. By calculating the parameters, precise data on the water quality of water courses, the classification of the way of using water resources and risk assessment of watercourse pollution of the observed basin could be obtained.

Keywords: *emerging substances; Novi Sad; water quality, WRASTIC index*

Acknowledgement

This work was supported by NATO Project DriWaQ-NS (ESP.EAP.SFP 984087) and Ministry of Education, Science and Technological Development, Republic of Serbia, through the project no. 451-03-68/2020-14/200156: “Innovative scientific and artistic research from the FTS domain”.

COMPUTER-BASED SIMULATION OF CORROSION OF OIL PIPELINES

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Abstract: During the life cycle, the structural elements of oil pipelines are exposed to various chemical, physical and biological influences that can cause their corrosion damage. As a result of corrosion, accidents such as fire, explosion, and toxic release can occur at oil pipelines, resulting in casualties, economic losses, and environmental problems, thus reducing the sustainability of pipeline transportation. To ensure the environmental and economic sustainability of the pipeline designing and selecting the best available systems and materials for pipelines and their corrosion protection systems is an important issue for the oil industry. This paper aims to study the corrosion process of mild steel in oil pipeline as different process parameters are simulated. FREECORP™ 2.0 corrosion prediction software was used for the simulation. The main features of this model include: prediction of corrosion rate caused by CO_2, H_2S, organic acids, i.e. CH_3COOH, and/or O_2, simulation of iron carbonate film and iron sulphide film growth and identification of major corrosive species by quantifying respective contributions from various species. The main parameters are temperature, time, pressure, pipe diameter and liquid velocity. The parameters of the aqueous solution are pH and concentration of corrosive species such as carbon dioxide, hydrogen sulphide, acetic acid, oxygen and concentration of Fe^{2+} ions. Based on specific input parameters, the uniform corrosion rate was calculated and the contribution of corrosive species to overall corrosion rate was determined.

Keywords: *Pipeline corrosion; Mild steel; Mechanistic model; Corrosion prediction.*

WASTEWATER-BASED EPIDEMIOLOGY – A NEW METHOD OF COLLECTING DATA ON STIGMATIZED HUMAN ACTIVITIES

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Abstract: The analysis of wastewater for concentrations of diverse trace substances and organisms, from chemicals and nutrients to biological agents and pathogens, has been used as an environmental and analytical tool for decades. The primary focus of analyses has been the determination of concentration levels for substances entering the wastewater treatment process, to monitor removal efficiencies of WWTP, and/or to evaluate wastewater effluent as a point source for environmental contamination. In recent years, Wastewater-based Epidemiology (WBE) has been solidified as a favoured methodology for providing real-time data on the utilization of drugs and habits of the human population. The complex matrix, such as wastewater generated in urban areas with a high load of adverse substance (a.k.a. bio-chemical markers of human activity), can be used as a reliable source of information and data, free of the stigma associated with illegal activities of the human population. Relationships between the concentrations in wastewater and population-scale use, consumption, or exposure rates can provide valuable qualitative or quantitative data within a given wastewater catchment area for a diverse group of bio-chemical markers (licit/illicit drugs, pharmaceuticals, industrial chemicals, infectious diseases or pathogens, and antibiotic resistance, etc.). The collected data can be used to provide information on licit and illicit drug use; illegal and uncontrolled disposal of industrial waste and release of industrial wastewater, etc. WBE is an emerging methodology used for normalization of analyte influent concentrations to per-capita mass loads utilizing flow and wastewater catchment area. WBE can provide reliable data on stigmatized human activities and habits, as it enables community-level assessment of chemical or biological compound per-capita consumption, exposure, and/or emission. Wastewater-based epidemiology as an assessment and data collection methodology has significant application possibilities in a wide variety of complex research areas of environmental engineering and other complex fields.

Keywords: *Wastewater-Based Epidemiology; Illicit drugs; Bio-markers; Stigmatized human activities.*

Acknowledgement

This work was supported by IPA7 Project and the Ministry of Education, Science and Technological Development Project no. 451-03-68/2020-14/200156: “Innovative scientific and artistic research from the FTS (activity) domain”.

DIGITALIZATION OF LABORATORY EXERCISES IN THE CLASSICAL AND INSTRUMENTAL ANALYTICAL CHEMISTRY – PROJECT OVERVIEW

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Abstract: In pandemic time, due to COVID-19, educational methods have mostly consisted of and relied on distance learning. On-line lectures and seminars can be a useful tool in teaching, but some of the subject that are taught are hard to explain and to acquire knowledge only using this form of teaching. For instance, integral part of universities that teach chemical sciences, natural sciences, environmental sciences, pharmacy, medical sciences, veterinary, food and agrochemistry are laboratory exercises, that improve students' skills and give them opportunity to perform their own experiments. This type of exercises is one of the crucial and unreplaceable parts for students of experimental disciplines. Digital and on-line approach for laboratory, but also field exercises is complex, complicated and their availability is scarce. Project *Digitalization of laboratory exercises in the classical and instrumental analytical chemistry (DigiLabAC)* has gathered four universities from Slovakia, Czech Republic, Slovenia and Serbia with the aim of developing web platform for students, containing manuals, audiovisual materials and computer simulations for sampling, laboratory tasks from classical analytical chemistry, separation, electroanalytical and spectrometric methods. All of materials will be provided in five languages: English, Slovak, Slovenian, Czech and Serbian. At the same time, a virtual laboratory will be created, with the possibility to generate laboratory tasks for various number of students for successful completion of a virtual laboratory exercise. The developed materials will be possible to use at all universities with this form of experimental exercises, whether in full form as a digitalized platform for teaching, or as supplementary materials for lectures and seminars.

Keywords: *analytical chemistry; laboratory exercises; pandemic; distance learning*

Acknowledgement

This work was supported by Erasmus+ Project "Digitalization of laboratory exercises in the classical and instrumental analytical chemistry" - DigiLabAC (agreement number: 2020-1-SK01-KA226-HE-094322).

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POLLUTION POTENTIAL OF URBAN TRANSFORMATIONS ON UNDERGROUND AQUATIC SYSTEMS IN NOVI SAD, SERBIA

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Abstract: Urban transformations are key indicators of city progress and development. Novi Sad as developing city is constantly growing and evolving, which can be determined by numerus active construction sites. Irreversible and hazard effect on the whole environment can be caused by urban transformations if they are not managed properly. Terrain configuration in the wider area of Novi Sad enables underground water levels to be very high and close to the surface. Pollution of water sources occurs when toxic substances end up in aquatic medium and it can be visible on the surface, deposited on the bottom or dissolved. Construction activities often involve the use of toxic chemicals and pollutants that can easily end up in the aquatic medium as result of drainage, seeping into soil and runoff. Common sources on construction sites that can inflict direct hazard effect on environment through pollution of underground aquatic systems are diesel and oil, cement, glues, paints and other toxic chemicals. Once polluted underground aquatic systems can disrupt the entire ecosystems. This paper examines potential that active urban transformation areas in larger Novi Sad zone possess to pollute underground aquatic bodies and disrupt existing biotic and abiotic systems.

Keywords: *Construction sites; Aquatic pollution; Urban transformations; Environmental protection.*

Acknowledgement

This research has been supported by the Ministry of Education, Science and Technological Development through the project no. 451-03-68/2020-14/200156: “Innovative scientific and artistic research from the FTS (activity) domain”.

ADSORPTION OF MALATHION ON CARBON MATERIALS DERIVED FROM BIOMASS IN AQUEOUS SOLUTION

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Abstract: Organophosphate compounds are mainly used as pesticides and pose a global threat to the environment and humans. Therefore, it is important to examine the possibilities of removing malathion from aqueous solutions. Viscose-based activated carbon material was successfully used for malathion removal from water. A detailed characterization of material properties was performed by several physico-chemical methods, such as Raman spectroscopy, BET analysis of material porosity, SEM and EDX. Experimental measurements of malathion adsorption efficiency on the characterized material were also performed. The adsorption of malathion was monitored under static and dynamic conditions and at different temperatures. From the obtained results, the parameters of adsorption isotherms were determined. Those parameters indicated that physisorption is more dominant than chemisorption under all examined experimental conditions. Regarding the influence of temperature, it can be concluded that the highest adsorption efficiency was at a temperature of 25 ^{0}C. Comparing the results obtained under dynamic conditions with the results under stationary conditions, it was shown that it is very efficient and convenient to perform malathion remediation from water under dynamic conditions, primarily because of the speed, efficiency and economy. The changes in the toxicity of the treated samples were monitored by measuring the activity of the AChE enzyme using the Ellman assay. Toxicity assessment showed a reduction in the toxicity of the aqueous solution under all investigated conditions, which means that this process does not generate more toxic products harmful to humans and the environment.

Keywords: *Organophosphates*; *Adsorption*; *Malathion*; *Carbon material*.

Acknowledgment

The authors acknowledge the support provided by the Serbian Ministry of Education, Science and Technological Development (Contract number: 451-03-9/2021-14/200017).

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1st DIFENEW International Student Conference
Online event
16th December 2021

IMPORTANCE OF RISK IDENTIFICATION FOR THE PROCESS OF BUILDING WASTEWATER TREATMENT PLANTS IN SERBIA

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Abstract: Before joining the European Union, Serbia faces a big task related to the treatment and purification of wastewater. The capital of Serbia, Belgrade, and some larger cities do not have wastewater treatment plants (WWTP). Although there are no plants in larger cities in Serbia, but they still exist on the territory of the state itself. However, either they are not in good condition, or they do not work with the projected capacity, or they do not work at all. There is no such thing as risk register for building of WWTP in Serbia. It is obviously that it is important to identify risks for process of building WWTP in Serbia in risk register. Projects for facilities like WWTP are extremely complex and require the participation of different types of engineers, spatial planners, and urban planners. Risk identification is important because of defining of potential problems and necessary actions to be taken to reduce the likelihood of adverse events or to reduce the negative impact on the project. Risk analysis and recognition should be a mandatory part of the project management process, but there is no proper risk register for wastewater treatment plants, and any recommendations. If a register were to be created, it would make it easier to make important decisions at certain stages of the project. Recognizing the risks that can lead to harmful effects for the project, analyzing possible harmful consequences and preparing responses to them takes place continuously throughout the lifespan of the project. The greatest responsibility is for risk identification, analysis, and response to them on the investor and his team. Since Serbia will have many projects of WWTP in the future, all the above leads to the conclusion that it is really important to identify the risks for building of these plants.

Keywords: *Risk, Risk register, Wastewater Treatment Plant.*

Acknowledgement

This work was supported by Faculty of Technical Sciences, within the project "Multidisciplinary theoretical and experimental research in education and science in the fields of civil engineering, risk management and fire safety and geodesy" conducted by the Department of Civil Engineering and Geodesy.

MULTI-STAGE LANDFILL LEACHATE TREATMENT USING CHEMICAL PRECIPITATION, AERATION AND FENTON PROCESS

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Abstract: In the presence of moisture, decomposition of disposed waste occurred whereby landfill leachate of complex chemical composition are formed, depending on the type and age of waste. Percolation of rainwater through the body of the landfill leads to the migration of leachate into the soil and groundwater, causing a significant impact on the environment. Contrary to this, controlled disposal of waste in so-called sanitary landfills is extremely important, where generated leachate is much easier to manage before discharging into the surface waters or sewage systems. Therefore, the purpose of this paper was the physico-chemical characterization of leachate from the sanitary Bikarac landfill and its treatment using chemical precipitation by lime, aeration and Fenton process. The initial sample is characterized as dark brown, pH = 9.06; Biological oxygen demand, BOD_5 = 22.12 mgO_2/L; Chemical oxygen demand, COD = 1,753.66 mgO_2/L; Kjeldahl nitrogen, K-N = 264.32 mgN/L and ammonia nitrogen, NH_3-N = 191.47 mgN/L. According to the Croatian law the parameters of COD, K-N and NH_3-N are above prescribed values for leachate discharge into the both, natural surface waters and sewage systems. After the implementation of chemical precipitation and aeration, only the COD was above the prescribed values and treated leachate cannot be discharged into the sewage systems. Furthermore, the influence of pH, concentration of Fe^{2+} and H_2O_2, and molar concentration ratio of Fenton reagents (Fe^{2+}:H_2O_2) on the decreasing of COD values was also investigated. The most effective decreasing of COD using Fenton process in the amount of 40 % was achieved under optimal process conditions: pH = 3, Fe^{2+} : H_2O_2 = 1:20, and concentration of 9 $mgFe^{2+}$/L. By applying the Fenton process, conditions were achieved only for the discharge of treated leachate into sewage systems.

Keywords: *Landfill; Leachate; Aeration; Chemical precipitation; Fenton process.*

Acknowledgement

We would like to thank Bikarac d.o.o. Šibenik, Croatia for collection of leachate samples.

SINGLE DROP MICROEXTRACTION AS AN EFFECTIVE TOOL IN PESTICIDE DETECTION IN WATER AND MILK SAMPLES

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Abstract: Complex samples represent a challenge in the effort to determine residues of harmful organic compounds at trace/ultratrace levels. Modern research trends are directed to the development of single comprehensive methods applicable for a wide range of substances with a single extraction in various matrices or a solvent minimized extraction at microscale level. Considering low levels of pesticide residues, the determination of these chemicals often requires extensive sample extraction and purification prior the instrumental analysis. Solvent-based microextraction methods are the emerging field of study which will provide inexpensive and solvent-minimized analysis of a wide range of analytes. Miniaturization and solvent-minimized operation are the important advantages of these techniques. In liquid-liquid microextraction techniques, extraction normally takes place between a small volume of a water-immiscible solvent and an aqueous phase containing the analytes of interest. The volume of the receiving phase is in the microlitre or submicrolitre range. Single drop microextraction (SDME) became one of these popular techniques. The contribution is devoted to the development of a new eco-friendly analytical method used for detection of multi-pesticide residues in water and milk samples. Binary solvent single drop microextraction in direct immersion mode was examined for isolation of pesticides from samples. The influence of selected parameters (extraction solvent, volume of extraction solvent, stirring rate and time of extraction, addition of sorbents) was the subject of examination.

Keywords: *Pesticide residues; Single drop microextraction; Dual solvent microdrop; Water samples; Milk samples.*

Acknowledgement

This work was supported by the Slovak Research and Development Agency under the Contract No. APVV-19-0149. The work was supported by the Scientific Grant Agency of the Ministry of Education of the Slovak Republic (VEGA project no. 1/0412/20).

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Online event
16th December 2021

ADSORPTION MECHANISM OF 3-(4-METHYLBENZYLIDENE) CAMPHOR ON DEGRADABLE AND NON-DEGRADABLE MICROPLASTICS IN WATER

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Abstract: Microplastics defined as plastic particles with sizes smaller than 5 mm, are considered an emerging global environmental concern. It has been indicated that microplastics interact with multiple chemicals, organic or inorganic contaminants. 4-Methylbenzylidene camphor (4-MBC) is one of the most commonly used organic UV filter with reported studies of its toxicological and adverse effects. 4-MBC can be transported into the aquatic environment by its direct release in the aquatic environment from everyday activities, through the domestic wastewaters during bathing and clothes washing. Preliminary studies indicated sorption affinity of 4-MBC toward different types of microplastics. Therefore, the main scope of this study was to understand the adsorption mechanism of 4-MBC on granulated polyethylene-PEg, polyethylene terephthalate-PET, polypropylene-PP and polylactic acid-PLA. The adsorption mechanism of 4-MBC on microplastic was determined by using five sorption isotherm models, Freundlich, Langmuir, Temkin, Dubinin-Radushkevich, and Redlich-Petersen. Based on the obtained results for adsorption of 4-MBC on PEg, PET and PP Langmuir adsorption model fitted data better indicating that adsorption of the 4-MBC occurs at a specific site on the microplastics, with no further adsorption occurring at the same site. Maximum adsorption capacities determined by the Langmuir model also indicated that phisyco-chemical properties of the selected types of microplastics have an important impact on adsorption behaviour of 4-MBC. Therefore, the highest adsorption capacity was determined for PET (q_{max}=16.6 μg/g) and the lowest for PEg (q_{max}=9.36 μg/g). On the other hand, for adsorption of 4-MBC on PLA, Freundlich model gave better correlation results indicating that both monolayer and multilayer sorption process takes place on the heterogeneous surface of a sorbent. The results of this study also indicated that microplastics can act as a transport vector for 4-MBC through freshwater bodies.

Keywords: *Microplastics; UV filters; 4-Methylbenzylidene camphor; Adsorption; Water.*

Acknowledgement

The authors acknowledge financial support of the Ministry of Education, Science and Technological Development of the Republic of Serbia (Grant No. 451-03-9/2021-14/200125).

MODEL FOR ESTIMATION OF QUANTITIES OF ASBESTOS AND IMPROVEMENT OF ASBESTOS MANAGEMENT IN SERBIA

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Abstract: The main goal was to define a methodology for determining the amounts of asbestos waste generated in the previous period and which will be generated in the future. The quantity prediction model was developed through the analysis of annual asbestos consumption and assessment of historical consumption, considering different types of asbestos products, analysis of the share and life expectancy of asbestos products and formulation of asbestos waste generation patterns. Monte Carlo analysis was used to define the sensitivity of the model. An additional goal of the research was to set up an algorithm of procedures and phases for the removal of asbestos-containing material, adapted to the waste management system in Serbia. The model of the improved methodology for safety at work when handling asbestos was developed on the current scientific knowledge on the impact of asbestos on the health of the working and general population, ways of exposure and efficiencies of various applied measures. asbestos was managed in a safe manner. Priorities and specific steps in the removal of asbestos-containing materials have been identified, with the aim of managing asbestos safely. The results provide a primary assessment of the flows and stocks of asbestos and its waste in the Republic of Serbia and can be the basis for implementing an optimal asbestos waste management system to minimize the negative impact on human health, through the selection of appropriate technologies and management procedures. Also, results can be of great importance for decision makers in this area and significantly contribute to the selection of appropriate guidelines for the establishment of adequate asbestos management in Serbia from the aspect of safety at work.

Keywords: *Asbestos, Asbestos waste, Model, Safe work.*