



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 SWIMING 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

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



THE INFLUENCE OF AGEING PARAMETERS ON MICROHARDNESS, ELECTRICAL CONDUCTIVITY AND MICROSTRUCTURE OF SOME Al-Mg-Si ALLOYS

Uroš Stamenković^{1*}, Ivana Marković¹, Vladan Čosović², Boštjan Markoli³

¹University of Belgrade, Technical Faculty in Bor, Vojske Jugoslavije 12,
19210 Bor, SERBIA

²University of Belgrade, Institute of Chemistry, Technology and Metallurgy, Njegoševa 12,
11000 Belgrade, SERBIA

³University of Ljubljana, Faculty of Natural Sciences and Engineering, Aškerčeva cesta 12,
1000 Ljubljana, SLOVENIA

*ustamenkovic@tfbor.bg.ac.rs

Abstract

This paper investigates the influence of ageing parameters (temperature and time) on the microhardness, electrical conductivity and structural properties of two Al-Mg-Si aluminium alloys. After the applied heat treatment, both microhardness and electrical conductivity were measured. Optical microscopy was used to investigate the microstructures after ageing. The heat treatment began by solutionizing the samples at 550°C for 1 hour, followed by quenching in ice water. Samples were then aged at two separate temperatures, 180°C and 200°C, for 1–8 hours. The results indicate that with the increase in ageing time, the microhardness gradually increases up to a maximum and then decreases, while the electrical conductivity continuously increases. Analysis on the optical microscope shows that with longer ageing, there is precipitation of a larger amount of the strengthening phases due to more intense diffusion of alloying elements from the solid solution.

Keywords: Al-Mg-Si, microhardness, electrical conductivity, ageing, microstructure.

INTRODUCTION

The EN AW-6082 and EN AW-6060 aluminium alloys are two of the several alloys that make up the Al-Mg-Si alloy system. These alloys have garnered the interest of researchers because of their technical significance and observable increase in hardness as a result of precipitation hardening [1–3]. Ageing (precipitation) can improve mechanical and structural properties as well as properties such as electrical conductivity [4,5]. Samples have to be solutionized, quenched, and then aged in order to cause precipitation hardening. During the ageing process, precipitates form in accordance with the previously established precipitation sequence, which may be written as: α_{ssss} (supersaturated solid solution) \rightarrow Mg:Si clusters \rightarrow GP zones (pre- β'') \rightarrow β'' \rightarrow β' \rightarrow β (Mg_2Si) [6–9]. The change in mechanical, electrical, and structural properties is caused by the precipitation of different metastable phases, mainly β'' precipitates [9]. Because of their incoherency with the matrix, formed precipitates cause significant lattice deformation, which reduces dislocation mobility and enhances the alloy's hardness [7]. Al-Mg-Si alloys are often aged for an extended period of time at temperatures

below 200°C in order to achieve proper hardening. Numerous investigations focused on the impact of ageing time on mechanical, structural, and other properties, as demonstrated by numerous works [2,3,8–11]. Both investigated alloys can become excellent candidates for the manufacturing of overhead electrical wires that require high strength in addition to good electrical properties. Consequently, several researchers have investigated the impact of precipitation on the electrical properties of the Al-Mg-Si alloys [4,5,12]. It can be inferred from the analyzed literature that electrical and mechanical properties are significantly affected by ageing parameters, which emphasizes the importance of continuing research in this area. Consequently, we concentrated our attention on studying the ageing characteristics, which comprised two ageing temperatures: one conventional (180°C) and one greater than the conventional (200°C). Microhardness, electrical conductivity and microstructure were examined after the samples were aged for one to eight hours at each of the two ageing temperatures.

MATERIALS AND METHODS

The aluminium alloys EN AW-6060 and EN AW-6082 were selected for this study. The alloys were delivered in T6 (aged) condition in the form of extruded rectangular bars. The "Belec Compact Port" optical emission spectrometer was used to determine the chemical composition of the investigated alloys. Table 1 reveals the results of the chemical analysis. All samples were annealed at 550°C for 6 hours in the electric resistance furnace Heraeus K-1150/2 and cooled in air to eliminate the as-received (aged) condition. In order to produce a supersaturated solid solution (α_{SSSS}), the samples were heated to 550°C for an hour and then quenched in icy water. This was done in order to prepare the samples for the ageing process. Samples were isothermally aged at 180°C and 200°C for one to eight hours post-quenching.

The properties of the aged samples were compared with those of the as-quenched samples (in the Figures marked as quenched state). Following the heat treatment, the samples underwent several analyses. Vickers microhardness values were measured using a 0.1 kg force and a 15-second dwell duration on a PMT 3 microhardness tester. The Sigmatest type 2.063 conductivity tester was used to measure the electrical conductivity values. Every measurement that is given was done at room temperature. All sample surfaces were ground to eliminate oxides before measurements. The samples have been analysed metallographically using the Carl-Zeiss Jena Epytip 2 optical microscope. The samples were prepared by wet grinding on an assortment of SiC papers and polishing with two different alumina suspensions containing different Al₂O₃ granulations (0.3 µm and 0.05 µm). The samples were etched by immersion in Dix-Keller solution in order to reveal the microstructure.

Table 1 Chemical compositions of the investigated alloys (wt. %)

EN AW-6060							EN AW-6082						
Si	Fe	Cu	Mn	Mg	Cr	Ni	Si	Fe	Cu	Mn	Mg	Cr	Ni
0.49	0.182	0.012	0.06	0.594	<0.03	0.028	0.807	0.354	0.042	0.453	0.696	<0.012	0.012
Zn	Ti	V	Co	Sn	Zr	Al	Zn	Ti	V	Co	Sn	Zr	Al
0.01	0.05	0.014	<0.003	<0.003	<0.003	98.62	0.115	0.25	<0.003	0.006	<0.003	<0.003	97.45

RESULTS AND DISCUSSION

The microhardness values of the investigated alloys during isothermal ageing are shown in Figure 1. It is evident from the graphs in Figure 1 that the microhardness values are significantly influenced by ageing. The microhardness of the aged samples gradually increases to a maximum and subsequently decreases with an increase in ageing time. The samples reached maximal microhardness values after ageing for five hours at 180 °C for the EN AW-6060 and for six hours for the EN AW-6082 alloy.

For the EN AW-6060 alloy, the highest obtained microhardness value was 110 HV_{0.1}, which is 42.8% higher than the microhardness value of the quenched sample (77 HV_{0.1}; α_1 on Figure 1). For the EN AW-6082 alloy, the highest obtained microhardness value was 146 HV_{0.1}, which is a 55.3% increase in comparison to the quenched state (94 HV_{0.1}; α_2 on Figure 1).

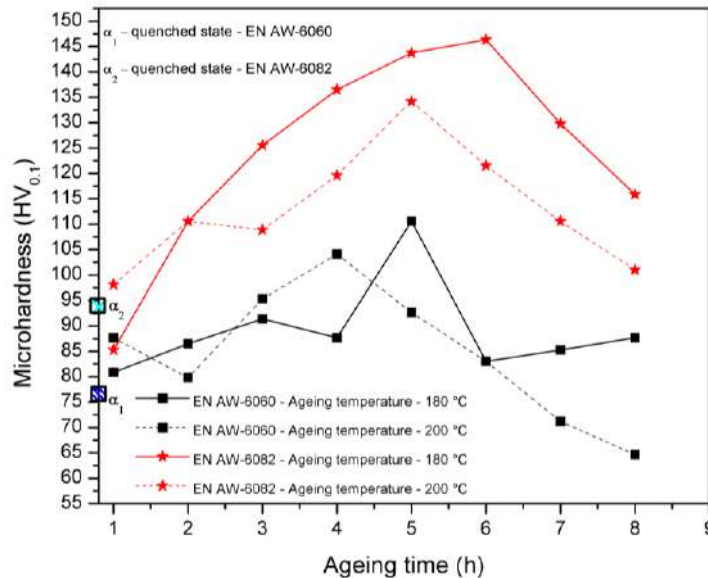


Figure 1 Change in microhardness values of the investigated alloys as a function of ageing time at two different ageing temperatures

It is assumed that the formation of multiple vacancies upon quenching, which encourages nucleation of the pre- β'' phase, causes this phase to precipitate during the first four hours of ageing. As ageing continues, the Si and Mg atoms migrate from the solid solution and towards the pre- β'' phase, trading places with the Al atoms. Precipitates that already exist, transform and grow in numbers overall, which eventually causes coherence with the Al lattice to be reduced. Phase changes proceed in accordance with the precipitation sequence as ageing progresses, together with the exchange of alloying element atoms with Al atoms [9]. Consequently, the maximum microhardness values displayed in Figure 1 are achieved due to the creation of the β'' metastable phase and have been observed by multiple investigators [1–3,8–13]. Marioara *et al.* [3] stated that even though the precipitate density is low during the precipitation of the β'' phase, there is an increase in incoherency with the lattice, leading to peak hardness values. After ageing for 6–8 hours, precipitates of the β'' phase grow and coagulate, causing a decrease in microhardness values. A deeper look at the graphs in

Figure 1 reveals that maximum microhardness values can be obtained faster as a result of higher ageing temperatures. However, after ageing at higher temperatures, the highest microhardness values obtained are not as high as those achieved at lower ageing temperatures. Diffusion rate increases with rising ageing temperature, which leads to faster precipitation of the pre- β'' phase and a faster loss of coherency, so the microhardness values are higher after an hour of isothermal ageing at 200°C as opposed to 180°C. However, the use of lower ageing temperatures with longer ageing times is essential for achieving a true peak-aged state.

The change in electrical conductivity values of the investigated alloys as a function of ageing time at two different ageing temperatures can be seen in Figure 2. In age-hardenable alloys, there is a strong relationship between electrical conductivity and precipitation [4]. Analysis of Figure 2 shows that with the increase in ageing time, the electrical conductivity gradually increases, reaching maximum values at the longest ageing times. When ageing for 1 hour, the electrical conductivity values are slightly lower than those obtained for the α_{SSSS} (quenched state). At these ageing parameters, the pre- β'' phase (GP-zone) is formed. These precipitates have the effect of scattering electrons, which leads to a decrease in electrical conductivity values [5,12,14]. After the initial decrease, there is a gradual increase in electrical conductivity values until the maximum is obtained. As the ageing time increases, an increasing amount of precipitates are formed due to the reduction of alloying elements in the saturated solid solution (α_{SSSS} becomes less saturated). As a result of this phenomenon, electrical conductivity increases due to the easier movement of electrons through the matrix. Electrical conductivity is highest when the saturation of the α_{SSSS} is the lowest, and in this case, this was achieved first by the precipitation of the pre- β'' phase, and with prolonged ageing, by the β'' phase [4,5].

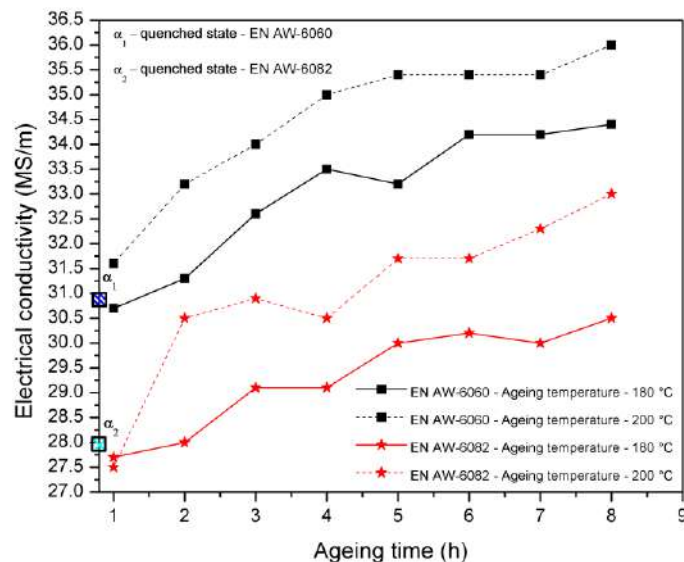


Figure 2 Change in electrical conductivity values of the investigated alloys as a function of ageing time at two different ageing temperatures

Unlike mechanical properties, a higher ageing temperature (200°C) leads to higher values of electrical conductivity. At higher ageing temperatures, diffusion is accelerated and

precipitation is intensified, which leads to a faster desaturation of the α_{SSSS} with alloying elements, as a result of which the electrical conductivity increases.

The maximum values of electrical conductivity for both alloys were achieved when ageing at 200°C for 8 hours. For the EN AW-6060 alloy, electrical conductivity increased from 30.8 MS/m in the quenched state (α_1 in Fig. 2) to 36 MS/m after isothermal ageing at 200°C for 8 h, so the relative increase in electrical conductivity compared to the quenched state was 16.89%. The relative increase in electrical conductivity for the alloy EN AW-6082 was slightly higher and amounted to 17.86%. For this alloy, electrical conductivity increased from 28 MS/m in the quenched state (α_2 in Fig. 2) to 33 MS/m after isothermal ageing at 200°C for 8 h.

For microstructural analysis, four different samples were chosen based on the microhardness measurements: underaged samples (aged for 1 hour at 180°C) as well as peak aged samples (aged for 5 or 6 hours at 180°C, depending on the alloy).

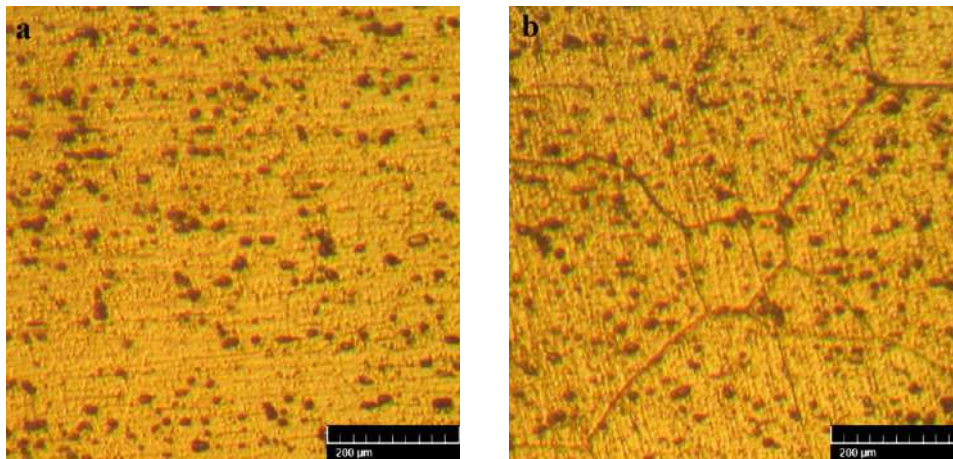


Figure 3 Influence of ageing temperature on the microstructure of the EN AW-6060 aluminium alloy: a) after ageing for 1 hour at 180°C (underaged sample); b) after ageing for 5 hours at 180°C (peak-aged sample)

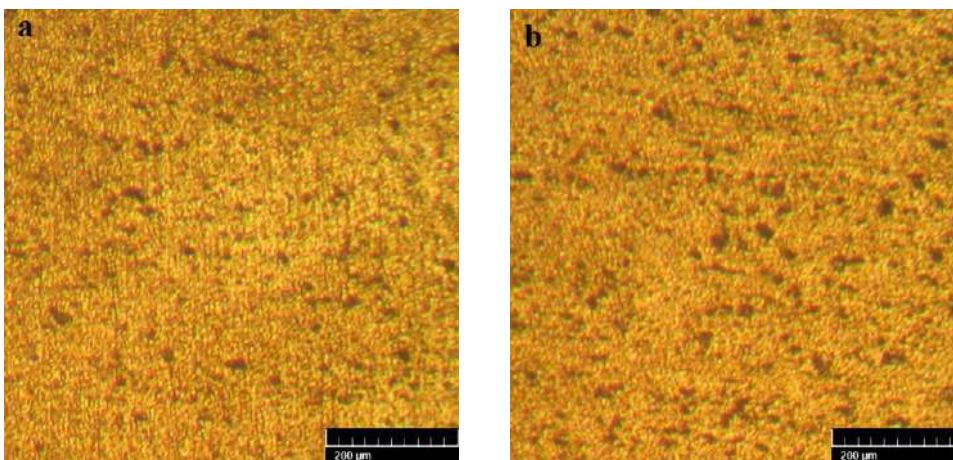


Figure 4 Influence of ageing temperature on the microstructure of the EN AW-6082 aluminium alloy: a) after ageing for 1 hour at 180°C (underaged sample); b) after ageing for 6 hours at 180°C (peak-aged sample)

Figures 3(a–b) and 4(a–b) show optical microphotographs of underaged and peak-aged samples of the EN AW-6060 and EN AW-6082 alloys after ageing at 180°C, respectively. From the presented microphotographs, it can be concluded that with longer ageing, there is precipitation of a larger amount of the strengthening phase, which further leads to an increase in the microhardness values, confirming the comments given in regards to the microhardness results [1,13,15].

CONCLUSIONS

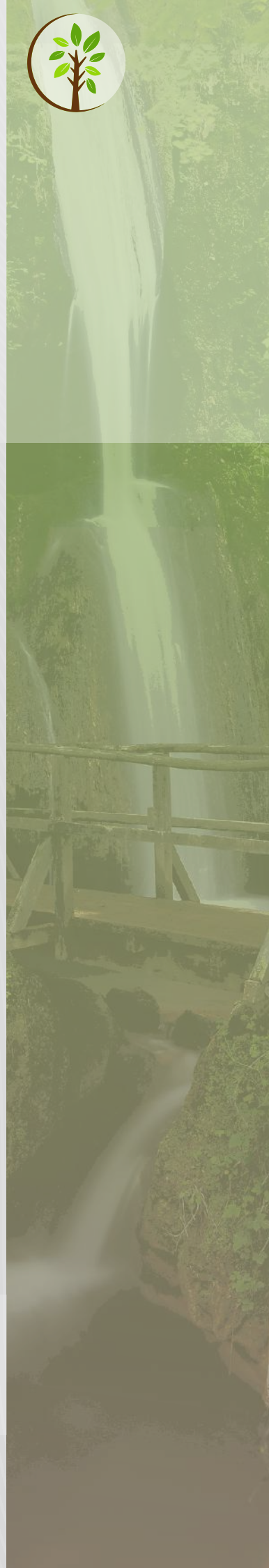
Isothermal ageing led to an evident rise in mechanical and electrical properties. After ageing at 180°C for five or six hours, depending on the alloy, the highest values of microhardness were achieved. After ageing for eight hours at 200°C, the electrical conductivity values peaked for both investigated alloys due to the highest level of precipitation from the solid solution. Microstructural analysis showed the presence of finely distributed metastable phases, which caused a change in mechanical and electrical properties. The β'' phase is thought to be primarily responsible for this improvement.

ACKNOWLEDGEMENT

The research presented in this paper was done with the financial support of the Ministry of Science, Technological Development and Innovation of the Republic of Serbia, within the funding of the scientific research work at the University of Belgrade, Technical Faculty in Bor, according to the contract with registration number 451-03-65/2024-03/200131.

REFERENCES

- [1] Tan C.F., Said M.R., Chiang Mai J. Sci. 36 (3) (2009) 276–286.
- [2] Abid T., Boubertakh A., Hamamda S., J. Alloys Compd. 490 (2010) 166–169.
- [3] Marioara C.D., Andersen S.J., Jansen J., *et al.*, Acta Mater. 51 (2003) 789–796.
- [4] Karabay S., Mater. Des. 27 (2006) 821–832.
- [5] Cui L., Liu Z., Zhao X., *et al.*, T. Nonferr. Metal. Soc. 24 (2014) 2266–2274.
- [6] Birol Y., T. Nonferr. Metal. Soc. 23 (2013) 1875–1881.
- [7] Zheng Y.Y., Luo B-H., Xie W., *et al.*, China Foundry 20 (2023) 57–62.
- [8] Birol Y., J. Mater. Process. Technol. 173 (2006) 84–91.
- [9] Gupta A.K., Lloyd D.J., Court S.A., Mater. Sci. Eng. A 316 (2001) 11–17.
- [10] Marioara C.D., Andersen S.J., Jansen J., *et al.*, Acta Mater. 49 (2001) 321–328.
- [11] Chang C.S.T., Wieler I., Wanderka N., *et al.*, Ultramicroscopy 109 (2009) 585–592.
- [12] Prabhu T.R., Eng. Sci. Technol. an Int. 20 (1) (2017) 133–142.
- [13] Masoud I.M., Abu Mansour T., Al-Jarrah J.A., J. Appl. Sci. Res. 8 (10) (2012) 5106–5113.
- [14] Edwards G.A., Stiller K., Dunlop G.L., *et al.*, Acta Mater. 46 (11) (1998) 3893–3904.
- [15] Mrówka-Nowotnik G., Arch. Mater. Sci. Eng. 46 (2) (2010) 98–107.



ISBN 978-86-6305-152-2