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DEPARTMENT OF ENVIRONMENTAL ENGINEERING AND OCCUPATIONAL SAFETY AND HEALTH

ABSTRACT BOOK

2nd DIFENEW INTERNATIONAL STUDENT CONFERENCE

Faculty of Technical Sciences,
University of Novi Sad

Hybrid event
December 6th 2022
Novi Sad, Serbia

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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

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PREFACE

On behalf of the Scientific and Organizing Committees, it is my pleasure to present the Abstract book of the 2nd DIFENEW 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 within International Student Conference DISC2022, which was held in hybrid mode on 6th December 2022. DISC2022 was organized by the Department of Environmental Engineering and Occupational Safety and Health, Faculty of the Serbian-Slovak Bilateral Project "*Microplastics impact on occurrence of plasticizers in surface water and effects on human health - PLASTICINE*". The Project is supported by the Ministry of Education, Science and Technological Development of Serbia and Slovak Research and Development Agency.

DISC2022 conference was a multidisciplinary forum where the research results in the field of Environmental Engineering, Environmental Monitoring, Environmental and Health Risk Assessment, Occupational Health and Safety, Sustainable Environmental and Occupational Health and Safety Project Management and Civil Engineering were shared between students and their professors from the entire world. At the same time, the event was the place for the promotion of the PLASTICINE results to a wider audience.

Since the main objective of DISC2022 is to encourage young researchers to exchange ideas and experiences, to present the results, raise the knowledge, and to expand scientific and professional networks, it is my great pleasure to inform you that, once again, a record number of abstracts was submitted. Moreover, this year, for the first time we had the special session dedicated for the presentation of ongoing projects and future events.

I would like to express my sincere thanks to all members of Scientific and Organizing committees, session chairs, presenters, projects coordinators as well as to many others who contributed to the success of DISC2022.

We are confident that the solid foundation created by the DIFENEW and PLASTICINE projects will continue to build up and strengthen the unique international network of young students, colleagues and experts.

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In Novi Sad, December 2022 Dr. Maja Petrović

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ABSTRACTS

TABLE OF CONTENTS

CIVIL ENGINEERING

OCCUPATIONAL HEALTH AND SAFETY

ENVIRONMENTAL AND HEALTH RISK ASSESSMENT

ENVIRONMENTAL MONITORING

ENVIRONMENTAL ENGINEERING

SUSTAINABLE ENVIRONMENTAL AND OCCUPATIONAL HEALTH AND SAFETY PROJECT MANAGEMENT

CIVIL ENGINEERING

DISC2022 – 2nd DIFENEW International Student Conference

6th December 2022

ARCHITECTURAL VALORIZATION OF THE TRADITIONAL RURAL HOUSE IN NOVO BRDO, KOSOVO AND METOHIJA

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Abstract: This paper deals with the architectural analysis of certain typologies of traditional dwelling architecture in the Paralovo village in the municipality of Novo Brdo in the eastern part of Kosovo and Metohija. The goal of the study is to explore the literature and, through the situation on the spot, find and document examples of traditional family houses. The historic development of the settlement is described in the first section of this paper. Furthermore, one typology of houses is singled out, and photographs of the existing condition and technical drawings that are made are being used as a base for an architectural analysis of form and spatial organization. Finally, in order to offer a suggestion for revitalization and contemporary interpretation in upcoming architectural designs as a method of preserving the region's architectural identity, the research also illustrated construction principles and used materials.

Keywords: *Rural Traditional Architecture; Architectural Identity; Novo Brdo; Kosovo i Metohija.*

DISC2022 – 2nd DIFENEW International Student Conference

6th December 2022

DYNAMICS OF THE DIVIDED CITY, KOSOVSKA MITROVICA

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Abstract: Over the centuries, the territory of today's Kosovska Mitrovica, later settlements and eventually the city, was under the rule of different political entities, as well as different administrative orders, which significantly affected its geopolitical position. Kosovska Mitrovica is a city in the north of Kosovo and Metohija, divided by the river Ibar into two parts, the southern and northern parts. Today, Albanians live in the southern part, Serbs in the north, with the exception of some settlements where the population is multi-ethnic. In a broader sense, the subject of the work is the creation of personal dynamics with the dynamics of space through searching and documenting the specifics of cause-and-effect and/or other connections between Kosovska Mitrovica, as a specific city in a conflict area on the one hand, and the personal "world" of students on the other. The goal of the research included in this work is to look at the everyday life of students and connect their feelings with the dynamics of the space in which they are, in an environment that is crisis, multi-ethnic, insecure and risky as far as security is concerned, while at the same time it provides various pleasures (learning, socializing, festivals, concerts, restaurants, cafes, art exhibitions). The time frame covered by the work is 10 years, more precisely the period from 2011 to 2021. The research was conducted using the method of comparative analysis of certain political, socio-economic changes that occurred in the subject area and influenced its transformation, as well as the analysis of the bridge as a space where conflict situations were most reflected, and the analysis of personal dynamics expressed in the same period. The work is based on the basic thesis that the war and post-war conflicts influenced both the transformation of Kosovska Mitrovica and its slow urban development, as well as the personal dynamics of its inhabitants.

Keywords: *Kosovska Mitrovica; Dynamics of Space; Personal Dynamic; Divided City; Bridge.*

DISC2022 – 2nd DIFENEW International Student Conference

6th December 2022

PROPERTIES OF GREEN CONCRETE WITH REDUCED CEMENT AND HIGH LIMESTONE POWDER CONTENT

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Abstract: Rational use of resources, recycling and reusing waste materials, energy efficiency, as well as reducing environmental and social impact in the construction sector, are the fundamental aspects of the obvious commitment to sustainable development. Within the concrete industry, which is the most dominant part of the construction sector, one of the biggest obstacles to a sustainable development path is cement production. Regardless of the constant improvement of technology and increasing efficiency, about 7-8% of total CO_2 emissions of anthropogenic origin are due to the cement production. With this in mind, the application of alternative and environmentally preferential materials, such as limestone (LS) powder, for partial replacement of Portland cement (OPC) can make a significant global contribution toward sustainability. The paper presents relevant properties of green concrete with reduced cement and high LS powder content, in a fresh (workability) and hardened (compressive strength) state, as well as rheology (creep, shrinkage) and durability (carbonation). Also, the sustainability aspect of this type of concrete is considered. A detailed understanding of these properties can play a key role in a wide practical application, in order to take advantage of all the positive effects, and eventually, reduce negative ones. The conducted analyses undoubtedly show the great potential and competitiveness of green concrete with reduced cement and high LS powder content and their potential application in all types of reinforced concrete structures. At the end, recommendations for further research are proposed.

Keywords: *Green Concrete; Limestone Powder; Mechanical Properties; Durability; Sustainability.*

Acknowledgement

This work was supported by the Ministry for Education, Science and Technology, Republic of Serbia (grant number TR36017); this support is gratefully acknowledged.

ADVANCED TECHNOLOGIES DEFINING THE RELATIONSHIP BETWEEN ARCHITECTURE AND ENVIRONMENTAL PROTECTION

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Abstract: The beginning of the 21st century has introduced and made available amazing advanced technologies to general population, which led the way to the 4th industrial revolution – 4IR. Digitalization of processes and operations has unlocked whole new dimension of competitiveness and creativity in all areas of human domain. The globalization treats are emphasized with the 4IR through digitalization. The utilization of advanced technologies implements core principles of inter/multi-disciplinarity in sciences and research. Architectural engineering requires implementation of technologies essential for creating comfortable and safe environments including the following infrastructure necessary for human civilization to function in 21st century. Engineering technologies and tools are employed to depict city development and connect it in interactive functional maps. Architecture in 21st century must be understood as the Petri dish in which human life and culture is developed by combining products of art and engineering in defining safe, beautiful and functional spaces. Inclusion of environmental protection principles in architectural Petri dish mix is the final piece of the puzzle called the circular economy and architecture. The relations between architecture and environmental protection are interconnected by unbreakable bonds and defined within the utility of the advanced technologies introduced by 4IR.

Keywords: *Advanced Technologies; Environmental Protection; Architecture; 4IR.*

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”. Mentor of this research for PhD thesis is Prof. emeritus Mirjana Vojinović Miloradov.

DISC2022 – 2nd DIFENEW International Student Conference

6th December 2022

ECOLOGICAL RISKS IN THE PRELIMINARY RISK ASSESSMENT MODEL FOR WASTEWATER TREATMENT PLANTS DESIGN

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Abstract: The preliminary risk assessment model was made as a unique result of the PhD research. This research was conducted with the Delphi method through three rounds. In this research, experts from different fields connected with the wastewater treatment process participated in evaluating and quantifying identified risks in the research. Risks were divided into six groups, and one of the groups was ecological risks. This group identified two risks which were that the location of the plant is not adequate in terms of environmental protection (ecosystem disturbance) and the location of the plant is not adequate in terms of distance and position from the populated place. During the literature research and analysis of finished projects, the ecological risks stood out as the risks with a high impact on the environment and public health. But there were no proven data to assume this state. The conception of the research focused on the expert's evaluation of the risks. They quantified every group of risks. For this, the Likert scale was used, and they could give marks from 1 to 5 for risks. After the quantification process, the statistical method was used, and every risk got the weight coefficient as the measure of the impact on the construction process of wastewater treatment plants. The ecological group of risks had the biggest weight coefficient regarding the other risk groups and are part of the formed preliminary risk assessment model for the construction process of the wastewater treatment plants. This research with evaluated and quantified risks in one place assumed that the ecological risks had the most impact on the construction process of the wastewater treatment plants.

Keywords: *Risk, Ecological, Wastewater, Preliminary Risk Assessment Model*

Acknowledgement

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

OCCUPATIONAL HEALTH AND SAFETY

AGING MANAGEMENT APPROACHES FOR HYDROGEN PRODUCTION PLANTS

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Abstract: Aging is the effect whereby a component suffers some form of material deterioration and damage (The Health and Safety Executive - HSE). Most affected places at hydrogen production plants that suffer from corrosion, hydrogen embrittlement, thermal fatigue and other damage mechanisms are piping and fixed equipment (electrolysers and storage tanks). High operating temperatures and unexpected shutdowns have significant contribution at accelerating the ageing process. Successful aging management is critical to the safety performance, but it is also affected by staff demographics, skills, training, and competencies. Due to the nature of the process, some plants are more susceptible to the aging effect than others. Current approach to asset management is reactive and the focus is on carrying out work that must be done now, rather than work that will prevent future problems. The result is often unanticipated failures, long backlogs of maintenance work and no time to carry out the preventive maintenance which would alleviate many of the problems. A proactive approach with thorough understanding of asset aging mechanisms and conditions and the ways in which assets interact is crucial for effectively managing the aging and ensure that the assets operate efficiently and safely. This research is focused on providing an overview of three aging management methodologies for hydrogen production plants which operate under critical conditions and are subject to rapid deterioration: Regulatory-based aging management; Risk-based aging management according to API 570, 580, 563, 574; and Economic-based ageing management. The legal framework is insufficient to control the aging process and related risks, therefore criticality screening and risk-based inspections are the key to prevent unexpected catastrophic failures, unscheduled downtime, and business interruption. Defining the business-critical equipment and stock of spare parts finalize the aging management process from economic point by reducing the downtime.

Keywords: *Aging Management; API580; Hydrogen Safety.*

DISC2022 – 2nd DIFENEW International Student Conference

6th December 2022

PHYSICS-BASED DATA-DRIVEN METHODS FOR DIAGNOSTICS OF ROTATING MACHINERY

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Abstract: Maintenance of rotating machinery is the essential part and core of every production process which directly affects its productivity and quality. As the level of complexity of modern rotating machinery grows, the need for an effective and efficient maintenance process increases as well. Based on numerous scientific papers in the field of condition monitoring, a conclusion can be drawn that the best indicator of the overall current state of the machine, which is sensitive to the appearance and development of a certain defect at the earliest stages is vibration. In order to accurately monitor and determine the current state of the machinery by measuring its vibrations, automation of the process of monitoring the condition and identification of possible faults has to be performed. The methods for automation generally can be divided into two large groups, physics-based and data-driven methods. This research gives an insight into the state-of-the-art of both methods and enhances their advantages and limitations. In order to overcome these limitations and take advantage of both, in the past few years a novel methodology in the field of rotating machinery diagnostics is proposed, the physics-based data-driven method. This research concentrates on discovering the potential for future work on physics-based data-driven methods in the field of rotating machinery. The first goal of this research would be the integration of purely physics-based models and purely data-driven models into a single hybrid model that would serve for vibration-diagnostic monitoring of the condition of rotating machines. In addition, the obtained from the hybrid model would be compared to the results obtained from the purely data-driven models, based on the obtained accuracy, the volume of the database, and calculation costs and time. In this way, it would be possible to conclude which method is superior for vibration-diagnostic monitoring of the condition of rotating machines.

Keywords: *Vibration, Physics-based Data-driven Methods, Diagnostics, Rotating Machinery.*

DISC2022 – 2nd DIFENEW International Student Conference

6th December 2022

EFFECTIVENESS OF CERAMIC FILTER WATER TREATMENT METHOD IN IMPROVING DRINKING WATER QUALITY AND REDUCING WATER-RELATED DISEASE: SYSTEMATIC REVIEW AND MET ANALYSIS

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Abstract: Lack of access to improved drinking water is global problem. Millions of peoples cannot get safe drinking water as defined by the World Health Organization Guidelines for Drinking Water Quality. Untreated drinking water has been reported in different studies as one of the major contributors to the human health problem (water related disease) such as cholera, typhoid, viral hepatitis and dysentery, and responsible for death of people in million each year. Middle and low-income countries are more affected by the problem. To scope up this problem many of these countries started to use household level water treatment methods like: chlorination, solar disinfection and ceramic water treatment method. The aim of this study is to pool out the available evidence on the effectiveness of the *ceramic filter* water treatment method in reducing diarrhea. Searches were conducted in PubMed, Google Scholar databases and references to other studies. The review included RCT studies on both children and adults found anywhere in the world regardless of sex, ethnicity and religion which were published or conducted in English from December 2000 to January 2022. Two independent reviewers critically reviewed and appraised the selected studies. Effect sizes were expressed in risk ratio and in their 95% CIs. 9 eligible studies were identified out of 14,007 studies pooled from data bases. In all identified studies, ceramic filter water treatment reduced the risk of diarrhea. The estimated pooled risk ratio of diarrhea among participants who used *ceramic filter* disinfection water treatment method was 0.49 (0.41, 0.57). The overall pooled results of the study show that using of ceramic disinfection water treatment method had reduced the risk of diarrheal disease by 51%. This study indicates using of *ceramic filter* water treatment method significantly reduced the risk of diarrheal disease both in children and adults.

Keywords: *Ceramic Filters; Water-related Disease; Water Quality; Diarrhea.*

DISC2022 – 2nd DIFENEW International Student Conference

6th December 2022

LABOR SAFETY IN CONSTRUCTION IN THE FACE ON NEW CHALLENGES

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Abstract: For a long time, it has been accepted in society that labor protection is the concern of large enterprises, where thousands of employees work, and that these issues rarely go beyond compliance with safety rules at work. However, over the past two years, a large number of issues have emerged that need to be discussed together, including the organization of work in the face of new challenges and with the use of new technologies in production. Maintaining health in the workplace is the most important task that concerns each of us. In the current realities, occupational health and safety management is not just a local task of organizations, but a key process that is in demand at the strategic level. Automation of this process leads to the development and implementation of information systems that contribute to improving and improving the culture of industrial safety, and improving environmental performance in order to improve working conditions, health and well-being of each employee. Currently, the industry is undergoing transformation: legislation is changing, the demand for security is growing, new technologies and trends are emerging, which contributes to the active development of the industry, including in the field of digitalization. Digital transformation is one of the tools to achieve the tasks set, as it accelerates the construction cycle and makes the construction more transparent and efficient. To date, the work on digitalization affects all areas of activity, including corporate culture, personnel training system, IT architecture, information security, operational activities. The introduction of digital technologies in the economy and social sphere should create conditions for improving the quality of life and the development of small, medium and large businesses. If we look at the digitalization process from the inside, we will see that this requires the use of information models on mobile and tablet devices with a description of technological processes and safety requirements during their production at all stages of construction. In addition, with regard to the ability to conduct video monitoring of work on the construction site, digital platforms are also appearing in this direction. Both directly integrating video cameras into a video surveillance system, and with the use of positioning systems that allow monitoring the movement of workers and vehicles. NOSTROY is working in the direction of using video systems in labor protection. The Association initiated the development of the electronic service "Electronic Labor Protection Inspector 2.0" (hereinafter referred to as the Electronic Inspector), in which, in addition to the electronic document management system and database, the function of monitoring labor safety by means of video recording, including remotely and around the clock, will be implemented. The module integrated into the Electronic Inspector based on machine learning and computer vision integrated with video surveillance systems at the construction site will allow identifying violations at the construction site, the availability of personal protective equipment for employees, as well as monitoring staff productivity.

Keywords: *Labor Safety in Construction; Occupational Risks; Industrial Work; Small and Medium-sized Businesses; Electronic Labor Protection Inspector.*

DISC2022 – 2nd DIFENEW International Student Conference

6th December 2022

OCCUPATIONAL SAFETY DURING BLOCK PRODUCTION WITH GLASS CULLET

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Abstract: Previous research has focused on examining the possibility of applying waste glass recycling in the production of new product. In order to find a potential solution for the existing problem in the waste glass management in Serbia and to find a way to improve sustainability in the field of industrial production, the use of waste glass cullet in powder form as a secondary raw material in the clay block production was tested. Obtained results of environmental impact assessment of clay/glass blocks production and its costs, represent a significant contribution for complete research and focus on a further research course in the field of waste utilization as a resource in industrial production. The extension of the mentioned research is in the direction of critical points identification from the aspect of occupational safety. In this sense, two systems are defined: waste management and production. First system is well described in literature. For that reason, further in the abstract, there will be the initial groundwork analysis of the second system. In addition to the common risks related to working conditions at a workplace (lighting, temperature, humidity…), the following specific risks are observed: grinding to obtain glass powder (manual handling with heavy lifting, chemical substances in form of dust, mechanical hazards such as cuts); making raw material (working postures-standing); shaping (mechanical hazards such as bruises and fractures, vibrations of work equipment); drying (high temperature and electricity of working machine); baking (high temperature and electricity of working machine); new product - property testing (manual handling). These are general risks for such a system, it is necessary to perform measurements on the specific process and employees to obtain a more complete analysis. This will be the continuation of research, together with the analysis of the first defined system on the example of the situation in Serbia.

Keywords: *Glass Cullet; Block Production; Occupational Safety; Specific Risks.*

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DISC2022 – 2nd DIFENEW International Student Conference

6th December 2022

ECONOMICS AND OCCUPATIONAL SAFETY – A REVIEW

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Abstract: The main objective of this study is to present comprehensive overview on the correlation between occupational health and safety preventive measures and economic resources. The most prominent problems are identified in methodologies for economic evaluation of occupational health and safety preventive measures benefits since they are difficult to observe, appraise and measure and it takes years to materialize them. There is a high limitation in understanding the economic and occupational health and safety performance indicators, that are usually conflicting in goals when observed from the different point of view (management and employees). Company employees and managers, economists, and health and safety professionals, usually, do not work together in the process of designing of the preventive occupational health and safety measures. Moreover, they usually do not understand the roles of each other in the process of managing the occupational health and safety. The management and economic experts usually face challenging resource allocation decisions to control identified significant risks to comply with health and safety law and bylaws. As there are many competing priorities, the applied approach usually focusses on the minimum required resources to comply with the law rather than to tackle risk control from a positive business management perspective. In Serbia, the out-dated health and safety law and bylaws requirements for most industrial branches are also enabling the fast compliance of required measures, which can lead to work injuries and illnesses. There is high need to conduct the cost-benefit analyses to evaluate the costs of work-related illness and/or injuries and best health and safety preventive measures for observed workplace. Occupational health and safety preventive measures are not expensive luxuries but a necessity for all parties involved in everyday working activities.

Keywords: *Economic Tools; Evaluation; Occupational Health and Safety.*

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DISC2022 – 2nd DIFENEW International Student Conference

6th December 2022

SIGNIFICANCE OF THE FORMATION OF THE METHODOLOGY FOR ASSESSING THE VULNERABILITY OF THE SEVESO PLANT

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Abstract: One of the consequences of the harmonization of the laws of the Republic of Serbia and the European Union is the harmonization of regulations related to Critical Infrastructure. Our country has not fully harmonized and defined the existence of critical infrastructure and all its components. As a new area in science, critical infrastructure is a topic that represents a great resource and potential that needs to be worked on in terms of research, in order to define all its factors and all potential multihazards, in order to determine adequate preventive measures. Oil tanks are recognized as one of the phenomena of critical infrastructure, which are also classified as SEVESO objects of the first order and, according to the categorization, are included in the objects of the first degree of danger. Currently, risk assessments at such facilities are performed based on the methodologies defined in the Act on Risk Assessment, Disaster Risk Assessment, Protection and Rescue Plans and Accident Protection Plan. According to current laws and regulations, a unique methodology to assess the vulnerability of SEVESO facilities as objects of critical infrastructure does not exist, which we consider to be a significant shortcoming because SEVESO facilities are a separate part of critical infrastructure and should be given special emphasis and importance. Accordingly, this paper is based on a comparative analysis of existing methodologies and indicates the need for a unique methodology for vulnerability assessment that will apply to SEVESO facilities.

Keywords: *Critical Infrastructure, Vulnerability Assessment, SEVESO Facilities.*

ENVIRONMENTAL AND HEALTH RISK ASSESSMENT

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6th December 2022

MICROBIAL ASSESSMENT OF THE INDOOR AIR QUALITY OF SELECTED LABORATORIES IN THE UNIVERSITY OF IBADAN

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Abstract: Exposure to bioaerosol in the occupational environment is associated with a wide range of health effects with major public health impacts, including infectious disease, acute toxic effects, allergies, and cancer. Bio-aerosols account for 5–34 % of indoor air pollution. This study aims to assess the microbial load present in the indoor air of the selected laboratories and how to reduce it to inhibit frequent health hazards. A cross-sectional study was conducted to assess the microbial load in the indoor air of selected laboratory rooms at the University of Ibadan. The laboratories were categorized into medical, chemical, microbiological, and technical. Samples were taken from 38 laboratories and cultured in the two media. Nutrient agar and potato dextrose agar for bacterial and fungi respectively. In each laboratory, two Petri dishes were exposed for 30 minutes. The average mean concentrations of bacteria and fungi aerosols in the indoor environment of the university laboratories ranged between 1399 and 5426 CFU/m^3. This study indicated that the microbiology laboratory had the highest average means bacterial load of 5426 CFU/m^3 and the lowest average bacterial concentration of 1399 CFU/m^3 was recorded in the technical laboratories. While for fungi, the technical laboratory had the highest average mean load of 3992 CFU/m^3 and the lowest average mean load of 2481CFU/m^3 was recorded at both technical and microbiology laboratories. According to the sanitary standard classification of the World Health Organization, all the laboratories, and indoor air of the University were heavily contaminated with bacteria and fungi with a range above 1000 CFU/m^3. So, it's necessary to pay attention to improving good housekeeping in the indoor environment of laboratories at the University of Ibadan to protect the health and safety.

Keywords: *Microbial Assessment, Indoor Air Quality, Laboratory Environment, University of Ibadan.*

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6th December 2022

IN SILICO INSIGHT INTO THE ENDOCRINE DISRUPTING POTENTIAL OF BISPHENOL A ANALOGUES ON ANDROGEN RECEPTOR

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Abstract: In recent years, bisphenol A (BPA) is being replaced by its analogues in the production of polycarbonate plastics and epoxy resins, due to the recognized negative biological effects of BPA. However, the endocrine-disrupting properties of these BPA substitutes have not been tested sufficiently. The aim of this study was to evaluate *in silico* if BPA structural analogues act as androgen receptor agonist considering the molecular properties of the analyzed compounds. The binding affinity of BPA and its 25 analogues for the androgen receptor (AR; PDB entry code: 5CJ6) was predicted using GOLD molecular docking tool and expressed as ChemPLP fitness score. Molecular properties were calculated using an online SwissADME tool. ChemPLP fitness score for the pre-existing co-crystallized ligand was 68.62, for BPA was 67.34, while the scores for the analyzed analogues were in the range of 9.40-70.48. Three compounds did not show binding activity (4,4'-bis(N-carbamoyl-4-methylbenzene sulfonamide) diphenylmethane, Bisphenol A bis(diphenyl phosphate), and urea urethane), three compounds showed higher score than BPA (bisphenol B, Bis(3-allyl-4-hydroxyphenyl) sulfone, and 1,7-bis(4-hydroxyphenylthio)-3,5-dioxaheptane), while the rest of the compounds showed a binding affinity similar to BPA. The highest binding affinity was observed for bisphenol B (70.48). The 23 out of 26 compounds had molecular weight, MW < 500 g/mol, 24 out of 26 compounds had polar surface area, PSA < 140Å^2, and 20 out of 26 had the average logP < 4.15 (an indicator of lipophilicity), which indicated good oral bioavailability. The obtained results suggest that BPA and its analogues could interfere with the androgen receptor which indicate the endocrine-disrupting potential of these compounds. Further studies are needed in order to determine the biological effects of BPA substitutes.

Keywords: *Bisphenol A; Endocrine Disruptors; Docking; In silico; Androgen Receptors.*

Acknowledgement

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DISC2022 – 2nd DIFENEW International Student Conference

6th December 2022

EFFECT OF DIBUTYL PHTHALATE TREATMENT ON INDUCIBLE NITRIC OXIDE SYNTHASE EXPRESSION IN RAT LIVER

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Abstract: Di-n-butyl phthalate (DBP) is an organic compound widely used as a plasticizer. Because of its chemical properties, DBP can leach or evaporate from final products into the environment during usage or disposal. It is estimated that more than 95% of the general population are exposed to DBP, while certain occupations have a higher prevalence to DBP exposure. It is known that DBP exposure can lead to inflammation and oxidative stress. Nitric oxide (NO) is an important physiological signaling molecule, however when produced in large excess, NO may display adverse effects. The aim of our study was to investigate whether different doses of DBP can cause changes in the expression of inducible nitric oxide synthase (iNOS) in rat hepatocytes. Twenty-four female Wistar rats were divided into 4 groups (6 per group) and treated subacutely (28 days) with 0, 100, 500 and 5000 mg DBP/kg diet, that corresponded to 8.54, 41.34 and 447.33 mg/kg BW/day. Formalin-fixed, paraffin-embedded liver tissue was cut into 5 µm thick sections and immunostained with anti-iNOS antibody. The amount of iNOS in liver section was demonstrated using Java based Image J program (Fiji). Optical density (OD) of immunolabeled images was measured, since OD is proportional to the concentration of the stain. Number of total positive cells was obtained using Image J plug-in IHC profiler. Statistical analysis of obtained data was performed using STATISTICA® version 13.0 (StatSoft, Inc). Data from control and treated rats were compared using One-way analysis of variance (ANOVA) for multiple comparisons, followed by Tukey post-hoc tests. Statistical analysis revealed dose-depended increase in iNOS optical density, although this increase was not of statistical significance. Number of total positive cells does not significantly differ in any of the treated groups compared to the control. Our results indicate that DBP subacute treatment does not affect expression of iNOS.

Keywords: *Liver; Rat; Dibutyl Phthalate; iNOS;*

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6th December 2022

EFFECT OF DIBUTYL PHTHALATE TREATMENT ON BLOOD GLUCOSE AND CHOLESTEROL LEVEL IN FEMALE RATS

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Abstract: Di-n-butyl phthalate (DBP) is phthalic acid ester widely used as a plasticizer. DBP does not covalently bond to final products, therefore leaching and evaporation may occur. It can then be deposited in soil and water and thus enter the food chain. The aim of our study was to investigate whether different DBP doses have an effect on serum levels of glucose and cholesterol. Twenty-four female Wistar rats were divided into 4 groups (6 per group) and treated subacutely (28 days) with 0, 100, 500 and 5000 mg DBP/kg diet, that corresponded to 8.54, 41.34 and 447.33 mg/kg BW/day. At necropsy, blood was collected in serum separating tubes and biochemical parameters were determined using Dialab Autolyser. Statistical analysis of obtained data was performed using STATISTICA® version 13.0 (StatSoft, Inc). Data from control and treated rats were compared using One-way analysis of variance (ANOVA) for multiple comparisons, followed by Tukey post-hoc tests. Statistical analysis revealed significant increase in glucose serum levels in the group treated with 500 mg DBP/kg diet compared to the control while cholesterol remained unaffected. Results indicate that glucose may be the most sensitive analyzed biochemical parameter upon DBP application.

Keywords: *Rat; Dibutyl Phthalate; Serum; Glucose.*

Acknowledgement

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6th December 2022

OVARIAN FOLLICLE COUNTS AFTER REPEATED 28-DAY EXPOSURE TO DIBUTYL PHTHALATE IN WISTAR RATS

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Abstract: Dibutyl phthalate (DBP) is an endocrine-disrupting chemical that can directly target the ovary, potentially causing defects in ovulation and fertility, is widely used in flexible plastics and consumer products, and has become prevalent contaminants in the environment. The aim of our study was to investigate whether exposure to DBP can affects the number of ovarian follicles of different developmental stages in female rats. Female Wistar rats, 40 days old at the beginning of the experiment, were divided into 3 groups (6 per group) and exposed 28 days to DBP added to the diet in concentrations: 0, 100, 500 mg DBP/kg diet, that correspond to 8.58 and 41.34 mg/kg BW/day. After treatment termination, the ovaries were fixed in Bouin's solution for 24 hours. The samples were dehydrated, paraffin-embedded and sectioned into 5-μm section. The slides were stained with hematoxylin and eosin. Ten samples from each ovary were randomly selected to determine the numbers of primordial, primary, secondary, preantral and antral follicles. The follicle stage was classified according to accepted published definitions (Pedersen and Peters, 1968). The numbers of different stages of follicles were determined under Olympus light microscope. Statistical analysis was performed using STATISTICA® version 13.0 (StatSoft, Inc). Data from control and treated rats were compared using One-way analysis of variance (ANOVA) for multiple comparisons, followed by Tukey post-hoc tests. While treatment in the group exposed to 500 mg DBP/kg diet didn't cause differences in follicles number when compared with control, DBP exposure at 100 mg DBP/kg diet resulted in transition from primordial to primary follicles, and transition from secondary to preantral follicles. However, statistical analysis revealed that observed transition are not significant. The results demonstrate that subacute exposure to 100 mg DBP/kg diet led to slight perturbation in the number of follicles.

Keywords: *Ovarian Toxicology; Dibutyl Phthalate; Endocrine Disruptor; Fertility; Environmental Pollution.*

Acknowledgement

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DISC2022 – 2nd DIFENEW International Student Conference

6th December 2022

EFFECT OF SUBACUTE DIBUTYL PHTHALATE TREATMENT ON THE LEVELS OF POTASSIUM AND SODIUM IN FEMALE RATS

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Abstract: Di-butyl phthalate (DBP) is a widely used synthetic plasticizer with massive production that allows it to exist in all environments, including air, water and soil. The aim of this study was to examine the subacute toxic effects of dibutyl phthalate (DBP) on electrolyte level in female Wistar rats. Female Wistar rats, 40 days old at the beginning of the experiment were exposed to DBP added to the diet in concentrations: 0, 100, 500, 5000 mg DBP/kg diet, that correspond to 8.58, 41.34 and 447.33 mg/kg BW/day. At necroscopy plasma was collected in vacutainer tube for determination of electrolytes level. Sodium and potassium were determined using Dialab Autolyser. Statistical analysis was performed using STATISTICA® version 13.0 (StatSoft, Inc). Data from control and treated rats were compared using One-way analysis of variance (ANOVA) for multiple comparisons, followed by Tukey post-hoc tests. Statistical analysis revealed a significant increase in potassium level in all treated groups compared to the control group, while sodium level was not significantly affected by DBP treatment. These results demonstrated that by affecting potassium level DBP exerts potentially toxic effects.

Keywords: *Ecotoxicity; Dibutyl Phthalate; Environmental Endocrine Disruptor; Microplastic; Electrolyte.*

Acknowledgement

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6th December 2022

SPATIAL EPIDEMIC WAVE DIFFUSION ACCORDING TO DIFFERENT SIZED SOURCING LOCATIONS

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Abstract: One of the main questions regarding epidemics is their place of origin. By identifying and understanding them adequately, more effective countermeasures can be implemented. Another question is referring to the size and connectedness of the epidemic starting location with other areas. To get an understanding of how epidemic waves behave when they start from different-sized locations, this study combines several approaches. The first approach is based on observing different sections of a country. Within the leading and trailing edges are identified so the spatial advance ('swash' stage) and retreat ('backwash' stage) of epidemic waves can be tracked as dimensionless integrals. The second approach simulates the country's population behavior by using an agent-based modeling approach; the population is aggregated into susceptible, infective, and recovered areas. Individuals traverse across areas according to social gravity forces while their population size is following a Zipfian distribution. Results show that weak gravitational forces of small locations help dissipate infections across the country quicker if the pathogen had originated from that location. The reason is that individuals have more impulse to migrate to more populated areas due to their higher social gravity. On the other hand, the gravitational forces of large cities help contain infections within them if they are the starting locations for the pathogen. Greater connectedness and symmetry allow for a more predictable epidemic outcome since there are no obstructions to spreading. To confirm the findings of this model with real-world events host countries are needed that experienced several epidemic waves. Finally, the results are supported by actual epidemic findings from Liberia, Sierra Leone, and Iceland and their Ebola, Covid-19, and measles epidemic waves.

Keywords: *Spatial Diffusion, Epidemic Waves, Agent-Based Modeling, Reservoir Infection, SIR Model*

Acknowledgement

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NON-TREATED BIOWASTE MATERIAL AS ADSORBENT FOR MALATHION

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Abstract: Malathion is an organo-thiophosphorous insecticide with a broad range of use. Even though the toxicity of malathion is moderate, by ingestion into the human body, it oxidizes to its more toxic oxo-form, malaoxon. As malathion is extensively used, its presence in the environment is undoubtful, and because of its harmful effects on humans and animals, it ought to be removed. The least invasive and safest way of eliminating malathion from the environment is adsorption. Many materials have been tested for this purpose, and biowaste materials showed the best balance of adsorption properties and material production cost. Coffee is one of the most used beverages in the world, and nearly 10 billion kg of coffee is produced yearly. After use, spent coffee grounds are tossed away, posing an environmental problem. Therefore, using spent coffee grounds to remove malathion has a double environment protective role. Firstly, using environmentally harmful material as adsorbent and secondly, removing toxic malathion. This work presents the kinetics and efficiency of malathion adsorption using different concentrations (1 mg mL^{-1} and 10 mg mL^{-1}) of non-treated spent coffee grounds as adsorbent. The concentration of malathion was determined using UPLC. To determine the kinetic parameters of adsorption, pseudo-first and pseudo-second order kinetic models were tested. Results showed that experimentally obtained data better fitted the pseudo-second kinetic model and the rate constants were 0.108 g mg^{-1} min^{-1} and 4.343 g mg^{-1} min^{-1} for 1 mg mL^{-1} and 10 mg mL^{-1} of adsorbent, respectively.

Keywords: *Malathion; Biowaste; Coffee; Adsorption*

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6th December 2022

MASS SPECTROMETRY DETECTION OF INTERMEDIARIES DURING ELECTROCHEMICAL OXIDATION OF BISPHENOL A

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Abstract: Electrochemical oxidation is a simple and clean technique for removing organic pollutants from wastewater. In recent years, bisphenol A is causing a great environmental concern due to its negative impact on the endocrine system of humans. Degradation of bisphenol A was carried out on SnO_2-MWCNT (multi-walled carbon nanotubes) anode. Experiments were performed in 0.1 M Na_2SO_4 at pH 4, as a supporting electrolyte for 5 hours. Aliquotes, of 0.5 ml volume, were taken every hour during the experiment, and analyzed by mass spectrometry using Waters Micromass Quattro micro API TQD. During the first two hours, peaks originating from hydroxylated derivates of bisphenol A, such as catehol, dicatehol and quinones, can be seen on mass spectrum. In the further hours of electrolysis, lower mass peaks can be observed on mass spectrum and they correspond to isopropenylphenol, hydroquinone, hydroxyacetophenone and dihydroxyacetophenone. All obtained degradation products indicate that the oxidation of bisphenol A occurs under the influence of hydroxyl radicals, while sulfate radicals do not play a significant role in the process itself. Based on literature data, the intermediaries from anodic oxidation of bisphenol A express lower endocrine-disrupting activity than bisphenol A.

Keywords: *Electrochemical Oxidation; Bisphenol A; SnO_2-MWCNT Electrode; Bisphenol A Intermediaries.*

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BIOWASTE-BASED CARBON MATERIAL FOR WASTEWATER TREATMENT

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Abstract: Due to the accelerated development of industry and agriculture, as well as the rise in the human population, there is increasing pollution of the environment. Water pollution can also be caused by irresponsible human behavior, such as dumping garbage into rivers, lakes, or seas. Furthermore, the development of agriculture leads to the excessive use of pesticides, fertilizers, and other chemicals used to protect crops from various pests. Among the most commonly used pesticides are organophosphate pesticides, which can accumulate in the water due to their high stability, use, and difficult hydrolysis. In general, organophosphates inhibit acetylcholinesterase, which is a key enzyme in controlling nerve signals. Therefore, they are very dangerous to the entire ecosystem. The removal of OP is very important, and there are many methods to achieve that. Among them, adsorption is mainly used. In the last few years, there has been a great interest in obtaining carbon materials that will be accessible, environmentally friendly, and cheap. One such material is carbon obtained from biomass and successfully used as an adsorbent for removing organophosphates from water. As part of this study, the adsorption of the organophosphate pesticide - malathion on carbon material was investigated. The efficiency of the process was determined and its application in environmental protection was evaluated. The results indicate that at a temperature of 25 ^{0}C, 18.34 mg of malathion was adsorbed on 1 g of material. Also, it was observed that the obtained results agree with the Freundlich isotherm model, indicating that it is a matter of multilayer adsorption and a heterogeneous surface of the material.

Keywords: *Organophosphate Pesticides; Carbon Material; Biomass; Adsorption; Malathion.*

Acknowledgment

This work was partially supported by the Ministry for Science of the Republic of Serbia (Grant no. 451–03–9/2022–14/200017).

ENVIRONMENTAL MONITORING

EVALUATION OF PHARMACEUTICALS INTO HORTICULTURAL SOILS IRRIGATED WITH RECLAIMED WASTEWATER

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Abstract: The demand for water suitable for irrigation in areas with freshwater scarcity implies adequate wastewater treatment systems that do not generate a risk for agroecosystems, including the organic micropollutants commonly found in wastewater (e.g., pharmaceuticals). Under the H2020 HYDROUSA project a wastewater treatment system has been installed in the Greek island of Lesvos, consisting of a combination of upflow anaerobic sludge blanket reactor, a constructed wetland, and UV disinfection. The objective of this study was to evaluate the input of pharmaceuticals, from the reclaimed water (RW) into arable soils, during the growth cycle of lettuce (Lactuca sativa) crops. Tap water (TW) was used as a negative control to irrigate the soil. Soil samples were taken before the first crops irrigation, two weeks after, and at harvesting time (one month). A total of 70 compounds were analyzed in the soil samples. A quadrupole linear ion trap tandem mass spectrometry (UHPLC-QqLIT) was used for the target analysis of pharmaceuticals. The extraction method was suitable for multi-residue analysis, with more than half of the analytes (n=42) showing recoveries above 50%. Up to 15 compounds were observed in the soil, ranging from 0.015 µg/kg to 14 µg/kg (dw). The analgesics (mainly acetaminophen, ketoprofen, and 2OH-ibuprofen) exhibited the highest occurrence, being detected in both the control (TW irrigated) and the RW-irrigated soils. Their concentrations in RW-soils did not show did not show significant differences with the initial soils, which might indicate a fast dissipation of the input compounds. The RW-irrigated soils showed the presence of cardiovascular and psychiatric drugs, while antibiotics were less frequently detected. It is important to highlight the occurrence of metabolites such as 2OH-ibuprofen and O-desmethyl-venlafaxine, which are not usually monitored. Future studies for assessing the impact of the irrigation, involve the metagenomic analysis of the soil microbial community.

Keywords: *Pharmaceuticals; Soil analysis; Mass spectrometry*

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DISC2022 – 2nd DIFENEW International Student Conference

6th December 2022

SMALL-MOLECULE MASS SPECTROMETRY FINGERPRINTING AS A DIAGNOSTIC TOOL IN WATER QUALITY SURVEILLANCE AND TREATMENT OPTIMIZATION (WATERDOM)

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Abstract: WaterDOM aims at providing rigorous analytical methods and tools for the holistic characterization of water samples based on high-resolution mass spectrometry (HRMS) fingerprinting of the dissolved organic matter (DOM). The fraction investigated in the waterDOM project includes natural organic matter (NOM), synthetic organic compounds, transformation products such as disinfection byproducts (DBPs) and soluble microbial products derived during biological processes of wastewater treatment. WaterDOM will validate the mass spectrometric approaches for the characterization of DOM profiles through (waste)water treatment to estimate and optimize treatment efficiency. The specific objectives of waterDOM are as follows: (i) Develop novel non-target strategies to fingerprint small molecule DOM in the different matrices selected for study (sewage, wastewater effluent, river water and drinking water); (ii) Select and prioritize specific contaminants (excreted contaminants or metabolic products) to be used as human health biomarkers and investigate its correlation with the chemical profile obtained with HRMS; (iii) Holistically evaluate the effects of wastewater treatment processes on water quality based on target and non-target analysis. Predict potential environmental effects related to the emission and uses of treated water; (iv) Investigate changes on drinking water sample fingerprints to predict treatment side effects such as formation of disinfection byproducts. First results show the comparison between the target analysis of 158 compounds including pharmaceuticals, antibiotics, pesticides, endocrine disrupting compounds (EDCs) and the profile of DOM.

Keywords: *High-Resolution Mass Spectrometry (HRMS); Natural Organic Matter (NOM); The Dissolved Organic Matter (DOM); Organic Contaminants.*

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6th December 2022

DETERMINATION OF VENLAFAXINE BY SPE-GC-MS FROM SURFACE WATERS

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Abstract: Venlafaxine is a widely used antidepressant, and since it is only partially removed by wastewater treatment plants, together with its metabolite O-desmethylvenlafaxine, it represents a significant source of pollution in the environment. The aim of this work was development and optimization of SPE method for the extraction of venlafaxine from water samples. Parameters, such as type of the elution solvent and its volume were tested. Based on the available literature and the properties of venlafaxine, Bond Elut C18 sorbent was chosen for extraction. Four SPE extraction methods were tested using different elution solvents (methanol (100%), methanol:water (80:20% vol), methanol:acetone (50:50% vol), methanol:2% acetic acid (90:10% vol)), while in each method, 5 extractions were performed using 2 ml of the eluent. Water samples were prepared by spiking distilled water with venlafaxine to achieve final concentration of 0.1 ppm, while the volume of the sample was 100 mL. Obtained extracts were analyzed by GC-MS in SIM mode. Best extraction efficiency was achieved when methanol and mixture of methanol:water (80:20% vol) were used. A mixture of methanol and acetone proved to be unsuitable, because even 10 ml of the elution mixture was not enough for the complete elution. Mixture of methanol and water with acetic acid did not show sufficient extraction efficiency. The subject of further work will be improving the SPE method by the investigation of the effect of methanol and water mixtures on elution to develop a simple, fast and reliable SPE method for venlafaxine from water samples.

Keywords: *venlafaxine; pharmaceuticals; solid phase extraction; gas chromatography; mass spectrometry.*

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6th December 2022

DETERMINATION OF ALIPHATIC AMINES IN WATER SAMPLES WITH GAS CHROMATOGRAPHY

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Abstract: Aliphatic amines belong to chemical and pharmaceutical industrial contaminants observed in environmental samples. These compounds could appear as precursors of N-nitrosoamines, which are potentially carcinogenic substances. Identification of aliphatic amines at trace concentration level requires an additional sample preparation step as well as derivatization procedure in the case of gas chromatographic analysis. Our work was focused on the development of stir bar sorptive extraction technique for determination of butylamine, iso-butylamine and pentylamine in water samples. A gas chromatograph (GC, Agilent Technologies) coupled with a time-of-flight mass spectrometer (TOF, Agilent Technologies) was used to analyze the samples. Separation of derivatized biogenic amines was performed using an BPX-5MS column (30 m × 0.25 mm × 0.25 µm). Isobutyl chloroformate was chosen as the derivatizing agent. Primary, the derivatization procedure was optimized to set up of experimental conditions. It was established as 40 min of derivatization time, pH of 11 and 43 µL of derivatization agent. Extraction of derivatives was performed with polydimethylsilixane covered stir bars (2 cm × 0.5 mm). The developed method allowed determining of selected compounds at 50 µg/L concentration level in water samples.

Keywords: aliphatic amines, water samples, derivatization, gas chromatography.

Acknowledgement

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DISC2022 – 2nd DIFENEW International Student Conference

6th December 2022

WIDE-SCOPE SCREENING OF SCRUBBER WATER DISCHARGES FROM SHIPS

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Abstract: Scrubber waters originate from exhaust gas cleaning systems (EGCs) which are used to reduce the impact of shipping emissions. Scrubber waters can be a major source of marine pollution. Several studies have pointed out the presence of potentially toxic organic contaminants in these matrices, mostly including polycyclic aromatic hydrocarbons (PAHs) and metals. Besides these contaminants, other potential chemical stressors are the alkylated derivatives of PAHs (alkyl-PAHs), which are expected to be relevant contaminants in these samples. In this study, an extended suspect screening methodology was used for a comprehensive chemical characterization of scrubber waters using solid phase extraction (SPE) followed by gas chromatography coupled to high resolution mass spectrometry (GC-HRMS). For compound identification, an in-house exact mass compound database was built, including 71 suspects (55 alkyl-PAHs + 16 priority PAHs). 45 tentative compounds were identified, including 7 PAHs and 37 alkyl-PAHs, together with benzothiophenes and benzofuranes determined by retrospective analysis

Keywords: *PAHs; Alkyl-PAHs; GC-HRMS; Scrubber Water; Shipping Emissions.*

Acknowledgement

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DISC2022 – 2nd DIFENEW International Student Conference

6th December 2022

PHYTOSOCIOLOGICAL ANALISIS OF FOREST CENOSES ON LJUBIĆ MOUNTAIN

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Abstract: Ljubic mountain is located in the southern edge of Pannonian Basin, in the North of Bosnia and Herzegovina. Different types of soil, together with the conditions of a moderate climate, influenced the formation of different plant communities, among which oak and beech forests are particularly significant, both economically and ecologically. During the last few decades, due to the anthropogenic effect, significant changes occurred in the structure of the mentioned forests and the degradation of some of them. This analysis determines the current state of forest associations of beech and oak in the mentioned area and gives us guidelines for further steps with the goal of its ecological preservation.

Keywords: *Beech and Oak Forests, Phytosociological Analysis, Ecological Preservation.*

Acknowledgement

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DISC2022 – 2nd DIFENEW International Student Conference

6th December 2022

POLYMER COATED VIALS FOR ANALYSIS OF POLLUTANTS IN WATER SAMPLES

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Abstract: The increasing problem of trace analysis of polar pollutants present in water samples leads to searching for new efficient sampling and extraction techniques. Liquid-liquid extraction (LLE), solid-phase extractions (SPE) have crucial disadvantages in case of trace analysis of polar pollutants, especially when big volumes of water sample is neccessary to use during analysis. Using of not traditional for SPE sorbents or polymers opens new possibilities for such type of analysis. In this work different types of siloxane polymers typically used as stationary phases in gas chromatography (PS-255, SP-2100, OV-17, OV-1701, OV-61, SE-54, SP-2401, OV-225) were used as coatings for sampling vials. Mentioned polymer`s layers were deposited on the internal walls of sample glass vials. After that prepared vials were tested for extraction of polar pesticides (tertbutryn, dichlorvos, aclonifen, chlorpyrifos, quinoxyfen, trifluralin) from water samples, and extracts were analyzed by GC-FID. Polymer coating worked as sorbent, while desorption of analytes was performed by use of small amounts of organic solvent. Extraction efficiency for each analyte was assessed. Proposed invial-sample preparation minimizes sample handling. Next step of study will be connected with optimization of chemical bonding of polymer coatings on the internal walls of glass vials, what will allow to increase the scale of desorption solvent polarity and stability of coatings.

Keywords: *Extraction; Sorbents; Organic pollutants; Trace analysis.*

Acknowledgement

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LLE EXTRACTION OF PRIORITY WFD COMPOUNDS FROM SURFACE WATER

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Abstract: In year 2000 the EU Water Framework Directive (WFD) 2000/60/EC was enacted to secure good quality of surface waters in EU Member States. To achieve good chemical status of surface waters, the list of priority substances was created, to know which compounds are the most threatening for the aquatic environment and needs to be eliminated from the environment and therefore also monitored with efficient analytical methods. Directive 2013/39/EU amends the previous legislation, revised environmental quality standards, and added more substances to the list. This work aims at determination of selected WFD priority substances from the group of pesticides and polyaromatic hydrocarbons (PAHs), including pesticides trifluralin and quinoxyfen, and PAHs anthracene, benzo[a]pyrene, benzo[b]fluoranthene, benzo[k]fluoranthene, benzo[g,h,i]perylene and indeno[1,2,3-cd]pyrene, which are considered as priority hazardous substances, from water samples using liquid-liquid extraction (LLE) as preconcentration and extraction technique. Obtained extracts were analysed by gas chromatography (GC) coupled to mass spectrometry detector. To increase the sensibility of the method, temperature vaporizing injector (PTV) which allows injection of higher sample volumes was used. Using dichloromethane as extraction solvent and reciprocating orbital shaker, with application of internal standard method, recoveries for pesticides and PAHs in the range from 12 % to 103 % with satisfactory repeatability for most of the compounds (≤ 20 % relative standard deviation, RSD) were achieved. By extracting 1 L of aqueous sample, carefully evaporating the solvent, and redissolving the settled residue, a preconcentration factor of 1000:1 was obtained. The process of extraction is yet to be optimized and the method further developed, for improving the recoveries of certain compounds and method parameters validation.

Keywords: *pesticides; polyaromatic hydrocarbons; liquid-liquid extraction; gas chromatography; mass spectrometry.*

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ENVIRONMENTAL ENGINEERING

DISC2022 – 2nd DIFENEW International Student Conference

6th December 2022

REVIEW OF AVAILABLE STUDIES ON MATERIAL FLOW ANALYSIS OF BISPHENOL-CONTAINING SUBSTANCES IN MUNICIPAL WASTE LANDFILL

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Abstract: The high consumption of plastics leads to generating large quantities of waste, which in return present significant challenges for the available waste management systems. Tackling the problem of plastic waste is becoming a global priority, encouraging stakeholders to take action to improve existing waste management systems and invest in new ones. The population is exposed to plastics through all environmental media. Various plastics additives are dispersed within the polymer matrix to improve plastic properties. In order to assess the influence of plastics additives, it is first necessary to assess the risk of exposure to various chemicals, as well as the routes and limits of exposure to these chemicals. The central methodology for industrial ecology is material flow analysis which quantifies the ways in which materials that enable modern society are used, recycled and decomposed. Material flow analysis can be scaled to higher levels with sufficient efforts and cooperation of multiple branches. This review covers MFAs for plastics from South Korea, USA, Norway, China, Japan, Austria, Germany, Netherlands and Jakarta. There are clear limits to the application of MFA in the areas of environmental engineering and management. MFAs are not sufficient means for assessing or supporting engineering or regulatory measures. However, they are an indispensable first step and a necessary basis for each management plans. The traditional weak point is recycling, which is likely to be improved by using new, more advanced technologies to identify materials during recycling. Next, this review concluded that flows of plastics additives, specifically bisphenols, are not analysed as a separate plastics category. Most of the time the hazardous endocrine disrupting chemicals are analysed together with other type 7 plastics, which in return has that no real exposure of humans to bisphenol-based materials can be presented nor bisphenol exposure can be quantified.

Keywords: *waste management; material flow analysis; endocrine disruptors; bisphenols.*

Acknowledgement

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DISC2022 – 2nd DIFENEW International Student Conference

6th December 2022

INVESTIGATION OF NOISE BARRIERS EFFECTIVNESS IN TRAFFIC NOISE POLLUTION REDUCTION: A CASE STUDY FOR THE CITY OF SKOPJE

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Abstract: In recent decades, the implementation of more rigorous laws related to environmental noise has resulted in a series of measures to reduce noise from different sources. These include urban planning measures such as the designation of noise-sensitive areas, regulations on vehicle speed limits or traffic restrictions, measures to improve the acoustic performance of vehicles, pavements and buildings, and the construction of noise barriers. The most commonly used method to reduce noise produced by traffic is the installation of sound barriers that are constructed and constructed along the highway. In the Republic of North Macedonia, sound barriers have been installed in several locations throughout the country, covering the major highways. In the capital city of Skopje, sound barriers have been installed in 2 locations, namely a reflective barrier at the transport center in the city center and reflective and reactive barriers on the ring road for entering and exiting the city. The international standard ISO 10847:199 establishes two methods for assessing barrier efficiency through field measurements, namely the direct and indirect methods. According to the standard, the indirect method implies an approach to be applied when the noise barrier is already installed and cannot be removed from the installed location in order to carry out measurements according to the direct method. This study describes the application of an indirect method for assessing the efficiency of two sound barriers that have already been installed in the city of Skopje. The research was conducted in order to provide insight into the degree of protection of barriers against traffic noise, which is the dominant source of noise in the city.

Keywords: *Noise Pollution; Noise Barriers; Environmental Noise; Case Study; ISO 10847:199*

DISC2022 – 2nd DIFENEW International Student Conference

6th December 2022

E-WASTE IN SERBIA: CURRENT STATE AND OPPORTUNITIES FOR IMPROVEMENT

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Abstract: During the recent decades, rapid technological and economic development resulted in the generation of huge volume of electrical and electronic waste (e-waste). E-waste is a complex mix of high-value materials, plastics and hazardous components, which makes it both potential source of valuable base metals, such as copper and aluminium, precious and rare earth elements (gold, silver, palladium and platinum), but also a potential threat to the environment and human health. This put a focus on how e-waste is handled, especially in developing countries, because improper disposal of this waste stream leads to negative impacts on environment and public health. Accordingly, this paper aims to analyze the e-waste management and recycling practices in Serbia. It takes Novi Sad as a study case, where material flow analysis was used for overview of the current system and was carried out with the help of software STAN. The results are given in MFA diagram, showing the overall e-waste flows during the reference year. Additionally, a survey was conducted among the households in Novi Sad to evaluate consumption of electronic devices in general, awareness of e-waste, environmental problems associated with improper disposal, and willingness to engage in managing e-waste. Based on the results of the MFA analysis and the conducted survey, shortcomings in the e-waste management system were highlighted and measures for improvement are suggested.

Keywords: *E-waste Management System; Material Flow Analysis; Recycling; Households Awareness.*

THE IMPORTANCE OF PREVENTION OF FOOD WASTE

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Abstract: The global problem of food waste is linked to sustainability challenges such as climate change, resource depletion and discarding of large amounts of food despite the persistence of world hunger. Prevention and reducing food waste has become a key goal of the United Nations Sustainable Development Framework, with the goal of halving food waste by 2030. The findings were translated into key recommendations for industry, policy and research: that a systemic approach is necessary for food waste prevention, that new pathways and directions for food waste prevention are identified and discovered more quickly, and that measurement protocols are introduced in such a way that the total food waste will be visible throughout the supply chain. The proposed framework interprets and applies the waste hierarchy in the context of food waste. It considers the three dimensions of sustainability (environmental, economic, and social), offering a more holistic approach in addressing food waste. Additionally, the materiality and temporality of food is taken into account. The food waste hierarchy posits that prevention, through minimization of food surplus and avoidable food waste, is the most attractive option. The second most attractive option involves the distribution of food surplus to groups affected by food poverty, followed by the option of converting food waste to animal feed. Although the proposed food waste hierarchy requires a fundamental rethink of the current practices and systems in place, it has the potential to provide substantial environmental, social and economic benefits.

Keywords *Food Waste, Waste Reduction, Waste Management, Sustainable Use.*

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6th December 2022

ENVIRONMENTAL IMPACT ASSESSMENT FOR WAVE ENERGY CONVERTER

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Abstract: Marine renewable energy has considerable potential for enhancing the diversity of renewable sources, to reduce our reliance on fossil fuels and combat climate change. For the wave energy production, the global wave energy resource is calculated to be 2.11 ± 0.05 TW, and part of such energy can be harvested by wave energy converters (WECs), transforming the kinetic and/or potential energy of waves into electricity. While the technological development of wave energy converters is progressing rapidly, their environmental impacts are still largely unknown, which is a barrier that could hinder their deployment. Given the uncertainties around the environmental impacts of WECs during the construction, operation and decommissioning phases, the wave energy sector is still largely perceived as a risky activity by regulators and stakeholders. Although the use of wave energy is considered a "clean" technology, the use of these renewable energy sources can also have consequences for the environment. Impacts on the environment in terms of the local shipping and fishing industry, coastal erosion, navigational hazards, disruption of fish migrations in the ocean, and even a threat to marine life have been noted. The likelihood and magnitude of adverse effects from stressors on ecological elements can be described as its ecological risk. The ecological risk assessment (ERA) requires the identification of interactions between human activities and pressures with all ecosystem components. Thus, ERA could be used to link, for a certain activity, the vulnerability of ecosystem elements with the occurrence and magnitude of pressures that such activity could pose in the environment. Unfortunately, research is still needed to achieve a universal methodology for ERA of marine energy projects.

Keywords: *Marine Renewable Energy, Wave Energy Converter, Environmental Impact, Ecological Risk Assessment*

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DISC2022 – 2nd DIFENEW International Student Conference

6th December 2022

ARTIFICIAL NEURAL NETWORKS IN PREDICTION ENERGY IN PHOTOVOLTAIC SYSTEM

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Abstract: The rapid boost of variable energy generations particularly from wind and solar energy resources in the power grid has led to these generations becoming a noteworthy source of uncertainty with load behavior still being the main source of variability. Generation and load balance is required in the economic scheduling of the generating units and in electricity market trades. More and more attention is being paid to predicting a possible amount of electricity obtained on the basis of solar radiation on photovoltaic panels, which is influenced by numerous external parameters such as air temperature, amount of clouds and humidity. Numerous previous studies have shown that certain significant techniques which have been used to predict and optimize the performance of various solar energy systems are machine learning and artificial neural networks. Artificial neural networks (ANNs) are widely accepted as a technology that offers a solution to very complex problems, they can handle incomplete data and can perform high-speed prediction. ANNs process can be considered as a black-box modelling with a set of input factors and output variables which are results of input factors treatment through a systematic neural network. Accurate forecasting provides significant information to grid operators and power system designers in generating an optimal solar photovoltaic plant and to manage the power of demand and supply. Back-propagation network is a type of multilayer feedforward neural network which achieves an arbitrary nonlinear map from inputs to outputs. In this research the back-propagation learning algorithm is used to construct a prediction model of photovoltaic power generation which can forecast the power outputs of photovoltaic system. Input variables are: global horizontal irradiation, direct normal irradiation, monthly average temperature and total monthly precipitation. A single node was at the output layer – monthly power generation.

Keywords: *Neural Network; Back-propagation; Photovoltaic; Energy.*

DISC2022 – 2nd DIFENEW International Student Conference

6th December 2022

FRACTIONATION OF SELECTED (POLY)PHENOLS USING CHOLINIUM IONIC LIQUID-BASED EXTRACTION STRATEGY

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Abstract: Polyphenols are interesting natural compounds mainly because of their antioxidant properties. They are present in relatively high concentrations in food wastes from where they could be extracted. The use of natural phenolic compounds for nutraceutical and cosmetic applications is highly advantageous compared to synthetic substitutes. Therefore, there is a need for the development of efficient and cost-effective methods for the extraction and purification of these valuable compounds. Traditional extraction with organic solvents needs to be switched to novel methods that are more efficient with reduced extraction times and low consumption of organic solvents. Aiming at developing sustainable extraction processes for phenolic compounds, we used two model compounds namely resveratrol and gallic acid to investigate ionic liquid-based aqueous biphasic systems (IL-ABS) formed by cholinium-based IL with dihydrogenphosphate anion in combination with polypropylene glycol with molecular mass 400g/mol (PPG400). IL-ABSs are formed when two water-soluble compounds are mixed in water and when above certain concentrations allow spontaneous phase separation. The phase split results in an aqueous IL-enriched bottom and a PPG-enriched upper phase. The ABS composition in two phase region was selected according to previously determined phase diagram. Extraction studies indicated preferential partition of resveratrol toward the hydrophobic PPG-rich phase that is mainly dominated by its hydrophobic nature and strong salting-out effect of ILs. On the other hand, due to considerably hydrophilic nature in comparison to resveratrol gallic acid preferentially migrates toward IL-phase. Moreover, at pH of ABS mixtures, gallic acid is mostly presented in its deprotonated form and tends to migrate to a more hydrophilic ionic phase. Achieved results demonstrated high extraction efficiencies of selected ABS (~99% for resveratrol for PPG-phase and 92% for gallic acid for IL-phase) with considerable selectivity demonstrating promising outcome for future optimisation studies and potential application.

Keywords: *Polyphenols; Ionic Liquid; Resveratrol; Gallic Acid; Extraction.*

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DISC2022 – 2nd DIFENEW International Student Conference

6th December 2022

IONIC LIQUIDS BASED EXTRACTION PLATFORM FOR REMOVAL OF SELECTED METALS FROM WASTEWATER

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Abstract: An increased discharge of metals into waters is consequence of increased use. The presence of traces of heavy metals is particularly dangerous since most of them are toxic and persistent. Therefore, wastewater decontamination is of great importance. Disadvantage of solvent extraction is the loss of volatile organics, which has a detrimental impact on the environment and human health. Use of ionic liquids (ILs) could overcome mentioned disadvantage considering their low vapour pressure. Moreover, designer nature of IL is a key feature for efficient extraction processes. The main goal of work was to test an innovative technology that involves ILs and aqueous biphasic system (ABS) for Cd^{2+},Zn^{2+}, and Pb^{3+} recovery from aqueous solutions. IL-ABS are formed when two water-soluble compounds are mixed and above certain concentrations allow phase separation. Studied tetrabutylphosphonium-ILs are based on salicylate or saccharinate anions (TBP[Sal] and TBP[Sacc]) that are known complexing agents. IL-aqueous solutions in combination with ammonium-sulphate were employed to form ABSs and to evaluate partition parameters (extraction efficiency and distribution coefficients). The ABS composition in two phase region was selected according to phase diagrams. Extraction studies indicated preferential partition of each metal toward the IL-rich phase in TBP[Sal]-based ABS, that is mainly influenced by strong salting-out effect of salt and complexing ability of salicylate anion of IL. High extraction efficiency is obtained (~88, 92 and 98% for Cd, Zn and Pb respectively) while logarithmic values of distribution coefficients, log K, were above 2 for each metal. Low efficiencies are achieved for Cd and Zn in TBP[Sacc]-based ABS (~14 and 18% respectively with negative values of logK). On the contrary, Pb preferentially migrates toward IL-phase (~93%) in the same ABS. Stability of metal complex at given pH value of ABS has large influence on metal partition. TBP[Sacc]-ABS has higher pH value than TBP[Sal]-ABS which imply their greater stability and better extraction performance.

Keywords: *Metals; Ionic Liquid; Aqueous Biphasic Systems; Extraction*, *Wastewater.*

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CITIZENS MOTIVATION FOR USING REVERSE VENDING MACHINES

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Abstract: The opinion of most people is that an individual cannot contribute to a significant change by recycling, so the motivation is at a low level. Motive should be visible so that people feel that they are contributing to the general benefits of the society and make them feel involved. The reverse vending machine would give a certain monetary value for each bottle, but since money is used as a motivator, the reverse vending machine can be misused for one's own benefit. People will overfill the reverse vending machine to get as much money as possible. The solution to this is that people don`t get any value for their own benefit, but that the value goes to some other purpose. Hence, the goal of this research was to investigate whether people would use reverse vending machines and what would be the leading motivation to use them. An online survey was conducted as the most suitable research method. The survey is short and anonymous. Total of 216 examinees were involved in this survey. Results of the survey analysis showed that a motive is needed. Therefore, most of the examinees answered that money from reverse vending machines should go to the humanitarian actions (42%). The second in order motivation would be ecological projects like greening the city (28%) or donation for helping animals (14%). Relatively high share of respondents (10%) answered that the motivation would be their own benefit. Only one respondent (0,3%) answered that they would use the reverse vending machine without any motivation. From this survey, we conclude that motivation is necessary in order to encourage people to recycle. System of benefits should be created in a way that rewards conscious citizens who are ready to make an effort to recycle.

Keywords: *Motivation; Reverse Vending Machines; Benefit System; Recycling.*

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DISC2022 – 2nd DIFENEW International Student Conference

6th December 2022

PRELIMINARY INVESTIGATION OF SORPTION OF THE HG(II) CHLORIDE COMPLEXES ON THE NATURAL ZEOLITE

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Abstract: In this paper, the possibility of using natural zeolite clinoptilolite (NZ) originating from the Vranjska Banja deposit, Serbia for the remediation of mercury-polluted water systems is examined. Namely, it is well-known that the area of the Idrija mine in Slovenia is still contaminated with mercury as a result of the excavation and processing of cinnabar ore, as well as inadequate disposal of mine tailings. Moreover, investigations have shown that runoff waters wash away the Hg species from contaminated soil into the Idrijca and Soča-Isonzo rivers, and finally to the Gulf of Trieste, where complexation of Hg species with chloride ions occurs. Mercury in seawater exists in the form of soluble chloride complexes available for the methylation process, most often in the sediment. Therefore, this paper examines the sorption of Hg(II) species from the $HgCl_2$ aqueous solution on the NZ under different experimental conditions. The results indicate that the optimal pH range is pH=2-5, since above pH>5, Hg(II) precipitation occurs. The optimal solid/liquid ratio in a wide Hg(II) concentration range is 6 g/L. The highest proportion of sorbed Hg(II) is achieved in 120 minutes, with the maximum sorption capacity of 0.07 mmol Hg/g of NZ. The obtained sorption capacity of NZ towards Hg(II) is lower compared to other tested heavy metals. The consequence of this behaviour probably lies in the fact that Hg(II) at pH<5 exists in the form of neutral complexes, $HgCl_2$ and HgOHCl, whereby the effect of electrostatic attraction is reduced on negatively charged NZ. Therefore, for the possible implementation of NZ for remediation purposes, it is undoubtedly necessary to carry out its chemical modification with sulphur species due to the well-known affinity of mercury toward sulphur species. Since NZ and sulphur species are natural constituents of the hydrogeological layer, the obtained material should be compatible with the environment with improved sorption properties.

Keywords: *Natural Zeolite; Mercury; Mercury Chloride Complexes; Sorption.*

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6th December 2022

A DFT STUDY OF ADSORPTION OF OER INTERMEDIATES ON RUTILE TiO_2 (100) SURFACE

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Abstract: The environmental contamination caused by organic compounds - pesticides, dyes, pharmaceuticals, aromatics - has become a major global problem in the last decades. Therefore, decomposition of organic pollutants in an energy-efficient and green way is highly desired. Electrochemical oxidation is a widely investigated environmentally friendly method, used to degrade organic pollutants in wastewater. At present, the electrode material is a critical component of the electrochemical treatment system to determine the efficiency of the degradation process. Fundamental understanding of electrode processes that occur during electrochemical oxidation, in particular oxygen evolution reaction (OER), is important for the design of novel and further improvement of existing electrode materials. Density functional theory (DFT) represents a common approach for investigation of electrochemical systems, particularly interaction of oxidoreduction intermediates with electrode surfaces. Thus, DFT represents an ideal tool to investigate OER behavior on the electrodes with potential application in electrooxidative depollution.

Within this work, optimization of the parameters for the establishment of the TiO_2 (rutile) surface model was performed. In the DFT-GGA approximation, the adsorption of hydroxyl radicals, peroxyl radicals and atomic oxygen on bare TiO_2 (100) plane, as well as on Sb-doped and N-doped TiO_2(100) surfaces, was examined. The adsorption energies of investigated species were determined and complemented by the electronic structure calculations. Obtained results provide the basic data on the energetics of OER on TiO_2 (100) surface, which will be further applied in the evaluation of the reactivity of modified TiO_2-electrodes in the anodic oxidation of organic pollutants.

Keywords: *Rutile TiO_2; OER; DFT Calculations; Organic Pollutants; Electrochemical Oxidation.*

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6th December 2022

THE NECESSITY OF MATHEMATICAL OPTIMIZATION FOR CLEANER PRODUCTION

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Abstract: The manufacturing industry, as one of the most important in the world, consumes a lot of energy. Since the industrial revolution, humanity has paid little attention to our environment while producing all of the goods required for rapid development. The time has come for every industry to abandon its "old ways" of doing business. In this regard, the manufacturing industry is no exception. To understand how we can make our plants more efficient, we must first understand the flow of energy in a manufacturing plant. The highest level, namely the enterprise level, receives total energy input and distributes it among various departments, such as design, production, and management. This proportion of energy flows through lighting and heating, ventilation, and air conditioning (HVAC) systems. The second level is the manufacturing sector. A typical scenario at this level is the need to manufacture several products, each of which can be manufactured on multiple production lines, each of which includes a variety of machine tools and auxiliary devices. The final level is known as the process level, and it is where energy is primarily consumed by machine tools, auxiliary equipment, tools, and material flow systems. The HVAC system consumes the majority of total energy in a manufacturing plant, rather than the machines that perform cutting, assembly, and other processes. The transition to cleaner production is difficult, but necessary. If we want cleaner and safer products and environments, mathematical optimization models must be implemented at all levels across all industries.

Keywords: *Environment; Production; Efficiency; Cleaner Production*

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DISC2022 – 2nd DIFENEW International Student Conference

6th December 2022

EXAMINATION OF APPLIED PARAMETERS FOR THE REMOVAL OF NICKEL FROM WATER USING THE ION EXCHANGE PROCESS

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Abstract: Heavy metals, which are classified as toxic pollutants and found in water supplies, present a serious threat to the environment and living organisms. Nickel is a potentially harmful metal that contaminates food, the environment, including soil, sediment, and water resources. Nickel concentration in drinking water can be reduced using a number of methods, including ion exchange, membrane, adsorption, and coagulation and flocculation. Ion exchange is one of these techniques that is thought to be the most appropriate since it offers a number of advantages, including great efficiency, the ability to regenerate used resins, minimal waste production, and a reasonably low cost. Commercial macroporous cationic ion exchange READ-HM was used to remove nickel from water. The effects of the initial nickel concentration, the dose of ion exchange resin, the pH value, the contact time, and the concentration of magnesium and calcium ions were investigated using the statistical method for experimental design DSD (definitive screening design). The analyzed process parameters were optimized based on the experimental design to achieve the highest level of nickel removal. It was discovered that the pH, contact time, nickel concentration and calcium concentration are significant factors. The only statistically significant two-factor interaction is pH * magnesium. The following parameters were estimated with the aforementioned resin to produce a nickel removal rate of 82%: pH 7, contact time of 350 minutes, resin dose of 0.5 ml/l, nickel concentration of 145.19 µg/l, calcium concentration of 500 mg/l, and magnesium concentration of 5 mg/l.

Keywords: *Drinking Water, Nickel, Ion Exchange, Experimental Design.*

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6th December 2022

AQUEOUS BIPHASIC SYSTEMS AS PRE-TREATMENT PROCEDURE FOR DETERMINATION OF PHARMACEUTICAL COMPOUNDS

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Abstract: Non-steroidal anti-inflammatory drugs (NSAIDs), a class of pain killers, due to their widespread use are continuously discharged into the aquatic environment where they are pseudo-persistent. The most commonly used technique for the pre-treatment and preconcentration of aqueous samples containing NSAIDs is solid-phase extraction (SPE). SPE requires an additional desorption step of the analyte, usually with hazardous volatile organic solvents. Therefore, developing alternative pre-treatment techniques for their extraction and preconcentration from aqueous samples prior to their quantification is important. Aqueous biphasic systems (ABS) are a category of liquid–liquid extraction proved to be appropriate techniques for extraction of pharmaceutical compounds of interest. In this study we proposed ABS based on copolymer PE6200 and different cholinium ionic liquids (ILs) as an alternative pre-treatment strategy for NSAIDs, namely diclofenac and nimesulide. First step was determination of phase diagrams of each PE6200-based ABS in combination with selected cholinium-based ILs accompained by different anions (dihydrogenphosphate, dihydrogencitrate and lactate). Top phases in each studied ABS are PE6200-enriched, while bottom phase are IL-enriched. Extraction studies were performed with all ABSs to identify the most promising system able to completely extract the two NSAIDs. According to partition coefficients both diclofenac and nimesulide migrate toward more hydrophobic PE6200-rich phase in each ABS, which is consistent with their hydrophobicity (logKow=4.52 and logKow=2.60). Extraction efficiencies greater than 99.9% were achieved using cholinium- dihydrogenphosphate while obtained conentration factors were above 100. Therefore, according to obtained results and considering the benignity of the ABS constituents, extraction system composed of PE6200 and cholinium- dihydrogenphosphate has potential as a pre-treatment procedure before quantification of NSAILs by chromatographic method. Further optimization studies to adjust the extraction conditions and composition of ABS are crucial steps in order to achieve maximal efficiency with minimal consumption of ABS constituents.

Keywords: *Aqueous Biphasic Systems; Copolymer; Ionic Liquids; Pre-treatment; Non-steroidal Anti-Inflammatory Drugs.*

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DISC2022 – 2nd DIFENEW International Student Conference

6th December 2022

DEVELOPMENT OF A SUSTAINABLE WEEE COLLECTION SYSTEM IN NOVI SAD

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Abstract: Electrical and electronic equipment (EEE) has become indispensable in modern societies, enabling instant communication and higher standards of living worldwide. However, waste from electrical and electronic equipment (WEEE or e-waste) is considered an emerging environmental problem. The production stage of these devices has several impacts on resource consumption, while inappropriate handling of WEEE is unsafe for both human health and the environment, discharging heavy metals and persistent organics into nature. Record quantities of generated e-waste and its potentially hazardous nature shed light on several challenges that governments need to overcome in planning and implementing procedures to meet the requirements imposed by European Union (EU) legislation. This paper identifies the main shortcomings of the Serbian e-waste collection system and investigates potential influencing factors on the implementation of an adequate e-waste collection system. Three scenarios were developed in order to design a sustainable WEEE collection system in Novi Sad. The scenarios vary depending on the management, logistics, and infrastructure solutions, taking into account economic and social criteria. It is concluded that a system designed to be accepted by the local population is equally important, which would contribute to greater efficiency and financial sustainability.

Keywords: *Electrical and Electronic Equipment; E-waste Collection System; European Union; Serbia.*

DISC2022 – 2nd DIFENEW International Student Conference

6th December 2022

IONIC LIQUIDS BASED AQUEOUS BIPHASIC SYSTEM FOR REMOVAL OF PESTICIDES FROM WASTEWATER

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Abstract: Organophosphorus pesticides (OPs) due to their extensive use for pest control and the prevention of diseases in agriculture and households are continuously discharged into the aquatic environment. Recently, ionic liquids (ILs) based aqueous biphasic systems (ABS) that are a class of liquid–liquid extraction proved to be promising techniques for extraction of different compounds of interest. The focus of this study was to examine and compare different IL-ABS with salicylate and bromide ILs for extracting OPs, namely malathion, azinphosmethyl and chloropyrifos, from wastewater. Both ILs 1,3-dibutylimidazolium salycilate ([bbim][Sal]) and 1,3-dibutylimidazolium bromide ([bbim]Br), form ABS with sodium-citrate. Top phase of each ABS corresponds to the IL-rich phase, while the bottom phase is salt-rich. Salicylate anion has three hydrogen bond acceptors and one hydrogen bond donor which imply that it achieves stronger bond with IL cation and is less hydrated than bromide anion. Consequently, salicylate-based IL is more hydrophobic and more easily salted-out in upper phase then bromide-IL, so it has a greater ability to form ABS. Extraction studies showed that all of three investigated OPs has partition coefficient higher than 1 implying that they migrate to IL-phase. Extraction efficiencies of OPs for each ABS are high (above 98%) with minor variations between studied pesticides. Based on obtained results and having in mind environmentally friendly nature of structurally different phase formers of IL-ABS, investigated systems have potential to be implemented as a platform for OPs removal from wastewater.

Keywords: *Organophosphorus Pesticides; Ionic Liquids; Extraction.*

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DISC2022 – 2nd DIFENEW International Student Conference

6th December 2022

NECESSITY OF CITIZENS EDUCATION ON REVERSE VENDING MACHINES AND RECYCLING

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Abstract: The environmental awareness of the majority of people in Serbia is at a low level so it`s important to make an effort to educate the citizens. The amount of packaging waste, especially in urban areas, is increasing and this problem needs to be solved. Reverse vending machines don`t solve the problem of waste, but they can symbolically influence people's consciousness.

An online survey was conducted as the most suitable research method. The survey is short and anonymous. Total of 216 examinees were involved in this survey. We got mostly positive answers (over 75% examinees) on questions if they are familiar with the term of reverse vending machines and if they are familiar reverse vending machines give certain monetary value for each bottle. However, in the additional question "Did this survey help you understand the importance of sorting and recycling packaging waste?", only 11% examinees answered that this survey didn`t help them because they have previous knowledge, 6% of examinees answered this survey didn`t help them and 83% of examinees answered this survey helped them. Although perception of 75% respondents is positive about reverse vending machines additional questions revealed that education is needed for more than 89% of respondents.

We concluded that our society is polarized because we have some answers where examinees don`t know about this subject at all and answers that reveal high awareness of the examinees. This shows that education is important and needed to raise people's environmental awareness. A systemic solution is needed. The education of citizens should start from the young age. It`s necessary to carry out large-scale actions with the youngest population (kindergarden and primary school) because they can influence adults in their life.

Keywords: *Reverse Vending Machines; Education; Recycling; Environmental Awareness.*

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MEHANOCHEMICALLY ACTIVATED PYROPHYLLITE WITH SILVER: CHARACTERIZATION TOWARDS IMPROVED MEDICAL ACTION

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Abstract: The biocompatibility of clay materials has made them suitable for designing hybrid clay systems as multifunctional carriers with improved efficacy for a wide range of biomedical applications. Their tunable structural, morphological and physicochemical properties have attracted great interest in the current development of theranostics and cancer research. In this study, pyrophyllite, $Al_2Si_4O_{10}(OH)_2$, one of the most commonly used clay materials, was mechanochemically activated with $AgNO_3$ (2, 5, and 10 wt% of silver). Thereby, the grinding time was varied from 20 to 320 min. The obtained samples were characterized by FTIR (Fourier-transform infrared spectroscopy), thermal analysis methods TGA (thermogravimetric analysis) and DSC (differential thermal analysis) as well as DLS (dynamic light scattering) for obtaining particle size distribution. The results revealed that AgNPs were generated during the mechanochemical processing of the pyrophyllite/$AgNO_3$ mixture and that the amount of silver incorporated into this aluminosilicate clay as well as the grinding time greatly affect the physicochemical properties of this composite. This system could serve as a base for further modifications required for developing clay-based drug delivery system to perform targeted and controlled drug delivery.

Keywords: *Pyrophyllite; Clay Composites; AgNPs; Mechanochemistry; Biomedical Application.*

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DISC2022 – 2nd DIFENEW International Student Conference

6th December 2022

ENVIRONMENTAL IMPACT ASSESSMENT FOR SUSTAINABLE HYDROPOWER

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Abstract: Hydropower (HP) is a clean, renewable, and environmentally friendly source of energy, whose generation increased 124 TWh (+3%) in 2020, reaching 4 418 TWh and remaining the largest renewable source of electricity, generating more than all other renewable technologies combined. Hydropower has the potential to balance a renewable energy system on a short term and on a medium to long term basis by using pumped-storage technology. It contributes significantly to the reduction of GHG emissions and to the security of the energy supply. For sustainable HP environmental impact that might occur during construction period, as well as during normal operation and malfunction should be taken into account. Environmental impact assessment is based on the harmful effects of dams, accumulation and operation of hydroelectric generators that can lead to changes in physical and chemical characteristics of water, changes in river flow, disturbed fish migration, emissions from equipment, consequences of aerobic and anaerobic decomposition of biomass in water, sludge load, and the impact of accumulated waste, especially microplastics that directly affect the biotic and abiotic matrix. Adequate assessment and management of HP, as well as maintaining the availability of water resources, will contribute to adaptation to climate change.

Keywords: *Sustainable Hydropower, Environmental Impact Assessment, Climate Change, GHG Mitigation.*

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6th December 2022

CALCULATION OF TRAFFIC NOISE USING CADNA A SOFTWARE PACKAGE

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Abstract: The impact of traffic noise has a negative effect on the quality of life of the surrounding population and their health. The noise generated by the traffic is intermittent, of variable intensity, with occasional impulses. It is necessary to implement appropriate protection measures against the unwanted impact of traffic noise if there are residential buildings in the immediate vicinity of the observed section of the road that is the subject of the project. For the purposes of determining the level of noise caused by traffic, the Cadna A software package is used, which uses the French national method for evaluating the road traffic noise indicator NMPB-Routes-96 (SETRA-CERTU-LCPC-CSTB), which is recommended by the Directive 2002/49/EC. The use of the French national method is defined by the Regulation on noise indicators, limit values, methods for evaluating noise indicators, disturbance and harmful effects of noise in the environment (Official Gazette of RS No. 75/10). For the purposes of the acoustic calculation, an acoustic model is created. The model includes a 3D model of the terrain, technical and technological characteristics of the road and vehicles, forecasted traffic for the last year of the planning period, layout and purpose of the facilities. The analyzed road is divided into sections with different characteristics (PGDS, speed limits, etc.). The input parameters for noise modeling are data from the existing project, road project and traffic study. For the calculation, a period of 24 hours is used, which is divided into three reference time intervals: the day lasts 12 hours (from 6 a.m. to 6 p.m.), the evening lasts 4 hours (from 6 p.m. to 10 p.m.) and the night lasts 8 hours (from 10 p.m. until 6 o'clock). Geodetic surveying of the terrain and buildings is carried out at the beginning of the project, in order to form the foundations necessary for work. As a result of the calculation, the necessary length and height of the walls is obtained, which would eliminate the negative impact of traffic noise. The height of the walls is defined in such a way as to ensure the reduction of the level of traffic noise below the permitted level in the settlements along the planned road.

Keywords: *Noise; Influence; Calculation; Walls; Cadna A.*

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6th December 2022

VALIDATION OF GC-MS METHOD FOR VOLATILE FATTY ACIDS

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Abstract: Organic acids with up to 7 carbon atoms are referred to as volatile fatty acids (VFAs), which are low-molecular-mass organic acids with a high hydrophilic property. The analyses of separate VFA molecules and their concentration are valuable for control of decomposition process of organic molecules, methane and carbon-dioxide production from waste. Various techniques have been published for identifying and analysing volatile fatty acids (VFAs) in wastewater. The basic titration approach is still the go-to method for determining VFA concentration in wastewater since it is quick and accurate for assessment of VFAs (high LOQ and low accuracy and precision). The GCMS method allows the detection and quantification of each VFA separately, which is not the case with titration. Several GCMS approaches have also been utilized for the detection and quantification of VFAs in wastewater; however the data is still ambiguous and scarce. It is required to optimize more effective techniques. In this research the wastewater samples were prepared via liquid-liqud extraction (LLE) procedure coupled with Kuderna Danish apparatus, and analysed via GC-MS. The performance of two solvents was evaluated, methyl-tert-butyl ether (MTBE) and dichloromethane (DCM), as the two most used solvents in methods for VFAs determination in wastewater samples. Samples were directly injected into the GC-MS system. The validation parameters limit of detection (LOD), limit of quantification (LOQ), linearity, precision and the accuracy for proposed method were observed. The GC-MS method using DCM as a solvent in LLE procedure for identifying VFAs has shown to be highly precise and accurate according to the data gathered during the validation procedure. The precision for DCM and MTBE were in ranges of 2 – 9 % and 1 – 7 %, respectively, and the accuracy in ranges of 90 – 107 % and 82 – 106 %, respectively.

Keywords: *Method Validation; Gas Chromatography; Volatile Fatty Acids.*

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DISC2022 – 2nd DIFENEW International Student Conference

6th December 2022

USE OF WASTE BY-PRODUCTS FROM THE OLIVE PROCESSING INDUSTRY IN THE TREATMENT OF WATER CONTAMINATED BY LEAD AND ZINC

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Abstract: In the Mediterranean area where olives are grown and processed on a large scale, a huge amount of waste by-products such as olive pits and olive pomace is generated. For achieving environmental sustainability, huge efforts are being made in order to find a useful purpose for such waste. This type of biomaterial is most often burned to obtain energy, but it could be used in treatment of water polluted by heavy metals, and afterwards burned in a controlled atmosphere. Therefore, this research is focused on use of olive pits and olive pomace pellets of particle size 0.56 - 1.00 mm, in removal of lead and zinc of two initial concentrations (0.5 mmol/L and 1.5 mmol/L) from monocomponent aqueous solutions. The experiments were performed by batch method on the laboratory shaker for 24 h, at 250 rpm, at ambient temperature, and at solid/liquid ratio of 1/100. The efficiency of the olive pits was 32.6% for the higher, and 70.6% for the lower initial lead concentration, while for zinc was 30.9% for the higher, and 64.6% for the lower initial zinc concentration. The efficiency of the olive pomace pellets was 24.4% for the higher, and 36.6% for the lower initial lead concentration, while for zinc it was 24.2% for the higher and 48.3% for the lower initial concentration. In general, the olive pits were more efficient in lead removal, while olive pomace pellets were more efficient in zinc removal, especially for the lower initial concentration. The lowest achieved residual concentrations were 0.164 mmol/L for zinc, and 0.142 mmol/L for lead, which are both above the limit values in wastewater (0.031 mmol/L for zinc and 0.002 mmol/L for lead) according to the Croatian legislative. The obtained results suggest that use of wasted industrial by-products, in at least pre-treatment stage, could lead to more economically viable water treatment.

Keywords: *Lead; Zinc; Industrial By-products; Olive Pits; Olive Pomace Pellets; Wastewater Treatment.*

DEGRADATION OF PER-AND POLYFLUORINATED ALKYL SUBSTANCES (PFAS) WITH PLASMA TREATMENT

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Abstract: Non-thermal plasma (NTP) in liquid and gas-liquid environments generates in situ nitrogen-containing species, hydroxyl radical, hydroperoxyl radical, atomic hydrogen and oxygen, as well as other radicals and active chemical species. These active species are capable of degrading the organic micropollutants (OMPs) from the solution relatively quickly, using a low power discharge. The aim of this study was to investigate degradation of per- and polyfluorinated alkyl substances (PFAS) in different water matrices using the NTP in gas-liquid environment with pin-type electrode configuration. It was found that in 10 minutes treatment time most of the selected compounds can be degraded up to 90% in pure water, while the degradation in "real" water samples - tap water and WWTP secondary effluent was around 50% and 17%, respectively.

Keywords: *Non-thermal Plasma; Organic Micropollutants; PFAS Substances; Removal; Water Treatment.*

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CHARACTERIZATION OF PYROPHYLLITE FOR POTENTIAL USE IN WATER FILTRATION

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Abstract: Water pollution has become a major source of concern and priority for society. So, it is important to find an adequate solution for its purification. Due to pyrophyllite's great physicochemical characteristics and distribution in nature, it is used in many industries as well as for wastewater treatment. In this study, the characterization of pyrophyllite was done with certain methods, in order to see the changes that occurred after modification, for possible use as a ceramic membrane for water filtration. Firstly, pyrophyllite was ultrasonically purified, then pastilles were made under the pressure of 50 MPa, and thermally treated at the temperature of 1050 °C in a time interval of 2-6 h. The methods that were used for the characterization were: X-ray structural analysis (XRD), infrared spectroscopy with Fourier transform (FTIR), scanning electron microscopy (SEM), Raman spectroscopy, as well as thermal analysis methods, thermogravimetric analysis (TGA) and differential thermal analysis (DSC). The thermal treatment removed impurities present in the sample and excess water was released. Also, amorphization and dehydroxylation were noticed, as well as a homogeneous arrangement of pores.

Keywords: *Pyrophyllite; Water Pollution; Ceramic Membrane; Water Filtration.*

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DISC2022 – 2nd DIFENEW International Student Conference

6th December 2022

THE SIGNIFICANCE OF DIRECTING HAZARDOUS SUBSTANCES INTO APPROPRIATE FINAL SINKS

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Abstract: The issue of quantity is important and it shows us that the more waste is collected and recycled, the status of human health and the environment is better. Every year, new products are introduced, more and more complex in terms of chemical composition, which very often contain new hazardous substances that have never been used before. Therefore, the treatment that meets the qualitative goals of protection of human health and the environment is even more important than the complete treatment of all waste. Possibility of recycled waste to replace primary resources and the ability of waste management to direct hazardous materials to final sinks are of vital importance. For hazardous organic materials, physical-chemical processes, such as waste-to-energy and other transformation processes represent final sinks. For hazardous inorganic materials, sinks are either safe deposits such as long-term after care free landfills or other transformation processes. Additionally, acceptable levels of emissions into the environment should be provided when treating waste. In every waste management system there are significant amounts of non-recyclable and hazardous materials that must be managed sustainably, and therefore it is important to direct the substances focusing not only on materials that can be recycled, but also on those that need to be disposed of in appropriate final sinks.

Keywords: *Waste Management; Final Sink; Hazardous Substances.*

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6th December 2022

OPTIMIZATION OF THE METHOD OF REMOVING MICROFIBERS FROM WATER BY COAGULATION AND FLOCCULATION

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Abstract: In the last few years, the presence of microfibers (MPFs) in the environment, most often in water, has attracted great concern and attention. The most common types of microfibers found today are synthetic microfibers, but also microfibers that contain fibers from natural sources such as wool and cotton. In the environment, microfibers can most often be characterized as small-sized fibers that are produced by the production and use of textiles. It has been found that one wash releases 6 million PES fibers and 700,000 acrylic fibers, which depends on the washing program, detergent, and textile properties. Previous research indicates that attention should be paid to synthetic microfibers. Based on research, it was found that after multiple treatments in WWTP plants, up to 88% of microplastics are removed, with coagulation and filtration treatments contributing the most. In research to date, coagulation has been used sparingly in WWTPs to remove microplastics. The goal of this work was to examine the possibility of removing microplastics or microfibers from water, using coagulation and flocculation treatment. The experiment was performed on Jar apparatus and a synthetic matrix (distilled water enriched with salts Ca, Mg and Na) was used as the matrix. Two coagulants were used in this experiment ($FeCl_3$ and PaCl). Based on the results obtained in the synthetic matrix, it can be established that both coagulants enabled a high degree of removal of microfibers, with the minimum efficiency achieved being around 60%, and optimal doses enabled complete removal. This research enables a better understanding of the removal of microplastics or microfibers at WWTP, with techniques that are easily available, cheap, but also effective.

Keywords: *Microplastics; Fibers; Water Treatment; Coagulation and Flocculation.*

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SUSTAINABLE ENVIRONMENTAL AND OCCUPATIONAL HEALTH AND SAFETY PROJECT MANAGEMENT

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FROM ZERO TO AGILE: HOW AGILE APPROACH IN PROJECT MANAGEMENT FOSTERS CHANGE AND CONTINUOUS PROCESS IMPROVEMENT

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Abstract: Frequent and intense changes in the business environment require a significantly higher level of adaptability and flexibility at all organizational levels. An agile approach in project management provides the opportunity to integrate changes into daily operations and achieve multiple benefits, both in the form of increased productivity and efficiency and improving all business processes in a company or organization. Therefore, an agile approach in project management, grounded in agile values and principles and adapted to the contemporary business environment, leads to better implementation and acceptance of changes, continuous process improvement, and optimal value creation. To succeed in this, organizations must go a long way from a non-agile or partially agile to an agile approach in project management and transform their own business, enabling them to accept changes and improve overall performance. Accordingly, the proposed research will focus on identifying the key steps and factors for the application of the agile approach in project management depending on the degree of agility of the organization and, as such, tends to indicate the specifics of its impact on business, especially in the change management and continuous process improvement domain. Also, it is important to note that certain companies or organizations (e.g. IT companies) are much more familiar with the agile approach in project management than others (e.g. public administration), which will represent a special challenge when determining guidelines for its further application in practice.

Keywords: *Agile Approach; Agile Project Management; Agile Transformation; Change Management; Process Improvement.*

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PROJECT SUCCESS BASED ON THE PROJECT MANAGER AND PROJECT TEAM MEMBERS

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Abstract: Project management is widespread in almost every organization, yet poor project performance is still common. In this regard, it is necessary to identify the key factors that influence the success of the project. The problem in defining the key success factors of projects stems from the fact that there are different types of organizations in different industries, and different types of projects with different characteristics. Today, there are numerous ways and criteria for evaluating the development and success of a project. One of the oldest is based on the so-called the iron triangle, which contains the principles of cost, time and quality, that is, the three main aspects that must be achieved and that characterize projects are: scope, cost and time. Success depends on many factors that can change from project to project and from organization to organization. Different authors, depending on the type of project, that is, on the area in which it is implemented, also mention different factors of project success as significant. With the expansion of project management as a discipline and the importance of the human factor in project implementation, it is important to deepen the field of research on critical project success factors, by putting the project manager and the project team and their related success factors in focus. The main goal of the research, within this work, is to present the most significant success factors of projects, based on the project manager and the project team, on the basis of theoretical analysis, that is, by searching secondary data. This paper, which includes a review of the literature, will systematically analyze and summarize the results of all relevant studies related to the topic of interest in a transparent manner.

Keywords: *Project Management; Project Manager; Project Team; Success Factors.*

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GREEN MANUFACTURING AS A PATH TO INDUSTRY 5.0

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Abstract: Today's industry, with an emphasis on companies in the manufacturing sector, greatly impacts the living environment and represents a challenge for achieving sustainability. This sector is very intensive in the consumption of resources, such as energy, material and water, therefore it is very important to approach the digital and green transformation. This active consumption of the aforementioned resources has led to air and water pollution and other environmental and climatic disasters, which have a direct negative impact on humans. In order to survive in the new conditions that require a more rational and efficient use of resources, manufacturing companies must reduce and transform their operations and establish the path to Industry 5.0. In this way, the industry contributes to society, i.e. the focus returns to the worker, who was not given enough attention during Industry 4.0, and therefore the well-being of the planet was neglected. Industry 5.0 tends towards a sustainable, resilient industry, where work is subordinated to man and his environment. If we take the situation with COVID-19 as an example, we can see that many companies met it completely unprepared, because they were not sufficiently resilient to external conditions, that is, they did not approach the consumption of natural resources in an efficient way. It can be said that Industry 5.0 represents an upgrade of Industry 4.0 in which the focus was primarily on the application of various autonomous or semi-autonomous processes and digital technologies that have become characteristic of this industry. This is precisely what led to alienation from the human factor, which is now increasingly being approached. The focus on people and the preservation of the environment results in the request to adjust business processes and research and find ways for more efficient exploitation of resources.

Keywords: *Industry 5.0; Sustainability; Resilience; Green Transformation; Manufacturing.*

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STRENGTHENING THE CAPACITY FOR TEACHING IN THE FIELD OF EU STUDIES THROUGH JEAN MONNET PROJECTS

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Abstract: During the realisation of the Erasmus plus project DOHASS, the lack of the knowledge and lot of disinformation on European Union (EU) issues and policies in Republic of Serbia have been confirmed. Learning about the objectives, strategies and the functioning of the EU is an important part of promoting active citizenship and the common values of freedom, tolerance, and non-discrimination, especially in developing countries such as Serbia, remote regions and third countries. In accordance with the main objective of the Jean Monnet Actions the multidisciplinary team of university professors and assistants from University of Novi Sad developed the project Challenges and opportunities for implementation of regulations on environment, occupational health and safety and labour relations based on the best European practices (ENROL). The project main objectives are to strengthen the capacity for teaching in the field of EU studies and to spread knowledge about the EU to a wider society. The ENROL project will introduce the courses in EU Studies with focus on the field of Environmental protection, Occupational safety and health and Labour relations through Summer schools which will be developed and implemented. The ENROL Summer schools will include the tailored courses based on the needs of society, the analysis of the lack of Euro-integrative subjects and topics within the academic curriculum of Serbian universities, and employers' needs. The ENROL Summer schools will be introduced to graduated students, master students, PhD students, academic personnel from other higher education institutions, experts, professionals and policy-makers. The ENROL project will result in strengthening the capacity of young people to acquire additional competences and soft skills based on the EU values.

Keywords: *Jean Monnet, EU Studies, Environmental Engineering, Occupational Safety and Health.*

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6th December 2022

ESG CRITERIA AND RESILIENCE: THE ROADMAP TO SUCCESS OF 21ST-CENTURY PROJECTS

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Abstract: It used to be very simple to evaluate a company's business success - the primary goal of every company was to maximise profits, and the best way for a company to contribute to the environment was through its growth and development and the achievement of financial goals. The evaluation of business success has changed, which indicates that the way of doing business in today's companies must change. Companies have begun to see multiple and long-term consequences of their actions, affecting their reputation and financial results. Understanding business success has become multidimensional and requires observing the bigger picture, which includes not only financial aspects but also the social and environmental aspects of the business. The complexity, uncertainty and instability that characterise the 21st century contributed to this as a trigger for considering and introducing new criteria for making decisions about company investments. An example is ESG criteria, performance measures or indicators of a company's environmental (E), social (S) and governance (G) issues. The company's ESG performance also indicates its resilience. By implementing these criteria in business strategy, the company increases the probability of better responding to new challenges, adapting to disruptions, and maintaining long-term value creation. The link between ESG criteria and financial performance is becoming more robust than ever. As a result, companies tend to create sustainable value, which offers the potential to help solve global environmental and social problems and create a more resilient business. Resilience implies a holistic view of the company, understanding risks and opportunities, internal and external, and adapting the business model. The traditional project success implied a triple constraint – projects must be completed on time, on budget, and in specifications. Therefore, a new question arises: "Do these modern observations of companies' business success impact the changes in criteria companies' project success is evaluated?". The proposed research aimed to investigate the relationship between ESG criteria and resilience and their influence on project success, perceived as a multidimensional construct.

Keywords: *ESG, Resilience, Project Success, Project Management.*