



University of Belgrade
Technical Faculty in Bor

EcoTEK

31st International conference

Ecological Truth & Environmental Research

Editor

Prof. Dr Snežana Šerbula

PROCEEDINGS

Hotel Sunce, Sokobanja, Serbia
18–21 June 2024

PROCEEDINGS

31st INTERNATIONAL CONFERENCE

ECOLOGICAL TRUTH & ENVIRONMENTAL RESEARCH – EcoTER'24

Editor:

Prof. Dr Snežana Šerbula, University of Belgrade, Technical Faculty in Bor

Technical editors of the Proceedings:

Dr Tanja Kalinović, University of Belgrade, Technical Faculty in Bor

Dr Jelena Kalinović, University of Belgrade, Technical Faculty in Bor

Prof. Dr Ana Radojević, University of Belgrade, Technical Faculty in Bor

Dr Jelena Jordanović, University of Belgrade, Technical Faculty in Bor

Sonja Stanković, MSc, University of Belgrade, Technical Faculty in Bor

Editor of the 6th Student Section:

Prof. Dr Maja Nujkić, University of Belgrade, Technical Faculty in Bor

Technical editor of the 6th Student Section:

Vladan Nedelkovski, MSc, University of Belgrade, Technical Faculty in Bor

Cover design:

Aleksandar Cvetković, BSc, University of Belgrade, Technical Faculty in Bor

Publisher: University of Belgrade, Technical Faculty in Bor

For the publisher: Prof. Dr Dejan Tanikić, Dean

Printed: University of Belgrade, Technical Faculty in Bor, 100 copies, electronic edition

Year of publication: 2024



This work is available under the Creative Commons Attribution-Non-commercial-NoDerivs licence (CC BY-NC-ND)

CIP - Katalogizacija u publikaciji
Narodna biblioteka Srbije, Beograd

502/504(082)(0.034.2)

574(082)(0.034.2)

INTERNATIONAL Conference Ecological Truth & Environmental Research (31 ; 2024 ; Sokobanja)

Proceedings [Elektronski izvor] / 31st International conference Ecological Truth & Environmental Research - EcoTER'24, Sokobanja, Serbia, 18-21 June 2024 ; [organized by] University of Belgrade, Technical faculty in Bor (Serbia) ; [co-organizers University of Banja Luka, Faculty of Technology – Banja Luka (B&H) ... [et al.]] ; [editor Snežana Šerbula]. - Bor : University of Belgrade, Technical faculty, 2024 (Bor : University of Belgrade, Technical faculty). - 1 elektronski optički disk (CD-ROM) ; 12 cm

Sistemski zahtevi: Nisu navedeni. - Nasl. sa naslovne strane dokumenta. - Preface / Snežana Šerbula. - Tiraž 100. - Bibliografija uz svaki rad.

ISBN 978-86-6305-152-2

a) Животна средина -- Зборници б) Екологија – Зборници

COBISS.SR-ID 147002889



**The 31st International Conference
Ecological Truth & Environmental Research – EcoTER'24**

is organized by:

UNIVERSITY OF BELGRADE
TECHNICAL FACULTY IN BOR (SERBIA)

Co-organizers of the conference:

University of Banja Luka, Faculty of Technology,
Banja Luka (B&H)

University of Montenegro, Faculty of Metallurgy and Technology, Podgorica
(Montenegro)

University of Zagreb, Faculty of Metallurgy, Sisak (Croatia)

University of Pristina, Faculty of Technical Sciences, Kosovska Mitrovica
(Serbia)

Society of Young Researchers – Bor (Serbia)



**The EcoTER'24 conference is financially supported
by
the Ministry of Science, Technological Development and
Innovation
of the Republic of Serbia**



Republic of Serbia

**MINISTRY OF SCIENCE,
TECHNOLOGICAL DEVELOPMENT AND INNOVATION**

Platinum donor of the EcoTER'24 conference



Platinum donor of the EcoTER'24 conference

HBIS SERBIA

Gold donor of the EcoTER'24 conference



Silver donor of the EcoTER'24 conference



**ИНЖЕЊЕРСКА
КОМОРА
СРБИЈЕ**

SCIENTIFIC COMMITTEE

Prof. Dr Snežana Šerbula, *President*

| | |
|---|---|
| Prof. Dr Alok Mittal (India) | Prof. Dr Milutin Milosavljević (Serbia) |
| Prof. Dr Jan Bogaert (Belgium) | Prof. Dr Nenad Stavretović (Serbia) |
| Prof. Dr A. Nadgórska-Socha (Poland) | Prof. Dr Ivan Mihajlović (Serbia) |
| Prof. Dr Luis A. Cisternas (Chile) | Prof. Dr Milovan Vuković (Serbia) |
| Prof. Dr Wenhong Fan (China) | Prof. Dr Nada Blagojević (Montenegro) |
| Prof. Dr Martin Brtnický (Czech Republic) | Prof. Dr Darko Vuksanović (Montenegro) |
| Prof. Dr I.M. De Oliveira Abrantes (Portugal) | Prof. Dr Irena Nikolić (Montenegro) |
| Prof. Dr Shengguo Xue (China) | Prof. Dr Šefket Goletić (B&H) |
| Prof. Dr Tomáš Lošák (Czech Republic) | Prof. Dr Džafer Dautbegović (B&H) |
| Prof. Dr Maurice Millet (France) | Prof. Dr Borislav Malinović (B&H) |
| Prof. Dr Murray T. Brown (New Zealand) | Prof. Dr Slavica Sladojević (B&H) |
| Prof. Dr Xiaosan Luo (China) | Prof. Dr Nada Šumatić (B&H) |
| Prof. Dr Daniel J. Bain (USA) | Prof. Dr Snežana Milić (Serbia) |
| Prof. Dr Che Fauziah Binti Ishak (Malaysia) | Prof. Dr Dejan Tanikić (Serbia) |
| Prof. Dr Richard Thornton Baker (UK) | Prof. Dr Milan Trumić (Serbia) |
| Prof. Dr Mohamed Damak (Tunisia) | Dr Jasmina Stevanović (Serbia) |
| Prof. Dr Jyoti Mittal (India) | Dr Dragana Randelović (Serbia) |
| Prof. Dr Miriam Balaban (USA) | Dr Viša Tasić (Serbia) |
| Prof. Dr Fernando Carrillo-Navarrete (Spain) | Dr Ljiljana Avramović (Serbia) |
| Prof. Dr Pablo L. Higuera (Spain) | Dr Stefan Đorđievski (Serbia) |
| Prof. Dr Mustafa Cetin (Turkey) | Prof. Dr Branimir Jovančićević (Serbia) |
| Prof. Dr Mauro Masiol (Italy) | Dr Mirjana Marković (Serbia) |
| Prof. Dr George Z. Kyzas (Greece) | Dr Lidija Mančić (Serbia) |
| Prof. Dr Mustafa Imamoğlu (Turkey) | Dr Tanja Brdarić (Serbia) |
| Prof. Dr Petr Solzhenkin (Russia) | Prof. Dr Tatjana Anđelković (Serbia) |
| Prof. Dr Yeomin Yoon (USA) | Prof. Dr Milan D. Antonijević (UK) |
| Prof. Dr Chang-min Park (South Korea) | Prof. Dr Jelena Mitrović (Serbia) |
| Prof. Dr Faramarz Doulati Ardejani (Iran) | Prof. Dr Polonca Trebše (Slovenia) |
| Prof. Dr Natalija Dolić (Croatia) | Prof. Dr Popescu Francisc (Romania) |
| Prof. Dr Adrian Eugen Cioablă (Romania) | |

HONORARY COMMITTEE

Dr. Petar Paunović

(Zaječar, Serbia)

Prof. Dr Zvonimir Stanković

(Bor, Serbia)

Prof. Dr Velizar Stanković

(Bor, Serbia)

Prof. Dr Milan M. Antonijević

(Bor, Serbia)

Prof. Dr Ladislav Lazić

(Sisak, Croatia)

Dragan Randelović, Society of Young Researchers – Bor

(Bor, Serbia)

Toplica Marjanović, Society of Young Researchers – Bor

(Bor, Serbia)

Mihajlo Stanković, Special Nature Reserve of Zasavica

(Sremska Mitrovica, Serbia)

ORGANIZING COMMITTEE

Prof. Dr Snežana Šerbula, *President*

Prof. Dr Snežana Milić, *Vice President*

Prof. Dr Đorđe Nikolić, *Vice President*

Prof. Dr Ana Radojević, *Vice President*

Dr Tanja Kalinović, *Vice President*

Prof. Dr Marija Petrović Mihajlović

Prof. Dr Milan Radovanović

Prof. Dr Milica Veličković

Prof. Dr Danijela Voza

Prof. Dr Maja Nujkić

Prof. Dr Ana Simonović

Dr Jelena Kalinović

Dr Jelena Jordanović

Dr Dragana Medić

Sonja Stanković, MSc

Vladan Nedelkovski, MSc

Aleksandar Cvetković, BSc

Dragan Milenković, IT service

PREFACE

The 31st international conference Ecological Truth & Environmental Research – EcoTER'24 focuses on showing the latest research findings and innovations in the field of ecology, environmental protection and sustainable development. The conference will be held in Sokobanja (Serbia) in hotel Sunce in the period of 18–21 June 2024.

The aim of the conference is to connect the experts in various fields in order to transform attitudes and behaviors in everyday practices, as well as in the industry and economy sector which is essential for achieving the desired changes that our society must undergo.

The 31st international conference Ecological Truth & Environmental Research – EcoTER'24 is organized by the University of Belgrade, Technical Faculty in Bor, and co-organized by the University of Banja Luka, Faculty of Technology; the University of Montenegro, Faculty of Metallurgy and Technology – Podgorica; the University of Zagreb, Faculty of Metallurgy – Sisak; the University of Pristina, Faculty of Technical Sciences – Kosovska Mitrovica and the Society of Young Researchers – Bor.

These Proceedings encompass 119 papers from the authors coming from the universities, research institutes and industries in 15 countries: Brazil, Norway, USA, Spain, Austria, Libya, Italy, Israel, Slovenia, Croatia, Romania, Bulgaria, Montenegro, Bosnia and Herzegovina, North Macedonia, and Serbia. It is a great honor and pleasure to cordially wish a warm welcome to all the participants of the conference.

As a part of this year's conference, the 6th Student Section – EcoTERS'24 will be held. We appreciate the contribution of the students and their mentors who have also participated in the conference and hope that students will continue to explore and to be curious, since education is a never-ending process, and knowledge is continuously growing.

The organization of the EcoTER'24 conference has been financially supported by the Ministry of Science, Technological Development and Innovation of the Republic of Serbia.

The support of the Donors and their willingness and ability to cooperate has been of great importance for the success of the EcoTER'24 conference. The organizing committee would like to extend their appreciation and gratitude to the Platinum donors of the conference – Serbia ZiJin Copper doo Bor and HBIS SERBIA, to the Gold donor of the conference – Elixir Group, as well as to the Silver donor of the conference – Serbian Chamber of Engineers.

We would like to express our sincere appreciation to all the authors who have contributed to the Proceedings. We would also like to express our gratitude to the members of the scientific, organizing and honorary committees, reviewers, speakers, chairpersons and all the conference participants for their support of the EcoTER'24. Sincere thanks go to all the people who have contributed to the successful organization of the EcoTER'24.

Prof. Snežana Šerbula,

President of the scientific and organizing committee



TABLE OF CONTENTS

Plenary Lectures

Branko Bugarski

ELECTROSTATIC DISPERSION OF POLYMER SOLUTIONS IN THE PRODUCTION OF MICROGEL BEADS CONTAINING BIOCATALYST 1

Anupama Ghosh, M. R. Del Grande, L. T. Teixeira, S. Letichevsky, C. A. Senna, M. D. Carbajal Ccoyllo, J. F. Chaves e Silva, V. C. Gois de Oliveira, R. N. Correia de Siqueira

HEAT TREATMENT OF IRON-ADSORBED FUNCTIONALIZED NANOCELLULOSE FIBERS IN ORDER TO SYNTHESIZE HYBRID INORGANIC-CARBON MATERIAL 8

Alena Bartonova

ENVIRONMENTAL PROTECTION: WHY IS EUROPE'S AIR (MOSTLY) SO CLEAN? 14

Invited Lectures

Nevenka Rajić, J. Pavlović

APPLICATION OF NATURAL ZEOLITE – CLINOPTILOLITE IN WATER TREATMENT BY ADSORPTION AND PHOTOCATALYSIS 17

Dušan Nikolić, A. Tasić

THE EUROPEAN PERCH (*Perca fluviatilis*) AS AN INDICATOR OF OCPs POLLUTION IN DIFFERENT TYPES OF RESERVOIRS IN SERBIA 24

Jelena Korać Jačić, M. R. Milenković, D. Bartolić

DEGRADATION OF TETRACYCLINE ANTIBIOTICS IN AQUATIC ENVIRONMENT BY UV IRRADIATION AND FERRIC ION PHOTOLYSIS 30

Conference Papers

Environmental monitoring and impact assessment

Aleksandra Papludis, S. Alagić, S. Milić, J. Nikolić, I. Zlatanović, S. Jevtović, V. Stankov Jovanović

NAPHTALENE SCREENING IN BOR'S MUNICIPALITY BASED ON ITS CONCENTRATIONS IN LEAVES AND STEMS OF *Hedera helix* L. 38

Darko Anđelković, M. Branković

APPLE PEEL AS A BARRIER TO PESTICIDES MIGRATION INTO DEEPER FRUIT PARTS 43

| | |
|---|-----|
| Darko Anđelković, M. Branković PERFORMANCES OF QuEChERS BASED GC-MS AND LC-MS/MS METHODS FOR PESTICIDES ANALYSIS IN APPLES | 49 |
| Darko Anđelković, M. Branković COMPARISON OF PESTICIDES STABILITY STORED IN TWO SOLVENTS OF DIFFERENT VISCOSITY | 55 |
| Milena Tadić, I. Nikolić, D. Đurović, N. Cupara, J. Vuković TRIHALOMETHANES CONTENT IN HOTEL'S SWIMMING POOLS WATER IN A SOUTH OF MONTENEGRO | 61 |
| Jelena Vranković, K. Jovičić, V. Đikanović FIRST LINE DEFENCE ANTIOXIDANT ENZYMES IN <i>Blicca bjoerkna</i> (LINNAEUS, 1758) FROM THE BELGRADE SECTION OF THE DANUBE RIVER | 66 |
| Miomir Mikić, R. Marković, V. Marjanović, R. Rajković, M. Jovanović RECUltIVATION OF RTH FLOTATION TAILINGS IN BOR, SERBIA | 71 |
| Miomir Mikić, V. Marjanović, R. Marković, M. Jovanović, R. Rajković MINING AND THE ENVIRONMENT, ENVIRONMENTAL IMPACT MONITORING PROGRAM FOR FLOTATION TAILING RTH-BOR, SERBIA | 77 |
| Vesna Obradović, M. Perović, T. Vučković EVALUATING CORROSION AND BIOFOULING POTENTIAL BASED ON GROUNDWATER MICROBIOLOGICAL COMPOSITION | 83 |
| Vesna Obradović, M. Perović, J. Lekić EVALUATION OF CORROSION POTENTIAL USING PHYSICO-CHEMICAL WATER QUALITY ASSESSMENT | 89 |
| Jelena Čanak Atlagić, A. Marić, K. Jovičić, J. Stanković, V. Đikanović, T. Mitić, M. Raković QUESTIONING THE RESILIENCE OF THE DANUBE FISH FAUNA UNDER THE PRESSURE OF BELGRADE WASTEWATERS | 95 |
| Vladan Marinković, M. Maksimović, M. Jovanović, S. Trujić MONITORING OF THE STATE OF THE ENVIRONMENT IN THE BOR DISTRICT, GIVEN THROUGH THE EXAMPLE OF THE DISTRIBUTION OF Pb IN THE SOIL LOCATED IN THE IMMEDIATE VICINITY OF THE BOR RIVER | 101 |
| Mirjana Ocokoljić, Dj. Petrov, N. Galečić, D. Skočajić, D. Vujičić, J. Čukanović, I. Simović EFFECTIVENESS OF <i>Photinia × Fraseri</i> 'RED ROBIN' IN THE URBAN LANDSCAPE: TOWARDS OF CLIMATE CHANGE | 106 |
| Mirjana Ocokoljić, Dj. Petrov, N. Galečić, D. Skočajić, D. Vujičić, J. Čukanović, I. Simović <i>Chaenomeles japonica</i> (Thunb.) Lindl. ex Spach IN THE DESIGN OF URBAN PARKS: LEARNING FROM NATURE | 113 |

| | |
|---|-----|
| Mirjana Ocokoljić, J. Čukanović, Dj. Petrov, N. Galečić, D. Skočajić, D. Vujičić, I. Simović <i>Parthenocissus quinquefolia</i> L.: PHENOMONITORING IN BLUE-GREEN INFRASTRUCTURE OF BELGRADE AND NOVI SAD | 119 |
| Bojana Tubić, J. Đuknić, K. Zorić, N. Popović, N. Marinković, M. Paunović, M. Raković EFFECTS OF THE IRON GATE DAMS ON THE BENTHIC MACROINVERTEBRATE COMMUNITY | 126 |
| Danica Bogdanović, T. Anđelković, I. Kostić Kokić, M. Milovanović GC-MS QUANTITATIVE DETERMINATION OF PHTHALATES IN PVC ARTICLES INTENDED FOR CHILDREN'S USE | 132 |
| Danica Bogdanović, T. Anđelković, I. Kostić Kokić, M. Milovanović OPTIMIZATION OF LIQUID-LIQUID PHTHALATES EXTRACTION FROM ARTIFICIAL SALIVA | 138 |
| Danica Bogdanović, T. Anđelković, I. Kostić Kokić, M. Milovanović MIGRATION OF DI-2-ETHYLHEXYL PHTHALATE AND DI-N-OCTYL PHTHALATE FROM PVC ARTICLES TO ARTIFICIAL SALIVA | 144 |
| Daliborka Stanković, D. Z. Rajković, M. Raković, S. Skorić HAEMOSPORIDIAN PARASITES IN LONG-EARED OWLS WINTERING IN BANAT, SERBIA | 150 |
| Nenad Zarić, I. Hotea, A. Lato, M. Zarić, F. Crista UNVEILING PESTICIDE CONTAMINATION IN TRANSBOUNDARY WATERS: A CASE STUDY OF SERBIA AND ROMANIA | 156 |
| Nenad Zarić, F. Crista, A. Berbecea, I. Hotea, L. Crista, M. Zarić COMPARATIVE ANALYSIS OF PESTICIDE RESIDUES IN AGRICULTURAL SOILS OF SERBIA AND ROMANIA | 160 |
| Milica Veličković, D. Voza THE RELATIONSHIP BETWEEN PM ₁₀ AND METEOROLOGICAL PARAMETERS CLOSE TO THE MINING AREA | 164 |
| Biljana Budzakoska Gjoreska, S. Trajanovski MACROZOOBENTHOS COMMUNITY AND ECOLOGICAL STATUS IN PRESVA LAKE (OTESHEVO, STENJE AND EZERANI) IN SPRING 2022 | 169 |
| Suzana Patcheva, J. Leshoski, E. Veljanoska Sarafiloska PHYTOPLANKTON COMMUNITY AS BIOINDICATOR OF WATER TROPHIC STATE IN LAKE PRESVA | 176 |
| Boris Novaković, M. Raković EARLY, LATE AND OUT-BREEDING SEASON BIRD SINGING – EFFECTS OF CLIMATE CHANGE? | 183 |
| Boris Novaković, M. Raković THE USE OF HOA (HEMIPTERA-ORTHOPTERA-AVES) INDICATORS TO FORMULATE THE SERBIAN CLIMATE CHANGE INDEX (S _{CCI}) | 189 |

| | | |
|---|---|-----|
| <i>Ana Marić, V. Nikolić, D. Škraba Jurlina, V. Sokolović, D. Miličić, T. Karan Žnidaršič, T. Kanjuh, P. Simonović</i> | ASSESSMENT OF NON-NATIVE SPECIES IMPACT ON FISH DIVERSITY IN THE ČELIJE RESERVOIR: IMPLICATIONS FOR CONSERVATION AND MANAGEMENT | 194 |
| <i>Ivana Jelić, A. Savić, T. Miljojčić, M. Rajković, M. Janković, N. Sarap, S. Dimović, M. Čurčić, V. Stanić, D. Antonijević, M. Šljivić-Ivanović</i> | THE IMPACTS OF WASTE MATERIALS UTILIZATION IN LIQUID RADIOACTIVE WASTE SOLIDIFICATION BY MORTAR MATRIX | 200 |
| <i>Stefan Đorđievski, M. Đukić, A. Petrović, D. Adamović, J. Petrović, Lj. Lekić</i> | INSIGHTS FROM THE DAILY MONITORING OF WATER QUALITY PARAMETERS IN CEROVO RIVER NEAR BOR CITY IN OCTOBER 2023 | 206 |
| <i>Nataša Kojadinović, S. Đuretanović, A. Milošković, M. Radenković, M. Jakovljević, T. Veličković, M. Nikolić, V. Simić</i> | FISH DIVERSITY ASSESSMENT OF THE IBAR RIVER: A 20-YEAR PERSPECTIVE | 212 |
| <i>Milanka Negovanović, L. Kričak, S. Milanović, N. Simić, J. Majstorović</i> | APPLICATION OF EXPANSIVE MORTARS FOR THE FORMATION OF ARTIFICIAL SCREENS DURING BLASTING IN URBAN AREAS | 216 |
| <i>Snežana Šerbula, T. Kalinović, A. Radojević, J. Kalinović, J. Jordanović</i> | AIR POLLUTION IN THE BOR REGION FROM 1994 TO 2023 | 225 |
| <i>Irena Blagajac, I. Samardžić</i> | CAUSES OF FLOODING AND MEASURES TO MITIGATE THE CONSEQUENCES – CASE STUDY OF RAKOVICA MUNICIPALITY (BELGRADE, SERBIA) | 231 |
| Urban and industrial ecology | | |
| <i>Žarko Radović, N. Tadić</i> | SIMULATION OF THE EAF DUST RECYCLING | 240 |
| <i>Mirko Gojić, S. Kožuh, I. Ivanić, D. Dumenčić</i> | DEVELOPMENT OF METALLURGY AND ENVIRONMENTAL PROTECTION IN THE REPUBLIC OF CROATIA IN THE PERIOD FROM 1900 TO 2020 | 246 |
| Air, water and soil pollution, prevention and control | | |
| <i>Viša Tasić, T. Apostolovski-Trujić, V. Kamenović, B. Radović, I. Zlatković, N. Ristić, Z. Damnjanović</i> | APPLICATION OF LOW-COST NETWORK FOR URBAN MICROCLIMATE AND AIR QUALITY MONITORING | 251 |

| | |
|--|-----|
| <i>Nebojša Tadić, Ž. Radović, A. Knežević</i> ANALYSIS OF THE INFLUENCE OF NATURAL GAS COMPOSITION AND EXCESS AIR COEFFICIENT ON COMBUSTION PRODUCTS | 258 |
| <i>Aleksandar Jovanović, N. Knežević, M. Bugarčić, J. Petrović, M. Sokić, M. Stevanović, A. Marinković</i> INVESTIGATION OF MULTI-CYCLE USAGE OF NANOPHOTOCATALYSTS IN DEGRADATION OF THIOPHANATE- METHYL | 265 |
| <i>Vesna Obradović, M. Perović, P. Pajić</i> PHYSICO-CHEMICAL AND MICROBIAL ANALYSIS IN SELECTED GROUNDWATER IN SERBIA | 270 |
| <i>Silvia Dimova, K. Zaharieva, O. Dimitrov, P. D. Petrov, H. Penchev</i> METHATHESIS SYNTHESIZED OLIGOMERIC POLYPHENYLACETYLENE AS STERIC STABILIZER OF CARBON NANOTUBES/PLANT EXTRACT SYNTHESIZED ZINC OXIDE HYBRIDS | 276 |
| <i>Miljan Marković, M. Gorgievski, N. Štrbac, V. Grekulović, M. Marković, K. Božinović, D. Jovanović</i> EQUILIBRIUM ANALYSIS OF COPPER IONS BIOSORPTION ONTO HAZELNUT SHELLS | 282 |
| <i>Vesna M. Marjanović, R. Marković, D. Božić</i> CALCULATION OF CALCIUM OXIDE CONSUMPTION IN THE MINE WASTEWATER TREATMENT FROM INACTIVE OPEN PITS OF THE COPPER MINE | 287 |
| <i>Marina Marković, M. Gorgievski, N. Štrbac, V. Grekulović, M. Marković, M. Zdravković, D. Jovanović</i> THERMODYNAMIC ANALYSIS AND INFLUENCE OF THE pH VALUE ON THE BIOSORPTION OF COPPER IONS ONTO HAZELNUT SHELLS | 294 |
| <i>Jelena Korać Jačić, D. Bartolić, M.R. Milenković</i> THE IMPACT OF FERROUS AND FERRIC IONS ON DEGRADATION OF ANTIHYPERTENSIVE DRUG DIHYDRALAZINE IN IRON-BASED FLOCCULATION AND COAGULATION METHODS FOR WASTE WATER TREATMENT | 299 |
| <i>Berina Sejdinović</i> OILY WASTEWATER | 305 |
| <i>Vesela Radović, S. Krnjajić, S. Stanković, V. Tomić, G. Knežević</i> ENVIRONMENTAL RISKS CAUSED BY THE POLLUTION FROM AGRICULTURAL PLASTICS – A BRIEF STATE OF ART | 311 |
| <i>Marija Koprivica, J. Dimitrijević, J. Petrović, M. Ercegović, M. Simić</i> COMPARISON BETWEEN HYDROCHAR AND ITS ALKALI MODIFIED FORM IN THE REMOVAL OF Cd(II) IONS FROM AQUEOUS SOLUTION | 317 |

| | | |
|--|---|-----|
| Milena Pijović Radovanović, M. Seović, I. Perović, N. Zdolšek, J. Georgijević, P. Laušević, S. Brković | EFFICIENT REMOVAL OF RHODAMINE B FROM AQUEOUS SOLUTIONS USING CARBONIZED WASTE CAR TIRES: CHARACTERIZATION AND ADSORPTION STUDIES | 323 |
| Svetlana Butulija, J. Maletaškić, B. Todorović, G. Branković, A. Krstić, R. Mihailović, B. Matović | SYNTHESIS, CHARACTERIZATION AND ADSORPTION POTENTIAL OF CORN COB-DERIVED ACTIVATED CARBON | 329 |
| Vladan Nedelkovski, S. Stanković, D. Medić, D. Buzdugan, I. Hulka, S. Milić, M. Radovanović | PHOTOCATALYTIC PROPERTIES OF C-ZnO NANOPARTICLES SYNTHESIZED <i>via</i> MECHANOCHEMICAL METHOD | 335 |
| Aleksandar Zdravković, M. Nikolić, D. Marković Nikolić, D. Stojadinović, G. Petković, T. Nikolić | EQUILIBRIUM AND THERMODYNAMICS OF NITRATE SORPTION BY MODIFIED ZEOLITE FROM AQUEOUS SOLUTION | 341 |
| Aleksandar Zdravković, M. Nikolić, D. Marković Nikolić, D. Stojadinović, I. Ristić, T. Nikolić | POTENTIAL USAGE OF OAT STRAW FOR ANIONS REMOVAL FROM WATER: A KINETIC STUDY | 348 |
| Aleksandar Zdravković, M. Nikolić, A. Pavlović, D. Marković Nikolić, G. Petković, T. Nikolić | ULTRASOUND-ASSISTED EXTRACTION OF ACETAMIPRID FROM POLLUTED SOIL | 354 |
| Katerina Zaharieva, B. Barbov | PLANT-MEDIATED SYNTHESIS AND PHOTOCATALYTIC INVESTIGATIONS OF CeO ₂ -ZnO COMPOSITES | 358 |
| Milena Milošević, M. Abdualatif Abduarahman, M. M. Vuksanović, Z. Veličković, N. Knežević, B. Najdanović, A. Marinković | CELLULOSE BASED MEMBRANE FOR CATIONIC POLLUTANTS REMOVAL FROM WATER | 363 |
| Milena Milošević, A. Marinković, M. M. Vuksanović, Z. Veličković, I. Đuričković, B. Najdanović, N. Knežević | HEMP MODIFIED WITH BETAINE AS A GREEN AND EFFICIENT ADSORBENT FOR REMOVAL OF ANIONIC DYES FROM WATER | 369 |
| Nevena Surudžić, M. Spasojević, M. Crnoglavac Popović, M. Stanišić, R. Prodanović, O. Prodanović | PHENOL REMOVAL FROM WASTEWATER WITH HORSERADISH PEROXIDASE IMMOBILIZED BY PERIODATE METHOD ONTO NOVEL MACROPOROUS POLY(GMA-CO-EGDMA) CARRIERS | 375 |

| | | |
|--|---|-----|
| <i>Miljana Radović Vučić, N. Velinov, J. Mitrović, S. Najdanović, M. Petrović, M. Kostić, A. Bojić</i> | MODIFIED ACTIVATED WOOD SAWDUST AS GREEN ENVIRONMENTAL-FRIENDLY CATALYST FOR TREATMENT OF PHARMACEUTICAL EFFLUENT | 381 |
| <i>Jelena Mitrović, M. Radović Vučić, N. Velinov, S. Najdanović, M. Kostić, M. Petrović, A. Bojić</i> | ADVANCE OXIDATION OF TEXTILE DYE BY ACTIVATED HYDROGEN PEROXIDE WITH UV-C LIGHT | 387 |
| Protection and preservation of natural resources | | |
| <i>Gordana Šekularac, M. Aksić, T. Dimitrijević, M. Ratknić, N. Gudžić</i> | QUANTIFYING SOIL EROSION OF THE TOM'S BROOK CATCHMENT (WESTERN SERBIA) | 393 |
| <i>Gordana Šekularac, M. Aksić, T. Dimitrijević, S. Gudžić, N. Gudžić, D. Gračak, M. Grčak, M. Ratknić</i> | EFFECT OF IRRIGATION RATE ON THE ONSET INTENSITY OF GREY MOULD AND LATE BLIGHT IN GREEN HOUSE TOMATOES | 399 |
| <i>Tatjana Dimitrijević, M. Ratknić, G. Šekularac, M. Aksić</i> | INFLUENCE OF SOIL TYPE ON MEAN TREE HEIGHTS OF FIR TREES IN A 40-YEAR PROVENANCE TRIAL | 406 |
| <i>Dragana Božić, Lj. Avramović, V. Trifunović, R. Marković, Z. Stevanović, V. Marjanović, E. Požega</i> | AGITATION LEACHING OF FLOTATION TAILINGS AT THE PILOT PLANT | 412 |
| <i>Ivana Kerkez Janković, D. Vilić, M. Nonić, J. Devetaković, M. Šijačić-Nikolić</i> | FOREST FRUIT SPECIES OF URBAN FOREST "KOŠUTNJAK" (SERBIA) – GENEPOOL ASSESSMENT AND CONSERVATION | 418 |
| <i>Boris Novaković, N. Paskaš, M. Raković</i> | NEW DATA ON THE DISTRIBUTION OF AQUATIC BEETLES IN SERBIA | 424 |
| <i>Matej Fike, M. Pezdevšek, A. Roger</i> | COMPARING FROST PROTECTION STRATEGIES FOR SUSTAINABLE AGRICULTURE IN SLOVENIA | 430 |
| <i>Filip Maksimović, M. Nonić, D. Vilotić, I. Kerkez Janković, M. Šijačić-Nikolić</i> | GENE POOL OF FOREST FRUIT TREES IN THE PROTECTED AREA OF THE NATURAL MONUMENT "KOŠUTNJAK FOREST" – THEN AND NOW | 435 |
| <i>Dragana Medić, S. Milić, N. Milošević, M. Nujkić, M. Pešić, V. Nedelkovski, S. Stanković</i> | APPLICATION OF THE SHRINKING CORE MODEL IN THE LEACHING PROCESS OF LiNiMnCoO ₂ | 441 |

Ecotoxicology and environmental safety

| | |
|--|-----|
| Branko Matovic, J. Maletaskic, S. Butulija, S. Petrovic, B. Todorovic IMMOBILIZATION OF LEAD USING CERIA CRYSTAL STRUCTURE | 448 |
| Dragana Medić, S. Milić, N. Milošević, M. Nujkić, S. Alagić, A. Cvetković, A. Papludis CAUSES AND POSSIBLE CONSEQUENCES OF THERMAL RUNAWAY IN LITHIUM-ION BATTERIES | 454 |
| Nena Velinov, M. Radović Vučić, J. Mitrović, M. Petrović, S. Najdanović, D. Bojić, A. Bojić KINETIC AND EQUILIBRIUM STUDIES OF CHROMIUM SORPTION USING ULTRASONICALLY MODIFIED WOOD SAWDUST BY ALUMINA | 460 |
| Hazardous materials and green technologies | |
| Uroš Stamenković, I. Marković, V. Čosović, B. Markoli THE INFLUENCE OF AGEING PARAMETERS ON MICROHARDNESS, ELECTRICAL CONDUCTIVITY AND MICROSTRUCTURE OF SOME Al-Mg-Si ALLOYS | 466 |
| Marija Simić, D. Aćimović, B. Savić Rosić, M. Ječmenica Dučić, K. Stojanović, D. Maksin, T. Brdarić KINETIC STUDY OF DEGRADATION BISPHENOL A BY FENTON PROCESS | 472 |
| Danka Aćimović, K. Stojanović, M. Simić, B. Savić Rosić, Z. Vranješ, M. Ječmenica Dučić, T. Brdarić DETECTION OF BISPHENOL A INTERMEDIATES DURING FENTON PROCESS AND PREDICTION OF REACTION PATHWAYS | 476 |
| Tanja Brdarić, D. Aćimović, B. Savić Rosić, K. Stojanović, M. Simić, Z. Vranješ, M. Ječmenica Dučić ADVANCED OXIDATION PROCESSES (AOPs) FOR WASTEWATER TREATMENT: BIBLIOMETRIC STUDY | 480 |
| Vanja Trifunović, S. Milić, Lj. Avramović POSSIBILITY OF ZINC AND CADMIUM RECOVERY FROM HAZARDOUS INDUSTRIAL WASTE – EAF DUST | 486 |
| Sandra Bulatović, N. Nedić, T. Tadić, B. Marković, A. Nastasović MAGNETIC BIOSORBENT BASED ON THE <i>Ambrosia arthemisiifolia</i> FOR ADSORPTION OF MALACHITE GREEN FROM WATER | 491 |
| Milan Nedeljković, S. Mladenović, J. Petrović, M. Mitrović STUDIES OF THE INFLUENCE OF GRAPHENE NANOSHEETS ON THE WETTABILITY OF ECO-FRIENDLY SOLDER ALLOYS | 497 |

| | |
|---|-----|
| <i>Ana Simonović, M. Petrović Mihajlović, M. Radovanović, Ž. Tasić, M. Antonijević</i> ELECTROCHEMICAL SENSORS FOR DETERMINATION OF ANTIBIOTICS | 502 |
| <i>Sonja Stanković, V. Nedelkovski, D. Buzdugan, I. Hulka, M. Gorgievski, S. Milić, M. Radovanović</i> INFLUENCE OF CALCINATION TEMPERATURE ON THE MORPHOLOGY, CHEMICAL COMPOSITION, AND STRUCTURE OF ZnO NANOPARTICLES | 508 |
| Human and ecological risk assessment | |
| <i>Milena Tadić, I. Nikolić, D. Đurović, J. Vuković, N. Cupara</i> CHILDREN HEALTH RISK ASSESSMENT OF TRIHALOMETHANES CONTENT IN HOTEL'S SWIMMING POOL WATER IN MONTENEGRO | 515 |
| <i>Miljan Bigović, D. Đurović, Lj. Ivanović, M. Blagojević, A. Orahovac</i> HEALTH RISK ASSESSMENT OF ACRYLAMIDE IN POTATO CHIPS FROM MONTENEGRIN MARKET | 520 |
| <i>Vesna Djikanović, K. Jovičić, J. S. Vranković, M. Dimitrijević, S. Kovačević, N. Pankov, B. Miljanović</i> ACCUMULATION OF HEAVY METALS AND HUMAN HEALTH RISK ASSESSMENT <i>via</i> THE CONSUMPTION OF FRESHWATER FISH <i>Esox lucius</i> | 524 |
| Agriculture: nutrition, organic food and health impacts | |
| <i>Vitaly Erukhimovitch, M. Huleihel</i> OPTIMIZATION OF PREPARATION PROCEDURES FOR FUNGAL INFECTED PLANTS BY FTIR ANALYSES | 531 |
| <i>Mahmoud Huleihel, V. Erukhimovitch</i> POSSIBLE USE OF FOURIER–TRANSFORM INFRARED (FTIR) MICROSCOPY FOR IDENTIFICATION OF FUNGAL PHYTO–PATHOGENS | 536 |
| <i>Ana Čučulović, J. Stanojković, R. Čučulović</i> RADIOACTIVITY IN SAMPLES OF IMPORTED MINERAL FERTILIZER ANALYZED IN THE PERIOD 2020–2022 | 541 |
| <i>Nenad Zarić, M. Zarić</i> METAL CONTENTS IN VEGETABLES ORIGINATING FROM COAL FIRED THERMAL POWER PLANTS REGION | 547 |
| Alternative energy: efficiency and environmental policy | |
| <i>Snežana Brković, N. Zdolšek, I. Perović, M. Seović, P. Laušević, J. Georgijević, M. Čebela</i> ENHANCING OXYGEN EVOLUTION: THE ELECTROCATALYTIC POWER OF Ag-DOPED BISMUTH FERRITE | 552 |

| | | |
|---|---|-----|
| <i>Nebojša Potkonjak, Đ. Čokeša, M. Marković</i> | NONLINERA PHENOMENA DURING VOLTAMMETRIC MEASUREMENT OF COPPER CORROSION | 558 |
| <i>Mirjana Marković, Đ. Čokeša, N. Potkonjak</i> | EVALUATION OF THE HYDROGEN DIFFUSION COEFFICIENT IN METAL HYDRIDE BATTERIES | 562 |
| Greenhouse effect and global climate change | | |
| <i>Slobodan Milutinović, T. Radenović, S. Živković</i> | FORESTS UNDER THREAT: IMPLICATIONS OF CLIMATE CHANGE ON SERBIAN WOODLANDS | 566 |
| <i>Danijela Nikolić, S. Jovanović, Z. Đorđević, D. Končalović, V. Vukašinić</i> | GLOBAL WARMING – TREND ANALYSIS IN THE REPUBLIC OF SERBIA | 574 |
| Sustainable development and green economy | | |
| <i>Dragana Randelović, A. Jovanović, B. Marković, M. Sokić</i> | CONTRIBUTION OF THE INSTITUTE FOR TECHNOLOGY OF NUCLEAR AND OTHER MINERAL RAW MATERIALS TO THE SDGs – TOWARDS INTERNATIONAL DECADE OF SCIENCE FOR SUSTAINABLE DEVELOPMENT | 580 |
| <i>Veljko V. Savić, J. D. Nikolić, V. Topalović, M. S. Djošić, M. Marković, S. Matijašević, S. Grujić</i> | CHEMICAL DURABILITY EVALUATION OF SINTERED FLY ASH BASED GLASS | 586 |
| <i>Stefan Mitrović, S. Brković, M. Seović, N. Zdolšek, P. Laušević, J. Georgijević, I. Perović</i> | RECYCLING ELECTRONIC WASTE CPUs FOR ENHANCED HYDROGEN AND OXYGEN EVOLUTION: AN ECO-FRIENDLY LEACHING APPROACH | 593 |
| <i>Adrijana Jevtić, D. Riznić, M. Vuković</i> | BRAND MANAGEMENT AND SOCIO-ECONOMIC ASPECTS OF ADAPTATION TO CLIMATE CHANGES | 598 |
| <i>Ana Radojević, J. Jordanović, T. Kalinović, J. Kalinović, S. Šerbula</i> | PROSPECTS OF SUSTAINABLE UTILIZATION OF FOOD WASTE | 606 |
| <i>Maja Bogdanović, I. Blagajac</i> | DECENTRALIZATION OF THE URBAN TOURIST ZONE OF ZLATIBOR | 613 |

Environmental biology

- Sladana Popović, N. Nikolić, Ž. Savković, M. Stupar, D. Predojević, A. Anđelković, O. Jakovljević**
ISOLATION AND CULTIVATION OF CHROOCOCCUS (CYANOBACTERIA) FROM AEROPHYTIC BIOFILM IN STOPIĆ CAVE 621
- Tamara Mitić, J. Čanak Atlagić, J. Tomović, J. Stanković, D. Mrdak, D. Škraba Jurlina, A. Marić**
MORPHOMETRIC STUDY OF EUROPEAN BULLHEAD *Cottus gobio* FROM DIFFERENT DRAINAGE POPULATIONS 626
- Jelena Đuknić, N. Popović, B. Vasiljević, B. Tubić, S. Andjus, M. Ilić, M. Paunović**
ECOLOGICAL POTENTIAL OF THE DANUBE RIVER THROUGH SERBIA BASED ON BIOLOGICAL QUALITY ELEMENTS 632
- Sladana Popović, G. Subakov Simić, S. Stanković, D. Lazić**
Chlorella vulgaris GROWTH IN SMALL OPEN CULTIVATION SYSTEMS 638
- Olga Jakovljević, S. Popović, D. Predojević**
EPIPHYTIC DIATOMS AS TOOL IN BIOINDICATION OF LAKE PALIĆ 643
- Mihailo Jovanović, J. Paunković**
IMPROVING PALEOENVIRONMENTAL RECONSTRUCTIONS BASED ON SMALL VERTEBRATES IN THE BALKANS 648
- Jovana Damjanović, M. Milković, A. Mišćević, M. Šćiban, V. Lakušić, M. Stanković**
SUPPLEMENT TO THE LIST OF ENTOMOFAUNA FROM THE RESEARCH ACTIONS AND CAMPS OF SRSBE “JOSIF PANČIĆ” AT SRN ZASAVICA 654
- Mihajlo Stanković**
“LIVING FOSSILS” IN THE CRASH FAUNA OF THE ZASAVICA SPECIAL NATURE RESERVE 662

Environmental and material flow management

- Nataša Knežević, A. Jovanović, M. Vuksanović, M. Savić, M. Milošević, A. Marinković**
DEGRADATION OF DYE CRYSTAL VIOLET RELEASED FROM THE TEXTILE INDUSTRY 669
- Milenko Jovanović, D. Kržanović, E. Požega, V. Marinković, M. Mikić**
APPLICATION AND ENVIRONMENTAL SUITABILITY OF HYBRID GEOGRIDS 674
- Miroslav Drljača**
MODERN APPROACH TO SUPPLY CHAIN BASED ON CIRCULAR ECONOMY PRINCIPLES 681

| | |
|---|-----|
| <i>Isidora Berežni, T. Marinković, N. Stanisavljević, M. Muhadinović, B. Batinić</i> ASSESSMENT OF THE MUNICIPAL SOLID WASTE MANAGEMENT – CASE STUDY: NOVI SAD (SERBIA) | 687 |
|---|-----|

| | |
|---|-----|
| <i>Ljubiša Balanović, D. Manasijević, I. Marković, U. Stamenković, K. Božinović</i> CALCULATION OF THERMODYNAMIC PROPERTIES Al-Ga-Sn TERNARY ALLOY USING GENERAL SOLUTION MODEL | 693 |
|---|-----|

Life-Cycle-Analysis (LCA)

| | |
|--|-----|
| <i>Danijela Nikolić, S. Jovanović, D. Mikić, Z. Đorđević</i> LIFE CYCLE ASSESMENT OF THE HAIR DRYER WITH ECO-it SOFTWARE | 701 |
|--|-----|

Student Section – EcoTERS'24

| | |
|---|-----|
| <i>Students: Sofija Kostić, Aleksa Marjanović (Serbia)</i> <i>Mentor: Maja Nujkić (Serbia)</i> SOME ASPECTS OF THE APPLICATION OF METAL-ORGANIC FRAMEWORKS | 709 |
|---|-----|

| | |
|--|-----|
| <i>Student: Jelena Janković (Serbia)</i> <i>Mentor: Maja Nujkić (Serbia)</i> MECHANISMS OF CADMIUM UPTAKE INTO THE PLANT | 711 |
|--|-----|

| | |
|---|-----|
| <i>Student: Jovana Kumbrijanović (Serbia)</i> <i>Mentors: Maja Nujkić, Sonja Stanković (Serbia)</i> COAGULATION PROCESS AND APPLICATION OF NEW ECOLOGICAL COAGULANTS | 713 |
|---|-----|

| | |
|--|-----|
| <i>Student: Lazar Cvetković (Serbia)</i> <i>Mentors: Maja Nujkić, Tanja Kalinović, Jelena Kalinović (Serbia)</i> SOME APPLICATION ASPECTS OF THE MATERIALS BASED ON THE GREEN MAGNESIUM OXIDE ECOLOGICAL COAGULANTS | 715 |
|--|-----|

| | |
|--|-----|
| <i>Students: Milena Radivojević, Kristina Konstadinović (Serbia)</i> <i>Mentors: Maja Nujkić, Dragana Medić (Serbia)</i> RECYCLING OF USED LITHIUM-ION BATTERIES | 717 |
|--|-----|

| | |
|---|-----|
| <i>Student: Milica Denić (Serbia)</i> <i>Mentor: Ana Radojević (Serbia)</i> MEDICAL WASTE ISSUES RELATED TO COVID-19 PANDEMIC | 719 |
|---|-----|

| | |
|---|-----|
| <i>Student: Sara M. Pantović (Serbia)</i> <i>Mentor: Enisa S. Selimović (Serbia)</i> PRESENCE OF TOXIC AND POTENTIALLY TOXIC ELEMENTS IN SOME DOMESTIC FRUIT FROM THE PEŠTER PLATEAU, SJENICA, SERBIA | 721 |
|---|-----|

| | | |
|--|--|-----|
| <i>Student: Milena Stanković (Serbia)</i> <i>Mentor: Ljiljana Stanojević (Serbia)</i> | CHEMICAL COMPOSITION OF ESSENTIAL OIL ISOLATED FROM FRESH AND DRY LEAVES OF <i>Geranium robertianum</i> L. | 723 |
| <i>Student: Nikola Petrović (Serbia)</i> <i>Mentor: Ana Simonović (Serbia)</i> | TOXIC EFFECTS OF PETROLEUM DERIVATIVES ON LIVING ORGANISMS FROM CONTAMINATED SOILS | 725 |
| <i>Students: Anja Antanasković, Nevena Ilić (Serbia)</i> <i>Mentors: Milan Miliwojević, Suzana Dimitrijević-Branković, Zorica Lopičić, Nikola Vuković (Serbia)</i> | ENZYME IMMOBILIZATION ON MODIFIED BIOMASS: OPTIMIZATION AND CHARACTERIZATION | 727 |
| <i>Student: Milena Balabanović (Serbia)</i> <i>Mentor: Ana Radojević (Serbia)</i> | BIOLOGICAL TREATMENT OF THE BIODEGRADABLE WASTE | 729 |
| <i>Student: Natalija Stojanović (Serbia)</i> <i>Mentors: Maja Nujkić, Vladan Nedelkovski (Serbia)</i> | ADSORPTION MATERIALS BASED ON NANOPARTICLES FOR THE REMOVAL OF ARSENIC FROM WASTEWATER | 731 |
| <i>Student: Jelena Vesković (Serbia)</i> <i>Mentor: Antonije Onjia (Serbia)</i> | HEALTH RISK ASSESSMENT OF RARE EARTH ELEMENTS IN GROUNDWATER NEAR A THERMAL POWER PLANT | 733 |
| <i>Students: Vladimir Topalović, Anja Antanasković, Veljko Savić (Serbia)</i> <i>Mentors: Marija Djošić, Zorica Lopičić, Ana Vujošević, Jelena Nikolić (Serbia)</i> | EFFECT OF PHOSPHATE GLASS AND BIOCHAR ON ROSE GROWTH | 735 |
| <i>Student: Aleksandra Milenković (Serbia)</i> <i>Mentor: Ljiljana Stanojević (Serbia)</i> | THE REDUCING POWER OF BLACK PEPPER (<i>Piper nigrum</i> L.) ESSENTIAL OIL HYDRODISTILLATION FRACTIONS | 737 |
| <i>Student: Marija Tasić (Serbia)</i> <i>Mentor: Dragan Cvetiković (Serbia)</i> | ENVIRONMENTAL METHOD OF GOLD NANOPARTICLES SYNTHESIS AND THEIR CHARACTERIZATION | 739 |
| <i>Student: Marija Stanković (Serbia)</i> <i>Mentor: Jelena Kalinović (Serbia)</i> | PURIFICATION METHODS FOR POLLUTED AIR | 741 |
| <i>Student: Marija Stanković (Serbia)</i> <i>Mentor: Jelena Kalinović (Serbia)</i> | PURIFICATION OF INDUSTRIAL WASTEWATER | 743 |

| | |
|---|------------|
| <i>Students: Željka Nikolić, Nebojša Radović (Serbia)</i> <i>Mentor: Olga Tešović (Serbia)</i> | |
| RISKS OF CHLORINE EXPOSURE IN HOUSEHOLD CLEANING: A CALL FOR AWARENESS AND PREVENTION | 745 |
| <i>Students: Željka Nikolić, Nebojša Radović (Serbia)</i> <i>Mentor: Olga Tešović (Serbia)</i> | |
| IS THERE A NEED TO INFORM CITIZENS MORE DIRECTLY ABOUT THE HANDLING OF HOUSEHOLD HAZARDOUS WASTE? | 747 |
| <i>Students: Nataša Simonović, Tamara Milosavljević (Serbia)</i> <i>Mentors: Jelena Stanojević, Ljiljana Stanojević, Jelena Zvezdanović, Dragan Cvetković (Serbia)</i> | |
| SOLID WASTE FROM HYDRODISTILLATION OF HERNIARIAE HERBA (<i>Herniaria glabra</i> L.) AS A POTENTIAL SOURCE OF ANTIOXIDANTS | 749 |
| <i>Students: Aleksa Vizi, Nebojša Radović, Željka Nikolić, Stefan Lekić (Serbia)</i> <i>Mentors: Goran Roglić, Ksenija Stojanović, Vele Tešević (Serbia)</i> | |
| SUSTAINABLE SOLUTIONS IN ANALYTICAL CHEMISTRY: COMBINING OF INSTRUMENTAL TECHNIQUES AND ENVIRONMENTAL-FRIENDLY NATURAL INDICATORS FOR CLASSICAL VOLUMETRY | 751 |
| <i>Students: Aleksa Vizi, Nebojša Radović, Željka Nikolić (Serbia)</i> <i>Mentors: Ivan Kojić, Ksenija Stojanović (Serbia)</i> | |
| EFFICIENT DETERMINATION OF UNDECYLENIC ACID CONTENT IN PHARMACEUTICAL PRODUCTS: A NOVEL SIMPLE APPROACH | 753 |
| <i>Student: Andrijana Miletić (Serbia)</i> <i>Mentor: Antonije Onjia (Serbia)</i> | |
| HEALTH RISK ASSESSMENT OF POTENTIALLY TOXIC ELEMENTS IN AGRICULTURAL SOIL OF BRANIČEVO DISTRICT | 755 |
| <i>Student: Jelena Obradovic (Serbia)</i> <i>Mentor: Antonije Onjia (Serbia)</i> | |
| DISTRIBUTION OF PM _{2.5} , CO ₂ , HCHO, AND TVOC IN AIR IN A HIGH SCHOOL CLASSROOM | 757 |
| <i>Student: Gordan Mišić (Serbia)</i> <i>Mentors: Ana Radojević, Jelena Jordanović (Serbia)</i> | |
| TOXICOLOGICAL EFFECTS OF MICRO- AND NANO-PLASTICS ON HUMAN HEALTH | 759 |
| <i>Student: Anđela Bogdanović (Serbia)</i> <i>Mentor: Marija Petrović Mihajlović (Serbia)</i> | |
| MAGNESIUM AND ITS ALLOYS | 761 |
| Author index | 763 |



IMMOBILIZATION OF LEAD USING CERIA CRYSTAL STRUCTURE

Branko Matovic^{1*}, Jelena Maletaskic¹, Svetlana Butulija¹, Sanja Petrovic²,
Bratislav Todorovic²

¹Vinča Institute of Nuclear Sciences - National Institute of the Republic of Serbia,
University of Belgrade, Mike Petrovića Alasa 12–14, 11000 Belgrade, SERBIA

²Faculty of Technology University of Nis, Bulevar Oslobođenja 124, 16000 Leskovac,
SERBIA

*mato@vinca.rs

Abstract

Lead is a very useful element that has found application in batteries, construction, bullets and hunting ammunition, it is part of solder and various alloys. It is especially used in piezoelectrics and as a shield against radiation. Unfortunately, lead is a potent neurotoxin that accumulates in soft tissues and bones over time. Therefore, it is of great interest to control Pb mobility and bio-accessibility by its immobilization in a suitable crystal structure. Ceria with fluorite structure could play essential roles in lead immobilization. Nanosized Pb-doped ceria ($Ce_{1-x}Pb_xO_2$) powders ($0.1 \leq x \leq 0.3$) were obtained by self-propagating room temperature reaction. X-ray diffraction analysis and field emission scanning microscopy results showed that the doped samples are single phase solid solutions with fluorite-type structure and all prepared powders were nanometric in size. The thermal stability of solid solution was followed by XRD. The mass of Pb [ppm] in the solution with different concentration of Pb in the doped ceria after its dissolution in different time intervals at different pH values was measured by means of Inductively coupled plasma (ICP) spectroscopy. The TEM investigation showed that pattern of CeO_2 before and after leaching confirms that samples are single phase CeO_2 .

Keywords: lead, immobilization, fluorite structure, stability of solid solution.

INTRODUCTION

Enhanced industrial activities and human actions in recent times have led to increased release of toxic heavy metals into the environment, particularly agricultural lands [1]. Lead (Pb) is commonly found in polluted soils, and its elevated levels can diminish environmental quality, causing reduced crop yields and groundwater contamination, thus posing significant risks to human and animal health [2]. Consequently, the remediation of contaminated soils is a pressing concern for ensuring safe water and food production.

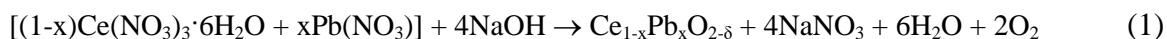
Various conventional techniques such as excavation, landfilling, and soil washing are commonly employed to remediate soils contaminated with heavy metals. However, these methods are often time-consuming, expensive, and sometimes not feasible. In contrast, the in situ immobilization technique has been anticipated as more environmentally friendly and effective for remediating heavy metals from contaminated soils [3,4]. One successful technique is immobilization, which has been primarily used for nuclear waste. Immobilization of heavy metals is the process of converting hazardous waste into a solid form to prevent its

release into the environment. This is done to reduce the risk of contamination and facilitate safe long-term storage or disposal. The most common method of immobilizing heavy metals is the use of suitable crystal lattice structures that can encapsulate and retain these elements.

In this work the powders were prepared by the self-propagating room temperature reaction (SPRT) [5]. This technique gives the possibility of producing very fine powders with very precise stoichiometry in accordance with the tailored compositions [6]. In addition, it is the first time that the results are shown, which evidence formation of solid solution between ceria and Pb. These solid solutions were obtained in a form of nanometric powders by applying SPRT. The effect of Pb concentration on the thermal and chemical stability of ceria solid solution was examined.

MATERIALS AND METHODS

Nanocrystalline $Ce_{1-x}Pb_xO_{2-\delta}$ ($x = 0.0-0.3$) powders were synthesized by SPRT method [7]. The starting materials for the preparation of Pb immobilization by ceria crystal lattice were cerium nitrate hexahydrate, lead nitrate and sodium hydroxide. Used chemicals were 99.9% pure as stated by the manufacturer (OLDRICH). The compositions of the starting reacting mixtures were calculated according to the nominal composition of the final reaction product, according to the equation (1):



Synthesis procedure was carried out in an alumina mortar by mechanical activation (by hand mixing instead by heating) of reactants for 3–5 min, that allowed rapid progress of the reaction at room temperature in the air. After being exposed to air for 2 h, obtained mixtures of reaction products according to equation (1) was dissolved in water and subjected to centrifugation at Centurion 1020D centrifuge at 4000 rpm, for 10 min. Rinsing procedure was repeated four times with distilled water and twice with ethanol, in order to eliminate $NaNO_3$ from the synthesized powder mixture. Finally, material was dried out at 70°C in ambient atmosphere. It should be outlined that this is the first time that solid solution powders were prepared directly after synthesis procedure was terminated.

The composition of the Ag-doped ceria was identified by means of powder XRD on a Rigaku IV, XRD diffractometer with Cu $K\alpha$ radiation at room temperature. The present phases were identified with the help of the PDXL2 software (version 2.0.3.0) [8], with reference to the patterns of the International Centre for Diffraction Data (ICDD) [9], version 2012.

Morphology of obtained powders as well as their evolution during calcination was studied by the Field emission electron microscope model FE-SEM JEOL-5200F (Japan). The mass of Pb [ppm] in the solution with different percentage of Pb in the doped ceria after its dissolution in different time intervals at pH 3, pH 7 and pH 11 was measured by means of inductively coupled plasma optical emission spectrometry instrument (ICP-OES, ARCOS FHE12, SPECTRO, Germany), according to the manufacturer's instructions.

The conventional and high-resolution (HR) transmission electron microscopy (TEM/HRTEM) analyses were carried out using the FEI Talos F200X microscope (Thermo Fisher Scientific, Waltham, MA, United States) operating at 200 kV. The elemental composition and change of Pb content before and after teaching is investigated by an energy-dispersive X-ray spectroscopy (EDXS) system.

RESULTS AND DISCUSSION

As-synthesized Pb immobilized in CeO₂ matrices, presented in Figure 1, revealed low intensity diffraction reflections in each sample and their significant broadening indicating small crystallite size. The obtained materials depicted explicit features of cubic fluorite crystal structure (space group 225), known as cerianite phase (JSPDS-ICDD 34-0394). The ceria peak shape of the plane reflections in the obtained samples broadened, with increasing Pb doping, respectively.

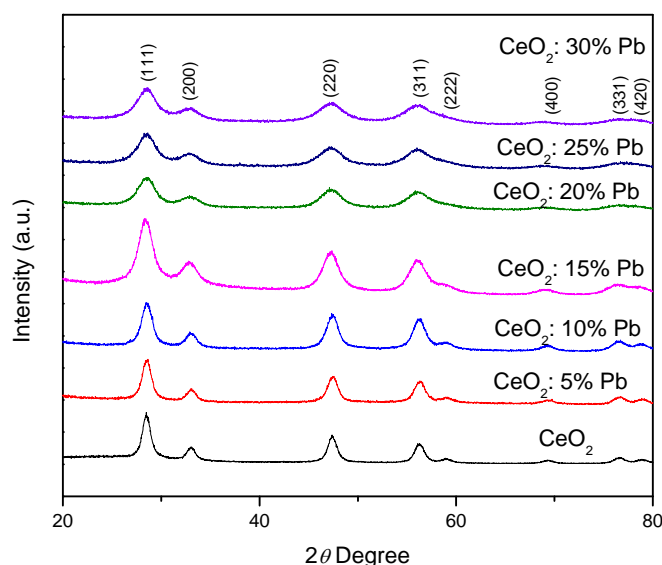


Figure 1 X-ray diffraction patterns of synthesized $Ce_{1-x}Pb_xO_{2-\delta}$ nanopowders at room temperature

The typical morphology of obtained solid solution is shown at Figure 2. As synthesized powders depict very small isometric particles which are agglomerated in the form of spheres. Roughly measured, the size of individual particles was about 5 nm, while the agglomerated spheres were about 100–150 nm.

In order to examine the stability of Pb immobilized in CeO₂ matrices (solid solutions), the samples Ce_{1-x}Pb_xO_{2-δ} (x = 0.0–0.3) were heat treated at the temperature of 600 and 900 °C for 1 h (Figure 3). All solid solutions throughout the entire range of Pb concentrations show stability at 600 °C. With further temperature increase to 900 °C, solid solutions with 15% Pb are also stable; however, at higher concentrations exceeding 15% of Pb (20 and 30%), the separation of PbO phase occurs at 900 °C. This confirms that the thermal stability of such a solid solution decreases with temperature.

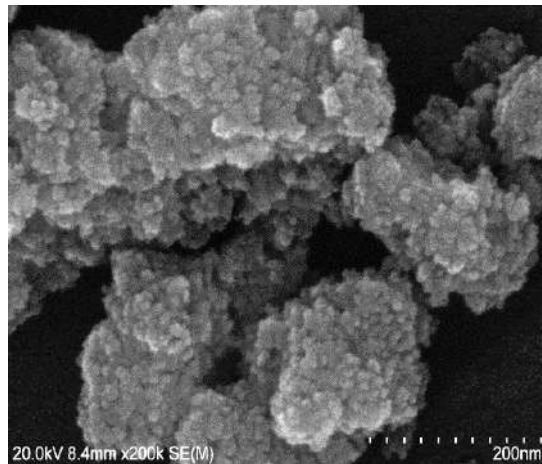


Figure 2 Typical FE SEM of obtained of $Ce_{1-x}Pb_xO_{2-\delta}$ nanopowders at room temperature

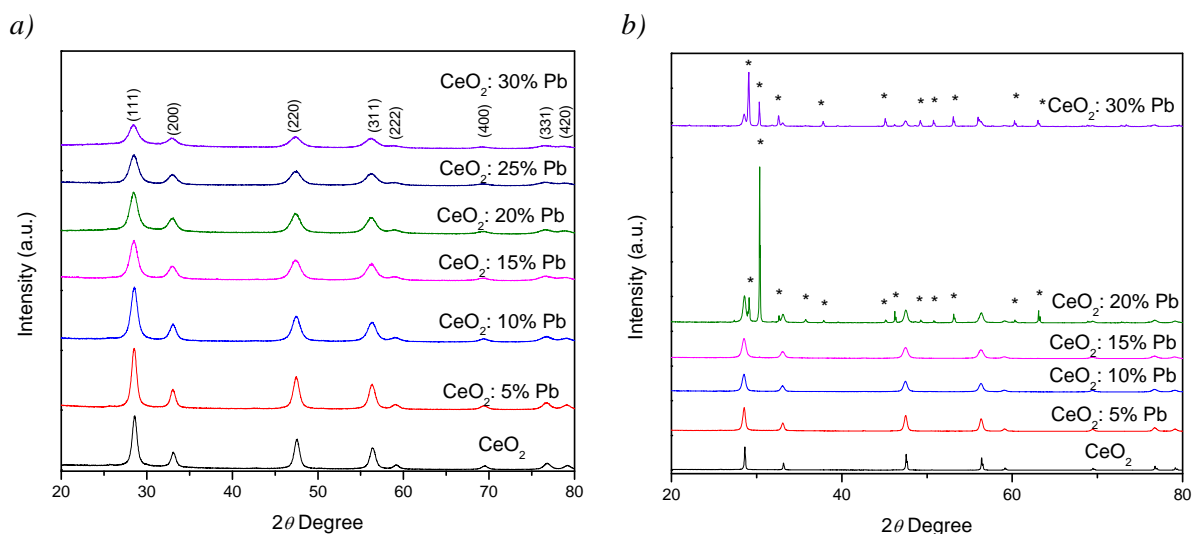


Figure 3 X-ray diffraction pattern of $Ce_{1-x}Pb_xO_{2-\delta}$ nanopowders calcined at a) 600; b) 900 °C: $-(PbO)$. Unmarked peaks belong to the fluorite structure

The chemical stability of immobilized lead in the matrix of cerium fluorite lattice was monitored at various time intervals at 3 different pH levels (3, 7, and 11), which is given in the Figure 4.

It is evident that under basic conditions, immobilized Pb is stable, while in neutral medium, it is partially soluble and highly soluble (around 20%) in acidic conditions. In the case of higher concentrations of Pb in the cerium matrix, this trend is even more pronounced. Specifically, in acidic conditions, almost 90% of Pb is dissolved after 30 hours, while in basic conditions, only 1.6% is dissolved in the same period (Table 1).

Considering that the highest concentration was 30% Pb, that sample was examined using TEM before and after Pb dissolution.

The TEM investigation of CeO_2 showed agglomerated nanoparticles (Figure 5a and b) with particle size of only few nanometers. The particle size observed with HRTEM matches the calculated particle size of 2.98 nm from XRD patterns. The HRTEM image (inset of Figure 5a) reveals the lattice fringes corresponding to (1 1 1) plane of CeO_2 with d spacing of 0.331 nm before leaching of Pb. The selected area electron diffraction (SEAD) pattern of CeO_2

before and after leaching confirms that samples are single phase CeO_2 and they are presented as insets of Figure 5 a,b. The SEAD pattern exhibits series of rings corresponding to the respective (1 1 1), (2 0 0), (2 2 0) and (3 1 1) planes of CeO_2 nanoparticles. The elemental composition and change of Pb content before and after leaching is investigated by EDS. EDS shows that the content of Pb is 15 at% before leaching and dropping to 4 at% after leaching. Beside the change of Pb content observed in EDS spectrum of the sample, the change of interplanar distance of (111) plane from 0.331 to 0.327 nm is also observed, confirming that the Pb cations are leached out from CeO_2 structure.

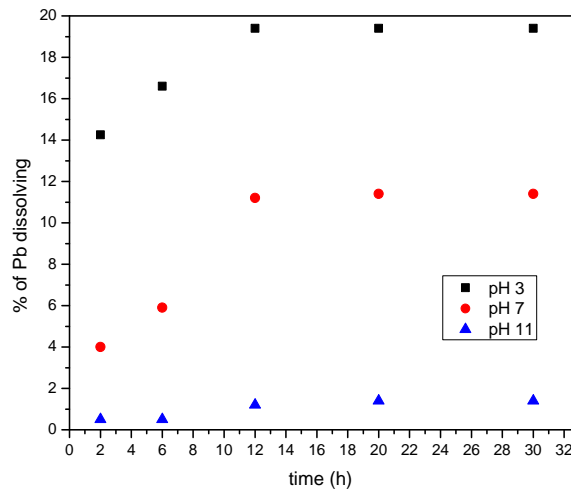


Figure 4 Dissolved Pb in mass percentages in the solution of the sample with 10% Pb after its dissolution at various time intervals at pH 3, pH 7, and pH 11

Table 1 Pb dissolution (mas.%) in the sample solution with 30% Pb after its dissolution at different time intervals at pH 3, pH 7 and pH 11

| Time (h) | pH 3 | pH 7 | pH 11 |
|----------|------|------|-------|
| 2 | 62 | 18 | 1.6 |
| 6 | 69 | 32 | 1.6 |
| 12 | 77 | 34 | 1.6 |
| 20 | 85 | 42 | 1.6 |
| 30 | 90 | 46 | 1.6 |

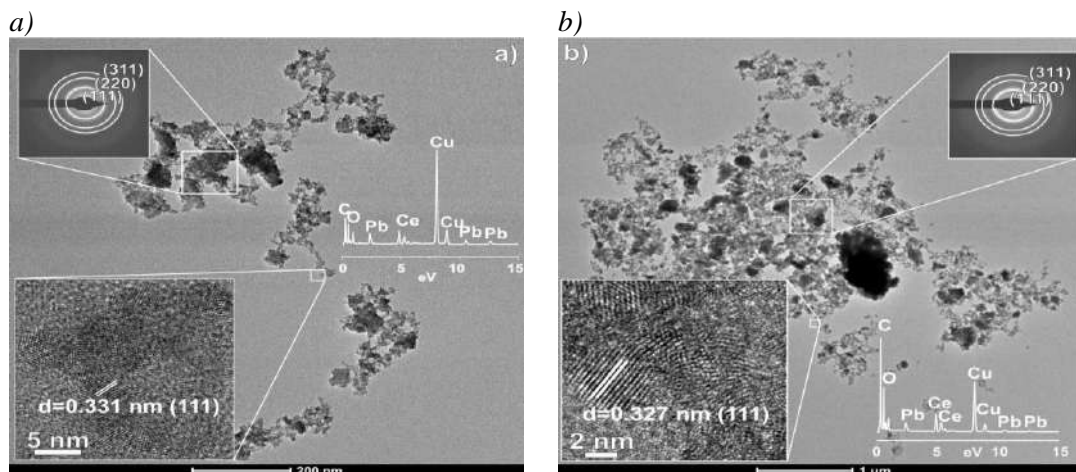


Figure 5 TEM spectra of $\text{Ce}_{0.7}\text{Pb}_{0.3}\text{O}_{2-\delta}$ solid solution a) before; b) after leaching (pH 3)

CONCLUSION

Single Pb-ceria solid solutions were synthesized by self-propagating room temperature method (SPRT). XRD and TEM spectroscopy confirmed the pure solid solutions.

The solid solubility of Pb into ceria lattice was the topmost reported so far. Average crystallite size of the powders was less than 5 nm.

The thermal stability of solid solutions are stable till 600°C, after that it decreases with increasing the amount of Pb concentration at 900°C

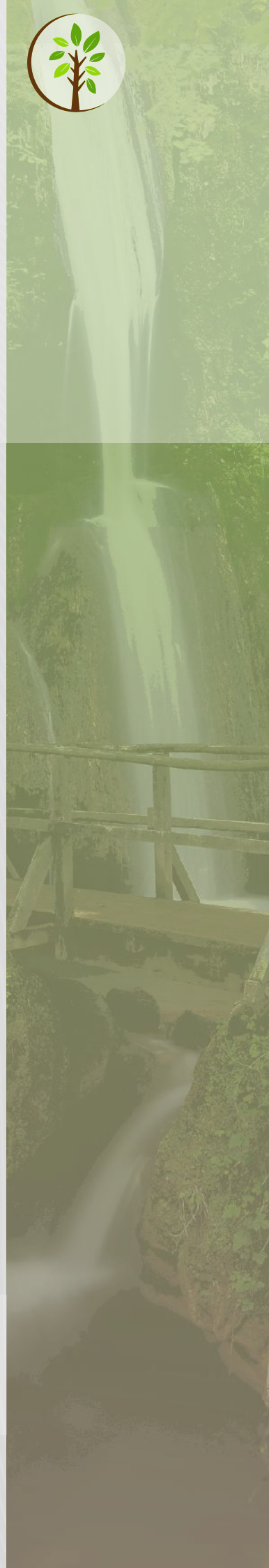
These results demonstrate the highly effective room temperature immobilization of Pb in the form of ceria solid solutions using the SPRT method.

ACKNOWLEDGEMENT

The authors are grateful to the Ministry of Science, Technological development and Innovation of the Republic of Serbia for financial support according to the contract with the registration number (e.g. 451-03-68/2024-14/200017).

REFERENCES

- [1] Bian R., Chen D., Liu X., *et al.*, Ecol. Eng. 58 (2013) 378–383.
- [2] Houben D., Evrard L., Sonnet P., Biomass Bioener. 57 (2013) 196–204.
- [3] Al Chami Z., Cavoski I., Mondelli D., *et al.*, Environ. Sci. Pollut. Res. 20 (2013) 4766–4776.
- [4] Liang Y., Cao X., Zhao L., *et al.*, Environ. Sci. Pollut. Res. 22 (2014) 4665–4674.
- [5] Boskovic S., Matovic B., Nanostructured Solid Solutions of the Fluorite Type Crystal Structure *in* Fluorite: Structure, Chemistry and Applications, Editor: van Asten M., Nova Science, New York (2019), p.1–111, ISBN: 978-1-53615-204-3.
- [6] Matovic B., Dohcevic-Mitrovic Z, Radovic Z., *et al.*, J. Power Sources 139 (1) (2009) 146–149.
- [7] Boskovic S., Djurovic D., Dohcevic-Mitrovic Z., *et al.*, J Power Sources 145 (2) (2005) 237–242.
- [8] PDXLVersion 2.0.3.0 Integrated X-ray Powder Diffraction Software, Rigaku Corporation, Tokyo, Japan, 2011, pp. 196–8666.
- [9] Powder Diffraction File, PDF-2 Database, announcement of new database release 2012, International Centre for Diffraction Data (ICDD).



ISBN 978-86-6305-152-2