



University of Belgrade, Technical Faculty in Bor  
29<sup>th</sup> International Conference Ecological Truth  
& Environmental Research



# EcoTER'22

## Proceedings



*Editor*

*Prof. Dr Snežana Šerbula*

*21-24 June 2022, Hotel Sunce, Sokobanja, Serbia*



University of Belgrade, Technical Faculty in Bor  
29<sup>th</sup> International Conference Ecological Truth  
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**29<sup>th</sup> INTERNATIONAL CONFERENCE**

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## **PREFACE**

*In today's world, the environment has been endangered by the use of outdated technology, fossil fuels and environmental law violations. Therefore, environmental and many other scientists all over the world have been concerned about finding sustainable technology in resolving these issues. That is why environmental research and ecological truth are at the focus of the 29<sup>th</sup> International Conference Ecological Truth & Environmental Research 2022 (EcoTER'22), which will be held in Sokobanja, Serbia, 21–24 June 2022. On behalf of the Organizing Committee, it is a great honor and pleasure to wish all the participants a warm welcome to the Conference.*

*We hope to convey the message of the conference, which is that a transformation of attitudes and behavior would bring the necessary changes. This is also an opportunity for the participants who are experts in this field to exchange their experiences, expertise and ideas, and also to consider the possibilities for their collaborative research.*

*The 29<sup>th</sup> International Conference Ecological Truth & Environmental Research 2022 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 Association of Young Researchers, Bor.*

*These proceedings include 85 papers from the authors coming from the universities, research institutes and industries in 6 countries: Bulgaria, Italia, Albania, Bosnia and Herzegovina, Montenegro and Serbia.*

*As a part of this year's conference, the 4<sup>th</sup> Student section – EcoTERS'22 is being held. We appreciate the contribution of the students and their mentors who have also participated in the Conference.*

*Financial assistance provided by the Ministry of Education, Science and Technological Development of the Republic of Serbia is gratefully acknowledged by the Organizing Committee of the EcoTER'22 conference.*

*The support of the Platinum donor and their willingness and ability to cooperate have been of great importance for the success of EcoTER'22. The Organizing Committee would like to extend their appreciation and gratitude to the Platinum donor of the Conference for their donation and support.*

*We appreciate the effort of all the authors who have contributed to these Proceedings. We would also like to express our gratitude to the members of the scientific and organizing committees, reviewers, speakers, chairpersons and all the Conference participants for their support to EcoTER'22. Sincere thanks go to all the people who have contributed to the successful organization of EcoTER'22.*

*Prof. Snežana Šerbula,*

*President of the Organizing Committee*



## TABLE OF CONTENTS

### Plenary Lectures

<b><i>Marija Petrović Mihajlović, M. Antonijević</i></b> PURINES AS GREEN CORROSION INHIBITORS	3
<b><i>Milan Radovanović, M. Antonijević</i></b> ENVIRONMENTALLY SAFE CORROSION INHIBITORS: AMINO ACIDS	12
<b><i>Hyusein Yemendzhiev, Y. Mersinkova, R. Koleva, G. Peeva, V. Nenov</i></b> BIO-ELECTROCHEMICAL SYSTEMS – STATE OF THE ART: BIOLOGY, ELECTROCHEMISTRY AND APPLICATION IN WASTEWATER MANAGEMENT	25
<b><i>Aleksandar Marinković</i></b> GREEN ORGANIC CHEMISTRY: A FRAMEWORK FOR SUSTAINABLE ENVIRONMENTAL PROTECTION	32

### Conference Papers

<b><i>Sanja Mrazovac Kurilić, A. Ćirišan, Z. Podražčanin, Lj. Nikolić Bujanović</i></b> SO <sub>2</sub> POLLUTION IN ŠABAC (2009–2020)	39
<b><i>Ana Čučulović, J. Stanojković, R. Čučulović, S. Nestorović, N. Radaković</i></b> THE DISTRIBUTION OF THE MASS CONCENTRATIONS OF K, Th AND U IN THE SOILS OF THE TEKIJIA REGION, THE NP ĐERDAP	43
<b><i>Jovana Bošnjaković, M. Bugarčić, M. Milošević, N. Prlainović, R. Salih, P. Batinić, A. Popović, M. Đolić</i></b> APPLICATION OF NANO- MnO <sub>2</sub> MODIFIED LIGNIN – BASED ADSORBENT FOR REMOVAL OF DICHROMATE IONS AND DICLOFENAC FROM WATER	49
<b><i>Branislava Matić, S. Živković Perišić, D. Jovanović, S. Dejanović, D. Miljuš, L. Kukobat</i></b> MAPPING HEALTH RISKS OF CRITERIA CHEMICAL(S) TO DEMONSTRATE BENEFITS OF RISK ASSESSMENT FOR DECISION-MAKERS	55
<b><i>Violeta Babić, B. Kanjevac, M. Milenković, S. Stajić, M. Vukin, N. Stavretović, M. Račić</i></b> CHARACTERISTICS OF WINTER TEMPERATURE REGIME IN SPRUCE FOREST ON KOPAONIK	62
<b><i>Dragana Pavlović, D. Čakmak, V. Perović, M. Matić, M. Marković, M. Mitrović, P. Pavlović</i></b> ENVIRONMENTAL RISK ASSESSMENT OF PTES IN AGRICULTURAL SOILS AFFECTED BY INDUSTRIAL ACTIVITIES IN BELGRADE	68
<b><i>Olga Kostić, G. Gajić, S. Jarić, Z. Mataruga, D. Sekulić, N. Radulović, M. Mitrović, P. Pavlović</i></b> ANALYSIS OF As AND Pb ACCUMULATION IN GARDEN SOIL AND VEGETABLE CROPS IN THREE BELGRADE MUNICIPALITIES	75

<b>Marija Ječmenica Dučić, D. Vasić Aničijević, B. Savić, D. Aćimović, M. Simić, D. Maksin, T. Brdarić</b>	NEW STRATEGIES FOR DEVELOPMENT OF HIGHLY SELECTIVE MATERIALS FOR CARBON DIOXIDE CAPTURE	81
<b>Miljan Bigović, D. Đurović, I. Nikolić, Lj. Ivanović, B. Bajić</b>	CHARACTERISTIC, SOURCE AND ECOLOGICAL RISK OF PAHs IN AGRICULTURAL SOILS PLJEVLJA MUNICIPALITY (MONTENEGRO)	85
<b>Jelena Vranković, K. Jovičić, V. Đikanović</b>	EFFECT OF DIFFERENT ENVIRONMENTAL CONDITIONS ON LIPID PEROXIDATION LEVEL IN <i>Rutilus rutilus</i> (ACTINOPTERYGII: CYPRINIDAE)	91
<b>Aurora Bakaj (Čizmja), M. Lika (Čekani)</b>	EVALUATION OF MICROBIAL ENVIRONMENT ON THE BEACH SAND	96
<b>Dragana Randelović, R. Pantović</b>	IMPACT OF THE MINING ACTIVITIES IN THE GOLIJIA NATURE PARK AREAS SITUATED ON THE TERRITORY OF RAŠKA MUNICIPALITY	104
<b>Bojana Tubić, K. Zorić, N. Popović, M. Raković, N. Marinković, M. Paunović</b>	INDICATIVE ECOLOGICAL STATUS ASSESSMENT OF SELECTED STREAMS ON ROGOZNA MOUNTAIN BASED ON AQUATIC MACROINVERTEBRATES	110
<b>Božica Vasiljević, J. Tomović, A. Atanacković, R. Petrović</b>	INDICATIVE ECOLOGICAL STATUS ASSESSMENT BASED ON EPILOTHIC DIATOMS OF SMALL RIVERS AT ROGOZNA MOUNTAIN	116
<b>Đuro Čokeša, M. Marković, N. Potkonjak, B. Kaluđerović, S. Radmanović, S. Šerbula</b>	ARSENITE-SOIL HUMIC ACID BINDING BY ISOTHERMAL TITRATION CALORIMETRY: THERMODYNAMICS AND MNIS MODEL	121
<b>Tatjana Anđelković, I. Kostić Kokić, B. Zlatković, D. Anđelković</b>	Cu(II) ACCUMULATION POTENTIAL OF AQUATIC MACROPHYTE <i>PISTIA STRATIOTES</i>	127
<b>Tatjana Anđelković, D. Bogdanović, I. Kostić Kokić, H. Kocić, G. Kocić</b>	PHTHALATES MIGRATION FROM ABSORBABLE SURGICAL SUTURES INTO MODEL SOLUTION	132
<b>Aleksandra Papludis, S. Alagić, S. Milić, I. Zlatanović, M. Filipović, J. Nikolić, V. Stankov Jovanović</b>	THE CONTENT OF DANGEROUS CONTAMINANTS PAHs IN THE SOIL AND ROOTS OF <i>HEDERA HELIX</i> IN SLATINA (BOR'S MUNICIPALITY)	137
<b>Jelena Milosavljević, S. Šerbula, A. Radojević, T. Kalinović, J. Kalinović, B. Spalović</b>	TOXIC METALS BIOACCUMULATION IN <i>Plantago lanceolata</i> FROM ANTHROPOGENICALLY DISRUPTED AREA	142
<b>Mirjana Ocokoljić, Dj. Petrov, N. Galečić, M. Miodrag</b>	ECOLOGICAL AND AESTHETIC CHARACTERISTICS OF TREES IN "BELGRADE WATERFRONT" PARKING LOTS	149
<b>Mirjana Ocokoljić, Dj. Petrov, A. Tutundžić, D. Skočajić, S. Petrović</b>	STATE, FUNCTIONS AND PERSPECTIVES OF DENDROFLORA IN THE SCHOOLYARD OF THE MEDICAL SCHOOL IN BELGRADE	154

<b>Mirjana Ocokoljić, Dj. Petrov</b>	TRACHYCARPUS FORTUNEI (HOOK.) H. WENDL. IN THE CONDITIONS OF CHANGED TEMPERATE CONTINENTAL CLIMATE IN BELGRADE	159
<b>Marija Perkunić, S. Vukić, Z. Živković, V. Stupar, M. Saulić</b>	GREEN OASIS EFFECT ON URBAN ENVIRONMENT	164
<b>Anđela Stojić, D. Tanikić</b>	APPLICATION OF GREEN AREAS AND GREEN ROOFS IN URBAN AREAS	169
<b>Gordana Šekularac, T. Ratknić, M. Aksić, N. Gudžić, M. Vranešević, M. Ratknić</b>	SOIL EROSION ASSESSMENT USING EPM: A CASE STUDY IN THE CATCHMENT AREA OF THE TURKISH BROOK, WESTERN SERBIA	174
<b>Nataša Knežević, A. Jovanović, R. Salih, Z. Veličković, A. Popović, P. Batinić, A. Marinković, J. Gržetić</b>	MODIFIED LIGNIN-BASED MICROSPHERES AS A GREEN SORBENT FOR THE REMOVAL OF CHROMIUM IONS	180
<b>Aleksandar Jovanović, N. Knežević, N. Čutović, M. Đolić, N. Prlainović, Z. Veličković, M. Vuksanović</b>	IMPROVED TECHNOLOGY FOR PRODUCTION OF PE AND PP REGRANULATES	186
<b>Jasmina Dedić, M. Mojsić, D. Lazarević, B. Stojčetočić, Ž. Šarkoćević</b>	A SHORT REVIEW OF TREPČA MINING WASTE IMPACT ON ENVIRONMENT	190
<b>Senad Čeragić, H. Husić, V. Aganović</b>	INFLUENCE OF UNDERGROUND MINING WORKS OF THE OMAZIĆI BROWN COAL MINE BANOVIĆI ON THE SURFACE TERRAIN	195
<b>Snežana Šerbula, J. Milosavljević, T. Kalinović, A. Radojević, J. Kalinović</b>	ARSENIC IN PARTICULATE MATTER ORIGINATED FROM MINING-METALLURGICAL PROCESSES	202
<b>Nevena Ristić, M. Veličković, D. Voza</b>	THE ASSOCIATION BETWEEN SHORT-TERM EXPOSURE TO SO <sub>2</sub> AND EMERGENCY ROOM ADMISSIONS IN URBAN AREA. CASE STUDY SERBIA	208
<b>Miljan Marković, M. Gorgievski, N. Štrbac, K. Božinović, V. Grekulović, A. Mitovski, M. Zdravković</b>	ADSORPTION ISOTHERMS FOR COPPER IONS BIOSORPTION ONTO WALNUT SHELLS	214
<b>Tanja Kalinović, J. Kalinović, S. Šerbula, J. Milosavljević, A. Radojević</b>	DETECTION OF THE TRAFFIC-RELATED POLLUTION BY THE ROADSIDE SOIL AND PLANT MATERIAL	219
<b>Vladan Nedelkovski, S. Stanković, M. Radovanović, M. Antonijević</b>	SYNTHESIS AND CHARACTERISATION OF Ti/SnO <sub>2</sub> -Sb-TYPE DSA ANODES FOR WASTEWATER TREATMENT	226
<b>Maja Radić, M. Avdagić, B. Marković, K. Ademović, S. Avdagić, S. Avdagić</b>	PROTECTION AND PRESERVATION OF NATURAL RESOURCES	233
<b>Mihajlo Stanković</b>	Annex 2: FAUNA OF MACROCRUSTACEA (INVERTEBRATA-ARTHROPODA) IN PERMANENT AND EPHEMERAL WATERS OF ZASAVICA WETLAND (SPECIAL NATURE RESERVES)	239

<b>Mihajlo Stanković</b>	OVERVIEW OF GALIS FAUNA (DIPTERA, HOMOPTER AND HYMENOPTER) – ZASAVICA RESERVE	246
<b>Vanja Marković, M. Božanić, O. Arapović, V. Gojšina, A. Tatović, K. Stojanović</b>	AQUATIC INSECTS DIVERSITY IN THE PART OF NERETVA RIVER DRAINAGE (BOSNIA AND HERZEGOVINA): PRELIMINARY RESULTS	253
<b>Aleksandar Savić, I. Jelić, M. Šljivić-Ivanović, S. Dimović</b>	RECYCLED CONCRETE AGGREGATE EFFECT ON SELF-COMPACTING CONCRETE AT LOW TEMPERATURES	258
<b>Ivana Bjedov, D. Obratov-Petković, V. Stojanović, M. Nešić, D. Marisavljević</b>	INVASIVE ALIEN SPECIES IN SERBIA: LEGISLATION, STRATEGY, AND PLANS	264
<b>Jelena Majstorovic, M. Korac, S. Savkovic</b>	THE EFFECTS OF GEOMECHANICAL RESEARCH “ <i>IN SITU</i> ” ON THE EXPLOITATION CONDITIONS OF THE OPEN PIT BAUXITE MINE “ZAGRAD”	271
<b>Isidora Berezni, T. Marinković, V. Bežanović, M. Živančev, B. Batinić</b>	ANALYSIS OF HOUSEHOLD'S E-WASTE AWARENESS, AND DISPOSAL BEHAVIOR IN NOVI SAD	276
<b>Maja Radić, M. Avdagić, B. Markovic, K. Ademović, S. Avdagić, S. Avdagić</b>	ECOLOGICAL ETHICS AND ECOLOGICAL EDUCATION	284
<b>Vanja Marković, K. Zorić, M. Ilić, S. Đuretanović, M. Smederevac-Lalić</b>	STONE CRAYFISH <i>AUSTROPOTAMOBIVUS TORRENTIUM</i> (Schrank, 1803) IN SOUTH-EASTERN SERBIA: CHILDREN KNOWLEDGE SURVEY	290
<b>Ana Radojević, J. Milosavljević, T. Kalinović, J. Kalinović, S. Šerbula</b>	THE IMPACT OF TEXTILE AND CLOTHES PRODUCTION ON THE ENVIRONMENT – PART I: ENVIRONMENTAL ISSUES	295
<b>Ana Radojević, J. Milosavljević, T. Kalinović, J. Kalinović, S. Šerbula</b>	THE IMPACT OF TEXTILE AND CLOTHES PRODUCTION ON THE ENVIRONMENT – PART II: WHAT CAN WE DO?	301
<b>Giorgia Santini, V. Memoli, L. Santorufo, G. Di Natale, G. Maisto</b>	EFFECTS OF UN-BIODEGRADABLE AND BIODEGRADABLE PLASTIC SHEETS ON ABIOTIC SOIL PROPERTIES	307
<b>Milica Rajačić, D. Todorović, J. Krneta Nikolić, I. Vukanac, N. Sarap, M. Janković</b>	RADIONUCLIDE CONTENT IN SAMPLES OF BERRIES	313
<b>Ivana Mikavica, D. Randelović, J. Stojanović, J. Mutić</b>	MICROPLASTIC OCCURRENCE IN URBAN AND SUBURBAN SOILS OF BOR, EASTERN SERBIA	319
<b>Maja Nujkić, V. Stiklić, Ž. Tasić, S. Milić, D. Medić, A. Papludis, I. Đorđević</b>	BIOSORPTION OF METAL IONS FROM SYNTHETIC SOLUTIONS USING DIFFERENT PARTS OF PLANT MATERIAL – A REVIEW	325
<b>Nataša Đorđević, S. Mihajlović</b>	ANALYSIS OF CHANGES OF MECHANICALLY ACTIVATED SODIUM CARBONATE SAMPLE	331
<b>Vanja Trifunović, S. Milić, Lj. Avramović, R. Jonović, S. Đorđievski</b>	ELECTRIC ARC FURNACE DUST – HAZARDOUS INDUSTRIAL WASTE WHOSE TREATMENT IS UNAVOIDABLE	336

<b>Goran Milentijević, T. Marinković, M. Rančić, M. Milošević, I. Đuričković, A. D. Marinković, M. M. Milosavljević</b>	OPTIMIZATION OF ZINC DIMETHYLDITHIOCARBAMATE SYNTHESIS PROCESS (ZIRAM)	343
<b>Miloš Prokopijević, D. Spasojević, O. Prodanović, N. Pantić, D. Bartolić, K. Radotić, R. Prodanović</b>	STABILITY OF SOYBEAN PEROXIDASE IMMOBILIZED ONTO HYDROGEL MICRO-BEADS FROM TYRAMINE-PECTIN	350
<b>Nevena Pantić, M. Spasojević, M. Prokopijević, D. Spasojević, A. M. Balaž, R. Prodanović, O. Prodanović</b>	COVALENT IMMOBILIZATION OF HORSERADISH PEROXIDASE ON NOVEL MACROPOROUS POLY(GMA-CO-EGDMA) FOR PHENOL REMOVAL	354
<b>Dragica Spasojević, M. Prokopijević, O. Prodanović, N. Pantić, M. Stanković, K. Radotić, R. Prodanović</b>	PREPARATION OF CROSSLINKED TYRAMINE-ALGINATE HYDROGEL USING EDC/NHS WITH SELF-IMMOBILIZED HRP	360
<b>Jelena Mitrović, M. Radović Vučić, N. Velinov, S. Najdanović, M. Kostić, M. Petrović, A. Bojić</b>	THE ROLE OF HYDROXYL AND SULFATE RADICALS IN THE UV ACTIVATED PERSULFATE DEGRADATION OF TEXTILE DYE RO16	364
<b>Milica Petrović, T. Jovanović, S. Rančev, M. Radović Vučić, J. Mitrović, S. Najdanović, A. Bojić</b>	ELECTROSYNTHESIZED CERIUM OXIDE CATALYST FOR ATMOSPHERIC PRESSURE PULSATING CORONA PLASMA DEGRADATION OF RB 5	369
<b>Slobodan Najdanović, M. Petrović, M. Kostić, N. Velinov, J. Mitrović, D. Bojić, A. Bojić</b>	PHOTOCATALYTIC DEGRADATION OF RANITIDINE BY BISMUTH OXO CITRATE	375
<b>Ana Simonović, Ž. Tasić, M. Radovanović, M. Petrović Mihajlović, M. Antonijević</b>	CAFFEINE AS A GREEN CORROSION INHIBITOR FOR COPPER IN SYNTHETIC BLOOD PLASMA SOLUTION	381
<b>Dragana Medić, S. Milić, S. Alagić, M. Nujkić, A. Papludis, S. Đordjević, S. Dimitrijević</b>	RECYCLING GOLD FROM WASTE PRINTED CIRCUIT BOARDS	387
<b>Uroš Stamenković, S. Ivanov, I. Marković</b>	CHARACTERIZATION OF CARBON AND LOW-ALLOY STEEL AFTER DIFFERENT HEAT TREATMENTS	393
<b>Violeta Babić, M. Milenković, Z. Govedar, S. Stajić, B. Kanjevac</b>	THE FOREST FIRES IN BULGARIA: THE TRENDS AND THE INFLUENCE OF TELECONNECTIONS	400
<b>Martina Petković, M. Božović, A. Klikovac, D. Knežević</b>	THE IMPORTANCE OF FIRE PROTECTION ON SHIPS	406
<b>Darko Stojićević, Z. Živković, M. Saulić, T. Sekulić, V. Stupar</b>	PESTICIDES – IMPACT ON HUMAN HEALTH AND THE ENVIRONMENT	413
<b>Zlata Živković, M. Saulić, D. Stojićević, M. Jevtić Đorović, V. Stupar</b>	ORGANIC AGRICULTURE: POTENTIAL OF THE FUTURE	419

<b>Tatjana Anđelković, K. Kitanović, I. Kostić Kokić, B. Zlatković, D. Bogdanović</b> CHANGES IN NITRATE AND NITRITE CONTENT IN FOR LETTUCE, CHARD AND SPINACH AFTER FREEZING	425
<b>Ivana Perović, S. Brković, N. Zdošek, G. Tasić, M. Seović, S. Mitrović, J. Ciganović</b> CAN LASER MODIFICATION OF COATED ELECTRODES IMPROVE THE HYDROGEN EVOLUTION REACTION IN ALKALINE ELECTROLYSERS?	430
<b>Nikola Zdošek, S. Brković, I. Perović, M. Čurčić, S. Dimović, M. Vujković</b> NEW GENERATION OF ELECTROCHEMICAL SUPERCAPACITORS	436
<b>Nebojša Potkonjak, Đ. Čokeša, M. Marković</b> THE HYDROGEN PRODUCTION ON Ni ELECTRODE CO-DEPOSITED WITH $\text{Co}+\text{V}_2\text{O}_5$ : THE ELECTROCALYTIC SYNERGETIC EFFECT	441
<b>Tatjana Ratknić, G. Šekularac, M. Ratknić, Z. Poduška, M. Aksić</b> EFFECTS OF CLIMATE CHARACTERISTICS ON THE DIAMETER INCREMENT OF CEDAR IN THE CITY OF BELGRADE (SERBIA)	446
<b>Natalija Čutović, M. Vuksanović, M. Milošević, M. Bugarčić, J. Bošnjaković, J. Gržetić, A. Marinković</b> RECYCLED POLY(ETHYLENE TEREPHTHALATE) BASED- PLASTICIZER FOR PVC REGRANULATES PRODUCTION	452
<b>Robert Vigi, G. Štrbac, D. Štrbac, M. Novaković</b> SYNTHESIS OF NEW Ag DOPED CHALCOGENIDE GLASS FOR APPLICATION IN ENERGY CONVERSION AND MEMORY STORAGE	459
<b>Tatjana Miljojčić, I. Jelić, M. Šljivić-Ivanović, S. Dimović, U. Ramadani</b> SUSTAINABLE UTILIZATION OF CATHODE-RAY TUBE WASTE GLASS IN CEMENTITIOUS MATERIALS – A REVIEW	465
<b>Dejan Riznić, A. Fedajev, A. Jevtić</b> ECOTURISM AS A FORM OF GREEN ECONOMY	471
<b>Vesna Đikanović, J. Vranković, K. Jovičić</b> DIET OF TWO CYPRINID SPECIES, WHITE BREAM (BLICCA BJOERKNA) AND COMMON ROACH (RUTILUS RUTILUS) IN THE DANUBE RIVER, BELGRADE	477
<b>Aleksandra Radić, D. Voza, Đ. Nikolić, M. Vuković</b> ENVIRONMENTAL PERFORMANCE CLASSIFICATION OF BALKAN COUNTRIES BASED ON TOPSIS-SORT METHODOLOGY	483
<b>Marijana Pantić, T. Maričić, S. Milijić</b> CITIZEN PARTICIPATION OFFERS LESSONS TO CLIMATE CHANGE MANAGEMENT	489
<b>Tanja Brdarić, D. Aćimović, B. Savić, N. Abazović, M. Čomor, M. Ječmenica Dučić, D. Maksin</b> INVESTIGATION OF $\text{ZrO}_2$ AND $\text{ZrO}_2/\text{TiO}_2$ ELECTRODES BY CYCLIC VOLTAMMETRY	495
<b>Branislava Savić, D. Aćimović, T. Brdarić, M. Ognjanović, D. Vasić Aničijević, M. Ječmenica Dučić, M. Simić</b> TESTING THE ELECTROCHEMICAL BEHAVIOR OF BPA ON GC, $\text{WO}_3$ AND MWCNT ELECTRODES	499
<b>Marijola Božović, M. Petković, S. Marković, B. Stojčetović</b> DISASTER RISK MANAGEMENT FRAMEWORK	504
<b>Author Index</b>	510

## DETECTION OF THE TRAFFIC-RELATED POLLUTION BY THE ROADSIDE SOIL AND PLANT MATERIAL

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### Abstract

*Biomonitoring abilities of elder (*Sambucus nigra*) were used in the examination of environmental pollution of the traffic zone in the vicinity of the Bor city (Eastern Serbia). The concentrations of the examined elements in the root zone soil and leaves of elder were determined by the simultaneous dual view inductively coupled plasma atomic emission spectrometer (ICP-AES) after the sample microwave digestion. The obtained results were compared with the biomonitoring data related to the background (not polluted) and urban-industrial (extremely polluted) zones. The results indicated the pollution of the roadside soil with the traffic pollution markers such as Cu, Zn, Pb, As and Cd, which pose the ecological risk due to the surrounding farmland ecosystems. The leaves content of Al, Fe and Zn could not be connected to the traffic, while the traffic emissions contributed to the Cu, Pb and As contents in the elder leaves. The differences (D) between the concentrations of the elements of the washed and unwashed elder leaves indicated the presence of the airborne particulate matter rich in Cu, Pb and As in the examined roadside environment. The pollution emitted from the traffic had far less impact on the quantities of toxic elements in the soil and vegetation samples compared to the pollution from the copper production processes.*

**Keywords:** elder, biomonitoring, traffic pollution markers, environmental pollution

### INTRODUCTION

Pollution related to the road traffic usually originates from combustion of fuel and oil, corrosion of metallic parts, tailpipe exhaust, tire wear, lubricants, brake wear and particle resuspension from the road surface (road abrasion). Brake wear emissions have been identified to contain significant amounts of Cu, Fe, Ba, Sb and Mn, while Cd, Pb and Zn are used in tire manufacture. Some metals, typically known as geogenics, such as Ca, K, Mg, Al, Fe and Mn, have been identified to be correlated with traffic markers [1]. Aksu [2] mentioned that the main source of Cu is diesel engines and unleaded gasoline, while Zn is used in lubricating oil. The distance from transport routes and traffic load intensity could influence certain content of the toxic elements in the roadside vegetation and soil [3]. Roadside planting at the particulate matter immission hotspots can substantially and quickly improve the urban air quality and reduce human exposure to it. It was proven that elder had very high capabilities for capture of the airborne ultrafine particles (70.5%) [4].

The aim of this study was to apply biomonitoring abilities of *Sambucus nigra* (elder) [5] in the examination of the roadside environmental pollution in the vicinity of the Bor city.

## MATERIALS AND METHODS

Naturally distributed elder (*Sambucu nigra*) and soil from the root zone of the plant were chosen for the purpose of the roadside pollution bimonitoring. The samples of soil and leaves were collected from the background zone without the impact of anthropogenic pollution. The traffic zone was situated along the road of the IB order (Bor-Selište), at the distance which was without the impact of pollution from the mining and metallurgical facilities. The urban-industrial zone was under the pollution emitted from the copper smelter, tailings ponds, city heating plant and the traffic. The root zone soil (10–20 cm depth) of three to five elder plants were sampled after the removal of surface layer of humus, at each sampling site. The samples of leaves were collected at 1.5 to 2 m height above the ground from the outer branches of canopy, in the period from September to mid-October. One half of foliar samples was retained as an unwashed sample (UL), while the other half was thoroughly washed (WL) with running distilled water for about 1 min at room temperature. After air drying at room temperature, the samples were ground to a fine powder and stored at room temperature until analysis. The digestion [6] and chemical analysis of the extracts (simultaneous dual view inductively coupled plasma atomic emission spectrometer, ICP-AES) were determined at the Institute of Mining and Metallurgy Bor (Serbia). The values of Enrichment factor (EF) were calculated by dividing the concentration of a certain element in the sample from the polluted zone by the concentration of the same element in the sample from the background zone. The values of  $EF > 2$  indicated environmental pollution [7].

## RESULTS AND DISCUSSION

### Soil

The concentrations of the studied elements in the soil samples depending on the zones were established in the increasing order as follows: background < traffic < urban-industrial (Table 1). The exception was Al with the maximum content in the soil from the traffic zone.

The enrichment of soil with Cu, Zn, Pb, As and Cd was noticed for the samples from the traffic and urban-industrial zones, with the higher EFs for the samples from the urban-industrial zone. Except the soil from the traffic and industrial zones, the Maximum limit value (MLV) for Cu [8] was exceeded in the soil from the background zone, which was probably the impact of the natural soil composition. The values of MLV for Zn, Pb and Cd were exceeded in the soil from the traffic and urban-industrial zones. The concentration of As in the soil from the urban-industrial zone was also higher than the MLV, while the concentration of As in the soil from the traffic zone was close to the MLV. The noted exceedances indicated that the level of contamination could disturb ecological balance, impose additional examinations of the soil, as well as limitations in soil usage [8], which is of high importance for the landowners engaged in the agricultural production in the studied area. The Remediation values (RV) for Cu, Zn, Pb, As and Cd [8] were not exceeded in the soil from the traffic zone, but only for the given elements in the urban-industrial zone. From the obtained results it could be noted that the pollution of the roadside soil with Cu, Zn, Pb, As and Cd existed and must not be ignored because of the surrounding farmland ecosystems.

**Table 1** Content (mg/kg d.w.) and the values of the Enrichment factor (EF) of the studied elements in the soil samples from the industrial, traffic, and background zones

	<sup>a</sup> Al	<sup>a</sup> Fe	Cu	Zn	Pb	As	Cd
<b>Urban-industrial</b>	4.59	4.94	9435.06	1836.89	1021.20	1141.29	19.83
<b>Traffic</b>	5.27	4.67	816.58	209.64	94.51	28.67	1.96
<b>Background</b>	3.39	2.44	39.42	84.22	22.70	7.39	<0.3 <sup>b</sup>
<b>EF<sub>industrial</sub></b>	1.36	2.03	239.37	21.81	44.99	154.50	>66.1 <sup>c</sup>
<b>EF<sub>traffic</sub></b>	1.56	1.91	20.72	2.49	4.16	3.88	>6.53 <sup>c</sup>
<sup>d</sup> MLV	/ <sup>f</sup>	/ <sup>f</sup>	36	140	85	29	0.8
<sup>e</sup> RV	/ <sup>f</sup>	/ <sup>f</sup>	190	720	530	55	12

<sup>a</sup> The content of element is expressed in %.

<sup>b</sup> The lower limit of determination for Cd.

<sup>c</sup> Values with the sign ">" are obtained by dividing the concentration of a certain element in the soil from a certain zone with the corresponding concentration of the element from the background zone which was below the lower limit of determination.

<sup>d</sup> MLV-maximum limit value according to the Serbian Regulation [8].

<sup>e</sup> RV-remediation value according to the Serbian Regulation [8].

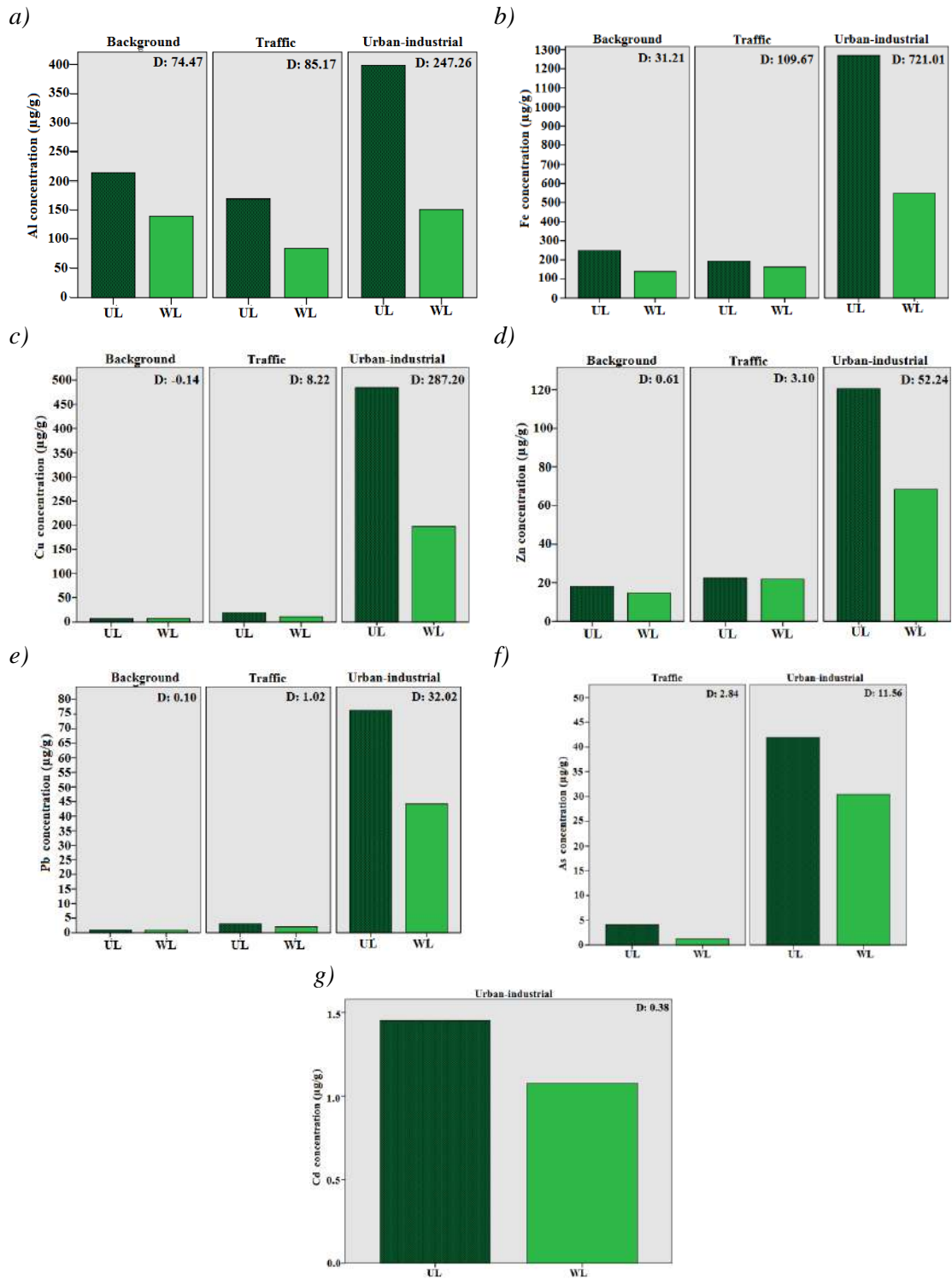
<sup>f</sup> not defined.

## Plant material

The lowest Al concentrations were detected in the unwashed and washed elder leaves from the traffic zone, while the highest Al contents were detected in the leaves from the urban-industrial zone (Figure 1a). The calculated D values indicated the highest Al washable content for the leaves from the urban-industrial zone, while the D values for the leaves from the background and traffic zones were similar. According to the presented results, including the EFs (Table 2), it could be said that the Al contents in the leaves from the traffic zone could not be related with the emissions from road traffic.

The Fe concentrations in the washed and unwashed elder leaves from the background and traffic zones did not differ much, while the elder leaves from the urban-industrial zone stood out with the highest Fe contents (Figure 1b). It could be noticed that the D value was lowest for the samples from the background zone, and the highest for the samples from the urban-industrial zone. The Fe contents in the washed elder leaves from the background and traffic zones were not above the Fe excessive content for the leaves of woody plants (500 µg/g) [9], which cannot be said for the contents of the washed leaves from the urban-industrial zone. The enrichment of the elder leaves from the traffic zone was not noticed according to the EFs (Table 2), while the leaves from the urban-industrial zone were enriched with Fe.

The Cu contents in the elder leaves from the background and traffic zones were far below the Cu contents in the leaves from the urban-industrial zone (Figure 1c). The D value for the leaves from the traffic zone existed, but it was much lower than for the leaves from the urban-industrial zone. The critical Cu concentrations for the leaves of woody plants (20 µg/g) [9,10] were not exceeded in the washed leaves from the background and traffic zones. The Cu concentrations in the washed leaves from the urban-industrial zone were about 10 times the critical Cu value.



**Figure 1** Concentrations of a) Al, b) Cu, c) Fe, d) Zn, e) Pb, f) As and g) Cd in unwashed (UL) and washed (WL) elder leaves from the background, traffic and urban-industrial zones. The D-difference (µg/g) of a certain element concentration between the unwashed and washed leaves

The values of EF were >2 for Cu in all the leaf samples, except for Cu in the washed leaves from the traffic zone (Table 2). This indicated that the traffic emissions contributed to some extent on the Cu content of particles deposited on the surfaces of the elder leaves which were sampled in the traffic zone.

**Table 2** The values of Enrichment factor of the analyzed elements in the washed and unwashed elder leaves from the traffic and urban-industrial zones

	Washed leaves		Unwashed leaves	
	traffic	urban-industrial	traffic	urban-industrial
<b>Al</b>	0.60	1.08	0.79	1.86
<b>Fe</b>	0.86	<b>3.38</b>	1.28	<b>6.56</b>
<b>Cu</b>	1.60	<b>29.89</b>	<b>2.90</b>	<b>75.01</b>
<b>Zn</b>	0.68	<b>3.14</b>	0.80	<b>5.39</b>
<b>Pb</b>	<b>2.21</b>	<b>46.58</b>	<b>2.98</b>	<b>72.90</b>
<b>As</b>	>1.23 <sup>a</sup>	> <b>30.38</b> <sup>a</sup>	> <b>4.07</b> <sup>a</sup>	> <b>41.94</b> <sup>a</sup>
<b>Cd</b>	/ <sup>b</sup>	>1.08 <sup>a</sup>	/ <sup>b</sup>	>1.45 <sup>a</sup>

<sup>a</sup> Values with the sign “>” are obtained by dividing the concentration of a certain element in the leaves from a certain zone with the corresponding lower limit of determination of the element in the leaves from the background zone.

<sup>b</sup> The concentrations of the analyzed elements in the leaves from a certain and background zone were below the lower limit of determination.

The values in bold are >2.

The Zn concentrations, D values and the values of EF for the elder leaves (Figure 1d, Table 2) indicated that emissions from the traffic did not cause chemical disturbance of the roadside environment with this element. The influence of the copper smelter on the Zn content in the leaves was significant, which could be seen from Figure 1d and Table 2. The concentrations of Zn in the washed elder leaves from the background and traffic zones were not above the excessive concentrations (>50–100 µg/g) [9], while the Zn content in the leaves from the urban-industrial zone was in the given range.

The Pb concentrations of the elder leaves, as well as the D values, followed the same increasing order depending on the sampling zone: background<traffic<urban-industrial (Figure 1e). It is significant to emphasize that the EF>2 (Table 2) indicated the enrichment of the leaves from the traffic zone with Pb, which is one of the main indicators of the pollution emitted from the traffic. Nevertheless, the obtained results showed the incomparable influence of the copper production processes on the Pb environmental content of the urban-industrial zone. The excessive Pb concentrations for the leaves of higher plants (30 µg/g) [9] were not exceeded in the washed leaves from the background and traffic zones, which could not be noted for the samples from the urban-industrial zone.

The As concentrations in the leaves from the background zone were below the LOD, and were not presented in the Figure 1f. The As concentrations of the elder washed and unwashed leaves, as well as the D values for the samples from the traffic zone, were far below the As concentrations and the D values for the leaves from the urban-industrial zone. However, the D value for the leaves from the traffic and urban-industrial zones indicated the presence of this carcinogenic element in the atmospheric deposition of the examined environments. These results were supported by the values of EF for As in the unwashed leaves from the traffic zone which were >2. The highest concentration that plants can tolerate in their tissues of 2 µg/g [11] and the toxicity limit value of 20 µg/g [12] were not exceeded in the washed

leaves from the background and traffic zones, which cannot be observed for the leaves from the urban-industrial zone.

The Cd concentrations in the leaves from the background and traffic zones were below the LOD, and were not presented in Figure 1 g, so environmental enrichment with Cd in the traffic zone cannot be assessed. The excessive concentrations defined for the leaves of higher plants 1–3 µg/g [9] were observed only in the washed leaves from the urban-industrial zone.

## **CONCLUSION**

The examined root zone roadside soil was polluted with Cu, Zn, Pb, As and Cd, which could lead to the contamination of soil-crop system due to the agricultural activities in the surrounding of the sampling sites. According to the obtained concentrations, the values of EF, and D values for Al, Fe and Zn in the elder leaves it can be concluded that the traffic emissions in the study area did not contribute to the environmental enrichment with these elements. The Cu, Pb and As concentrations in the elder leaves, as well as the washable quantities of these elements, indicated the presence of airborne particulate matter rich in Cu, Pb and As, in the examined roadside environment.

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## **REFERENCES**

- [1] K. Alexandrino, F. Viteri, Y. Rybarczyk, *et al.*, *Ecol. Indic*; 117 (2020) 106701.
- [2] A. Aksu, *J. Environ. Health Sci. Eng*; 13 (2015) 79.
- [3] S.K. Georgieva, A. Georgieva, Z. Peteva, *et al.*, *Environ. Sci. Pollut. Res*; 28 (2021) 59277–59283.
- [4] H. Wang, B.A Maher, I.A.M. Ahmed, *et al.*, *Environ. Sci. Technol*; 53 (2019) 6906–6916.
- [5] T.S. Kalinovic, S.M. Serbula, A.A. Radojevic, *et al.*, *Geoderma*; 262 (2016) 266–275.
- [6] U.S. EPA (U.S. Environmental Protection Agency), 1996. Acid Digestion of Sediments, Sludges, and Solids (3050B), Washington, DC.
- [7] G. Bertolotti, S. Gialanella, *Anal. Methods*; 6 (2014) 6208–6222.
- [8] Official Gazette of Republic of Serbia, Regulation on Limit Values for Polluting, Harmful and Hazardous Substances in the Soil, No 30/2018 (in Serbian).
- [9] P. Rademacher, (2003): Atmospheric heavy metals and forest ecosystems, Work Report, No. 2003/12, Federal Research Centre for Forestry and Forest Products (BFH), Institute for World Forestry, Hamburg.
- [10] A.M.B. Pålsson, *Water Air Soil Pollut*; 47 (1989) 287–319.

- [11] A. Kabata-Pendias, H. Pendias, Trace Elements in Soils and Plants, 3rd ed., CRC Press, Boca Raton, Florida (USA) (2001), ISBN: 978-0-8493-1575-6.
- [12] T. Vamerli, M. Bandiera, G. Mosca, Environ. Chem. Lett; 8 (2010) 1-17.

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