



prehrambeno  
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Sveučilište  
u Zagrebu

*Water for All*

*International Scientific and Professional Conference*

*Voda za sve*

*Međunarodni znanstveno-stručni skup*

DANUBE PARKS



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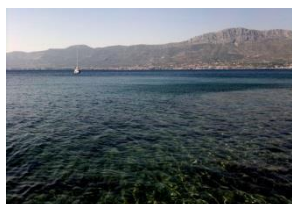
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Sadržaj / Contents

---

**PLENARNA PREDAVANJA**  
**PLENARY LECTURES**

Tibela Landeka Dragičević

**BIOLOGICAL NUTRIENT REMOVAL IN WASTEWATER TREATMENT**  
**BIOLOŠKO UKLANJANJE HRANJIVIH TVARI U OBRADI OTPADNE VODE** ..... 1

Dražen Vouk, Domagoj Nakić, Mario Šiljeg, Aleksandra Anić Vučinić

**ZBRINJAVANJE MULJA S UPOV-A U EU I HRVATSKOJ: KRITIČKI OSVRT NA**  
**DOSADAŠNJU PRAKSU I SMJERNICE ZA UČINKOVITIJA RJEŠENJA**  
**DISPOSAL OF SEWAGE SLUDGE IN EU AND CROATIA: CRITICAL REVIEW OF**  
**CURRENT PRACTICE AND GUIDELINES FOR MORE EFFICIENT SOLUTIONS** ..... 2

**USMENA PRIOPĆENJA**  
**ORAL LECTURES**

Igor Tadić, Branimir Barač

**PRIPREMA EU SUFINANCIRANIH PROJEKATA ODVODNJE I PROČIŠĆAVANJA**  
**OTPADNIH VODA S OSVRTOM NA PROBLEMATIKU NA PODRUČJU**  
**SLAVONIJE I BARANJE**  
**PREPARATION OF EU FINANCED WASTEWATER COLLECTION AND**  
**TREATMENT PROJECTS WITH REGARD TO DIFFICULTIES IN**  
**SLAVONIA-BARANJA REGION** ..... 3

Marija Leko-Kos, Denis Vrabc, Edon Novoselić

**UREĐAJ ZA PROČIŠĆAVANJE OTPADNIH VODA GRADA OSIJEKA**  
**WASTE WATER TREATMENT PLANT OF THE CITY OF OSIJEK** ..... 4

Andreja Hajdinger, Lidija Tadić

**ZBRINJAVANJE OTPADNIH VODA NA PODRUČJU POŽEŠKO-SLAVONSKE**  
**ŽUPANIJE**  
**WASTEWATER TREATMENT IN THE POŽEGA-SLAVONIA COUNTY** ..... 5

Anita Ptiček Siročić, Bojan Đurin, Nada Glumac, Lucija Nađ

**ANALIZA ODSUPANJA VRIJEDNOSTI POKAZATELJA KAKVOĆE**  
**OTPADNE VODE POMOĆU RAPS METODE**  
**VARIANCE ANALYSIS OF QUALITY INDICATORS VALUES OF**  
**WASTEWATER BY RAPS METHOD** ..... 7

Save Španja, Sanda Šikić

**MOGUĆNOSTI POBOLJŠANJA METODOLOGIJE ODREĐIVANJA ADEKVATNOG**  
**RECIPIJENTA ZA PRIHVAT PROČIŠĆENIH OTPADNIH VODA**  
**NASELJA DO 10.000 ES-a**  
**POSSIBILITIES FOR IMPROVEMENT OF THE METHODOLOGY FOR**  
**DETERMINING ADEQUATE RECIPIENT FOR ACCEPTANCE OF**  
**TREATED WASTE WATER FOR SETTLEMENTS UP TO 10.000 PE** ..... 9

---

|   |    |
|---|----|
| Selma Čustović<br><b>UREĐAJ ZA PROČIŠĆAVANJE PITKE VODE (UPPV) – DUBROVNIK</b><br><b>DRINKING WATER TREATMENT PLANT – DUBROVNIK</b> .....   | 10 |
| Ljiljana Bečvardi, Nikola Sakač, <u>Martina Medvidović-Kosanović</u> , Maja Karnaš,<br>Marija Jozanović, Dora Harangozo, Marija Kraševac, Tomislav Balić, Milan Sak-Bosnar<br><b>ELECTROCHEMICAL IMPEDANCE SPECTROSCOPY AND POTENTIOMETRIC</b><br><b>CHARACTERIZATION OF TENSIDE SENSOR WITH MWCNT</b> .....  | 11 |
| <u>Marta Jerković</u> , Lidija Tadić<br><b>KORIŠTENJE PROČIŠĆENE OTPADNE VODE ZA NAVODNJAVANJE</b><br><b>TREATED WASTEWATER USED IN IRRIGATION</b> .....  | 12 |
| <u>Mira Zovko</u> , Ines Katić, Dunja Pofuk, Ivana Gudelj<br><b>VAŽNOST UČINKOVITOG UPRAVLJANJA VODAMA ZA OČUVANJE</b><br><b>ZDRAVLJA LJUDI</b><br><b>IMPORTANCE OF EFFICIENT WATER MANAGEMENT FOR THE</b><br><b>HUMAN HEALTH PROTECTION</b> .....  | 13 |
| <u>Hrvoje Sučić</u> , Vera Santo, Suzana Čavar, Marika Kralj, Dario Kolarić, Hrvoje Babić<br><b>VALIDACIJA ANALITIČKE METODE ZA ODREĐIVANJE UKUPNOG</b><br><b>DUŠIKA (TN) U OTPADNIM VODAMA</b><br><b>VALIDATION OF ANALYTICAL METHOD FOR THE DETERMINATION</b><br><b>OF TOTAL NITROGEN (TN) IN WASTEWATERS</b> .....   | 14 |
| <u>Kiril Lisichkov</u> , Stefan Kuvendziev, Mirko Marinkovski, Mahi Ljatifi,<br>Zoran Bozhinovski, Mirna Habuda-Stanić<br><b>BIOSORPTION AS A GREEN TECHNOLOGY FOR REMOVAL OF HEAVY METALS</b><br><b>FROM WATER RESOURCES: MODELING AND SIMULATION</b> .....  | 15 |
| <u>Adela Krivohlavek</u> , Martina Ivešić, Sonja Tolić, Sandra Šikić, Valerija Musić<br><b>PRISUTNOST I UKLANJANJE ANTIMIKROBNIH TVARI U I IZ VODE</b><br><b>PRESENCE AND ELIMINATION OF ANTIMICROBIAL SUBSTANCES</b><br><b>IN AND FROM WATER</b> .....   | 16 |
| <u>Filip Stević</u> , Mirna Habuda-Stanić, Anastazija Školka, Marija Nujić, Vlatko Rožac,<br>Dubravka Špoljarić Maronić, Tanja Žuna Pfeiffer, Matej Šag<br><b>FITOPLANKTONSKE ZAJEDNICE I FIZIKALNO-KEMIJSKI POKAZATELJI</b><br><b>KVALITETE VODA U MELIORACIJSKIM KANALIMA KOPAČKOG RITA</b><br><b>PHYTOPLANKTON AND PHYSICO-CHEMICAL INDICATORS OF WATER QUALITY</b><br><b>IN THE WATER OF DRAINAGE CHANNELS IN KOPAČKI RIT</b> ..... | 17 |
| <u>Martina Jurković</u> , Darja Sokolić, Daniela Kenjeric, Mirna Habuda-Stanić<br><b>UNOS VODE ODRASLE POPULACIJE RH</b><br><b>WATER INTAKE IN CROATIAN ADULTS</b> .....  | 19 |



Sadržaj / Contents

---

|   |    |
|---|----|
| <u>Edgar Kralj</u> , Ksenija Kralj, Mirna Habuda-Stanić, Vera Santo, Ante Nevistić<br><b>PRAĆENJE STANJA KOEFICIJENTA ADSORPCIJE NATRIJA (SAR)<br/>PODZEMNIH VODA ISTOČNE HRVATSKE<br/>MONITORING OF SODIUM ADSORPTION RATIO (SAR) IN<br/>GROUNDWATER OF EASTERN CROATIA</b> .....  | 20 |
| <u>Teuta Tompić</u> , Gordana Hajduk, Dunja Turk<br><b>ODREĐIVANJE POLIBROMIRANIH DIFENIL-ETERA (PBDE) U VODI METODOM<br/>PLINSKE KROMATOGRAFIJE S MASENOM SPEKTROMETRIJOM (GC-MS/MS)<br/>DETERMINATION OF POLYBROMINATED DIPHENYL ETHER (PBDE) IN WATER<br/>BY GAS CHROMATOGRAPHY-MASS SPECTROMETRY (GC-MS/MS)</b> ..... | 22 |
| <u>Darija Vukić Lušić</u> , Arijana Cenov, Marin Glad, Aleksandar Bulog, Dražen Lušić<br><b>KAKVOĆA MORA ZA KUPANJE NA PODRUČJU OPATIJE OD 2001. DO 2016.<br/>BATHING SEAWATER QUALITY IN OPATIJA AREA 2001 – 2016</b> .....  | 24 |
| Josip Suver<br><b>ULOGA MELIORACIJSKOG SUSTAVA U ODVODNJI VODA<br/>FUNCTION OF LAND IMPROVEMENT SYSTEM IN DRAINAGE WATER</b> .....  | 26 |
| <u>Lovorka Gotal Dmitrović</u> , Hrvoje Selec, Vesna Dušak<br><b>MODELIRANJE INFORMACIJSKOG SUSTAVA ZA PROČIŠĆAVANJE<br/>OTPADNE VODE<br/>INFORMATION SYSTEM'S MODELLING FOR WASTEWATER TREATMENT</b> .....   | 27 |
| <u>Mustafa Erhan</u> , Kiril Lisichkov, Mirko Marinkovski, Stefan Kuvendziev,<br>Zoran Bozhinovski, Eyup Ljayifi<br><b>DESIGN AND DETERMINATION OF PERMEABILITY CHARACTERISTICS OF<br/>POLYMERIC MEMBRANE MODULE FOR DIFFERENT AQUEOUS SOLUTIONS</b> .....  | 28 |
| <u>Marija Nujić</u> , Mirna Habuda-Stanić<br><b>CONVERTING WASTE INTO A RESOURCE FOR NITRATE REMOVAL</b> .....  | 29 |
| <u>Vlatko Rožac</u> , Georg Frank<br><b>PROJEKT: POVEZIVANJE ZAŠTIĆENIH PODRUČJA NA DUNAVU<br/>U KORIDOR STANIŠTA „DANUBEPARKSCONNECTED“<br/>PROJECT: BRIDGING THE DANUBE PROTECTED AREAS TOWARDS<br/>A DANUBE HABITAT CORRIDOR “DANUBEPARKSCONNECTED”</b> .....  | 30 |
| <u>Zoran Bozhinovski</u> , Stefan Kuvendziev, Kiril Lisichkov, Mirko Marinkovski,<br>Mirna Habuda-Stanić, Dejan Dimitrovski<br><b>DETERMINATION OF ADSORPTION CAPACITY FOR ARSENIC<br/>REMOVAL IN A LABORATORY SCALE FIXED BED COLUMN</b> .....   | 32 |

---

|  |    |
|--|----|
| Dijana Podravac, Martina Jurković, Tomislav Klapac, Tihomir Kovač,<br>Biljana Crevar, <u>Bojan Šarkanj</u><br><b>DOES THE DIET STYLE AFFECTS THE CREATININE EXCRETION?</b> .....   | 33 |
| <u>Natalija Velić</u> , Kazimir Antunović, Hrvoje Pavlović, Antonija Kezerle,<br>Kristina Mastanjević, Darko Velić<br><b>OBEZBOJENJE SINTETSKOG BOJILA MALAHITNOG ZELENILA POMOĆU<br/>MICELIJSKIH PELETA <i>Trametes versicolor</i><br/>DECOLOURISATION OF SYNTHETIC DYE MALACHITE GREEN USING<br/><i>Trametes versicolor</i> MYCELIAL PELLETS</b> ..... | 34 |
| <u>Dino Obradović</u> , Marija Šperac<br><b>PROČIŠĆAVANJE OTPADNIH VODA NAVODNJAVANJEM ZEMLJIŠTA<br/>WASTEWATER TREATMENT WITH LAND IRRIGATION</b> .....   | 36 |
| Bojan Đurin, <u>Lucija Baić</u> , Sanja Kovač<br><b>NOVI POGLEDI NA POVEZANOST REŽIMA CRPLJENJA I POTROŠNJE<br/>VODE ZA PIĆE U NASELJIMA<br/>NEW ASPECTS OF THE CONNECTION BETWEEN THE PUMPING AND<br/>CONSUMPTION REGIME OF DRINKING WATER IN HUMAN SETTLEMENTS</b> .....   | 38 |
| <u>Jasmina Ibrahimpašić</u> , Halid Makić, Azra Bakrač, Aida Džaferović, Samira Dedić,<br>Merima Toromanović<br><b>UTJECAJ KOMUNALNIH OTPADNIH VODA NA KAKVOĆU RIJEKE UNE<br/>THE IMPACT OF MUNICIPAL WASTEWATER ON UNA RIVER QUALITY</b> .....  | 39 |
| <u>Jasna Šoštarić</u> , Marko Josipović, Monika Marković, Meho Majdančić<br><b>VIŠAK I MANJAK VODE U POLJOPRIVREDI<br/>EXCESS AND DEFICIT OF WATER IN AGRICULTURE</b> .....  | 40 |
| Noura Touabi, Sanja Martinez, Moussa Bounoughaz<br><b>REMOVAL OF ZINC AND COPPER FROM WASTEWATER BY<br/>POTENTIOSTATIC DEPOSITION</b> .....  | 41 |
| Iva Čobanković<br><b>ARSENIC IN EASTERN CROATIA – PROBLEMS AND SOLUTIONS</b> .....   | 42 |
| <b>POSTERSKA PRIOPĆENJA<br/>POSTER PRESENTATIONS</b>   |    |
| Dragan Adamović, Maja Turk Sekulić, Sabolč Pap, Veselin Bežanović,<br>Nevena Živančev, Jelena Radonić<br><b>EVALUATION OF HEAVY METAL IONS ADSORPTION FROM WASTEWATER<br/>USING THE ALTERNATIVE ADSORBENT IN THE CONTINUOUS FIXED-BED<br/>COLUMN</b> .....   | 43 |

Sadržaj / Contents

---

|  |    |
|--|----|
| Birkan Akyol, Necdet Alpaslan, Baris Yilmaz<br><b>ANALYSIS OF BIOLOGICAL PHOSPHORUS REMOVAL PROCESS AT<br/>BAYINDIR WWTP, TURKEY</b> .....   | 44 |
| Ana Amić, Lidija Tadić<br><b>SADRŽAJ NITRATA U POVRŠINSKIM VODAMA SLIVA KARAŠICA-VUČICA<br/>NITRATE CONCENTRATION IN KARAŠICA-VUČICA RIVER SURFACE WATERS</b> ...  | 45 |
| Tamara Apostolović, Jelena Tričković, Marijana Kragulj Isakovski, Aleksandra Tubić,<br>Dejan Krčmar, Božo Dalmacija, Jasmina Agbaba<br><b>CHARACTERIZATION AND SORPTION POTENTIAL FOR PENTACHLOROPHENOL<br/>OF ALLUVIAL SEDIMENT OF THE DANUBE RIVER</b> .....   | 47 |
| Katerina Atkovska, Mahi Ljatifi, Kiril Lisichkov, Mirko Marinkovski, Stefan Kuvendziev,<br>Gordana Ruseska, Anita Grozdanov<br><b>APPLICATION OF AGRICULTURAL WASTES FOR REMOVAL OF Fe(II) IONS<br/>FROM WATER RESOURCES</b> .....   | 48 |
| Sejit Bobar, Munir Mehović<br><b>SADRŽAJ NITROGENOVIH SPOJEVA U VODI RIJEKE DREŽANKE<br/>CONTENT OF NITROGEN COMPOUNDS IN DREŽANKA RIVER</b> .....   | 49 |
| Marina Bubalo Kovačić, Monika Zovko, Gabrijel Ondrašek, Davor Romić, Petra Dubić,<br>Ivana Ivanković<br><b>UTJECAJ POLJOPRIVREDNE PROIZVODNJE NA KAKVOĆU VODE<br/>U RAZLIČITIM AGROEKOLOŠKIM UVJETIMA<br/>AGRICULTURAL PRODUCTION IMPACT ON WATER QUALITY WITHIN<br/>DIFFERENT AGROECOLOGICAL CONDITIONS</b> ..... | 50 |
| Blagica Cekova, Dragan Jovanov, Viktorija Bezovska, Filip Jovanovski<br><b>PHYSICO – CHEMICAL PROCEDURES FOR WASTEWATER TREATMENT</b> .....  | 51 |
| Aleksandra Čavić, Ivana Mihajlović, Boris Obrovski, Nevena Živančev, Milenija Marković, Maja<br>Đogo, Mirjana Vojinović Miloradov<br><b>PRINCIPAL COMPONENT AND CLUSTER ANALYSIS OF RESIDUAL<br/>CONCENTRATIONS OF HEAVY METALS CATIONS AND ZINC IN SURFACE<br/>WATER OF THE DANUBE, DTD AND TISZA</b> .....       | 52 |
| Amela Đurakovac, Mirjana Sekulić<br><b>APLICATION OF RAIN GARDENS IN ORDER TO IMPROVE WATER QUALITY<br/>IN NOVI SAD</b> .....  | 53 |
| Tajana Đurkić, Jelena Molnar Jazić, Jasmina Agbaba, Marijana Kragulj Isakovski,<br>Aleksandra Tubić, Snežana Maletić, Božo Dalmacija<br><b>PHOTOCHEMICAL DEGRADATION OF ALACHLOR IN WATER</b> .....  | 54 |

---

|   |    |
|---|----|
| Maja Ergović Ravančić, Mirna Habuda-Stanić<br><b>UTJECAJ FLUORIDA U VODI ZA PIĆE NA ZDRAVLJE</b><br><b>EFFECT OF FLUORIDE IN DRINKING WATER ON HEALTH</b> .....   | 55 |
| Vilim Filipović, Dragutin Petošić, Mario Maloić, Ivan Mustać, Ivan Šimunić, Lana Filipović,<br>Nada Maurović, Marina Diana Igrc, Filip Kranjčec<br><b>SOIL WATER FLOW AND NITRATE TRANSPORT MODELING USING</b><br><b>LYSIMETER DATA</b> .....   | 56 |
| Vilim Filipović, Lana Filipović, Thomas Weninger, Andreas Schwen<br><b>WATER REPELLENCY EFFECT ON SOIL HYDRAULIC PROPERTIES</b><br><b>UNDER VARIABLE CLIMATE CONDITIONS</b> .....   | 57 |
| Dajana Gašo-Sokač, Mirna Habuda-Stanić, Valentina Bušić, Dora Zobundžija<br><b>OCCURENCE OF PHARMACEUTICALS IN SURFACE WATER</b> .....  | 58 |
| Jasna Grabić, Simonida Đurić, Vladimir Ćirić, Pavel Benka<br><b>WATER QUALITY AT SPECIAL NATURE RESERVES IN VOJVODINA, SERBIA</b> .....   | 59 |
| Marko Grgić, Snežana Maletić, Jelena Spasojević, Srđan Rončević, Marijana Kragulj Isakovski,<br>Jasmina Agbaba, Aleksandra Tubić, Božo Dalmacija<br><b>INVESTIGATING ALKYLPHENOL BIOAVAILABILITY IN AGED SEDIMENTS</b><br><b>AMENDED WITH CARBON-RICH SORPTION AGENTS</b> .....                     | 60 |
| Sonja Gvozdenc, Vojislava Bursić, Jelena Tričković, Mladen Tatić, Jelena Ovuka,<br>Sandra Cvejić, Jasna Grabić<br><b>GERMINATION ENERGY AND SEED GERMINATION OF CULTIVATED</b><br><b>PLANTS AS INDICATORS OF WATER CONTAMINATION</b> .....  | 61 |
| Mirna Habuda-Stanić, Filip Stević, Radomir Čvarković<br><b>PROGRAM PRAĆENJA STANJA OBORINSKIH I PODZEMNIH VODA</b><br><b>SANIRANOG I ZATVORENOG ODLAGALIŠTA KOMUNALNOG OTPADA</b><br><b>MONITORING OF RAINFALL WATER AND GROUNDWATER OF CLOSED</b><br><b>AND REHABILITATED WASTE LANDFILL</b> ..... | 62 |
| Anita Ivanković, Predrag Ivanković, Danijela Petrović, Tea Anđelić, Jerina Majstorović<br><b>MONITORING FIZIKALNO-KEMIJSKIH PARAMETARA VODE DONJEG TOKA</b><br><b>RIJEKE NERETVE</b><br><b>MONITORING OF PHYSICO-CHEMICAL WATER PARAMETERS OF THE</b><br><b>LOWER RIVER NERETVA</b> .....           | 63 |
| Munir Jahić, Sanel Buljubašić<br><b>MODERAN PRISTUP GOSPODARENJA VODOOPSKRBNIM SUSTAVIMA</b><br><b>MODERN APPROACH TO MANAGEMENT OF WATER SUPPLY SYSTEMS</b> .....  | 65 |

Sadržaj / Contents

---

|  |    |
|--|----|
| Munir Jahić, Azra Kajtazović, Emir Bajramović<br><b>PLANIRANJE KANALIZACIONIH SISTEMA</b><br><b>PLANNING OF SEWER SYSTEM</b> .....   | 67 |
| Nebojša Jerković, Mirna Habuda-Stanić, Zoran Mateljak, Jelena Đugum<br><b>KAKVOĆA VODA I NJENA DOSTUPNOST U DELTI RIJEKE NERETVE</b><br><b>QUALITY AND QUANTITY OF WATER IN THE AREA OF RIVER</b><br><b>NERETVA DELTA</b> .....  | 68 |
| Dragan Jovanov, Blagica Cekova, Vesna Markoska, Kiril Lisichkov<br><b>THE IMPACT OF THE ANTHROPOGENIC FACTOR ON THE</b><br><b>MICROBIOLOGICAL POLLUTION ON THE TRESKA RIVER</b> .....  | 70 |
| Davor Jurlina, Matej Karl, Stjepanka Lešić, Marko Matijević, Martina Vrdoljak<br><b>VODA I ORALNO ZDRAVLJE</b><br><b>WATER AND ORAL HEALTH</b> .....   | 71 |
| Antonija Kezerle, Nataša Ljubić, Natalija Velić<br><b>PROCJENA TOKSIČNOSTI NA DAFINIJE (<i>Daphnia magna</i>) OTPADNE</b><br><b>KOLEKTORSKE VODE I OTPADNE VODE INDUSTRIJE DETERGENATA</b><br><b>EVALUATION OF COLLECTOR WASTEWATER AND DETERGENT</b><br><b>INDUSTRY WASTEWATER TOXICITY ON <i>Daphnia magna</i></b> ..... | 72 |
| Milenko Korica, Jelena Bijelić, Igor Đerd<br><b>UČINKOVITO UKLANJANJE FOSFATA I KONGO CRVENOG SINTETSKOG</b><br><b>BOJILA IZ OTPADNIH VODA</b><br><b>EFFICIENT PHOSPHATE AND CONGO RED SYNTHETIC DYE REMOVAL</b><br><b>FROM WASTEWATER</b> .....   | 74 |
| Elvira Kovač-Andrić, Marija Paurević, Martina Šrajter Gajdošik<br><b>POTENTIAL EFFECTS OF SULPHATE PARTICLES AND OZONE ON</b><br><b>CALCAREOUS SINTER AT PLITVICA LAKES</b> .....  | 75 |
| Marijana Kragulj Isakovski, Jelena Tričković, Jasmina Agbaba, Snežana Maletić,<br>Jelena Molnar Jazić, Srđan Rončević, Tamara Apostolović, Božo Dalmacija<br><b>ADSORPTION MECHANISMS OF ORGANOPHOSPHORUS PESTICIDES</b><br><b>ON MULTIWALLED CARBON NANOTUBES</b> .....   | 76 |
| Dragana Kukić, Marina Šćiban, Jelena Prodanović, Vesna Vasić, Mirjana Antov,<br>Nataša Nastić<br><b>APPLICATION OF NATURAL COAGULANTS EXTRACTED FROM</b><br><b>COMMON BEAN FOR WASTEWATER TREATMENT</b> .....  | 77 |
| Nikoleta Kukučka Stojanović, Andrej Kukučka, Miroslav Kukučka<br><b>POSSIBILITIES OF AMMONIUM ION REMOVAL FROM GROUNDWATER</b><br><b>ON SYNTHETIC ZEOLITE IN CONTINUOUS FIXED BED SYSTEM</b> .....   | 78 |

|   |    |
|---|----|
| Lucija Kuna, Jelena Jakab, Tea Omanović, Nikola Raguž Lučić, Martina Smolić,<br>Aleksandar Včev<br><b>OSTATCI FARMACEUTSKIH SPOJEVA U VODENOM OKOLIŠU</b><br><b>PHARMACEUTICAL RESIDUES IN THE AQUATIC ENVIRONMENT</b> .....  | 79 |
| Ante Lončarić, Tihomir Kovač, Marija Nujić, Mirna Habuda-Stanić<br><b>PRIPREMA TEHNOLOŠKE VODE ZA INDUSTRIJSKU PROIZVODNJU PIVA</b><br><b>WATER PREPARATION FOR INDUSTRIAL BREWING</b> .....  | 80 |
| Magdi Lučić Lavčević, Antonio Penava<br><b>ZnO NANOSTRUCTURED PHOTOCATALYSTS FOR WATER TREATMENT</b><br><b>APPLICATIONS</b> .....   | 81 |
| Damir Magdić, Mirna Habuda-Stanić, Andrea Gross-Bošković<br><b>ANALIZA POJAVNOSTI KEMIJSKIH ELEMENATA U VODI ZA PIĆE</b><br><b>NA PODRUČJU REPUBLIKE HRVATSKE</b><br><b>ANALYSIS OF THE INCIDENCE OF CHEMICAL ELEMENTS</b><br><b>IN DRINKING WATER IN CROATIA</b> .....   | 82 |
| Zvonimira Medverec Knežević, Renata Josipović, Martina Nadih, Danijela Opačak<br><b>KVALITETA TEHNOLOŠKIH OTPADNIH VODA ANALIZIRANIH</b><br><b>U ZZJZ BRODSKO-POSAVSKE ŽUPANIJE U 2016. GODINI</b><br><b>QUALITY OF TECHNOLOGICAL WASTE WATERS ANALYZED AT THE</b><br><b>INSTITUTE OF PUBLIC HEALTH OF BROD-POSAVINA COUNTY IN 2016</b> ..... | 83 |
| Munir Mehović, Sejit Bobar<br><b>SEZONSKA PROMJENA POJEDINIH PARAMETARA KVALITETA VODE</b><br><b>U RIJECI RADOBOLJI</b><br><b>SEASONAL CHANGES OF SOME WATER QUALITY PARAMETERS IN THE</b><br><b>RADOBOLJA RIVER</b> .....  | 85 |
| Zoltán Melicz, Ernő Fleit<br><b>SOME CONCLUSIONS ON DRINKING WATER QUALITY IMPROVEMENT</b><br><b>PROJECT IN HUNGARY</b> .....   | 86 |
| Hamdije Memedi, Katerina Atkovska, Kiril Lisichkov, Mirko Marinkovski,<br>Stefan Kuvendzjev, Shaban Jakupi, Arianit A. Reka<br><b>SEPARATION OF Cr(VI) IONS FROM AQUEOUS SOLUTIONS BY</b><br><b>BENTONITE : THE INFLUENCE OF pH</b> .....   | 87 |
| Jelena Molnar Jazić, Jasmina Agbaba, Aleksandra Tubić, Malcolm Watson,<br>Dejan Krčmar, Srđan Rončević, Božo Dalmacija<br><b>IMPACT OF OZONE AND ADVANCED OXIDATION PROCESSES ON THE</b><br><b>FORMATION POTENTIAL OF NITROGENOUS BY-PRODUCTS IN WATER</b> .....  | 88 |

Sadržaj / Contents

---

|  |    |
|--|----|
| Korana Nikšić, Ana Pavelić<br><b>UČINKOVITOST RADA UREĐAJA ZA PROČIŠĆAVANJE OTPADNIH VODA<br/>SLAVONSKI BROT<br/>THE WORK EFFICIENCY OF WASTEWATER TREATMENT PLANT<br/>SLAVONSKI BROT</b> .....  | 89 |
| Marija Nujić, Dragana Milinković, Mirna Habuda-Stanić<br><b>UKLANJANJE NITRATA IZ VODE IONSKOM IZMJENOM<br/>NITRATE REMOVAL FROM WATER BY ION EXCHANGE</b> .....   | 90 |
| Boris Obrovski, Jovan Bajić, Ivana Mihajlović, Mirjana Vojinović Miloradov,<br>Branislav Batinić, Dragan Adamović, Vladimir Rajš<br><b>SENSOR TECHNOLOGY FOR MONITORING OF AQUATIC MEDIUM</b> .....  | 91 |
| Gabrijel Ondrašek, Zed Rengel, Peta L. Clode, Matt R. Cliburn, Paul Guagliardo,<br>Davor Romić, Monika Zovko<br><b>DETEKCIJA I VIZUALIZACIJA ULTRA RIJETKIH IZOTOPA Cd I Zn U<br/>RHIZOSFERNIM OTOPINAMA I HRANI POMOĆU NAJNAPREDNIJIH<br/>TEHNIKA MASENE SPEKTROMETRIJE<br/>DETECTION AND VISUALIZATION OF ULTRA-TRACE Cd AND Zn ISOTOPES IN<br/>RHIZOSPHERE SOLUTIONS AND FOOD BY MOST ADVANCED MASS</b> ..... | 92 |
| Gabrijel Ondrašek, Monika Zovko, Filip Kranjčec, Marina Bubalo, Davor Romić,<br>Radovan Savić, Vilim Filipović<br><b>MOGUĆNOST PRIMJENE PEPELA IZ BIOMASE NA KISELIM I HRANIVIMA<br/>OSIROMAŠENIM POLJOPRIVREDNIM TLIMA<br/>POSSIBILITY OF APPLICATION OF FLY ASH FROM BIOMASS ON ACID<br/>AND NUTRIENT-DEFICIENT AGRICULTURAL SOILS</b> .....   | 93 |
| Palma Orlović-Leko, Ivo Galić, Irena Ciglencečki, Nevenka Mikac<br><b>KARAKTERIZACIJA RUDNIČKE VODE<br/>CHARACTERIZATION OF THE MINE WATER</b> .....   | 94 |
| Ayşegül Pala, Ceyla Inmeler<br><b>BALLAST WATER MANAGEMENT IN TANKERS</b> .....  | 96 |
| Sabolč Pap, Maja Turk Sekulić, Dragan Adamović, Jelena Radonić<br><b>THERMODYNAMIC STUDY OF Pb<sup>2+</sup>, Cd<sup>2+</sup> AND Ni<sup>2+</sup> ADSORPTION<br/>ON CHERRY/SWEET CHERRY KERNEL ACTIVATED CARBON</b> .....   | 97 |
| Mara Pavelić<br><b>UPRAVLJANJE OTPADNIM VODAMA – BRIGA ZA OKOLIŠ<br/>I ZDRAVLJE LJUDI</b> .....  | 98 |

---

|  |     |
|--|-----|
| Valentina Pavlova, Tatjana Blazhevaska, Marija Menkinoska, Ilinka Gjorgjievska,<br>Martina Pavlovska<br><b>THE NUTRITIONAL ASPECT OF WATER'S IMPORTANCE</b> .....  | 99  |
| Marija Pejakić, Marko Matijević<br><b>FLUORIDACIJA VODE ZA PIĆE</b><br><b>FLUORIDATION OF DRINKING WATER</b> .....   | 100 |
| Ariana Penava, Mato Matijević, Ivana Flanjak<br><b>KONCENTRACIJE NITRATA U VODI NA PODRUČJU POŽEŠKO-SLAVONSKE</b><br><b>ŽUPANIJE ODREĐENE SPEKTROFOTOMETRIJSKOM METODOM</b><br><b>NITRATES IN WATER IN POŽEGA-SLAVONIA COUNTY AS DETERMINED</b><br><b>BY SPECTROPHOTOMETRIC METHOD</b> .....                     | 101 |
| Dijana Podravac, Natalija Velić, Hrvoje Pavlović<br><b>MIKROBIOLOŠKA POPULACIJA VOĆNIH SOKOVA, GAZIRANIH NAPITAKA I</b><br><b>VODE U BOCI, NAKON OTPIJANJA</b><br><b>MICROBIOLOGICAL POPULATION OF SOFT AND CARBONATED BEVERAGES</b><br><b>AND BOTTLED WATER AFTER SIPPING</b> .....                             | 102 |
| Delia Teresa Sponza, Gökçe Pehlivaner<br><b>REMOVAL OF TWO BROMINATED MICROPOLLUTANTS (A-HBCDD AND TBBPA)</b><br><b>IN A HOSPITAL WASTEWATER IN İZMİR (TURKEY) BY SEQUENTIAL</b><br><b>BIOLOGICAL AND REVERSE OSMOSIS PROCESSES</b> .....  | 103 |
| Leon Stojanov, Kiril Lisichkov, Valentin Mirceski<br><b>PREPARATION AND DETECTION OF SILVER NANOPARTICLES IN AQUEOUS</b><br><b>SOLUTIONS BY ADVANCED PULSE VOLTAMMETRIC TECHNIQUES</b> .....   | 104 |
| Danijela Stražanac, Leonard Matijević, Jasenka Petrić, Dario Čagalj, Jasenka Babić,<br>Brigita Hengl<br><b>IZLOŽENOST STANOVNIŠTVA GRADA ZAGREBA KONTAMINANTIMA</b><br><b>IZ VODE ZA LJUDSKU POTROŠNJU</b><br><b>POPULATION EXPOSURE OF ZAGREB CITY AREA TO CONTAMINANTS</b><br><b>FROM DRINKING WATER</b> ..... | 105 |
| Goran Šarić, Bojan Matijević, Marijana Blažić, Sandra Zavadlav, Jasna Halambek<br><b>OTPADNE VODE IZ PIVOVARA - OTPAD ILI SIROVINA?</b><br><b>BREWERY EFFLUENTS - WASTE OR RAW MATERIAL?</b> .....   | 106 |
| Maja Turk Sekulić, Sabolč Pap, Tatjana Šolević Knudsen, Nikola Bošković, Dragan Adamović,<br>Nevena Živančev, Jelena Radonić<br><b>THERMOCHEMICAL MODIFICATION OF APRICOT KERNELS FOR</b><br><b>REMOVAL OF PRIORITY, HAZARDOUS PRIORITY AND EMERGING</b><br><b>SUBSTANCES FROM AQUEOUS WASTES</b> .....          | 107 |



**Sadržaj / Contents**

---

|   |     |
|---|-----|
| Jelena Vešligaj Turkalj, Željka Romić, Mario Jakopec, Angelina Paić, Melita Pašić,<br>Mirna Habuda-Stanić<br><b>MONITORING KONCENTRACIJE KLORIDA I SULFATA U BUNARIMA<br/>B-17 I B-18 CRPILIŠTA VINOGRADI KOD OSIJEKA<br/>MONITORING CONCENTRATION OF CHLORIDES AND SULPHATES<br/>IN THE WELLS B-17 AND B-18 WATER SUPPLY VINOGRADI NEAR OSIJEK</b> ..... | 108 |
| Gorica Vuković, Marina Đukić, Vojislava Bursić, Aleksandra Popović,<br>Aleksandra Petrović, Sonja Gvozdenc, Jasna Grabić, Radoš Zemunac<br><b>METHOD VALIDATION OF MICROCYSTIN-LR IN WATER</b> .....  | 109 |
| Srećko Vuković, Mirna Habuda-Stanić, Vera Santo, Zdenko Drahotuski, Dora Vuković<br><b>REVITALIZACIJA I KAKVOĆA VODE KUPALIŠTA „BIZOVAČKI BAJER“<br/>REVITALIZATION AND WATER QUALITY OF BRICK FACTORY POND<br/>„BIZOVAČKI BAJER“</b> .....   | 110 |
| Nevena Živančev, Srđan Kovačević, Zoran Čepić, Maja Turk Sekulić, Jelena Radonić<br><b>TECHNOLOGIES FOR REMOVAL OF UV FILTERS</b> .....   | 111 |
| <b>KAZALO AUTORA<br/>AUTHOR INDEX</b> .....   | 112 |
| <b>SPONZORI<br/>SPONSORS</b> .....  | 117 |



**Plenarna predavanja / *Plenary lectures***



## **BIOLOŠKO UKLANJANJE HRANJIVIH TVARI U OBRADI OTPADNE VODE**

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Hranjive tvari (dušik i fosfor) su primarni uzročnici eutrofikacije površinskih voda. Prije ispuštanja otpadnih voda u okoliš važno i obvezno je uklanjanje dušika i fosfora do odgovarajuće koncentracije. Proces biološkog uklanjanja hranjivih tvari (engl. *Biological Nutrient Removal*) znači kombinaciju procesa uklanjanja N i P. Najuobičajeniji način uklanjanja dušika iz otpadne vode je kombinacija dva biološka procesa u slijedu: I. autotrofna nitrifikacija (prevođenje  $\text{NH}_4\text{-N}$  u  $\text{NO}_2\text{-N}$  pomoću amonijak-oksidirajućih bakterija, i  $\text{NO}_2\text{-N}$  u  $\text{NO}_3\text{-N}$  pomoću nitrit-oksidirajućih bakterija), i II. heterotrofna denitrifikacija (redukcija  $\text{NO}_3\text{-N}$  do  $\text{N}_2$ ) pomoću heterotrofnih denitrificirajućih bakterija pri anoksičnim uvjetima. Uklanjanje P se postiže primjenom procesa naprednog biološkog uklanjanja P (engl. *Enhanced Biological Phosphorus Removal*, EBPR). Za uklanjanje nutrijenata, dušika i fosfora, iz otpadne vode važno je postići kompromis u odabiru uvjeta, okolišnih i procesnih, jer su uvjeti zahtijevani za te procese različiti. Strategija obrade je ili voditi proces kombinirajući odgovarajuće i povoljne uvjete za procese uklanjanja N i P uz nitrificirajuće, denitrificirajuće i defosfatirajuće vrste kao dvomuljni proces, ili proces voditi kombinacijom uvjeta za nitrifikaciju i denitrificirajuću defosfataciju.

## **BIOLOGICAL NUTRIENT REMOVAL IN WASTEWATER TREATMENT**

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Nutrients (nitrogen and phosphorus) are the primary causes of eutrofication in surface waters. Nitrogen and phosphorus removal to an appropriate concentration is important and compulsory before wastewaters are discharged into the environment. The combination of P and N removal is referred to as biological nutrient removal (BNR). The most common way to remove nitrogen from wastewater is a combination of two sequential biological processes: I. autotrophic nitrification (conversion of  $\text{NH}_4\text{-N}$  to  $\text{NO}_2\text{-N}$  by ammonia-oxidizing bacteria, and  $\text{NO}_2\text{-N}$  to  $\text{NO}_3\text{-N}$  by nitrite-oxidizing bacteria), and II. heterotrophic denitrification ( $\text{NO}_3\text{-N}$  reduction to  $\text{N}_2$ ), by heterotrophic denitrifying bacteria under anoxic conditions. P removal is achieved using an engineered process known as enhanced biological P removal (EBPR). Polyphosphate-accumulating organisms (PAOs) are responsible for enhanced biological phosphorous removal (EBPR). In order to remove nutrients (N and P) from wastewater, it is necessary to achieve a compromise in regard to the selection of environmental and process conditions, because the conditions required for those processes are different. The strategy of the processing is to either conduct the process by combining the suitable and optimal conditions for the N and P removal process with nitrifying, denitrifying and dephosphating bacteria as a two-sludge process, or, conduct the process by combining conditions for a nitrifying and denitrifying dephosphatation.

**ZBRINJAVANJE MULJA S UPOV-A U EU I HRVATSKOJ: KRITIČKI  
OSVRT NA DOSADAŠNJU PRAKSU I SMJERNICE  
ZA UČINKOVITIJA RJEŠENJA**

**DISPOSAL OF SEWAGE SLUDGE IN EU AND CROATIA: CRITICAL  
REVIEW OF CURRENT PRACTICE AND GUIDELINES  
FOR MORE EFFICIENT SOLUTIONS**

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Kao glavni nusprodukt na uređajima za pročišćavanje otpadnih voda (UPOV) nastaje mulj, čije je zbrinjavanje skup te ekološki i socijalno osjetljiv postupak. Generirani mulj potrebno je adekvatno obraditi na samom UPOV-u i zbrinuti u okoliš u skladu sa zakonskom regulativom. Dodatno se naglašava da zbrinjavanje mulja nije važno isključivo s aspekta zadovoljenja zakonskih propisa, već i s aspekta odabira optimalne koncepcije pročišćavanja, uključivo i samu obradu mulja. Navedeno je posebno izraženo kroz mogućnosti korištenja mulja kao sirovine, bilo u poljoprivredi, ozelenjavanju krajolika, proizvodnji građevinskih proizvoda, cestogradnji, poboljšanju tla i dr. U radu će se prikazati dosadašnja praksa s kritičkim osvrtom na zbrinjavanje mulja u EU. Dodatno će se iznijeti i kritički osvrt dosadašnjih saznanja o mogućnostima i preporukama zbrinjavanja mulja u Hrvatskoj. Na konkretnim primjerima tehničkih i ekonomskih analiza različitih mogućnosti zbrinjavanja mulja na regionalnoj razini u Hrvatskoj ukazat će se na potrebu za novim pristupom u rješavanju dane problematike. U konačnici će se na temelju prethodno izvedenih analiza definirati prijedlog smjernica za daljnje učinkovito rješavanje problema zbrinjavanja mulja u Hrvatskoj.

*Zahvala:* Ovaj rad je financirala Hrvatska zaklada za znanost projektom "Reuse of sewage sludge in concrete industry – from microstructure to innovative construction products - (7927)".

**Usmena priopćenja / *Oral lectures***





**PRIPREMA EU SUFINANCIRANIH PROJEKATA ODVODNJE I  
PROČIŠĆAVANJA OTPADNIH VODA S OSVRTOM NA  
PROBLEMATIKU NA PODRUČJU SLAVONIJE I BARANJE**

**PREPARATION OF EU FINANCED WASTEWATER COLLECTION AND  
TREATMENT PROJECTS WITH REGARD TO DIFFICULTIES IN  
SLAVONIA-BARANJA REGION**

Igor Tadić, Branimir Barač

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Republika Hrvatska je ulaskom u Europsku Uniju preuzela obveze ispunjenja zahtjeva Direktive o odvodnji i pročišćavanju komunalnih otpadnih voda (91/271 EEZ) i Okvirne Direktive o vodama (2000/60/EZ). Sastavni dio ispunjenja obveza odnosi se na izgradnju vodno-komunalne infrastrukture čime će se postići zahtijevani stupanj priključenja stanovništva i gospodarstva na sustave odvodnje te zahtijevani stupanj pročišćavanja otpadnih voda u odnosu na veličinu i položaj aglomeracija. Autori će u radu dati pregled potrebne dokumentacije za prijavu infrastrukturnih projekata izgradnje sustava odvodnje i pročišćavanja komunalnih otpadnih voda s naglaskom na izradi Studija izvodljivosti i Aplikacijskih paketa u cijelosti. Obzirom na specifičnosti područja, navedeni pregled bit će dan kroz dosadašnjih iskustava na pripremi projekata na području Slavonije i Baranje. Priprema infrastrukturnih projekata zahtijeva cjelovit pristup, od analize postojećih ulaznih podataka (stanovništvo, gospodarstvo, potrošnje pitke vode), odabira optimalnih varijantnih rješenja što uključuje definiranje obuhvata aglomeracije kao i tehničke mjere odvodnje i pročišćavanja otpadnih voda, do financijske i ekonomske analize projekta te aspekata zaštite okoliša. Problematika na prijavama projekata je raznovrsna, no dominantno se odnosi na negativna demografska kretanja, nizak stupanj izgrađenosti i priključenosti na sustave odvodnje, financijsku prihvatljivost projekta, ali i nedorečenu regulativu te poteškoće koje proizlaze iz uvjeta zaštite okoliša. Rad će na sažet način prezentirati probleme prilikom odobrenja apliciranih projekata, ali i možebitna rješenja.

## UREĐAJ ZA PROČIŠĆAVANJE OTPADNIH VODA GRADA OSIJEKA

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Izgradnja Uređaja za pročišćavanje otpadnih voda grada Osijeka dio je „Projekta Osijek“ koji se sufinancira sredstvima EU u okviru Operativnog programa Okoliš 2007-2013, kada je i započeta realizacija. Cilj projekta je poboljšanje vodoopskrbe i upravljanja otpadnim vodama u Osijeku i okolnim naseljima sukladno nacionalnim i EU direktivama. Uređaj za pročišćavanje otpadnih voda (UPOV) grada Osijeka i okolnih naselja kapaciteta je 170.000 ES, konvencionalna tehnologija pročišćavanja – III stupanj. U radu će se dati pregled projektne dokumentacije i potrebnih akata do ishodenih građevinskih dozvola. Projekt je podijeljen u tri faze: izgradnja obaloutvrde, kanala za odvodnju oborinskih voda i uređenje parcele – platoa; izgradnja dijela uređaja za mehaničko pročišćavanje otpadnih voda s izljevom u rijeku Dravu i izgradnja objekata za biološko pročišćavanje otpadnih voda s postrojenjem za obradu mulja i bioplinskim postrojenjem Naglasak rada je na dokumentaciji, odnosno tehničkom rješenju obrađenom glavnim projektom, prikaz objekta UPOV-a po pojedinim fazama glavnih projekata kao i cjelokupnog postrojenja.

## WASTE WATER TREATMENT PLANT OF THE CITY OF OSIJEK

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The construction of the Wastewater Treatment Plant of Osijek is part of the "Project Osijek" which is co-financed by EU funds under the Operational Programme "Environment" 2007-2013, when the realization started. The aim of the project is to improve water supply and wastewater management in Osijek and the surrounding settlements in accordance with national and EU directives. The capacity of the Wastewater Treatment Plant (WWTP) of Osijek and the surrounding settlements is 170,000 EC, conventional wastewater treatment technology – tertiary treatment level. The paper will give an overview of the project documentation and the documents necessary to obtain building permits. The project is divided into three phases: the construction of embankments, drainage canals and landscaping plot - plateau; the construction of a mechanical wastewater treatment plant with effluent discharge into the River Drava and the construction of facilities for biological wastewater treatment with a sludge treatment plant and a biogas plant. The emphasis of the paper is on documentation, i.e. the technical solution done in the main project, the presentation of the WWTP objects at individual stages of main projects as well as the entire plant.

## **POŽEŠKO-SLAVONSKE ŽUPANIJE**

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Požeško-slavonska županija prema teritorijalnim osnovama pripada vodnom području sliva rijeke Save, a slivna područja su: sliv rijeke Orljave i sliv rijeka Ilova-Pakra. U cilju zaštite voda ovih slivova izrađena je Studija zaštite voda Požeško-slavonske županije (Hidroprojekt-ing, 2008. godine) koja će poslužiti kao podloga za izradu idejnih i izvedbenih projekata odvodnje i pročišćavanja otpadnih voda. Odvodnja otpadnih i oborinskih voda riješena je djelomično u gradovima Požega, Pleternica, Kutjevo, Pakrac i Lipik te u općinskim središtima Velika, Kaptol i Jakšić, dok se kod većine perifernih naselja odvodnja otpadnih voda još uvijek rješava putem sabirnih i septičkih jama. Mehanički centralni uređaji za pročišćavanje izgrađeni su u Požegi, Pakracu i Lipiku. Plan izgradnje i dogradnje sustava odvodnje i pročišćavanja otpadnih voda rađen je na temelju sociološkog, ekonomskog i kriterija zaštite resursa, ukupni troškovi su procijenjeni na 853.000.000,00 kuna, dok troškovi pogona i upravljanja objektima iznose 8.500.000,00 kuna godišnje. Plan obuhvaća tri faze: prva faza do 2021. godine, druga faza do 2031. godine i treća faza nakon 2031. godine. Planirana je izgradnja najmanje 7 uređaja za pročišćavanje otpadnih voda, a za 4 je već pokrenut postupak za dobivanje lokacijske dozvole.

## **WASTEWATER TREATMENT IN THE POŽEGA-SLAVONIA COUNTY**

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According to the territorial basis Požega-Slavonia County belongs to water area of the river Sava basin, and river basin districts are: river Orljava basin district and rivers Ilova-Pakra basin district. Study of water protection Požega-Slavonia County (Hidroprojekt-ing, 2008.) is made for the water protection of these basins. It will be the basis for preliminary and detailed designs of drainage and wastewater treatment. Wastewater and stormwater drainage is partially solved in Cities of Požega, Pleternica, Kutjevo, Pakrac, Lipik and in municipal centers of Velika, Kaptol and Jakšić. In majority of peripheral settlements wastewater treatment is still solving with sewers and septic tanks. Mechanical central sewage treatment plants are built in Požega, Pakrac and Lipik. The upgrading plan is made by social, economics and protect resources criteria, total costs are estimated at

853.000.000,00 kuna, while facility and management costs are amount 8.500.000,00 kuna for year. Plan contains three phases: first phase untill 2021. year, second phase untill 2031. year und third phase after 2031. year. It is planned to build at least 7 sewage treatment plant. For 4 sewage treatment plant is allready started procedure for location licence.

## **ANALIZA ODPSTUPANJA VRIJEDNOSTI POKAZATELJA KAKVOĆE OTPADNE VODE POMOĆU RAPS METODE**

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Kako bi se zaštitili prirodni vodni sustavi, komunalne otpadne vode prije ispuštanja u okoliš moraju udovoljiti određenim uvjetima kakvoće. Zahvati u svrhu korištenja voda ujedno su mjesta čovjekove intervencije u hidrološki ciklus jer voda više ne slijedi zakone hidrološkog ciklusa, nego se podvrgava zakonima ljudskih htijenja. Odgovarajuća obrada otpadnih voda znači korištenje fizikalnih, kemijskih i/ili bioloških procesa pri čemu obrađena voda nakon ispuštanja ne narušava dobro stanje vodoprijemnika. Pokazatelji kakvoće otpadne vode u većini slučajeva definiraju niz u određenom vremenskom periodu. Analizom vremenskih nizova pojedinih pokazatelja kakvoće otpadne vode primjećuju se nepravilni trendovi njihovih vrijednosti, stoga je potrebno koristiti određene metode za utvrđivanje njihovog stvarnog stanja. U tu svrhu se često primjenjuje RAPS (*Rescaled Adjusted Partial Sums*) metoda, koja se koristi za utvrđivanje slučajnih i sustavnih pogrešaka u svakom vremenskom nizu, a samim time i u nizu vrijednosti pokazatelja kakvoće otpadne vode. Cilj ovog rada je istražiti nepravilnosti u vrijednostima određenih pokazatelja kakvoće otpadne vode, što u konačnici ukazuje na moguće probleme tijekom postupaka pročišćavanja otpadnih voda. RAPS metodom moguće je okarakterizirati niz pojedinih parametara s ciljem procjene kakvoće pročišćene vode i efikasnosti primjene uređaja za pročišćavanje.

## **VARIANCE ANALYSIS OF QUALITY INDICATORS VALUES OF WASTEWATER BY RAPS METHOD**

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In order to protect the quality of the natural water system, certain conditions need to be complied with before municipal wastewater is released into the environment. Procedures for different water purposes are also places of human intervention into hydrological cycle because water does not follow the rules of hydrological cycle anymore but it is subjected to the laws of human aspiration. Appropriate processing of wastewater includes physical, chemical and/or biological processes where by processed water does not violate condition of the water recipient after it has been released. Indicators of wastewater quality in most cases define a range in a specific period. By analysing timeline of the individual quality indicators of wastewater, irregular trends of their values have been noticed, so it is necessary to use certain methods to determine actual state of the water system. For this purpose, RAPS (*Rescaled Adjusted Partial Sums*) method is used. This method determines

accidental and systematic mistakes in each time series and in that way shows t a range of quality indicators of the wastewater. The purpose of this paper is to investigate irregularities in values of certain quality indicators of wastewater, which ultimately indicate possible problems during the wastewater purification treatments. With RAPS method, it is possible to follow the series of particular parameters to assess the quality of treated water and the efficiency of treatment plants.

**MOGUĆNOSTI POBOLJŠANJA METODOLOGIJE ODREĐIVANJA  
ADEKVATNOG RECIPIJENTA ZA PRIHVAT PROČIŠĆENIH  
OTPADNIH VODA NASELJA DO 10.000 ES-a**

**POSSIBILITIES FOR IMPROVEMENT OF THE METHODOLOGY FOR  
DETERMINING ADEQUATE RECIPIENT FOR ACCEPTANCE OF  
TREATED WASTE WATER FOR SETTLEMENTS UP TO 10.000 PE**

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Određivanje graničnih vrijednosti emisija onečišćujućih tvari za ispuštanje u površinske vode obuhvaćeno je Metodologijom kombiniranog pristupa. Hrvatske vode donijele su Metodologiju usklađenu sa svim relevantnim zakonskim aktima koja je stupila na snagu kolovoza 2015.g. Načelo Metodologije je smanjenje onečišćenja voda iz točkastih i raspršenih izvora onečišćenjau svrhu postizanja dobrog stanja voda, pri čemu je primjena iste obvezna za sva vodna tijela. Kod definiranja lokacije ispusta s UPOV-a sagledava se sastav ispuštenih pročišćenih otpadnih voda kao i njihov utjecaj na stanje prijemnika. U ovom radu utjecaj analize onečišćenja će se suziti na vode s UPOV-a naselja veličine do 10.000 ES-a. Trenutnom primjenom Metodologije problem onečišćenja recipijenta tretira se kao točkasti, analizira se isključivo kritično mjesto recipijenta za ostvarenje postavljenih uvjeta (lokacija ispusta). Opterećenja koja proizlaze iz sanitarnih otpadnih voda definiraju se kao biološka pri čemu je  $BPK_5$  glavni analizirani faktor u sklopu Metodologije za sve UPOV-e s II. stupnjem pročišćavanja. Kako bi se ispunili uvjeti postizanja/očuvanja dobrog stanja vodnih tijela problem onečišćenja treba promatrati kao linijski, odnosno uzeti u obzir trajektoriju kretanja onečišćenja od ispusta nizvodno. Potrebno je definirati kritičnu dužinu na kojoj bi se ograničili dodatni pritisci na recipijent iz drugih izvora onečišćenja, točkastih i raspršenih.

## **UREĐAJ ZA PROČIŠĆAVANJE PITKE VODE (UPPV) – DUBROVNIK**

### **DRINKING WATER TREATMENT PLANT – DUBROVNIK**

Selma Čustović

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Vodopskrbna mreža Grada Dubrovnika napaja se vodom iz izvorišta rijeke Omble. Pojava povišene mutnoće izvorišta, u posljednjih desetak godina, sve je učestalija, a maksimalno izmjerene vrijednosti su sve više. Tijekom povišenog zamućenja, svi sektori, službe i odjeli Vodovoda Dubrovnik d.o.o. poduzimaju mjere i postupke predviđene za nastalu situaciju, sukladno HACCP planu i ISO 22000:2005 normi; uključujući obavješćivanje javnosti, alternativnu isporuku vode za piće, pojačanu kontrolu itd. Zamućenje vode, iznad dozvoljene vrijednosti, predstavlja veliki problem za sve potrošače vode na području Dubrovnika. Između ostalog, prestaje isporuka vode brodarskim kompanijama, koje tijekom sezone pune tankove brodova vodom iz dubrovačkog vodopskrbnog sustava, hotelske kuće često nisu u mogućnosti koristiti vodu za pranje posteljine itd. Obzirom na navedeno, 2016. godine započeta je izgradnja uređaja za pročišćavanje pitke vode, a završetak radova je predviđen za srpanj ove godine. Radi se o uređaju sa šest ultrafiltracijskih jedinica, ukupnog kapaciteta 490 l/s. Prema kapacitetu, UPPV Dubrovnik bit će, za sada, najveći uređaj ovog tipa u Republici Hrvatskoj.



## ELECTROCHEMICAL IMPEDANCE SPECTROSCOPY AND POTENTIOMETRIC CHARACTERIZATION OF TENSIDE SENSOR WITH MWCNT

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A low-cost, high sensitive solid contact tenside sensors with ion-pair, multi walled carbon nanotubes (MWCNTs) and low-cost graphite pencil lead (as a sensor layer carrier), were fabricated. The MWCNT nanomaterials were used to increase the active surface, to reduce the membrane resistance and to reduce the signal-to-noise ratio. The sensor was characterised by electrochemical impedance spectroscopy (EIS) and direct potentiometry. EIS measurements were performed in sodium dodecyl sulfate (DS) solutions (concentration range varied from  $c = 2.5 \cdot 10^{-4}$  M to  $4.0 \cdot 10^{-3}$  M) with sodium sulfate ( $I_c = 1 \cdot 10^{-2}$  M). The impedance spectra were recorded at the  $E_{oc}$  on MWCNT-tenside sensor. The sinusoidal excitation signal with excitation amplitude 10 mV was used in the frequency range from 100 kHz to 1 mHz. The impedance spectra were fitted to an equivalent electrical circuit by using CH1604E software. Direct potentiometric response measurements performed in DS water solution exhibited a Nernstian slope, -57.1 mV; with linear response range  $2.0 \cdot 10^{-7}$  M to  $1.0 \cdot 10^{-3}$  M. Potentiometric titrations performed by the hexadecyltrimethylammonium bromide as a titrant and DS as analyte exhibited a reproducible, well defined and sharp inflexion points. The MWCNT-tenside sensor was used as an end-point indicator in direct potentiometric titrations of samples from the waste waters.

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## **KORIŠTENJE PROČIŠĆENE OTPADNE VODE ZA NAVODNJAVANJE**

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Važnost navodnjavanja poljoprivrednih površina za povećanje proizvodnje hrane te podizanje životnog standarda odavno je utvrđena u svijetu. Međutim, izuzetno velika potrošnja vode za navodnjavanje i naglo rastuće potrebe ostalih potrošača za vodom potaknule su mnoge stručnjake i institucije da se sve više pozabave idejom korištenja voda niže kvalitete za potrebe navodnjavanja. Naglo povećanje broja stanovnika na Zemlji dovodi do povećanja potreba za hranom, a istovremeno i do proizvodnje sve veće količine otpadne vode. Uporabom pročišćenih otpadnih voda za navodnjavanje mogu se povećati raspoložive količine voda za navodnjavanje u krajevima siromašnim vodom. Iako se otpadna voda u nekim zemljama svijeta za navodnjavanje koristi već više stotina godina, sustavnoj analizi utjecaja otpadnih voda na poljoprivredne kulture i zdravlje ljudi pristupilo se tek poslije 1900. godine. Planirano korištenje otpadne vode za navodnjavanje štedi kvalitetnu vodu za druge namjene i u znatnoj mjeri uzgajane kulture opskrbljuje hranjivim tvarima što bitno smanjuje troškove proizvodnje. Zato su mnoge zemlje razvile standarde i propise za sigurnu primjenu otpadnih voda u poljoprivredi. U Hrvatskoj nema mnogo primjera korištenja pročišćene otpadne vode u navodnjavanju, te će u ovom radu biti iznesene neke smjernice za njenu potencijalnu upotrebu.

## **TREATED WASTEWATER USED IN IRRIGATION**

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The importance of irrigation of agricultural lands for increasing both food production and life standard has been recognized for a long time. However, extremely high water usage for irrigation and growing consumer demand has encouraged experts to think about using lower quality water for irrigation purposes. Because of the rapid population growth, needs for food are increasing. At the same time, the amount of produced wastewater is increasing. Reuse of treated wastewater for irrigation can lead to solving water deficit problems in water deprived regions of the world. Although the reuse of wastewater for irrigation was practiced hundreds of years ago, its effect on crops and human health began to be systematically analyzed only after 1900 [1]. Planned use of wastewater for irrigation would lower massive consumption of high quality water and, to some extent, supply crops with nutrients essential for their growth. Therefore, the production cost would be decreased. That is why many countries have standards and requirements for safe usage of treated wastewater in agriculture. There aren't many examples of treated wastewater use for irrigation in Croatia, in this paper some guidelines for its potential use will be presented.

## **VAŽNOST UČINKOVITOG UPRAVLJANJA VODAMA ZA OČUVANJE ZDRAVLJA LJUDI**

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Iako građani EU profitiraju od visokih standarda za pitku vodu i vodu za kupanje, učinkovitost njenog korištenja nije zadovoljavajuća. Stoga je Europska komisija usvojila pristup procjene pritisaka, proizvodnje i potrošnje te usluga vodenih ekosustava, čime su sagleđani i integrirani mogući učinci - ekonomski, ekološki i socijalni. Naime, uz već postojeće, predložen je dodatan skup pokazatelja, kako bi se do zadanih rokova ispunila dva cilja zacrtana Sedmim akcijskim programom EU za okoliš: zaštita, očuvanje i povećanje prirodnog dobra EU te zaštita građana EU od pritisaka i opasnosti za njihovo zdravlje i dobrobit koji su povezani s okolišem. Ovakav holistički pristup opisuje različite systemske pritiske, daje informaciju o njihovim posljedicama i procjenjuje stanje vode kao resursa temeljnog za ljudsko zdravlje i opstojnost čovječanstva. Upravljanje vodama na osnovi integracije svih komponenti održivog razvitka (ljudi, profit, okoliš) ključan je čimbenik i u rješavanju globalnih izazova - očuvanju i unapređenju zdravlja svjetske populacije, iskorjenjivanju siromaštva i osiguranju socijalne pravednosti.

## **IMPORTANCE OF EFFICIENT WATER MANAGEMENT FOR THE HUMAN HEALTH PROTECTION**

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Although EU citizens have a benefit from high standards of drinking and bathing water quality, water resource efficiency is not sufficient. Therefore European Commission has implemented approach of estimating pressures, consumption and production, and ecosystem services by which possible effects are analysed and integrated – economic, ecologic and social. Besides the existing, the additional set of indicators is proposed, in order to reach two objectives outlined in Seventh Environmental Action Programme: to protect, conserve and enhance the Union's natural capital and to safeguard the Union's citizens from environment-related pressures and risks to health and wellbeing. This holistic approach describes different system pressures, gives information about their consequences and assess status of water as a basic resource for human health and existence of mankind. Furthermore, water management based on integration of all sustainable development components (people, profit and environment) is a key factor in addressing the global challenges - preserving and improving the health of the world's population, eradicating poverty and ensuring social justice.

## VALIDACIJA ANALITIČKE METODE ZA ODREĐIVANJE UKUPNOG DUŠIKA (TN) U OTPADNIM VODAMA

Hrvoje Sučić, Vera Santo, Suzana Ćavar, Marika Kralj, Dario Kolarić, Hrvoje Babić

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Određivanje ukupnog dušika (TN) neizostavni je parametar gotovo svake analize otpadne vode. Dušik kao plin nalazi se u atmosferi, a pri posebnim uvjetima (električno pražnjenje, sijevanje) oksidira se u dušikov oksid te ispiranjem atmosfere, oborinskom vodom dospijeva u vodne sustave, no najveći dio dušikovih spojeva u vodi nastaje kao ishod razgradnje organske tvari. Obogaćivanje vode hranjivim tvarima, spojevima dušika, koji uzrokuju ubrzani rast algi i viših oblika biljnih vrsta dovodi do neželjenog poremećaja ravnoteže organizama u vodi i promjene stanja voda. Validacija je postupak dokazivanja da je analitička metoda prikladna za točno određenu namjenu. Cilj istraživanja bio je provesti validaciju analitičke metode za određivanje TN u otpadnim vodama na analizatoru ukupnog dušika s kemiluminiscentnim detektorom, koji omogućava detekciju puno nižih koncentracija ukupnog dušika u uzorku. Validacijom su ispitani slijedeći parametri: linearnost, granica kvantifikacije i detekcije, preciznost te točnost. Svi navedeni parametri nalaze se u kriteriju prihvatljivosti, stoga metoda odgovara zadanoj namjeni.

## VALIDATION OF ANALYTICAL METHOD FOR THE DETERMINATION OF TOTAL NITROGEN (TN) IN WASTEWATERS

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Determination of total nitrogen (TN) is an indispensable parameter in almost every analysis of wastewater. Nitrogen as gas can be found in the atmosphere while due to some special conditions (electrical discharge, lightning) it oxidizes into nitric oxide and through atmospheric washout with rainwater it gets into the water systems. However most of the nitrogen compounds in the water occur as a result of decomposition of organic substance. Enrichment of water with nutrients such as nitrogen compounds, which cause an accelerated growth of algae and higher forms of plant, leads to undesirable disturbance to the balance of organisms in the water and to changes of the water itself. Validation is the process of proving that the analytical method is suitable for a particular purpose. The aim of this study was to conduct the validation of the analytical method for determining TN in wastewater on the total nitrogen analyzer with chemiluminescence detector, which allows the detection of much lower concentrations of total nitrogen in the sample. With the process of validation the following parameters were tested: linearity, limit of quantification and detection, precision and accuracy. All these parameters are located in the eligibility criteria, therefore the method corresponds to the given application.

## **BIOSORPTION AS A GREEN TECHNOLOGY FOR REMOVAL OF HEAVY METALS FROM WATER RESOURCES: MODELING AND SIMULATION**

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Modern trends of the process engineering stipulate the need of design and modeling of new processes that comply with the basic principles of the Green chemistry and green process engineering. The main focus is on the zero emission concept that requires redesigning of the classical linear technological processes (end-of-pipe concept) into modern, cyclic processes, where the output (or by-product) of the initial production process represents a potential input for a newly designed process. The sustainable development of separation processes is focused on development of modern bioseparation techniques for elimination of toxic metals from wastewaters using nonconventional sorbents with low commercial values. The main goal of this work is modelling and optimization of the process of biosorption of Mn(II) from water resources through application of natural and modified biosorbent of domestic origin. Out of several investigated potential biosorbents, rice husk from Kochani region produced the highest biosorption affinity towards the investigated heavy metal. Experimentally obtained results were used for modelling of the studied biosorption equilibrium through fitting the experimental data using several adsorption isotherms (Langmuir, Freundlich, Langmuir-Freundlich и Redlich-Peterson) by application of the "MATLAB/Curve fitting toolbox" software. The study of the dynamics of the above-mentioned bioseparation process was performed using "SuperPro Designer" process simulator.

## PRISUTNOST I UKLANJANJE ANTIMIKROBNIH TVARI U I IZ VODE

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Suvremeni način života doveo je do raširene upotrebe antimikrobnih tvari ponajviše u humanoj i veterinarskoj medicini, ali i u akvakulturi, uzgoju bilja itd. Sve to dovelo je do općepresutnosti antimikrobnih tvari i u vodi gdje se ovisno o vrsti vode koncentracije prisutnih antimikrobnih tvari kreću od viših  $\mu\text{g L}^{-1}$  za bolničku otpadnu vodu, nižih  $\mu\text{g L}^{-1}$  za otpadnu vodu iz domaćinstava, viših i nižih  $\mu\text{g L}^{-1}$  za površinsku, podzemnu i morsku vodu u lukama, ali još uvijek vrlo rijetko u pitkim vodama. Prisutne antimikrobne tvari koje dospiju u otpadnu vodu mogu se eliminirati putem primarne eliminacije ili eliminacijom organskih molekula kroz biološke procese (biodegradacija bakterijama ili gljivicama) ili ne biološke procese poput sorpcije, hidrolize, fotolize, oksidacije ili redukcije. Ako se antimikrobne tvari ne eliminiraju iz otpadne vode mogu ući u okoliš i nepovratno utjecati na vodene i kopnene organizme, a ako se zagade izvori pitke vode i na čovjeka. Kako bi se utvrdilo trenutno stanje voda u RH napravljen je monitoring površinskih voda tijekom 2013 i 2014 godine. Rezultati su pokazali kako su proučavane antimikrobne tvari (sulfonamidi, kloramfenikol, fumagilin, torasemid i makrolidni antibiotici prisutni u nekim površinskim vodama u koncentracijama od  $0.02 \mu\text{g L}^{-1}$  -  $5.3 \mu\text{g L}^{-1}$ .

## PRESENCE AND ELIMINATION OF ANTIMICROBIAL SUBSTANCES IN AND FROM WATER

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Modern life has led to the widespread use of antimicrobial agents mainly in human and veterinary medicine, as well as in aquaculture, the cultivation of plants and so on. All of this has led to the ubiquity of antimicrobial substances in the water, where depending on the type of water concentration present antimicrobial substances range from higher  $\mu\text{g L}^{-1}$  for hospital waste water, lower  $\mu\text{g L}^{-1}$  for waste water from households, higher and lower  $\mu\text{g L}^{-1}$  for surface, ground and sea water in ports, but still very rare in the drinking water. The present antimicrobial substances from the waste water can be eliminated through the primary elimination or elimination of organic molecules through biological processes (biodegradation with bacteria or fungi) or nonbiological processes such as sorption, hydrolysis, photolysis, oxidation or reduction. If the antimicrobial substances are not eliminated from the waste water they can enter the environment and adversely affect the aquatic and terrestrial organisms, and if they contaminate sources of drinking water they can affect humans. In order to determine the current state of water in the Republic of Croatia the monitoring of surface waters during 2013 and 2014 years was made. The results showed that the studied antimicrobial agents (sulfonamides, chloramphenicol, fumagillin, torasemid and macrolide antibiotics are present in some surface waters at concentrations from  $0.02 \mu\text{g L}^{-1}$  -  $5.3 \mu\text{g L}^{-1}$ .

## **FITOPLANKTONSKE ZAJEDNICE I FIZIKALNO-KEMIJSKI POKAZATELJI KVALITETE VODA U MELIORACIJSKIM KANALIMA KOPAČKOG RITA**

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Riječna poplavna područja su prepoznatljiva kao najproduktivniji i najraznolikiji ekološki sustavi čija se dinamičnost očituje kroz prostorno-vremensku raznolikost. Istodobno, ona su i vrlo atraktivna područja za ljudske djelatnosti, što predstavlja potencijalnu prijetnju biološkoj raznolikosti i može dovesti do njihovih promjena. U ovom radu će biti predstavljeni rezultati istraživanja fitoplanktonskih zajednica i fizikalno-kemijskih pokazatelja kvalitete vode provedenih od travnja do lipnja 2016. godine na sedam mjernih postaja u melioracijskim kanalima na području Parka prirode Kopački rit. Ove postaje predstavljaju točke ulaska voda, opterećenih otpadnim vodama okolnih naselja i farmi, na zaštićeno područje Kopačkog rita, u koje se također skupljaju i vode s okolnih poljoprivrednih i šumskih površina. Tijekom istraživanog razdoblja fizikalno-kemijski čimbenici kretali su se u sljedećim granicama: temperatura vode od 11,3 do 24,4 °C, dubina vode od 1 do 2,4 m, prozirnost vode od 0,4 do 2,1 m, električna provodljivost vode od 327 do 921 μS/cm, koncentracija kisika od 4,6 do 12,5 mg/L, koncentracije nitrita od 20 do 180 μg/L, nitrata od 40 do 80 μg/L, ukupnog dušika od 210 do 610 μg/L i ortofosfata od 160 do 300 μg/L. Na svim postajama je ukupno utvrđeno 168 fitoplanktonskih svojti. Najzastupljenije su bile vrste rodova *Cryptomonas*, *Chrysococcus*, *Synura*, *Dinobryon*, *Cyclotella*, *Monoraphidium*, *Raphidocelis*, *Koliella* te različiti predstavnici te nanofitoplanktona. Također su utvrđene vrste koje su indikatori lošeg ekološkog stanja kao što su *Nitzschia palea* i predstavnici skupine cijanobakterija (*Anabaena*, *Dolichospermum*, *Microcystis*) što ukazuje na opterećenost voda melioracijskih kanala hranjivim tvarima.

## **PHYTOPLANKTON AND PHYSICO-CHEMICAL INDICATORS OF WATER QUALITY IN THE WATER OF DRAINAGE CHANNELS IN KOPAČKI RIT**

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The river-floodplains are recognized as the most productive and diverse ecosystems whose dynamics is reflected through the space-time diversity. At the same time, they are very attractive

areas for human activities and exposed to biodiversity threats which can lead to their changes. This paper will present the results of research on phytoplankton development and physical and chemical water parameters conducted from April to June 2016 at seven monitoring stations located in drainage channels in the area of the Kopački Rit Nature Park. These sites are the water entry points to the protected area of Kopački Rit, which are loaded with wastewaters from surrounding villages and farms, while also collecting runoff from the adjacent agricultural and forest areas. During the study period, physical and chemical parameters were in the following ranges: water temperature from 11.3 to 24.4 °C, water depth from 1 to 2.4 m, water transparency from 0.4 to 2.1 m, conductivity from 327 to 921 µS/cm, oxygen concentration from 4.6 to 12.5 mg/L, nitrite concentration from 20 to 180 mg/L, nitrate concentration from 40 to 80 mg/L, total nitrogen concentration from 210 to 610 mg/L and orthophosphate from 160 to 300 mg/L. A total of 168 phytoplankton species were found at all sites. Species from the genera *Cryptomonas*, *Chrysococcus*, *Synura*, *Dinobryon*, *Cyclotella*, *Monoraphidium*, *Raphidocelis*, *Koliella* and different nanophytoplanktonic taxa were the most represented. Some indicator species of poor environmental conditions found in the samples, such as *Nitzschia palea* and representatives of cyanobacteria (*Anabaena*, *Dolichospermum*, *Microcystis*) indicate a high nutrient load in the channels.



## **UNOS VODE ODRASLE POPULACIJE RH**

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Voda je ključna sastavnica ljudskog organizma i esencijalna sastavnica svakodnevne prehrane. Istovremeno procjena unosa vode vrlo slabo je zastupljena u prehranbenim istraživanjima pa nedostaje podataka potrebitih za razvoj kvalitetnijih smjernica za preporuke njezina unosa s ciljem očuvanja zdravlja i prevencije bolesti. Stoga je cilj ovoga rada bio procjena unosa vode u odrasloj populaciji Republike Hrvatske. Rezultati pokazuju prosječan unos vode od 0,99 L/dan za cijelu ispitivanu populaciju pri čemu je unos u žena 0,97 L/dan a u muškaraca 1,00 L/dan što zadovoljava prosječno 48,5 % adekvatnog unosa u žena odnosno 50 % u muškaraca. Osim za ukupnu populaciju rezultati su obrađeni i prema regijama te prema podskupinama formiranim obzirom na mjesto prebivališta, spol, status uhranjenosti i dob. Prema regijama rezultati pokazuju da je prosječan unos vode u Zagrebu i okolici 1,04 L/dan, u Sjevernoj Hrvatskoj 0,86 L/dan, u Slavoniji 0,95 L/dan, u Dalmaciji 0,90 L/dan, u Istri, Primorju i Gorskom kotaru 1,45 L/dan i u Lici i Banovini 0,74 L/dan. Konzumira se uglavnom negazirana voda (0,94 L/dan) pri čemu dominira ona iz sustava javne vodoopskrbe (0,85 L/dan), dok su pakirana voda (0,05 L/dan) i voda iz privatnih zdenaca (0,05 L/dan) slabo zastupljene.

## **WATER INTAKE IN CROATIAN ADULTS**

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Water is one of the main building blocks of human body and essential constituent of daily diet. In despite of that fact, water intake is rarely a part of dietary surveys and as a result scientific evidences needed for meaningful public health strategies or reference intake values are scarce. Therefore, the aim of this study was to estimate daily water intake in Croatia. Results indicate average intake of 0.99 L/day for the whole studied population, 0.97 L/day in a female subgroup and 1.00 L/day in a male group. These intakes contribute with 48.5% and 50% to European adequate intakes for total water in female and male subgroups respectively. Results in different regions indicate average intake of 1.04, 0.86, 0.95, 0.90, 1.45 and 0.74 L/day in Zagreb region, northern Croatia, Slavonija region, Dalmacija region, Istra, Primorje and Gorski kotar region and Lika and Banovina region, respectively. Intake is mostly a result of consumption of non-carbonated water (0.94 L/day) with domination of tap water (0.85 L/day) while bottled water (0.05 L/day) and water from private wells (0.05 L/day) are poorly represented.

## PRAĆENJE STANJA KOEFICIJENTA ADSORPCIJE NATRIJA (SAR) PODZEMNIH VODA ISTOČNE HRVATSKE

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Natrij je kation koji ima jedinstven utjecaj na tlo. Ovisno o svojoj koncentraciji, može uzrokovati štetne fizikalno-kemijske promjene u strukturi tla, što rezultira raspršenjem čestica i smanjenjem brzine infiltracije vode i zraka u tlo. Zajedno s kalcijem definira alkalitet i salinitet tla što znatno utječe na rast biljke i njenu mogućnost upijanja vlage iz tla. Višak natrija u odnosu na kalcij i magnezij u tlu dovodi do oštećenja u strukturi glinastih tala te dolazi do bubrenja čestica čime se mijenja hidraulički kapacitet tla. Ovakva tla nalaze se u disperznom stanju, ljepljiva su, stvaraju koru i zadržavaju vodu, a sušenjem postaju vrlo teška. U ovom radu prikazani su rezultati ispitivanja koeficijenta SAR (engl. Sodium adsorption ratio), tj. omjera koncentracije natrija (štetni element) i koncentracije kalcija i magnezija (korisni elementi). Iako se prilikom izračuna ovog koeficijenta ne uzimaju u obzir promjene koncentracija kalcija u vodi uslijed promjena topljivosti zbog taloženja ili otapanja tijekom navodnjavanja, SAR se smatra prihvatljiv za ocjenu većine voda koje se koriste za navodnjavanje. Praćenje stanja je obavljeno tijekom pet godina na 40 lokacija istočne Hrvatske, na kojima je prikupljena neprerađena podzemna voda.

## MONITORING OF SODIUM ADSORPTION RATIO (SAR) IN GROUNDWATER OF EASTERN CROATIA

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Sodium is cation with unique effect on soil. Depending on its concentration it can cause detrimental physicochemical effects on soil structure, which result in particle dispersing and reduction of water and air infiltration in soil. Combined with calcium it effects alkalinity and salinity of soil effecting plant growth and its water absorption. Excess of sodium in regard to calcium and magnesium in soil, leads to breakdown of clay soils structure and particle swelling which changes hydraulic capacity of soil. These soils are dispersed, sticky, create a crust and retain water, and upon drying become very hard. In this paper results of monitoring of SAR (Sodium adsorption ratio), i.e. ratio of sodium

**Knjiga sažetaka / Book of abstracts**

**Usmena priopćenja / Oral lectures**

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(detrimental element) to the combination of calcium and magnesium (beneficial elements) are presented. Although the calculation of this ratio does not take into account changes in the concentration of calcium in the water due to changes in solubility due to precipitation or dissolution during irrigation, SAR is considered acceptable indicator for the assessment of most of the water used for irrigation. Monitoring was carried out over the period of five years at 40 different locations in eastern Croatia, and collected groundwater was not processed.

## **ODREĐIVANJE POLIBROMIRANIH DIFENIL-ETERA (PBDE) U VODI METODOM PLINSKE KROMATOGRAFIJE S MASENOM SPEKTROMETRIJOM (GC-MS/MS)**

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Polibromirani difenil-eteri (PBDE) koriste se kao dodaci sredstvima za sprječavanje plamena. Stoga ih nalazimo u plastičnim dijelovima automobila, televizora, računala, različitih električnih naprava, potom tepiha, namještaja, izolacijskih cijevi, električnih vodova i sl. Kako se PBDE-aditivi kemijski ne vežu za plastiku tako PBDE-i konstantno migriraju u okoliš. Dokazani su i u prašini obrisanog s monitora računala. Postojani su, imaju bioakumulacijska svojstva te potencijal prijenosa na velike udaljenosti u okolišu. Poznati su toksični učinci na biljke i životinje uključujući i sisavce. Ovim radom opisana je metoda određivanja PBDE-a u vodi za ljudsku potrošnju, podzemnim, površinskim i otpadnim vodama. Uzorci vode za ispitivanje pripremaju se ekstrakcijom na čvrstoj fazi (SPE), a identifikacija i kvantifikacija se provodi tehnikom plinske kromatografije s masenom spektrometrijom (GC-MS/MS). Prema trenutno važećoj regulativi Republike Hrvatske u površinskim i otpadnim vodama ispituje se 6 kongenera: BDE-28, BDE-47, BDE-99, BDE-100, BDE-153 i BDE-154. Njihova suma se uspoređuje s propisanim standardima kakvoće odnosno graničnim vrijednostima. Validacijom metode je dokazana njena primjenjivost namjenjenoj svrsi te zadovoljenje zahtjeva regulative s obzirom na granice određivanja. Sudjelovanjem u međulaboratorijskim poredbenim ispitivanjima postignuti su zadovoljavajući rezultati pa je metoda akreditirana u skladu s normom HRN EN ISO/IEC 17025:2007.

## **DETERMINATION OF POLYBROMINATED DIPHENYL ETHER (PBDE) IN WATER BY GAS CHROMATOGRAPHY-MASS SPECTROMETRY (GC-MS/MS)**

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Polybrominated diphenyl ethers (PBDEs) are used in additives for preventing the flames. Therefore, they are found in the plastic parts of cars, TVs, computers, various electrical devices, carpets, furniture, insulation pipes, power lines, etc. As the PBDE-additives do not chemically bond to the plastic they constantly migrate into the environment and they are proven in the dust from computer monitors. They are stable, have bioaccumulative properties and potential transmission over long distances in the environment. They have toxic effects on plants and animals. This paper describes the method of determination of PBDEs in different kinds of water. Water samples are prepared by solid phase extraction (SPE), and the identification and quantification is carried out with the technique of gas chromatography mass spectrometry (GC-MS/MS). According to the current

**Knjiga sažetaka / Book of abstracts**

**Usmena priopćenja / Oral lectures**

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regulations of the Republic of Croatia in surface and waste waters six congeners are examined: BDE-28, BDE-47 and BDE-99, BDE-100, BDE-153 and BDE-154. Sum of congeners is compared with the prescribed quality standards or limit values. Validation of method has proven its applicability for intended purpose and meet the requirements of regulations. Satisfactory results were achieved by participating in interlaboratory comparisons and the method is accredited according to HRN EN ISO/IEC 17025: 2007.

## KAKVOĆA MORA ZA KUPANJE NA PODRUČJU OPATIJE OD 2001. DO 2016.

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Kakvoća mora za kupanje jedan je od ključnih elemenata turističke ponude priobalnih destinacija. Tijekom gotovo tri desetljeća provedbe nacionalnog programa monitoringa hrvatske obale Jadrana mijenjala se zakonska legislativa, način statističke obrade podataka i kriteriji ocjenjivanja. Ovaj rad prikazuje rezultate mikrobiološke kakvoće, koji su jednoznačno statistički obrađeni, na način propisan aktualnom Uredbom (NN 73/2008). Time je omogućena slika kakvoće mora za kupanje na području Opatije na dužoj vremenskoj skali. Rad daje prikaz kakvoće mora na plažama Opatijskog područja (18 lokacija) u šesnaestogodišnjem periodu od 2001. do 2016. Najveće mikrobiološko opterećenje evidentirano je na lokacijama Hotela Kristal i kupališta Slatina, a najmanje na kupalištu Puntica. Također, opisan je slučaj pojave onečišćenja mora na području kupališta Slatina u 2013. g., višeinstitucionalni angažman rješavanja ovog problema, provedba dodatnog monitoringa izvan sezone 2013./2014. (ukupno 325 uzoraka), mjere sanacije kao i rezultati provedenih mjera. Rezultati rutinskog monitoringa pokazali su da je ukupna kakvoća mora na području Opatije u promatranom razdoblju bila najlošija u godinama 2001. i 2002., te 2013., kada je zabilježena pojava onečišćenja kupališta Slatina. Nakon puštanja u rad Uređaja za pročišćavanje otpadnih voda u Ičićima (2012.), sanacije oštećenja na tlačnom vodu (2013.), more je na svim opatijskim lokacijama izvrsne kakvoće.

## BATHING SEAWATER QUALITY IN OPATIJA AREA 2001 – 2016

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Seawater bathing quality is one of the key elements of touristic offer of coastal destinations. During the almost three decades of this program conduct on the Croatian Adriatic coast, legal requirements have changed, along with statistical elaboration of the data as well as the evaluation criteria. This study elaborates the results of the microbiological analysis according to the actual Directive (Official Gazette No 73/2008). This has enabled the actual picture of seawater quality in the Opatija area during the longer time scale. This study presents the quality of seawater at the beaches of the Opatija area (18 locations) during the 16-year period (2001-2016). The highest microbiological pollution were detected at the locations of the Hotel Kristal and Slatina beach and the lowest at the

**Knjiga sažetaka / Book of abstracts**

**Usmena priopćenja / Oral lectures**

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location of Puntica beach. Moreover, a case of 2013 seawater pollution in the area of Slatina beach was described: a multi-institutional commitment in resolving of this issue, carrying out the additional off-season monitoring 2013/2014 (325 samples), the measures of remediation as well as the results of the implemented measures. The results of the routine monitoring showed that overall quality of the seawater in Opatija area during the observed period was worst in the years 2001, 2002 and 2013, when the first notice of pollution of the Slatina beach was registered. After first Wastewater treatment device in Ičići was put into operation (2012) and the repair of damaged pressurized pipeline was finished (2013), from then on, the seawater quality has received excellent grade at all Opatija's locations.

## ULOGA MELIORACIJSKOG SUSTAVA U ODVODNJI VODA

### FUNCTION OF LAND IMPROVEMENT SYSTEM IN DRAINAGE WATER

Josip Suver

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Uloga cijelog melioracijskog sustava zajedno sa pratećim objektima (ustave, cijevni propusti, čepovi, crpne stanice, vodne stepenice) je odvodnja oborinskih voda prvenstveno s poljoprivrednih površina, zatim šumskih, komunalnih, naseljenih i prometnih površina. Najbolja iskorištenost melioracijskog sustava odvodnje je da se na vrijeme evakuira višak vode sa ugrožene površine, a samim time se snizi i nivo podzemne vode kako bi podkorijenski sustav biljaka imao optimalnu vlažnost za kvalitetan i visok prinos u proizvodnji. Okrupnjavanje zemljišta – komasacija je osnovni uvjet za projektiranje i izvedbu kvalitetne odvodnje, tj. kanalske i putne mreže zajedno sa svim pratećim hidrotehničkim objektima. Kako bi melioracijski sustav kvalitetno obavljao svoju funkciju vrlo bitno je redovito gospodarsko i tehničko održavanje u svrhu kvalitetne odvodnje i uspostavljanja kontinuiranog vodnog režima. Osim odvodnje hidrotehnički objekti za odvodnju površinskih voda, sve više se koriste za navodnjavanje u sušnim periodima pametnim gospodarenjem preko hidrotehničkih objekata kao što su akumulacije – brane, crpne stanice i sustavi ustava. Napredak u kompletnoj melioracijskoj odvodnji ostvaren je u izgradnji akumulacija i crpnih stanica koje su omogućile kvalitetniju odvodnju i u vrijeme kišnog razdoblja i trajanja obrane od poplava. Izgradnja i redovito gospodarsko i tehničko održavanje kako zaštitnih objekata za obranu od poplava tako i hidrotehničkih objekata za odvodnju i navodnjavanje zemljišta preduvjet je za razvoj poljoprivredne proizvodnje.



## **MODELIRANJE INFORMACIJSKOG SUSTAVA ZA PROČIŠĆAVANJE OTPADNE VODE**

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U radu je prikazan razvoj modela informacijskog sustava za pročišćavanje otpadne vode, tako da je razvijen model, stvarnog, složenog, inženjerskog sustava za pročišćavanje otpadne vode. Razvoj modela informacijskog sustava obuhvaća izradu konceptualnih modela, matematičkog modela i modela sustavske dinamike. Pomoću modela razvijen je adaptivni model sustava pročišćavanja vode. Razvijen računalni model koristi varijable slučajno odabranih vrijednosti prema teoretskoj razdiobi vjerojatnosti. Za validaciju modela, s obzirom na to da su distribucije asimetrične, primijenjen je ne-parametarski test. Metodologija predložena u radu temelji se na simulacijskom modeliranju. Predviđena su mjesta potpunog zastoja sustava koji može izazvati materijalne štete, štete u okolišu te utjecati na zdravlje ljudi. Kontrola rada sustava je pomoću statističke kontrole procesa (SPC). Karakteristika ovog procesa je da nema donje granice kontrole na kontrolnom grafu. U tom slučaju, gornja granica ( $3\sigma$ ) je maksimalno dopuštena koncentracija (MAC), između granica  $2\sigma$  i  $3\sigma$  zona rizika, a zona između  $1\sigma$  i  $2\sigma$  je zona upozorenja.

## **INFORMATION SYSTEM'S MODELLING FOR WASTEWATER TREATMENT**

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This paper presents the development of information system model for wastewater treatment. For this purpose, the models of real, complexity, engineering systems have been created. The development of an information system model includes the development of conceptual models, mathematical model and model of dynamic systems. The model enabled the development of the adaptive water purification system model. Developed computer model uses variables randomly selected values from the theoretical probability distribution of the variables applied. For validation of the model, given that the asymmetric distribution, the applied non-parametric test. The methodology proposed in the work is based on simulations modelling. Additionally, the total adaptive system deadlocks, which may cause material or environmental damage and even affect human health, have been predicted. For work control of system was using Statistical Process Control (SPC). The characteristic of this process is there is no lower control limit on the control chart. In this case, upper control limit ( $3\sigma$ ) is maximum allowable concentration (MAC), between the limit of  $2\sigma$  and  $3\sigma$  is risk zone, and the zone between  $1\sigma$  and  $2\sigma$  is the warning zone.

## DESIGN AND DETERMINATION OF PERMEABILITY CHARACTERISTICS OF POLYMERIC MEMBRANE MODULE FOR DIFFERENT AQUEOUS SOLUTIONS

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The novel trend in the separation processes are guided with designs of integrated membrane system for treatment of water resources. Membrane filtration can be a very efficient and economical way of separating components that are suspended or dissolved in a liquid. The aim of this work was to design a polymeric membrane module and determination of permeability capacity of the studied system. In this investigation, polymeric membrane (PES) was assembled in a module. The designed membrane module was managed through dead end filtration. In this paper the following working parameters were examined: Trans membrane pressure (TMP), the types of the solution, the working temperature and the influence of agitation on the feeding solution to the specific membrane flux and permeability characteristics. The tested PES membranes in this designed system have diameter of 5.0 cm and pore size of 0.04  $\mu\text{m}$ . Before the test, membrane element activation was done, as the membrane elements were submersed in a water produced with reverse osmosis for 24 hours. Initial referent values were obtained using water produced with reverse osmosis, with specific conductivity of 21  $\mu\text{S}$ .

## **CONVERTING WASTE INTO A RESOURCE FOR NITRATE REMOVAL**

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Nitrogen compounds discharged into the environment affects the suitability of river water for human use and causing problems such as the eutrophication of rivers and deterioration of water sources. Furthermore, nitrates can also form nitrosamines and nitrosamides, potentially carcinogenic compounds. Therefore, the removal of nitrogen from wastewater is a major objective for pollution control. Adsorption and ion exchange are reliable methods for removing nitrate from wastewater. Rapid increase in volume and types of agricultural waste materials, has become a burden issue. Agricultural biomass have been investigated as adsorbents for pollutant removal from wastewater. They are widely available and cheap. Many research has been made on agricultural wastes for the removal of nitrate from water. Some of these materials are rice hull, sugarcane bagasse, coconut shells, wheat straw, almond shell, giant reed and many more. Agricultural wastes as adsorbents for nitrate showed low or moderate adsorption capacities, however, chemical and physical modifications can increase their adsorption capacities. Different modification methods have been examined, but amine grafting method showed remarkable results for the adsorption of nitrate from water. This work studied different waste materials and modification methods for nitrate removal from water and wastewater.

## PROJEKT: POVEZIVANJE ZAŠTIĆENIH PODRUČJA NA DUNAVU U KORIDOR STANIŠTA „DANUBEPARKSCONNECTED“

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Fragmentacija staništa predstavlja veliku prijetnju biološkoj raznolikosti u Europi, što je ujedno i jedan od glavnih limitirajućih faktora za usluge ekosustava. Vrijednost područja zaštite često je izolirana unutar intenzivno korištenih kultiviranih krajobrazza, a ekološka komunikacija između prirodnih i polu-prirodnih područja je inhibirana udaljenošću i antropogenim ometanjima. Zaštićena područja čuvaju najvrjednija područja duž Dunava, ali je mala ukupna površina zemljišta proglašena zaštićenom kroz nacionalne legislative. Općenito je veličina zaštićenih područja premala kako bi u njoj mogle opstati samo-održive populacije divljih svojti. Rijeke često imaju važnu ulogu zelenih koridora za divlje svojte. To se posebice odnosi na rijeku Dunav zbog njene iznimne uloge kao poveznice između bio-regija i to više od bilo kojeg drugog europskog koridora. Dok Mreža zaštićenih područja na Dunavu čuva njegova najvrjednija područja, fragmentacija staništa ograničava napore zaštite cjelovitog ekosustava. Zbog svega navedenog, povezivanje zaštićenih područja na Dunavu suprotstavljeno je fragmentaciji kako bi učinilo Dunav ključnim ekološkim koridorom. To je ujedno i glavni cilj projekta „DANUBeparksCONNECTED“, ali i prioritet politika Europske unije. Projekt nudi strategije duž cijelog Dunava i pilot aktivnosti s ciljem obnove i održavanja povezanosti svih stanišnih elemenata:

1. Koridor Divljih otoka štiti riječne otoke, koji predstavljaju neometanu riječnu dinamiku i ključna staništa karakterističnim vrstama.
2. Kartiranje poplavnih šuma i suhih travnjaka duž dolina rijeke Dunav pokazat će njihovu povezanost.
3. Slobodno nebo nad Dunavom osigurava migracijsku rutu ptica duž Dunava slobodnom od stradanja sudarom s dalekovodima ili strujnim udarom.

Ključni korisnici prostora iz područja vodnih putova, šumarstva i energetike podržavaju projekt kao bi se osigurao preko-sektorski pristup u svim radnim paketima.

## PROJECT: BRIDGING THE DANUBE PROTECTED AREAS TOWARDS A DANUBE HABITAT CORRIDOR “DANUBEPARKSCONNECTED”

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In Europe, landscape and habitat fragmentation is a major threat for biodiversity, and one of the main limiting factors for ecosystem services. Areas of conservation value are often isolated within an intensely used cultivated landscape, and ecological communication between natural or semi-

**Knjiga sažetaka / Book of abstracts**

**Usmena priopćenja / Oral lectures**

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natural areas is inhibited by distance and by anthropogenic obstructions. Protected Areas preserve the most valuable sites along the Danube, but the amount of land designated as national conservation areas is small and the size of protected areas is generally too small to cover self-sustaining wildlife populations. Rivers often play important roles as Green Wildlife Corridors. This pertains to the Danube in particular, due to its outstanding role as a link between more bio-regions than any other corridor in Europe. While the Network of Danube Protected Areas preserves the most valuable sites, habitat fragmentation limits efforts to preserve a cohesive ecosystem. Consequently, BRIDGING THE DANUBE PROTECTED AREAS TO COUNTERACT landscape and habitat FRAGMENTATION and TO MAKE THE DANUBE A KEY ECOLOGICAL CORRIDOR is the main objective of DANUBE parks CONNECTED and a priority of EU policies. The project offers Danube-wide strategies and pilot actions aiming to restore and maintain connectivity in all habitat elements:

1. The Danube Wild island corridor program protects the river islands, which represents intact river dynamics and flagship habitats of characteristic species.
2. Mapping of riparian forests and dry grasslands along the Danube river valleys will show their connectivity.
3. Danube free sky ensures electrocution and collision-free bird migration along the Danube flyway.

Key stakeholders from waterway, forestry and energy support the Project, to ensure the cross-sectoral approach in all work packages.

## DETERMINATION OF ADSORPTION CAPACITY FOR ARSENIC REMOVAL IN A LABORATORY SCALE FIXED BED COLUMN

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Two commercially available adsorbents, white tuff from Strmosh region and a material with a commercial name Zeofit obtained from Kriva Palanka region, were investigated as possible raw materials for adsorption of arsenites and arsenates from aqueous solutions. These raw materials were modified through chemical insertion of iron within the basic material structure and ionic substitution of calcium and magnesium ions with sodium ions in order to improve the sorptive and ion-exchange properties of studied raw materials. Investigated materials produced different properties where the white tuff from Strmosh generated appropriate selectivity towards arsenic as well as lower adsorption capacity. On the other hand, the Zeofit material from Kriva Palanka produced high adsorption capacity. The same results were experimentally obtained when using mixed fraction composition of each of the investigated sorbents. In the applied mixed fraction filter bed, the studied materials retain their adsorption capacity properties. Drinking water from the water supply system in Skopje was used for preparation of the studied arsenic ions solutions.

## **CREATININE EXCRETION IN HEALTHY SUBJECTS ON DIFFERENT DIETS**

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There is a growing interest in alternative diets such as vegan or lacto-ovo vegetarian diet. The choice is made mainly for ethical, health reasons or both. Creatinine is a waste product of creatine phosphate metabolism in muscle, and the excretion rate is relatively constant. Forty-nine participants were tested in total: 5 lacto-ovo vegetarians, 14 vegans, and 30 omnivores. To compare the groups, all participants had a similar diet consisting of bread, bran flakes and wheat bran. The creatinine level was measured before the initiation of the diet in the first morning void, and in the sample of 24 hr urine. The results confirmed a slightly higher mean creatinine levels in males ( $1139 \pm 517$  mg/L), compared to females ( $901 \pm 539$  mg/L). An effect of regular consumption of different diets did not show up as statistically significant differences in datasets on either first void or 24 hr samples. The highest median result after 24 h was determined in lacto-ovo vegetarians (2175 mg/L), followed by omnivores (1328 mg/L), while vegans had the lowest median (1235 mg/L). Based on these results, there is no evidence that the vegetarian or vegan lifestyle influences the creatinine excretion rate.

## OBEZBOJENJE SINTETSKOG BOJILA MALAHITNOG ZELENILA POMOĆU MICELIJSKIH PELETA *Trametes versicolor*

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U ovom radu istražena je mogućnost upotrebe micelijskih peleta gljive bijelog truljenja *Trametes versicolor* CCBAS AG 613 s ciljem uklanjanja sintetskog bojila malahitnog zelenila iz vodene otopine. Istraživan je utjecaj početne koncentracije biomase, koncentracije malahitnog zelenila i dodatka glukoze u otopinu bojila na postotak uklanjanja bojila. U gotovo svim provedenim pokusima postotak uklanjanja bojila nakon 24 h iznosio je preko 80 %. Povećanjem početne koncentracije biomase došlo je do povećanja postotka uklanjanja bojila; dok je povećanje koncentracije bojila, neovisno o početnoj koncentraciji biomase, imalo suprotan učinak. Dodatak glukoze u vodenu otopinu bojila rezultirao je manjim postotkom uklanjanja bojila. Nadalje, istražena je mogućnost ponovnog korištenja peleta u drugom ciklusu testa obezbojenja. U ponovljenom testu obezbojenja peleti su zadržali sposobnost obezbojenja vodene otopine malahitnog zelenila, ali u nešto manjem postotku nego prilikom prvog korištenja. Ovi preliminarni rezultati upućuju na mogućnost korištenja micelijskih peleta *T. versicolor* CCBAS AG 613 za biološku obradu otpadnih voda obojenih malahitnim zelenilom.

## DECOLOURISATION OF SYNTHETIC DYE MALACHITE GREEN USING *Trametes versicolor* MYCELIAL PELLETS

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The aim of this study was to investigate the malachite green decolourisation ability of white rot fungus *Trametes versicolor* CCBAS AG 613 mycelial pellets. The effect of initial biomass concentration, malachite green concentration and glucose addition on dye percentage removal was investigated. The dye percentage removal of more than 80% was achieved after 24 h in almost all runs. An increase in the initial biomass concentration positively affected the decolourisation, resulting in higher dye percentage removal. However, the increase in dye concentration had the opposite effect. The addition of glucose to the dye solution resulted in slightly lower dye percentage removal. Furthermore, the longevity of pellets' decolourisation activity was tested in repeated-batch mode. When used in repeated-batch mode, pellets still exhibited the malachite green decolourisation



**Knjiga sažetaka / Book of abstracts**

**Usmena priopćenja / Oral lectures**

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activity but to a slightly lower extent. These preliminary results indicate that *T. versicolor* CCBAS AG 613 mycelial pellets could be effectively used for bioremediation of malachite green coloured wastewaters.

## **PROČIŠĆAVANJE OTPADNIH VODA NAVODNJAVANJEM ZEMLJIŠTA**

Dino Obradović, Marija Šperac

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Pročišćavanje otpadne vode navodnjavanjem zemljišta je kontrolirano nanošenje vode na površinu tla prekrivenu vegetacijom, gdje fizikalni, kemijski i biološki procesi pročišćavaju otpadnu vodu kako ona prolazi kroz tlo. Uloga biljnog pokrivača je smanjenje sadržaja hranjivih tvari u otpadnoj vodi, kontrola erozije i održavanje potrebnog stupnja infiltracije. To je najstariji i najviše upotrebljavan način pročišćavanja, a daje najbolju kvalitetu obrađene otpadne vode. Također, navodnjavanje se smatra najpouzdanijim i najboljim načinom pročišćavanja otpadne vode zemljištem, a jednostavno je za primjenu. Nedostatak ove vrste pročišćavanja vode zemljištem je potreba za velikim površinama zemljišta te nemogućnost upotrebe za vrijeme zime i kišnog doba godine. Ovisno o izvedbi sustava navodnjavanja, dio ili sva pročišćena voda se može koristiti za navodnjavanje vegetacije, za obnavljanje podzemnih voda ili za ponovnu upotrebu. Voda za ponovnu upotrebu može se dobivati crpljenjem iz bunara ili drenažnih cijevi. Obzirom na klimatske promjene sve veća je potreba za navodnjavanjem zemljišta što otvara i veće mogućnosti pročišćavanja otpadne vode procesom navodnjavanja. Navodnjavanje otpadnom vodom je često jedini raspoloživi izvor vode za navodnjavanje. Obično se navodnjava obradivo zemljište na kojemu se uzgajaju usjevi, neke druge povrtno-kulturne ili voćke, čijom prodajom se nadoknađuje dio troškova.

## **WASTEWATER TREATMENT WITH LAND IRRIGATION**

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The slow rate land treatment (irrigation) of wastewater is the controlled application of water on a vegetated land surface, where physical, chemical, and biological processes purify wastewater as it passes through the soil. The role of a vegetated land surface is to reduce the amount of nutrients in the wastewater, to control erosion, and to maintain the necessary infiltration rates. It is the oldest and most widely used method of purification and provides the best quality of treated wastewater. Also, irrigation is considered to be the most reliable and the best land wastewater treatment system, and it is easy to apply. The disadvantage of this type of land wastewater treatment is the need for large land areas and the inability to use those areas during winter and periods of wet weather. Depending on the irrigation system design, some or all of the purified water may be used for irrigation of vegetation, groundwater recharge, or for reuse. Water for reuse can be produced by

**Knjiga sažetaka / Book of abstracts**

**Usmena priopćenja / Oral lectures**

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pumping from wells or underdrains. Due to climate change, the need for land irrigation increases, which creates more opportunities for wastewater treatment using the process of irrigation. Wastewater irrigation is often the only available source of irrigation water. Arable land for growing crops, other vegetables, and fruit trees is usually irrigated and the products are sold to reimburse a part of the costs.

## **NOVI POGLEDI NA POVEZANOST REŽIMA CRPLJENJA I POTROŠNJE VODE ZA PIĆE U NASELJIMA**

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Potrošnja odnosno potreba za vodom jedan je od čimbenika koji definiraju režim crpljenja vode za piće u crpnim stanicama. Zajedno sa vodospremom, navedeno definira tlačne uvjete u vodoopskrbnom sustavu naselja. Modeliranje režima crpljenja i potrošnje vode u vodoopskrbnom sustavu podrazumijeva analizu velikog skupa podataka, čiju funkcionalnu ovisnost ponekad nije lako utvrditi. Početak, odnosno trajanje crpljenja kao i utjecaj maksimalne dnevne potrebe za vodom nisu jednoznačno i linearno povezane ovisnosti. Ovaj rad predstavlja i analizira navedenu problematiku. Pri tome se nastoji izraditi matematički model koji će prikazati povezanost volumena vodospreme sa režimom crpljenja i potrošnje vode u naselju. Svrha analize predstavljene problematike je istražiti kako i na koji način navedeni režimi utječu na volumen vodospreme kao varijable odlučivanja u vodoopskrbnom sustavu.

## **NEW ASPECTS OF THE CONNECTION BETWEEN THE PUMPING AND CONSUMPTION REGIME OF DRINKING WATER IN HUMAN SETTLEMENTS**

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Water consumption or water demand is one of the factors that define the pumping regime of drinking water in pumping stations. Along with a water reservoir, the above - mentioned defines pressure conditions in a water supply system of human settlements. Modeling of the water pumping and consumption regime in a water supply system includes analysis of large data sets, whose functional dependency is not sometimes easy to determine. The start or duration of pumping as well as the impact of the maximum daily water needs are not clearly and linearly connected. This paper presents and analyzes this issue. In doing so, the goal is to develop a mathematical model to show the connection between the water reservoir volume and the regime of water pumping and consumption in human settlements. The purpose of the analysis (of the presented problem) is to explore how and in what manner the above - mentioned regimes affect the volume of a water reservoir as the decision variable in a water supply system.

**ZBRINJAVANJE OTPADNIH VODA NA PODRUČJU  
UTJECAJ KOMUNALNIH OTPADNIH VODA  
NA KAKVOĆU RIJEKE UNE**

**THE IMPACT OF MUNICIPAL WASTEWATER  
ON UNA RIVER QUALITY**

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U ovom radu obrađena je tematika onečišćenja rijeke Une uslijed ispuštanja nepročišćenih komunalnih otpadnih voda. Analizirana je kvaliteta vode u rijeci Uni, na području Općine Bihać, koja je svakodnevno izložena opterećenju komunalnim otpadnim vodama koje se ispuštaju bez procesa pročišćavanja. Uzorkovanja su rađena kroz tri godine, tri puta godišnje na tri lokacije, Lohovo (uzvodno), Hatinac (gradsko naselje) i Pokoj (nizvodno). Ispitivani su slijedeći fizikalno-hemijski pokazatelji; temperatura, pH vrijednost, električna provodljivost, otopljeni kisik, suspendirane tvari, petodnevna biokemijska potrošnja kisika BPK<sub>5</sub>, kemijska potrošnja kisika (KPK), ukupni dušik, ukupni fosfor i mikrobiološki pokazatelji (fekalni koliformi). Nadalje, u ovom istraživanju su razvijeni i testirani modeli za predviđanja fizičko-kemijskih pokazatelja kvaliteta vode rijeke Une. Modeli su dobijeni pomoću GPdotNET programskog alata za modeliranje, koji pri razvoju predikcijskih modela koristi metodu genetskog programiranja. Izvršeno je modeliranje za otopljeni kisik u rijeci Uni, na temelju ulaznih varijabli, pH, provodljivosti i temperature. Rezultati ispitivanja su pokazali da rijeka Una pokazuje dobar kvalitet u skladu okvirnom direktivom o vodama, razlog tome je dobar autopurifikacijski efekat rijeke Une, iako se u rijeku ispuštaju neprečišćene otpadne vode. Evidentirane su primjetne razlike ovisno o lokalitetu ispuštanja otpadnih voda i godišnjem dobu.

## VIŠAK I MANJAK VODE U POLJOPRIVREDI

### EXCESS AND DEFICIT OF WATER IN AGRICULTURE

Jasna Šoštarić<sup>1</sup>, Marko Josipović<sup>2</sup>, Monika Marković<sup>1</sup>, Meho Majdančić<sup>3</sup>

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Optimalni sadržaj vode u tlu za uzgoj kulturnog bilja je pri vrijednosti poljskog vodnog kapaciteta. Voda se tlu može nalaziti u suvišku što se rješava odvodnjom (površinskom, podzemnom ili kombiniranom). U sustavu površinske odvodnje, u potpunosti su izgrađeni sustavi na 43,3 % površina, na 37, 3 % površina treba izgraditi sustave, a na 19,4 % površina su sustavi djelomično izgrađeni. Cijevna drenaža je u potpunosti izvedena tek na 14,8 % površina od ukupno potrebnih, a na 81,9 % površina potrebno je izvesti cijevnu drenažu. Djelomično izvedena cijevna drenaža je na 3,3 % površina. Razlog nedovoljne izgrađenosti cijevne drenaže je u visokoj cijeni izvedbe i neriješenim vlasničkim odnosima. Problem nedostatka vode rješava se navodnjavanjem. Prema planu navodnjavanja iz 2005. godine predviđeno je da se do 2020. godine u Hrvatskoj navodnjava 65 000 ha (6 % ukupno obradivih površina). Do 2016. godine realizirano je 40 % ukupnog plana.

## **REMOVAL OF ZINC AND COPPER FROM WASTEWATER BY POTENTIOSTATIC DEPOSITION**

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Water is a scarce natural resource in many countries around the world. Besides being an economically impeding factor, the lack of clean water may present a serious health and environmental issue. Industry is both, a big water consumer and a big effluent source. Industrial effluents are loaded with pollutants, especially heavy metals, and present critical environmental problem of today. Treating of wastewater with the aim of reducing environment pollution and reclaiming water, is therefore of primary interest. It has been found that 83% of industrial discharges contain zinc or one of its compounds. Copper, nickel, chromium and lead or their compounds were respectively found to be present in the following percentages: 75%, 58%, 54% and 37%. This data underline the importance of removing zinc and copper from wastewaters. In the present work, the possibility of the recovery of copper and zinc from wastewater by potentiostatic deposition was studied. Copper and Zinc were deposited potentiostatically on a graphite electrode with graphite auxiliary electrode and saturated calomel electrode as a reference. Cyclic voltammetry, electrochemical impedance spectroscopy and chronoamperometry were used to characterize the kinetics of nucleation and electroplating of copper and zinc deposits. The study of the effect of the scanning rate on cyclic voltammograms shows that both copper and zinc were deposited under diffusion control in a quasi reversible process. Characterization of the deposits formed was done by scanning electron microscopy (SEM), Fourier transform infrared spectroscopy (FTIR) and X-ray diffraction (XRD). Excellent efficiency of copper and zinc recovery was achieved with deposits easily removable from the cathode by simple scratching due to the rough structure obtained under potentiostatic deposition.

## ARSENIC IN EASTERN CROATIA – PROBLEMS AND SOLUTIONS

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One of the biggest public health problems in the world is the presence of arsenic in drinking water. Groundwater in the eastern Croatia contains elevated concentrations of inorganic arsenic. The biggest well field in that area has an average arsenic concentration of 200 µg/L and it supply the population of around 200,000 people with drinking water. Croatian Regulation has adopted guidelines from European Council Directive for the maximum concentration limit (MCL) of 10 µg/L of As in drinking water. However, it has been estimated that almost 120,000 people drink water from that well field with a concentration of arsenic over 10 µg/L. The aim of this study was to investigate the problem of arsenic in the eastern Croatia and to suggest solutions and methods for its efficient removal.



**Posterska priopćenja / *Poster presentations***



## **EVALUATION OF HEAVY METAL IONS ADSORPTION FROM WASTEWATER USING THE ALTERNATIVE ADSORBENT IN THE CONTINUOUS FIXED-BED COLUMN**

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In order to achieve the adequate level of heavy metal ions removal from wastewater by using alternative adsorbents that, in addition to the high efficiency, have a price that justifies their implementation in industrial systems, the research was conducted in the continuous fixed-bed adsorption column. Based on the results obtained previously within the batch adsorption studies, the dynamic of the adsorption process was investigated using the mass transfer zone concept in the fixed-bed column filled with granular activated carbon prepared from apricot kernels. We have studied the uptake capacity of the Pb<sup>2+</sup> ions. The initial concentration of Pb<sup>2+</sup> was 50 mg/L, while the average flow rate during the experiment was 4 mL/min. 5.32 g of the adsorbent gave a total effective bed depth of 2 cm. The experiment lasted for 700 min and the exhaustion point came after 620 min. The adsorbent retained the exceptionally high efficiency (90%) during the experiment, 220 min from the start. Thomas model was used for further analysis of the experimental data and high correlation coefficient ( $r^2=0.91$ ) has been obtained. We have determined the value of the Thomas rate constant ( $K_{th}= 0.203$  mL/mg/min), as well as uptake capacity of the Pb<sup>2+</sup> ions (16.618 mg/g).

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## ANALYSIS OF BIOLOGICAL PHOSPHORUS REMOVAL PROCESS AT BAYINDIR WWTP, TURKEY

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Biological phosphorus removal (BPR) is a very complex process and many factors effect it. In this study, it is intended to review the biological phosphorus removal process to clarify affecting factors both in design and operation. The study was carried out at the Bayındır Wastewater Treatment Plant (BWTP), which has low removal efficiency of P and N in the range of 40-50 percent. Parameters that affect BPR process such as influent COD/TP and BOD/TP ratio, rbCOD, SRT, pH, anaerobic contact time, DO concentration in anaerobic and aerobic zone, recycle NO<sub>3</sub>-N and O<sub>2</sub> were determined and their effects on process performance were analyzed. The results showed that (i) anaerobic reactor has been acting as anoxic because of high recycled NO<sub>3</sub>-N and thus high dissolved oxygen concentrations, (ii) since the required environmental conditions for PAOs were not provided, the efficient phosphorus removal was not possible. Finally, the recommendations to improve the phosphorus removal performance at BWTP were given.

## **SADRŽAJ NITRATA U POVRŠINSKIM VODAMA SLIVA KARAŠICA-VUČICA**

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Svjetska populacija je u veljači 2017. godine premašila brojku od 7,3 milijardi stanovnika. Toliko povećanje populacije rezultira povećanom potražnjom za hranom i intenzivnom urbanizacijom, što za posljedicu ima smanjenje broja obradivih površina. Kako bi se povećao prinos poljoprivrednih kultura često se koriste gnojiva, osobito dušik koji znatno pridonosi stvaranju uroda visoke kvalitete. Međutim, dušična gnojiva su i značajan izvor onečišćenja tla i voda, a najveće koncentracije nitrata u vodama prisutne su upravo na područjima intenzivne poljoprivredne proizvodnje. U ovom radu prikazani su i analizirani podaci koji se odnose na sadržaj nitrata u površinskim vodama sliva Karašice i Vučice. Nitrati su soli dušične kiseline, a nastaju kao krajnji produkt oksidacije dušikovih spojeva. Povoljni su za rast algi i viših vodenih biljaka, ali vrlo visoke koncentracije (> 90 mg/L) djeluju toksično na vodene organizme. Izvori povećanja nitrata su razni - raspad organske tvari u sedimentu, poljoprivreda, kanalizacijski ispusti. Povećane koncentracije nitrata u vodi za piće mogu uzrokovati razne bolesti (methemoglobinemija i rak), ali i dovesti do negativnih utjecaja na okoliš, kao što je eutrofikacija površinskih voda koja je osobito izražena u nizinskim rijekama Europe. U radu su analizirane koncentracije nitrata u površinskim vodama pritoka rijeke Drave - Karašice i Vučice. Proučavanje se odnosi na period od zadnjih pet godina, a uzorci za analizu su uzimani s nekoliko lokacija (Karašica Crnac-Krčenić, Karašica Črnkovići, Karašica nizvodno od Valpova, Vučica Marijančaci, Vučica Petrijevići).

## **NITRATE CONCENTRATION IN KARAŠICA-VUČICA RIVER SURFACE WATERS**

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In February 2017 world population has exceeded the number of 7.3 billion, what resulted in higher demand for food production and intensification of urbanization. As a result, amount of available cultivated land is decreasing. In order to increase agricultural yield, various types of manure are used, especially nitrogen, which significantly increases yield of high quality agricultural products. However, nitrogen manure is a significant source of soil and water pollution, with highest concentrations of nitrates found in water in areas of intensive agriculture. In this paper, the results of analysis of concentration of nitrates in Karašica-Vučica river surface waters are shown. Nitrates are salts of nitric acid, and a final product of oxidation of nitrogen compounds. They are necessary for

algal growth and development of aquatic plants, though concentrations greater than 90 mg/L are toxic for aquatic organisms. Sources of nitrates are various - decomposition of organic matter in sediment, agriculture, sewage. Increased amount of nitrates in drinking water can cause various illnesses (methemoglobinemia and cancer), and also have a negative impact on environment, such as eutrophication of surface waters, which is especially pronounced in lowland rivers of Europe. This paper studies the concentration of nitrates in surface waters of tributary of the river Drava-Karašica and Vučica. Samples were taken over the period of five years, and cover several locations along the river flow (Karašica Crnac-Krčeničnik, Karašica Črnkovci, Karašica downstream form Valpovo, Vučica Marijančaci, Vučica Petrijevcici).

## CHARACTERIZATION AND SORPTION POTENTIAL FOR PENTACHLOROPHENOL OF ALLUVIAL SEDIMENT OF THE DANUBE RIVER

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The alluvial sediment of the Danube River represents a medium through which the process of bank filtration is carried out and therefore its characteristics are of great importance in assessing the risk for transport of pollutants to drinking water sources. The characterization of the alluvial sediment column layers has shown that the alluvial sediment of the Danube river is a mesoporous sandy material with certain differences in the properties of the individual layers considering clay and organic matter content, hydraulic permeability, specific surface area and pore volume. In order to investigate the sorption potential for pentachlorophenol (PCP) of the studied alluvial deposit, three layers have been selected based primarily on the difference in their hydraulic permeability. The results of static sorption experiments showed a slightly higher affinity for PCP sorption in the layer with the highest clay content, indicating that interactions with the sediment mineral fraction might be of great importance in the overall sorption process. In addition, all layers showed significantly higher sorption capacities at pH 4 in comparison with pH 7.5. This can be attributed to the hydrophobic nature of PCP at pH 4 ( $pK_a$  of PCP is 4.7,  $\log K_{ow} = 5.12$ ), as well as to variations in the surface charge of the geosorbent at different pH conditions.

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## **APPLICATION OF AGRICULTURAL WASTES FOR REMOVAL OF Fe(II) IONS FROM WATER RESOURCES**

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Excess heavy metals into aquatic system occur via a wide range of processes and pathways by natural and anthropogenic sources. The heavy metal pollution is slow and interminable, as these toxic metal ions are non bio-degradable. The hazardous effects of heavy metals on the environment is a matter of serious concern. The intensification of industrial activity and environmental stress greatly contributes to the significant rise of heavy metal pollution in water resources making threats on public health and aquatic life and this becomes the major environmental problem. Therefore, finding the ways to eliminate and reduce heavy metals from water resources is very important. The different types of agricultural waste may have potential as low cost heavy metal biosorbents, as they represent unused resources, widely available and are environmentally friendly. For that purpose, the ability of natural peanut husks and rice husks, as a natural agricultural byproduct, to remove Fe(II) ions from aqueous solutions, was investigated in this study. The biosorbtion equilibrium was analyzed by fitting the experimental data using several adsorption isotherms. The particle size distribution, the chemical composition and SEM of both applied biosorbents, are also represented in this study.



## **SADRŽAJ DUŠIKOVIH SPOJEVA U VODI RIJEKE DREŽANKE CONTENT OF NITROGEN COMPOUNDS IN DREŽANKA RIVER**

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Svrha je ovog istraživanja bila utvrditi sadržaj dušikovih spojeva u vodi rijeke Drežanke u periodu prije obrade poljoprivrednih površina i u periodu vegetacijskih razdoblja biljnih kultura. Istraživanja su provedena na pet lokaliteta duž toka rijeke Drežanke, obuhvaćajući uzorkovanje i određivanje odabranih kemijskih parametara, amonijak, nitriti i nitrati. Definirana ispitivanja su izvršena u dva ciklusa. Prvi ciklus istraživanja vršen je u periodu prije obrade poljoprivrednih površina (februar/veljača), a drugi ciklus ispitivanja vršen je u periodu gnoidbe i zasijavanja biljnih kultura na poljoprivrednim površinama koje gravitiraju prema koritu rijeke Drežanke (mart-april/ožujak-travanj). Primjenjena je metodologija u skladu sa smjernicama EU i važećim Pravilnikom o metodama za ispitivanje površinskih voda. Na svim lokalitetima istraživanja u drugom ciklusu zabilježene su povećane vrijednosti nitrita i nitrata, varirale su u intervalu od 0,008 mg/l do 0,012 mg/l nitriti i od 0,28 mg/l do 0,56 mg/l nitrati. Najviši sadržaj nitrita utvrđen je na lokalitetu četiri 0,012 mg/l, a nitrata na lokalitetu pet 0,56 mg/l. Provedena istraživanja ukazuju da se u periodu zasijavanja i vegetacijskog razdoblja biljnih kultura značajno povećane koncentracije dušikovih spojeva u vodi rijeke Drežanke u odnosu na period prije obrade poljoprivrednih površina.

## UTJECAJ POLJOPRIVREDNE PROIZVODNJE NA KAKVOĆU VODE U RAZLIČITIM AGROEKOLOŠKIM UVJETIMA

### AGRICULTURAL PRODUCTION IMPACT ON WATER QUALITY WITHIN DIFFERENT AGROECOLOGICAL CONDITIONS

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Vodni resursi, nepravilno raspoređeni u prostoru i vremenu, su pod pritiskom raznih prirodnih uvjeta i antropogenih djelovanja. Budući da se voda za potrebe poljoprivrede, ali i drugih djelatnosti (industrije i vodoopskrbe) koristi iz različitih izvora, neizbježan je utjecaj tih djelatnosti na kvalitetu vode zbog interakcije površinskih i podzemnih voda. Poljoprivredne aktivnosti koje su izvori onečišćenje mogu se klasificirati kao izvori koji ispuštaju supstance kao rezultat planske aktivnosti, a to su: primjena navodnjavanja – povratni tok (eng. *return flow*), neprimjerena primjena pesticida i gnojiva i neprikladno skladištenje organskog gnojiva. Ukupno 47 % kopnene površine Republike Hrvatske zauzima poljoprivredno zemljište, a od toga je 72 % stvarno korišteno za neki oblik poljoprivredne proizvodnje. Polazište istraživanja je utvrđivanje utjecaja poljoprivredne proizvodnje, biljne i stočarske, na kakvoću vode u tri različita područja: dolina rijeke Neretve, samoborsko-zaprešićki vodonosnik i Vukovarsko-srijemska županija. Cilj istraživanja je utvrditi postoji li značajan utjecaj položaja točkastih izvora hranjiva (stočarskih farmi) i različitih uzgojnih mjera kod različitih kultura (gnojidba) na kvalitetu vodnih resursa u neposrednoj blizini, a prema podacima s postaja nacionalnog monitoringa kakvoće površinske i podzemne vode.

## **PHYSICO – CHEMICAL PROCEDURES FOR WASTEWATER TREATMENT**

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There are three basic types of processes for purification: biological, chemical and physical. Biological processes include, rotating biological filters, systems with active sludge and anaerobic decomposition. Chemical processes include precipitation of heavy metals precipitation of phosphor, adding acids or bases to control pH and disinfection with chlorine or hypochlorite. Physical processes include systems with sieves and bars, primary and secondary accruing-sedimentation, filtration and centrifugation. Physico-chemical procedures for wastewater treatment can be used on both communal and industrial wastewater. Namely, some physical or chemical procedures are combined with biological treatment that is mainly used for treatment of communal wastewater and wastewater containing biodegradable components. Today's standards for drinking water and wastewater discharges water are becoming tighter. To meet the set criteria, is necessary to introduce new procedures which would have made that wastewater treatment cheaper. Using now existing processes for wastewater treatment and stricter criteria and legal regulations make the entire procedure more expensive.

**PRINCIPAL COMPONENT AND CLUSTER ANALYSIS OF RESIDUAL  
CONCENTRATIONS OF HEAVY METALS CATIONS AND ZINC IN  
SURFACE WATER OF THE DANUBE, DTD AND TISZA**

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Surface water of river basins contain organic load and relatively high concentrations of heavy metal cation of iron, manganese, copper, chromium, nickel, lead, cadmium, mercury and light metal zinc as inorganic load. Increased concentrations of chromium (Cr<sup>6+</sup>), cadmium and lead belong to the toxic metal and to priority hazardous chemical species and with incised concentration could have negatively impact onto aquatic environment. National law and bylaws in the Republic of Serbia define control monitoring with a maximum permissible concentrations of organic and inorganic contaminants. The paper presents a review of ten research years in surface waters for concentration level of metal cations at representative locations on the Danube River, Tisza and canal Danube-Tisa-Danube (DTD). The results of experimental research have been applied for principle component and cluster analysis to indicate the location with the largest negative loads on the environment.

## **APPLICATION OF RAIN GARDENS IN ORDER TO IMPROVE WATER QUALITY IN NOVI SAD**

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Rain gardens are specially constructed, ecological systems, that are designed to absorb, filter and purify stormwater flowing from impermeable surfaces. Rain gardens are not just naturally "decoration", but the expression of attitude and an integrated form considerations of space, resource and element structure of vital importance for the functioning of urban and cultural landscape. Through the physical, biological and chemical processes, rain gardens filter large amounts of pathogens and heavy metals such as copper, lead, zinc and cadmium from stormwater, thereby reducing the pollution of rivers, lakes and the sea, that can seriously affect the environment and human health. As a result of increase of impermeable surfaces, Novi Sad faces with many negative impacts, some of which are reflected in reduced water quality. Implementation of rain gardens in Novi Sad, can improve the quality of the water and also reduce flooding of many recorded parts of the city, during heavy rains, thanks to their ability to absorb large quantities of water. In this paper will be shown the positive aspects of implementation of the rain gardens as natural biofilters, on micro and macro level, with a suggestion of their applications in the city of Novi Sad.

## PHOTOCHEMICAL DEGRADATION OF ALACHLOR IN WATER

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This study investigates the photochemical degradation of alachlor, a representative of a chloroacetanilide herbicide. All experiments were conducted in ultra-pure deionized water (ASTM Type I quality) using direct ultraviolet (UV) photolysis and a UV/H<sub>2</sub>O<sub>2</sub> advanced oxidation process. Direct UV photolysis and UV/H<sub>2</sub>O<sub>2</sub> experiments were conducted in a commercial photochemical reactor with a quartz reaction vessel equipped with a 253.7 nm UV low pressure mercury lamp (Philips TUV 16 W). Experimental results demonstrate that UV photolysis was very effective for alachlor degradation (up to 97% removal using a high UV fluence of 4200 mJ/cm<sup>2</sup>). The UV/H<sub>2</sub>O<sub>2</sub> process promoted alachlor degradation compared to UV photolysis alone, with a high degree of decomposition (97%) achieved at a significantly lower UV fluence of 600 mJ/cm<sup>2</sup> when combined with 1 mg H<sub>2</sub>O<sub>2</sub>/L. Note that applying a UV fluence of 600 mJ/cm<sup>2</sup> by UV photolysis alone gave a negligible 4% of alachlor degradation. The photo degradation of alachlor in both direct UV photolysis and the UV/H<sub>2</sub>O<sub>2</sub> process followed pseudo first-order kinetics. The rate constant was about 6 times higher for the UV/H<sub>2</sub>O<sub>2</sub> process than for UV photolysis, as a consequence of accelerated generation of highly reactive and unselective hydroxyl radicals during the advanced oxidation process.

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## **UTJECAJ FLUORIDA U VODI ZA PIĆE NA ZDRAVLJE**

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Ovisno o koncentraciji u kojoj se nalaze, fluoridi prisutni u vodi za piće mogu imati pozitivan ili negativan učinak na ljudsko zdravlje. Prema preporuci Svjetske zdravstvene organizacije kao i Pravilnika o parametrima sukladnosti i metodama analize vode za ljudsku potrošnju maksimalno dopuštena koncentracija fluorida u vodi za piće iznosi 1,5 mg/L. Koncentracija fluorida u površinskim i podzemnim vodama ovisi o pH vrijednosti vode, dostupnosti i topljivosti minerala bogatih fluoridima s kojima voda dolazi u doticaj, poroznosti stijena, brzini protjecanja vode i temperaturi. Drugi znatni izvori fluorida su industrije fosfatnih gnojiva koje mogu povisiti prirodnu koncentraciju fluorida u vodi, zatim proizvodnja kemikalija kao što su fluorovodična kiselina, kalcijev i natrijev fluorid te sumporni heksafluorid, proizvodnja opeke, keramike i stakla te korištenje pesticida koji sadržavaju fluoride. Kao posljedica konstantnog unosa u organizam vode koja sadrži koncentracije fluorida veće od maksimalno dopuštene dolazi do nastanka fluoroza koje se manifestiraju na različite načine. Procjenjuje se da je oko 200 milijuna ljudi diljem svijeta zahvaćeno nekim od oblika fluoroze. Cilj ovoga rada je detaljno prikazati utjecaj povišenih koncentracija fluorida u vodi za piće na zdravlje ljudi.

## **EFFECT OF FLUORIDE IN DRINKING WATER ON HEALTH**

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Fluoride in drinking water presents beneficial and harmful effect on health. According to World Health Organization and Croatian legislative on water for human consumption maximum permissible concentration of fluoride in drinking water is 1.5 mg/L. The natural concentration of fluoride in water depends on several contributing factors such as pH, total dissolved solids, porosity and acidity of the soil and rock, flow rate of water and temperature. Due to various ecological factors either natural or anthropogenic, the groundwater is getting polluted because of deep percolation from intensively cultivated field, disposal of hazardous wastes, wastes from industries and sewage disposal. Depending upon the amount and period of ingestion, illness of varying degree like dental fluorosis, skeletal fluorosis and non-skeletal fluorosis could occur. It is estimated that around 200 million people may be affected by fluorosis. The aim of this paper is to present influence of high fluoride amount in drinking water on human health.

## SOIL WATER FLOW AND NITRATE TRANSPORT MODELING USING LYSIMETER DATA

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Nitrogen fertilizers are frequently used on agricultural soils in large amounts which cannot be completely absorbed by plants and therefore leaching, which is usually closely linked with the soil water flow, is likely to occur. As computer models are becoming more important in the assessment of groundwater pollution, the objectives of this research were to assess water flow and nitrate transport in gley soils and to validate HYDRUS-1D model based on collected field lysimeter data installed at the Biđ field. The field data was collected at 6 location (12 lysimeters) which included extensive soil physical properties measurement, lysimeter outflow and nitrate concentration, climatic data, cropping rotation and fertilizer application information. The results confirmed good reliability of a model to fit the observed lysimeter water outflow and nitrate dynamics during 2014 – 2016 period. Increased nitrate concentrations were observed mostly during the period without crop or during winter/spring period with a large amount of rainfall. Results indicate that agricultural practices may have a significant role in groundwater nitrate contamination, even in soils with heavier texture. Additionally, tested model can be used as a tool in prevention of groundwater pollution by enabling the optimization of application (amount, timing, type) for different fertilizer.



## **WATER REPELLENCY EFFECT ON SOIL HYDRAULIC PROPERTIES UNDER VARIABLE CLIMATE CONDITIONS**

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Prolonged drought periods with increased risk of forest fires or a redistribution of rainfall may increase soil water repellency (SWR), affecting soil hydrology and solute transport processes in soil. In the Austrian Alps, prolonged dry periods may cause a re-orientation of the organic molecules on solid surfaces and increased SWR. In Mediterranean environments such as the Croatian coast, frequently occurring forest fires may also have an impact on SWR due to heating of organic soil matter. This work is a part of Croatian Austrian bilateral project focused on SWR effect on soil hydraulic properties. The field site is set up in Rosalia forest demonstration center (Austria) with three climate change scenarios: moderate, extreme and natural rainfall (control). In Croatia the test site is located near Šibenik with three treatments in relation to fire occurrence: heavily affected, affected and non-affected (control). On both sites water and ethanol infiltration measurements were performed. First results indicate strongly reduced infiltration of water compared to ethanol at both test sites i.e. high degree of SWR. This could cause a change in soil hydraulic properties of the same soil type. Due to changed SWR, local scale hydrology and consequently transport processes in soil could be affected.

## OCCURENCE OF PHARMACEUTICALS IN SURFACE WATER

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Pharmaceuticals constitute a large group of human and veterinary medicinal organic compounds which have long been used throughout the world. According to their therapeutic activity they are classified in several groups: antibiotics, analgetics/antipyretic, CNS (Central Nervous System) drugs, cardiovascular drugs, endocrinology treatments, diagnostic aid-adsorbable organic halogen compounds. Pharmaceuticals are designed to have a physiological effect on humans and animals in trace concentrations. After their excretion (in un metabolized form or as active metabolites) from humans or animals via urine or faeces, pharmaceuticals end up in soil, surface waters and eventually in ground water, wich can be used as source of drinking water. The possible fates of pharmaceuticals once they get into the aquatic environment are mainly three: (i) ultimately they are mineralized to carbon dioxide and water, (ii) the compound does not degrade readily because it is lipophilic and is partially retained in the sedimentation sludge and (iii) the compound metabolizes to a more hydrophilic molecule, passes through the wastewater treatment plant and ends up in the receiving waters (which are surface waters, mainly rivers). These compounds exhibit the highest persistence in the environment. In recent years and in particular after the use of advanced measurement technologies many pharmaceuticals have been identified and detected at ng/L levels (trace concentrations) worldwide in the aquatic environment and are considered as an emerging environmental problem due to their continuous input and persistence to the aquatic ecosystem, even at low concentrations.

## **WATER QUALITY AT SPECIAL NATURE RESERVES IN VOJVODINA, SERBIA**

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Although protected, special nature reserves (SNRs) are not isolated from anthropogenic influences entering from outside their borders. Especially, endangered is water quality at three SNRs in Vojvodina, ie. SNR Ludaško jezero (Ludas Lake), SNR Craska bara (Imperial Pond) and SNR Obedska bara (Obed pond). The SNR Obedska bara (Obedska Pond) and SNR Ludaško jezero (Ludaš Lake) are under the pressure of agricultural runoff and untreated wastewater resulting in serious eutrophic processes and the SNR Carska bara is potentially influenced from nearby fish farms and agriculture. The monitoring conducted in spring/summer and in autumn period in 2016, at the three mentioned SNRs included water sampling on several locations within each SNR. The analyses included basic water quality parameters, microbiological analyses, as well as water mineralization. Both, water quality and microbiological results have proven highly eutrophic status of the SNR Ludaško jezero and significant difference in salinity between north and south part of the lake. The results on the other two investigated SNRs are a bit better indicating moderate eutrophic conditions. According to the abundance of different groups of microorganisms it can be concluded that the north part of Ludaš lake had greater eutrophication compared to all other sampling sites at SNRs.

## INVESTIGATING ALKYLPHENOL BIOAVAILABILITY IN AGED SEDIMENTS AMENDED WITH CARBON-RICH SORPTION AGENTS

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This study aimed to assess the effect of aging on sediment amended with carbon-rich sorption agents (activated charcoal (AC), biochar (BC) and humus (HM)) on the bioavailability of selected alkylphenols (4-octylphenol and 4-nonylphenol). The sediment was amended with 0.5%, 1%, 5% and 10% AC, BC and HM separately, and left to age for 90 days. After this period, alkylphenol bioavailability was determined, as was the bioavailability in the unamended sediment (zero state). Bioavailability was assessed by desorption experiments with XAD-4 resin, and by modeling the obtained results as follows:  $S_t/S_o = F_{rap} \cdot e^{-k_{rap} \cdot t} + F_{slow} \cdot e^{-k_{slow} \cdot t}$ .  $F_{rap}$  represents the rapidly desorbing fraction which is considered the bioavailable fraction. The initial bioavailable fraction for 4-octylphenol and 4-nonylphenol without amendment was determined as 87.0 and 94.4% respectively. This study showed that sediment amendment and aging with all three agents considerably reduced the bioavailable fraction of both alkylphenols. In aged amended sediment with carbon-rich sorption agents, the bioavailable fraction of the examined alkylphenols decreased significantly, ranging from 35.5% to below the method detection limit for 4-octylphenol and from 38.6 to 0.065% for 4-nonylphenol. Amendment with AC was considerably more effective at reducing bioavailability than the BC and HM amendments, due to the higher sorption capacity of AC. However, it should be noted that satisfactory results were also obtained in the presence of BC and HM. In addition, it has been shown that the aging of sediment has a significant role in reducing the bioavailable fraction of alkylphenols in the sediment.

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## **GERMINATION ENERGY AND SEED GERMINATION OF CULTIVATED PLANTS AS INDICATORS OF WATER CONTAMINATION**

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Contamination of irrigation water is a pronounced problem in agricultural and industrial regions. The use of polluted water for irrigation can cause phytotoxic effects and affect crop production. An important step in mitigating possible negative effects is continuous monitoring of water quality in biotests. The selection of suitable plant species and parameters that reliably indicate at changes in water quality are crucial for the relevance of the tests. The aim of this study was to assess indicators potential of germination energy (GE) and seed germination (G) of sorghum, white mustard and sunflower in detection of metal (Zn, Cd and Cr) presence in water. A filter paper method according to ISTA was used. Metals were applied in series of concentrations including maximum allowable concentrations (MAC's). Applied at MAC rates, Zn significantly reduced GE and G of sorghum and white mustard, while GE and G of sunflower seeds were stimulated at all applied rates. Cr did not affect GE and G of tested species at MAC rates, while Cd significantly inhibited GE and G of white mustard at 1 µg/l (less than MAC in irrigation water). GE and G of sorghum and sunflower were not influenced by Cd presence in water at MAC rates.

**PROGRAM PRAĆENJA STANJA OBORINSKIH I PODZEMNIH VODA  
SANIRANOG I ZATVORENOG ODLAGALIŠTA  
KOMUNALNOG OTPADA**

**MONITORING OF RAINFALL WATER AND GROUNDWATER  
OF CLOSED AND REHABILITATED WASTE LANDFILL**

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Saniranje odlagališta komunalnog otpada podrazumijeva niz postupaka koji se provode u cilju postizanja sigurnosnih uvjeta pri kojima nema opasnosti za život i zdravlje ljudi kao niti opasnosti za okoliš. Općina Darda je, zajedno s Fondom za zaštitu okoliša i energetske učinkovitost, 2008. godine započela sanaciju odlagališta komunalnog otpada "Švajcerova ada", koja je okončana 2009. godine. Sanaciju odlagališta otpada obavila je tvrtka „Baranjska čistoća“ d.o.o. iz Belog Manastira, pri čemu je sanirano odlagalište ograđeno sa svih strana, površina odlagališta je ozelenjena, a oko odlagališta je uređen zeleni pojas. U cilju provedbe postupka procjene utjecaja na okoliš, odnosno zahvata sanacije i zatvaranja odlagališta komunalnog otpada „Švajcerova ada“, tadašnje Ministarstvo zaštite okoliša, prostornog uređenja i graditeljstva 2006. godine imenovalo je zahtjev za Komisiju za ocjenu utjecaja predmetnog zahvata koja je izradila Program praćenja stanja okoliša u cilju praćenja utjecaja saniranog odlagališta na okoliš, odnosno utjecaja na oborinske i podzemne vode. U ovom radu prikazani su rezultati analiza fizikalno-kemijskih i bioloških pokazatelja kakvoće oborinske i podzemne vode saniranog odlagališta komunalnog otpada "Švajcerova ada" koje se provode jednom godišnje uzorkovanjem oborinske vode na ispustu iz obodnog kanala te uzorkovanjem podzemne vode iz dva piezometra bušenim u dolaznom i odlaznom toku podzemnih voda u odnosu na tijelo odlagališta.

## **MONITORING FIZIKALNO-KEMIJSKIH PARAMETARA VODE DONJEG TOKA RIJEKE NERETVE**

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Donji tok rijeke Neretve (delta) jedinstvena je vlažna mediteranska oblast s nekoliko važnih i zaštićenih vlažnih staništa, ornitoloških, ihtioloških i botaničkih rezervata. Ova oblast obuhvaća oko 20.000 hektara. Mjerenjem fizikalnih (salinitet, temperatura, električna vodljivost) i kemijskih (otopljeni kisik i pH) parametara na 20 lokacija utvrđena je kvaliteta vode s posebnom pozornošću na pojavu zaslanjenosti. Višegodišnjim smanjenjem podzemnih priliva svježih voda iz rijeke Trebišnjice kao i nekontrolirano produbljenje korita rijeke Neretve, a s druge strane porast razine mora kao posljedica globalnog zatopljenja dovodi do porasta saliniteta voda neretvanskog sliva. Vodni režim u donjem toku rijeke Neretve vrlo je složen zbog utjecaja mora s nizvodne strane i izgrađenog hidroenergetskog sustava s uzvodne strane. Prodor mora u vodonosnik kao i u površinske tokove doline ovisi o količini dotoka svježe vode sa sliva. U sušnom razdoblju, kada su dotoci sa sliva smanjeni i dužeg trajanja, more se uvlači u korito rijeke u obliku slanog 'klina', a u vodonosniku se izdiže iz dubokih slojeva prema površini terena. Ta pojava prostire se duboko uzvodno u dolinu rijeke. Tijekom jednogodišnjeg monitoringa obavljena su terenska ispitivanja fizičko-kemijskih parametara donjeg toka rijeke Neretve na 20 lokacija značajnih za ispitivanje maritimnog utjecaja na kvalitetu vode. Od fizikalnih parametara mjereni su temperatura, električna vodljivost i salinitet, a od kemijskih: količina otopljenog kisika izraženog u postotcima i mg/L u vodi i pH vrijednost. Vrijednosti navedenih parametara mjereni su na terenu terenskim kombiniranim mjeračem WTW Multi-Parameter Instruments.

## **MONITORING OF PHYSICO-CHEMICAL WATER PARAMETERS OF THE LOWER RIVER NERETVA**

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The lower flow of the river Neretva (delta) is a unique humid Mediterranean area with a number of important and protected wetland habitats, ornithological, ichthyology and botanical reserve. This area covers approximately 20.000 hectares. By measuring the physical (salinity, temperature, electrical conductivity) and chemical (amount of dissolved oxygen in water and pH) parameters at 20 locations, water quality was determined with special attention to the occurrence of salinity. Multi-annual reduction of groundwater inflow of fresh water from the river Trebišnjica and uncontrolled deepening

of the Neretva riverbed, and on the other side rise of sea level due to global warming leads to an increase in the salinity of water Neretva basin. Water regime in the lower course of the Neretva River is very complex because of the downstream side impact and built hydropower system with the upstream side. Sea inflow into the aquifer and the surface flows of the valley depends on the amount of flow of fresh water from the basin. In the dry season, when inflows from the catchment reduced and longer duration, can not be drawn into the bed of the river in the form of salt 'wedge', and in the aquifer rises from deeper layers to the surface. This phenomenon extends deep upstream in the river valley. During the one-year monitoring field tests were conducted on physical-chemical parameters of the lower course of the Neretva river at 20 locations of significant testing maritime impacts on water quality. The physical parameters-temperature, conductivity and salinity; and the chemical parameters-the quantity of dissolved oxygen (expressed as a percentage and  $\text{mg L}^{-1}$ ) in water and the pH value were conducted. The values of the above parameters were measured on the field with combined meter WTW Multi-Parameter Instruments.



## **MODERAN PRISTUP GOSPODARENJA VODOOPSKRBNIM SUSTAVIMA**

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Pravilan i moderan pristup gospodarenja u jednom vodoopskrbnom sustavu podrazumijeva primjenu dijagnostičke, mjerne i upravljačke opreme integrisane u telemetrijski sistem kontinuiranog nadzora u dispečerskom centru. Zahtjevi modernog gospodarenja vodoopskrbnim sustavom, podrazumijevaju ispunjavanje niza uvjeta:

- kontinuirana isporuka dovoljnih količina vode propisanog kvaliteta,
- rad ukupnog vodoopskrbnog sustava i njegovih pojedinih dijelova, ostvariti uz max. sigurnost i održavanje najveće čistoće,
- nadležni organi zaduženi za kontrolu rada vodoopskrbnog sustava treba stalno da vrše nadzor nad radom istog, poznavajući ukupan sustav i njegove karakteristike,
- gospodarenje sustavom treba vršiti na principima i modelima iz projektnog rješenja sustava, što je i poenta u datom radu, uz model optimalnog održavanja ispunjavajući uslove samoodrživog razvoja vodoopskrbnog sustava,
- kvarovi i zastoji na vodoopskrbnom sustavu moraju se kontinuirano pratiti i otklanjati. Prikupljeni podaci tokom životnog vijeka sustava moraju biti integrisani u jedinstvenu bazu podataka. Interakcija vještačke inteligencije na jedinstvenu bazu podataka treba da stvara uvjete za kontinuirano optimiranje sustava - "sustav koji uči".
- zaposleni u vodoopskrbnom sustavu treba da budu u dovoljnom broju i odgovarajuće kvalifikacije uz kontinuirano praćenje novih tehnoloških dostignuća.
- korisnici sustava treba da su upoznati sa značajem i važnošću kvalitetne vodoopskrbe, zaštititi izvorišta i drugim ekološkim značajkama.

## **MODERN APPROACH TO MANAGEMENT OF WATER SUPPLY SYSTEMS**

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The proper and modern approach to management in a water supply system includes the application of diagnostic, measurement and control equipment integrated in the telemetry system of continuous control in the control center. The requirements of modern management of water supply system, means fulfilling a series of conditions:

- Continuous supply of sufficient quantities of water required quality,
- work of the whole water supply system and its individual parts, realized with max. safety and maintenance of the highest purity,

- the competent authorities responsible for the control of the water supply system should constantly supervise the work of the system, given the overall system and its features,
- management system should be made on the principles and models of the project design of the system, what is the point in a given work, with the model of optimal maintenance of fulfilling the requirements of self-sustainable development of water supply system,
- failures and standstills in the supply system must be continuously monitored and rectified. Data collected during the exploitation of the system must be integrated into a single database. The interaction of artificial intelligence on a single database should create conditions for the continuous optimization of the system - "system that teaches".
- employees of the water supply system should be in sufficient numbers and with appropriate qualifications continuous monitoring of new technologies.
- system users should be aware of the significance and importance of the quality of water supply, protection of water sources and other environmental features.

## **PLANIRANJE KANALIZACIJSKIH SUSTAVA**

### **PLANNING OF SEWER SYSTEM**

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Planiranje kanalizacijskih sustava (mreža i sistema za pročišćavanje) najviše je vezano za izradu prostornih planova i nižih razina urbanističkog planiranja. Zbog većeg broja čimbenika, planiranje kanalizacijskih sustava podrazumijeva izradu situacija ili idejnih rješenja, na bazi kojih se, shodno važećim propisima, radi tenderska dokumentacija i uvjetuje propisivanje tendera. Iza toga slijedi ili izrada glavnog projekta ili inženjerski angažman. Za isto urbano područje izgradnja kanalizacijskog sustava je i do 2,5 puta skuplja od izgradnje vodovodnog sustava jer čimbenici prostora mogu uzrokovati značajan zastoј u realizaciji izgradnje sustava kanalizacije. Bitni čimbenici planiranja kanalizacijskog sustava su sanitarno-higijenski uvjeti, vodoprivredni, urbani i regionalni čimbenici, posebno sagledani s aspekta zaštite okoliša pri čemu je najvažnije definiranje načina financiranja i rokovi izvršenja planiranih aktivnosti.

## KAKVOĆA VODA I NJENA DOSTUPNOST U DELTI RIJEKE NERETVE

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Sliv rijeke Neretve s pritokama Trebišnjice i Trebižata teritorijalno pripadaju dvjema državama, Bosni i Hercegovini i Republici Hrvatskoj. Neretva do mjesta Počitelj, smještenog u Bosni i Hercegovini, u svojim prirodnim uvjetima ima bujično-erozijske karakteristike, dok nizvodno od Čapljine prelazi u deltno područje s ravničarskim meandrirajućim tokom. Izuzimajući proširenja kod Jablanice i Mostarskog polja, Neretva ima usku kanjonsku dolinu koja je bila pogodna za stvaranje umjetnih akumulacija i hidrocentrala u dijelu svog srednjeg toka. Za gornji dio sliva Neretve karakteristično je intenzivno površinsko dotjecanje, dok je za središnji dio karakteristično podzemno dotjecanje vode. Zbog velikog hidroenergetskog potencija, u slivu rijeke Neretve tijekom posljednjih desetljeća izgrađeno je jedanaest hidroelektrana koje su, uz nekontrolirano zahvaćanje vode u svrhu navodnjavanja poljoprivrednih površina, značajno utjecale na hidrodinamiku, a novija istraživanja crpilišta vode za piće smještenih u neposrednoj blizini korita rijeke Neretve na području Gabela polje u Bosni i Hercegovini ukazuju na učestaloj pojavi zaslanjenja podzemnih voda. U ovom radu prikazan je utjecaj hidrotehničkih zahvata na kakvoću i količinu vode rijeke Neretve te posljedice nastale uslijed desetljeća nepravilnog gospodarenja ovim vodnim resursom koje se, između ostalog, očituju u vidu uslojenog tipa tečenja slatke vode i pojave morskog klina koji tijekom ljetnih mjeseci doseže i do granice Bosne i Hercegovine i Republike Hrvatske.

## QUALITY AND QUANTITY OF WATER IN THE AREA OF RIVER NERETVA DELTA

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Neretva river basin, with tributaries Trebišnjica and Trebižat, territorially belong to two countries, Bosnia and Herzegovina and Croatia. Up to the place of Počitelj (Bosnia and Herzegovina) Neretva basin is characterized by torrential-erosion features, while downstream from town of Čapljina takes the form of the deltaic area with plain meandering stream. Excluding enlargement near Jablanica and Mostar field, Neretva has a narrow canyon valley suitable for the building of artificial reservoirs and hydropower plants. The upper part of the Neretva river basin is characterized by an intense flow

**Knjiga sažetaka / Book of abstracts**

**Posterska priopćenja / Poster presentations**

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of the surface water, while the central part of river basin is characterized by the flow of groundwaters. Due to the large hydropower potential, over the last decades a significant number of various hydrotechnical activities were performed on the Neretva river basin. Eleven hydropower plants were built, which, along with uncontrolled water catchments for irrigation of agricultural land, made a significant impact on hydrodynamics and water fluctuation. The analyses of groundwaters taken from water-wells placed near the Neretva riverbed in the area Gabela field in Bosnia and Herzegovina indicate frequent occurrence of elevated water salinity. This paper presents the effect of hydrotechnical activities on the water quality and quantity in the area of river Neretva Delta. The consequences of improper water management, such as layered type of river water flow and appearance of saltwater intrusion during the summer months that can reach the border of Bosnia and Herzegovina and the Republic of Croatia, are also presented.

## **THE IMPACT OF THE ANTHROPOGENIC FACTOR ON THE MICROBIOLOGICAL POLLUTION ON THE TRESKA RIVER**

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The aim of this paper is to analyze the microbiological and chemical quality of the water from the Treska river. Water's chemical and microbiological characteristics were analyzed. Also for better understanding of the results, some physical analyses of the water were made. From the microbiology parameters: ammonia nitrificators, yeast and fungi were analyzed. The analyses are made from the sample's obtained from three different points: the springs of the river `Treska`, from the flow in Kicevo and from the flow in Makedonski Brod. From the analyzed sample's an increase in the microorganism's populations is evident, especially starting from June until September. The microbiological analyses made from the measurements points on the river Treska, shows that the human factor has a great impact on the water pollution of the river Treska.

## **VODA I ORALNO ZDRAVLJE**

Davor Jurlina, Matej Karl, Stjepanka Lešić, Marko Matijević, Martina Vrdoljak

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Kako bi ljudski organizam optimalno funkcionirao, potreban mu je svakodnevni unos čiste vode. Međutim, u današnje se vrijeme na tržištu mogu pronaći mnoge inačice vode kod kojih, uz izostanak određenih dobrobiti, pronalazimo i štetne učinke na oralno zdravlje. Čista voda označava zdravstveno ispravnu vodu bez štetnih primjesa. Fluoridi su jedina poželjna primjesa u „čistoj“ vodi sa gledišta dentalne medicine i prevencije karijesa. Znanstveno je dokazan njihov utjecaj na smanjenje pojavnosti karijesa i pojačavanje kvalitete zubnih tkiva. Većina voda u bocama, dostupnim za kupnju, ne sadrže značajne količine fluorida te samim tim, ne doprinose smanjenju pojavnosti karijesa. Mineralne vode u svom sastavu, osim većih koncentracija određenih minerala u odnosu na čistu vodu, imaju i različit pH koji iznosi oko 5,2, a vode sa okusom još niže vrijednosti, s pH oko 3,3. Konzumacijom pića nižeg pH pojačava se trošenje cakline te posljedično, preosjetljivost zuba i zubnih vratova, kao i pojavnost karijesa na bočnim ploham zuba. Brojne studije su također pokazale da je visoki udio fruktoznih sirupa, askorbinske kiseline i umjetnih boja za hranu koje se nalaze u aromatiziranim vodama povezan s erozijom zuba, kao i povećanom pojavnosti karijesa, gingivitisa i parodontitisa.

## **WATER AND ORAL HEALTH**

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For the human body to function optimally, a daily intake of clean water is required. However, at nowadays market, one can find many versions of water with, alongside the absence of certain benefits, detrimental effects on oral health. Clean water means healthy, safe water without harmful substances. Fluoride is the only desirable additive in the “clean” water, from the standpoint of dental medicine. It’s impact on reducing the occurrence of caries has been scientifically proven. Bottled water, available for purchase, usually does not contain a significant amount of fluoride, and therefore, does not contribute to reducing the occurrence of caries. Mineral water, in addition to higher concentrations of certain minerals in relation to pure water, also has a different pH of approx. 5.2, and flavored water has an even lower value, its pH being approx. 3.3. The consummation of beverages with lower pH enhances the wear of the enamel and causes teeth sensitivity, as well as the occurrence of approximal caries. Numerous studies have also shown that a high percentage of fructose syrup, ascorbic acid, and food colorings contained in the flavored water are associated with teeth erosion, as well as with the increased occurrence of caries, gingivitis and periodontitis.

## PROCJENA TOKSIČNOSTI NA DAFINIJE (*Daphnia magna*) OTPADNE KOLEKTORSKE VODE I OTPADNE VODE INDUSTRIJE DETERGENATA

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Procjena toksičnosti otpadne vode različitim ekotoksikološkim testovima važan je čimbenik u praćenju kakvoće otpadne vode te pruža informaciju o negativnim učincima onečišćujućih tvari na organizme u prirodnim prijemnicima u koje se otpadne vode ispuštaju. *Daphnia magna* ili vodenbuha standardni je testni organizam koji se koristi za praćenje utjecaja različitih onečišćujućih tvari na vodene ekosustave. Ovo istraživanje uključilo je procjenu toksičnosti na dafnije kolektorske vode grada Osijeka te otpadne vode jedine kemijske industrije priključene na sustav javne odvodnje grada Osijeka (industrije detergenata). Uzorci kolektorske vode prikupljeni su na mjestu ispuštanja kolektorske otpadne vode u rijeku Dravu (kod Nemetina), dok su industrijski uzorci prikupljeni na posljednjem kontrolnom oknu interne kanalizacijske mreže tvornice detergenata. Na svim prikupljenim uzorcima proveden je test toksičnosti na dafnije te standardne fizikalno-kemijske metode: pH, KPK, BPK<sub>5</sub>, ukupni N, ukupni P, TOC i suspendirana tvar. Dobiveni rezultati ukazuju kako kolektorska voda na mjestu izljeva u rijeku Dravu ne pokazuje toksičnost na vrstu *Daphnia magna*, odnosno najniže razrijeđenje koja ne uzrokuju oštećenje je bilo manje od 2 ( $LID_D < 2$ ), dok otpadna voda industrije detergenata pokazuje izrazitu toksičnost.

## EVALUATION OF COLLECTOR WASTEWATER AND DETERGENT INDUSTRY WASTEWATER TOXICITY ON *Daphnia magna*

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Evaluation of wastewater toxicity using different ecotoxicological test methods is an important parameter of wastewater quality monitoring. Furthermore, it provides information on detrimental effects of pollutants on aquatic organisms in natural recipients of wastewaters. The water flea *Daphnia magna* is a standard test organism used for regulatory toxicity testing of different pollutants, i.e. their monitoring in the aquatic ecosystems. The aim of this study was to evaluate the toxicity of collector wastewater of Osijek city, as well as the wastewater of the only chemical industry connected to the city's sewer network (detergent industry) to *Daphnia magna*. The collector wastewater samples were collected at the main wastewater discharge location to river Drava (Nemetin), while the industrial samples were collected at the last control shaft of the internal



**Knjiga sažetaka / Book of abstracts**

**Posterska priopćenja / Poster presentations**

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sewer network of detergents production plant. The toxicity test to *Daphnia magna*, as well as standard physical-chemical analyses, namely pH, COD, BOD5, total N, total P, TOC and suspended solids, were performed in all samples. The results indicate that collector wastewater at the discharge location to river Drava did not show the toxicity to *Daphnia magna*, i.e. the lowest-observed-dilution that does not induce damage was lower than 2 . However, the detergent industry wastewater showed pronounced toxicity.

## UČINKOVITO UKLANJANJE FOSFATA I KONGO CRVENOG SINTETSKOG BOJILA IZ OTPADNIH VODA

### EFFICIENT PHOSPHATE AND CONGO RED SYNTHETIC DYE REMOVAL FROM WASTEWATER

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Pravilno strukturirani mezoporozni silicijev dioksid dopiran samarijevim oksidom (Sm-MCM-41) se prema istraživanjima pokazao kao obećavajući kandidat za uklanjanje fosfata iz otpadnih voda. Može se sintetizirati laganim sol - gel postupkom u jednom koraku koristeći CTAB (cetiltrimetilamonijev bromid) kao predložak, TEOS (tetraortosilikat) kao izvor silicijevog dioksida i samarijev klorid heksahidrat kao prekursor. Sintetizirani su materijali sa Sm/Si molarnim omjerom od 0.2 do 0.8. Mezoporozni sastojci su korišteni kao novi adsorbens za uklanjanje fosfata iz sintetske vodene otopine. Kapacitet uklanjanja fosfata koristeći Sm-MCM-41 u molarnom omjeru 0.6 je dosegao čak do 20 mg P/g. Sm-MCM-41 materijali, u usporedbi s MCM-41 i Sm<sub>2</sub>O<sub>3</sub> česticama, imaju veliki kapacitet za uklanjanje fosfata. Osim fosfata, u otpadnim se vodama mogu naći i sintetska bojila korištena u industriji, kao što je slučaj s azo bojom kongo crveno (CR). Prema istraživanjima, nanočestice cerijevog oksida pokazale su se kao obećavajući kandidat za uklanjanje ovog bojila iz otpadnih voda. Nanočestice cerijevog oksida sintetizirane su uporabom cetiltrimetilamonijevog bromida (CTAB) i cerijevog klorida heksahidrata CeCl<sub>3</sub> · 6H<sub>2</sub>O pri sobnoj temperaturi. Katalitička aktivnost nanostrukturiranog CeO<sub>2</sub> testirana je prema razgradnji azo-boje Congo Red (CR). Da bi se dobili optimalni uvjeti razgradnje CR boje, aktivnost CeO<sub>2</sub> u više oblika (sferne nanočestice, nanoštapići i njihova smjesa) za uklanjanje CR iz otpadnih voda, testirana je pri različitim koncentracijama CR boje i količinama nanostrukturiranog CeO<sub>2</sub>.

## **POTENTIAL EFFECTS OF SULPHATE PARTICLES AND OZONE ON CALCAREOUS SINTER AT PLITVICA LAKES**

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National Park Plitvice lakes presents one of the most beautiful karst complexes in the world. Its waters are supersaturated with dissolved calcium carbonate (calcite) which is released and deposited in the form of tiny crystals as a result of water splashing at tufa barriers. Sulphates, present in the particulate matter (PM), can be deposited on the surface of the calcite. In the air, sulphate particles are formed by the oxidation of SO<sub>2</sub> in a series of chemical reactions. Fast oxidation of SO<sub>2</sub> in nature can also take place on the surface of calcite in the presence of ozone and is significantly enhanced by high humidity. The resulting sulfates can destroy the surface of calcite and indirectly influence the composition and quality of water. Hourly concentrations of ozone, PM<sub>10</sub> and PM<sub>2.5</sub> at the monitoring station Plitvice Lakes in the period from 2012 till 2014 are presented. Measured concentrations of PM were highest during the winter period, while the highest ozone concentrations were measured during the spring, but were also higher in winter. Following work shall investigate changes of water composition at tufa barriers of Plitvica lakes in regard to the concentration of sulphate particles and ozone.

## ADSORPTION MECHANISMS OF ORGANOPHOSPHORUS PESTICIDES ON MULTIWALLED CARBON NANOTUBES

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This work studies the adsorption of organophosphorus pesticides (OPPs) by multiwalled carbon nanotubes (MWCNTs) from aqueous solution. The adsorption parameters of two OPPs (methylparathion and fenitrothion) were determined for two MWCNTs, functionally modified by acid treatment (FMWCNT) and by amino group (FMWCNT-NH<sub>2</sub>). All adsorption isotherms were performed in conventional batch adsorption experiments, using a background solution of 0.01 M CaCl<sub>2</sub> in doubly distilled water with 100 mg/l NaNO<sub>3</sub> as a biocide. After equilibrating at room temperature by continuous shaking for 3 h, the flasks were allowed to settle for 24 h and a sample of clear supernatant was removed for gas-chromatographic determination of the OPP equilibrium concentration. All adsorption isotherms well fitted with the Freundlich model. The nonlinearity of isotherms ranged from 0.362 to 0.935. Distribution coefficients ( $K_d$ ) were calculated at selected equilibrium concentrations (1%, 5% and 50%  $S_w$ ). The results showed that  $K_d$  values for both adsorbents have higher adsorption affinities for FMWCNT possibly due to their large specific surface area (269 m<sup>2</sup>/g) and specific interactions with the surface area of the adsorbent. In addition, the impact of  $\pi$ - $\pi$  interactions in all adsorption mechanisms were determined using  $K_d/K_{ow}$  values. For both investigated pesticides, higher  $K_d/K_{ow}$  values were obtained for the lowest concentration. These two pesticides belong to the monoaromatic organic compounds with electron withdrawing groups (nitrobenzene) and the high polarisable surface area of the carbon nanotubes has electron donor character, causing the formation of  $\pi$ - $\pi$  electron donor-acceptor interactions. These mechanisms control the adsorption of these compounds on carbon nanotubes.

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## **APPLICATION OF NATURAL COAGULANTS EXTRACTED FROM COMMON BEAN FOR WASTEWATER TREATMENT**

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In this work, the possibility of applying natural coagulant, obtained from beans, to remove colloidal particles from wastewater was considered. Three types of wastewaters were used for the experiments: stillage from bioethanol production, wastewater from sugar production and model water. Natural coagulant is extracted from the crushed beans using 0.5 M NaCl. Jar test was made with different doses of coagulant at different pH values. After precipitation, coagulation activity was determined by measuring turbidity. Results showed that the highest removal efficiency was achieved for the stillage at pH 9 and the applied dose of coagulant 5mL/L. The best coagulation activity for wastewater from sugar production was achieved at pH 8, at dose of 0.4 mL/L, while the coagulation activity for model water was the best at pH 5.5 at applied dose 0.4 mL/L.

## POSSIBILITIES OF AMMONIUM ION REMOVAL FROM GROUNDWATER ON SYNTHETIC ZEOLITE IN CONTINUOUS FIXED BED SYSTEM

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Exploration of the possibility of ammonia removal from the city of Kikinda aquifer using artificial zeolite was conducted. Obtained results show that adsorption process of ammonium - ion kinetically takes place in three stages, namely the first, slow phase that lasted the shortest and then the second stage which was characterized by rapid increase in ammonia concentrations in the effluent and was the longest. The third phase occurred very slowly, with a slight increase in the ammonia concentration in the effluent that clearly asymptotically approached the value of the inlet concentration. The high linear correlation in the Freundlich's model was obtained for all experimental points, and especially for points that belong to the second and third stage of adsorption. Langmuir's model showed a weak linear correlation to the overall number of points, but a high correlation for the second and third stage of adsorption. Freundlich's isotherm shape showed that investigated adsorption process was multilayer, and the Langmuir's isotherms provided the values of monolayer adsorption capacity, which amounted 6.67 mg NH<sub>4</sub><sup>+</sup> -N/g CR. Applied zeolite type can be successfully used for ammonia removal from the groundwater with high efficiency of over 90% for the amount of passed water of 350 BV.

## **OSTATCI FARMACEUTSKIH SPOJEVA U VODENOM OKOLIŠU**

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Ostatci farmaceutskih spojeva su prisutni u vodama, uključujući jezera, rijeke, podzemne vode, pa i pitku vodu. Čak i male koncentracije lijekova mogu imati značajne biološke učinke na organizme kronično izložene njihovom djelovanju. Lijekovi ostvaruju biološki učinak i u niskim dozama te su otporni na inaktivaciju prije postizanja učinka u organizmu. Navedene karakteristike su odgovorne za njihovu bioakumulaciju i toksične učinke u vodenom okolišu. Bolnice otpuštaju ostatke farmaceutskih spojeva, kemijske tvari, patogene i radioizotope u bolničke otpadne vode, što predstavlja kemijsku i biološku opasnost za ljude i okoliš. Velik broj takvih spojeva ne može biti eliminiran tijekom obrade otpadnih voda, niti su biorazgradivi. Zbog toga završavaju u površinskim vodama i utječu na hranidbeni lanac. Iz tog razloga postoji sve veća potreba za poboljšanjem sustava čišćenja. Neke industrijske zemlje imaju svoje metode pročišćavanja otpadnih voda, ali ne pridaju pozornost ograničavanju ostataka farmaceutskih spojeva i patogena u svojim otpadnim vodama. Neki od koraka koji se mogu poduzeti su smanjenje potrošnje lijekova, zamjena postojećih supstanci s onima koje su kompatibilne s okolišem, te prikladno odlaganje neželjenih lijekova.

## **PHARMACEUTICAL RESIDUES IN THE AQUATIC ENVIRONMENT**

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Pharmaceutical residues are present in aquatic environments such as lakes and rivers, groundwater, and even drinking water. Even low concentrations of pharmaceuticals may have significant biological effect in chronically exposed nontarget organisms. What makes pharmaceuticals different is their biological effects at low doses and resistance to inactivation before exerting their effects in organism. Those characteristics are responsible for their bioaccumulation and toxic effects in aquatic environments. Hospitals discharge pharmaceutical residues, chemical substances, pathogens and radioisotopes in hospital wastewater, thus representing a chemical and biological risk for public and environmental health. Many of these compounds are often not eliminated during waste water treatment and also not biodegraded in the environment. In that way they can end up in surface waters and even interfere with the food chain. Therefore, the improvement of cleansing systems is a major need, along with the increase of green pharmacy practices. On the other hand, some industrial countries have their methods of treatment for fluents, but none have a pharmaceutical residue and pathogen limitation before discharge in water. Some of the steps that can be taken are reducing the consumption of drugs, substitution with more ecocompatible compounds, and appropriate disposal of unwanted drugs.

## **PRIPREMA TEHNOLOŠKE VODE ZA INDUSTRIJSKU PROIZVODNJU PIVA**

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Voda je vrlo važna sirovina za proizvodnju piva jer pivo sadrži 85-95 % vode. Prema Pravilniku o temeljnim zahtjevima za pivo i pivu slične proizvode (NN 6/98), tehnološka voda koja se koristi za proizvodnju piva mora u fizikalnom, kemijskom i mikrobiološkom smislu odgovarati kvaliteti vode za piće, čije karakteristike su propisane Pravilnikom o parametrima sukladnosti i metodama analize vode za ljudsku potrošnju (NN 125/13). Kako bi pivovare bile neovisne o gradskim vodovodima često imaju svoje vlastite izvore-bunare. U prirodnim vodama uvijek postoje određene količine raznih otopljenih tvari. Ovisno o otopljenim mineralnim tvarima, vode se dijele na meke, srednje tvrde i tvrde vode. Tehnologija obrade voda u pivarstvu je vrlo važna jer kvaliteta odnosno vrsta piva značajno ovisi o njoj, stoga u većini slučajeva pivovare provode obradu vode u svrhu dobivanja tehnološke vode za proizvodnju piva određenih karakteristika. Kada govorimo o obradi vode u pivovarama s vlastitim izvorima vode koje sadržavaju veće količine željeza, mangana i arsena, tada bi obrada vode svakako uključivala uklanjanje manganovih odnosno feratnih bikarbonata putem pješčanih filtera i aeracije, uklanjanje mikroorganizama doziranjem klora, uklanjanje slobodnog klora i ostalih primjesa adsorpcijom na aktivnom ugljenu te pročišćavanje vode putem membranskih metoda odnosno reverzne osmoze. Navedenom obradom vode se može dobiti voda s optimalnim vrijednostima koja je spremna za proizvodnju piva.

## **WATER PREPARATION FOR INDUSTRIAL BREWING**

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Water quality for beer production is very important, because beer contains 85-95% of water. Water for beer production due to physical, chemical and microbiological characteristics must comply with the Regulations on the basic requirements for beer and beer like products (NN 6/98) and the Regulations on the parameters of assessment and methods of analysis of water for human consumption (NN 125/13). Breweries often use water from their own wells. In natural water certain amount of dissolved matter are present. Depending on dissolved minerals, water can be divided into soft, medium hard and hard water, respectively. Water treatment for beer production is very important because the quality or type of beer depend on it. Water treatment for beer production with elevated concentrations of iron, manganese and arsenic in water, certainly would include removal of manganese and ferric bicarbonate by sand filter and aeration, removal of microorganisms with chlorine, removal of free chlorine and other impurities by adsorption on activated carbon and water treatment with membrane processes such as reverse osmosis. This technologies for water treatment are promising for production of high quality beer products.



## **ZnO NANOSTRUCTURED PHOTOCATALYSTS FOR WATER TREATMENT APPLICATIONS**

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Metal oxide semiconductor materials, designed to be applied in photocatalytic systems for water purification, are required to have large specific surface areas, because chemical reactions induced by suitable irradiation take place by contact between their surface and fluid. Zinc oxide is well known as a material that forms various morphologies at the micro- and nanoscale, which can fulfill this requirement. Like most of the photocatalytic semiconductors, it has a band gap in the ultraviolet region. Photocatalytic degradation of an organic dye, as a model pollutant, was studied in aqueous solutions using nanostructures of zinc oxide synthesized in the form of prism, spiky stick and grass blade. They were grown from a solution and their entire morphology was simply controlled by varying the growth conditions, without using any capping or surfactant agents. Detailed characterization of their structure and porosity on the micro- and nanoscale was performed by scanning electron microscope and X-ray scattering measurements. All nanostructures exhibited notable photocatalytic activities. However, remarkable results were achieved with nanostructures in the form of grass blade, which exhibited enhanced photocatalytic activity, even in sunlight. This was ascribed to their specific morphology characterized with a high degree of mesoporosity.

## ANALIZA POJAVNOSTI KEMIJSKIH ELEMENATA U VODI ZA PIĆE NA PODRUČJU REPUBLIKE HRVATSKE

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Uzorci vode za piće s područja RH uzeti su iz vodoopskrbnih sustava gradova županijskih središta (20) te Grada Zagreba (1). Neki gradovi imaju više vodocrpilišta te su analizirana ukupno 33 uzorka. Cilj rada je određivanje pojavnosti 15 različitih kemijskih elemenata i spojeva. U uzorcima vode za piće određene su koncentracije fluora, selen, bakra, joda, cinka, željeza, klorida, fosfata, mangana, natrija, kalija, magnezija, kalcija, nitrata i sulfata. Analize pokazuju varijabilnost koncentracija elemenata u analiziranim uzorcima vode za piće u rasponu od 29 % do 178 %. Najmanje se uzorci razlikuju po koncentraciji Ca, Mg i F, a najviše po koncentraciji Zn, Na, Fe i Mn. Visoke korelacije u analizi pojavnosti pokazuju Ca, K, Cl i SO<sub>4</sub><sup>2-</sup>. Analiza glavnih komponenti pokazuje da je umjesto analiziranih 15 varijabli (koncentracija elemenata) dovoljno devet da bi se opisala varijabilnost analiziranog seta podataka (kumulativna varijanca iznosi 96,53 %).

## ANALYSIS OF THE INCIDENCE OF CHEMICAL ELEMENTS IN DRINKING WATER IN CROATIA

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Samples of drinking water from the area of the Republic of Croatia were taken from the water supply systems of cities county centers (20) and the City of Zagreb (1). Some cities have more water wells and 33 samples analyzed in total. The aim was to determine the incidence of 15 different chemical elements and compounds. In samples of drinking water the concentrations of fluorine, selenium, copper, iodine, zinc, iron, chloride, phosphate, manganese, sodium, potassium, magnesium, calcium, sulfate and nitrate measured. Analyzes show the variability of concentrations of elements in the analyzed samples of drinking water in the range of 29% to 178%. At least the samples vary in the concentration of Ca, Mg and F, and most of the concentration of Zn, Na, Fe and Mn. High correlations calculated among concentrations of Ca, K, Cl and SO<sub>4</sub><sup>2-</sup>. Principal component analysis shows that nine of the fifteen used variables (concentration of elements) are enough to describe the variability of the analyzed data sets (cumulative variance calculated to be 96.53%).

## **KVALITETA TEHNOLOŠKIH OTPADNIH VODA ANALIZIRANIH U ZZJZ BRODSKO-POSAVSKE ŽUPANIJE U 2016. GODINI**

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Otpadne vode nastaju uporabom vode iz brojnih vodoopskrbnih sustava za određene namjene, pri čemu dolazi do promjena njenog prvotnog sastava odnosno fizikalnih, kemijskih i mikrobioloških značajki. Nakon uporabe, otpadne vode (kućne, tehnološke, oborinske) odlaze ili u sustav javne odvodnje ili direktno u prirodne prijemnike. Cilj rada je prikazati kemijsku kvalitetu tehnoloških otpadnih voda analiziranih u ZZJZ Brodsko-posavske županije u 2016. godini. U uzorcima otpadnih voda analizirani su kemijski parametri sukladno važećim vodopravnim dozvolama, a najčešće su to: biokemijska potrošnja kisika, kemijska potrošnja kisika, pH, ukupna suspendirana tvar, detergentski, ukupni fosfor, ukupni dušik, masti i ulja, taložive tvari i drugo. Uzorci su ocijenjeni prema uvjetima propisanim u vodopravnim dozvolama i Pravilnikom o graničnim vrijednostima emisija otpadnih voda (NN 80/13). U 2016. godini analizirano je i ocijenjeno 114 uzoraka otpadne vode na određene kemijske pokazatelje, od kojih 14,04 % ne zadovoljava uvjete propisane vodopravnom dozvolom. Pravne i fizičke osobe koje pri obavljanju gospodarske ili druge poslovne djelatnosti unose, ispuštaju ili odlažu opasne ili druge onečišćujuće tvari u vode, dužne su te tvari prije ispuštanja u građevine javne odvodnje ili drugi prijemnik, djelomično ili potpuno odstraniti u skladu s izdanom vodopravnom dozvolom za ispuštanje otpadnih voda.

## **QUALITY OF TECHNOLOGICAL WASTE WATERS ANALYZED AT THE INSTITUTE OF PUBLIC HEALTH OF BROD-POSAVINA COUNTY IN 2016**

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Waste waters can originate from different activities as a result of using water from a number of water supply systems for certain purposes, where there is a change of its original composition and physical and microbiological features. After use, waste waters (household waste waters, technological waste waters, storm waters) go to the public sewage system or directly into the surface waters. The aim of this paper is to show the chemical quality of waste waters analyzed at the Institute of Public Health of Brod-Posavina County in 2016. Chemical parameters, mainly biochemical oxygen demand, chemical oxygen demand, pH value, total suspended solids, detergents, total phosphorus, total nitrogen, fats and oils, depositing substances, were analyzed in

waste water samples, in accordance with their current water management permits. The samples were evaluated according to the conditions determined in water permits and the Regulations on waste waters emission limits (NN 80/13). 114 samples of waste waters were analyzed and evaluated in 2016. on certain chemical parameters and 14,04% were not in accordance with water permits. Legal and physical entities, who release hazardous pollutants in the water, are obliged to, prior to disposal into the public sewage or other receiver, partially or completely remove the pollutants in accordance with existing water permit for wastewater discharge.

**SEZONSKA PROMJENA POJEDINIH PARAMETARA  
KAKVOĆE VODE U RIJECI RADOBOLJI**

**SEASONAL CHANGES OF SOME WATER QUALITY  
PARAMETERS IN THE RADOBOLJA RIVER**

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Rijeka Radobolja izvire iz kraškog izvora u podnožju Mikuljače i svojim tokom od oko 5 km protječe kroz prigradsko i gradsko područje grada Mostara do ušća u rijeku Neretvu. Zbog svog geografskog položaja, međudjelovanje rijeke i naselja kroz koja protječe je značajno. Jedna od bitnih osobina vodotoka rijeke Radobolje jest velika fluktuacija vodostaja ovisno o godišnjem dobu. U ovom radu praćena je kakvoća vode na pet mjernih mjesta od izvora do ušća u razdoblju visokog vodostaja (svibanj) i u periodu niskog vodostaja (srpanj) u cilju utvrđivanja utjecaja zagađenja. Između ostalog, uočeno je da se pH vrijednost i sadržaj otopljenog kisika ne mjenjaju značajno bez obzira na vodostaj rijeke sa vrijednostima od 7,43 do 8,30 za pH i od 10,45 do 13,12 mg/l za otopljeni kisik. S druge strane, utrošak  $\text{KMnO}_4$  varira od 0,38 do 3,20 mg/l i HPK od 3,72 do 20,38mg/l ovisno o godišnjem dobu. Iz navedenog je moguće zaključiti da je ekološko opterećenje rijeke Radobolje ovisno o sezonskom dijelu godine.

## **SOME CONCLUSIONS ON DRINKING WATER QUALITY IMPROVEMENT PROJECT IN HUNGARY**

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The Hungarian government launched the “Drinking Water Improvement Program” aiming the fulfillment of the requirements of the European Directive (Drinking Water Directive (98/83/EC)). The project has finished in 2015. The program was conducted in two tiers, requiring 500 million Euros for investments altogether during the last five-six years. Meanwhile, the government launched a program for decreasing the tariffs of public services (including drinking water supply, sewerage and wastewater treatment) by forcing the water utilities to decrease the water services price. In the South Hungarian region (the water is generally abstracted from deep wells) the water quality problems were related to high concentration of arsenic and ammonium. Removal of these pollutants generally associated with higher operational costs, causing contradictories in pricing by the public water utilities. While drinking water quality meets the EU demands and served to near 2.2 million people in Hungary, the investments for water treatment technologies has resulted in some constraints. The new technologies generally operate at higher costs, the treated drinking water flows through old and oversized pipeline systems. The presentation reveals a brief summary of the results and the lessons learned from the Program.

## **SEPARATION OF Cr(VI) IONS FROM AQUEOUS SOLUTIONS BY BENTONITE : THE INFLUENCE OF pH**

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Pollution with heavy metals in water resources is a serious environmental problem. Chromium Cr(VI), is toxic to all life forms and is considered the main pollutant. When it accumulates in living organisms can cause major health problems. For this aim a low-cost adsorbent bentonite, from Kriva Palanka as a natural mineral raw material has been investigated for removal of Cr(VI) ions from aqueous solution. XRD, TGA-DTA and FT-IR analysis are used for characterization of natural material. The surface area of the sorbent was determined by BET method. The adsorption experiment was performed at laboratory batch reactor, at constant room temperature, different initial Cr(VI) ions concentrations and at different pH of the solution. The equilibrium data were analyzed by several adsorption isotherms. It was observed that the adsorption capacity of the adsorbent was highly dependent on the pH of the solution. As results show, the optimum pH was observed at pH 1 and 2. The results confirm the possibility of applying the natural material, bentonite, as effective and economic sorbent for heavy metals removal from water resources.

## IMPACT OF OZONE AND ADVANCED OXIDATION PROCESSES ON THE FORMATION POTENTIAL OF NITROGENOUS BY-PRODUCTS IN WATER

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This work investigates the impact of advanced oxidation processes (AOPs) using ozone, ultraviolet (UV) light and hydrogen-peroxide ( $O_3/UV$ ,  $H_2O_2/UV$  and  $O_3/H_2O_2/UV$ ) on the formation potential (FP) of nitrogenous disinfection by-products (N-DBPs) in water. The examined groundwater is rich in natural organic matter ( $5.82 \pm 0.39$  mg C/L TOC) which is highly reactive towards forming carbonaceous (C)-DBPs<sup>[1]</sup>. For the N-DBPs, the haloacetonitrile (HAN) precursor contents ( $9.83$   $\mu\text{g/L}$  HANFP) were significantly lower compared to the C-DBPs, while chloropicrin (CP) precursors were not detected ( $<0.40$   $\mu\text{g/L}$ ). Application of ozone alone decreased HAN precursors by 71%. During  $O_3$  based AOPs ( $O_3/UV$  and  $O_3/H_2O_2/UV$ ), HANFP varied significantly ( $3.49$ - $10.1$   $\mu\text{g/L}$ ) with no clear relation between the changing HANFP and increasing UV dose. During UV photolysis and  $UV/H_2O_2$  processes, increasing the UV dose doubled the HANFP. In all the treatments, only dichloroacetonitrile and dibromoacetonitrile precursors were observed. None of the investigated treatments has any influence on the formation of CP precursors. The absence of a correlation between N-DBPs with C-DBPs and oxygen containing DBPs indicates the completely different nature of their precursors. Treatment with ozone ( $0.5$  mg  $O_3$ /mg DOC) was shown to be more efficient in reducing HAN formation than the UV AOPs.



## **UČINKOVITOST RADA UREĐAJA ZA PROČIŠĆAVANJE OTPADNIH VODA SLAVONSKI BROD**

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*Vodovod d.o.o. Slavonski Brod, N. Zrinskog 25, 35000 Slavonski Brod, Hrvatska*

Sustav javne odvodnje grada Slavenskog Broda obuhvaća područje aglomeracije Slavonski Brod koja obuhvaća uz grad Slavonski Brod sa katastarskim općinama Slavonski Brod, Podvinje, Brodski Varoš i Brodsko Vinogorje te velik dio naselja. Ukupna dužina kanalizacijske mreže kojom upravlja Vodovod d.o.o. na području grada Slavenskog Broda iznosi cca 215 km, a u ostalim naseljima na području aglomeracije cca 35 km. Sredinom 2014. godine počeo je s radom novosagrađeni Uređaj za pročišćavanje otpadnih voda, smješten uz rijeku Savu nizvodno od središta grada i gradskog kupališta te je zaštićen nasipom protiv poplava uzduž rijeke. Kapacitet UPOV-a je 80.000 ES, obuhvaća 3. stupanj pročišćavanja, tj. strožu obradu komunalnih otpadnih voda postupkom kojim se uz drugi stupanj pročišćavanja postižu zahtjevi i za ukupni fosfor i dušik iz Pravilnika o graničnim vrijednostima emisija otpadnih voda. Specifičnost UPOV-a Slavonski Brod zasniva se na C-Tech tehnologiji (Cyclic Activated Sludge Technology - ciklička tehnologija aktivnog mulja). U ovom radu prikazat će se učinkovitost pročišćavanja otpadnih voda grada Slavenskog Broda u 2015.g. i 2016.g. kroz ulazne i izlazne koncentracije parametara zadanih Vodopravnom dozvolom.

## **THE WORK EFFICIENCY OF WASTEWATER TREATMENT PLANT SLAVONSKI BROD**

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The public sewage system of the city Slavonski Brod includes area agglomeration of Slavonski Brod which also includes its cadastral district, Brodski Varoš and Brodsko Vinogorje. Vodovod Ltd. manages the total of 215 km of sewage network in Slavonski Brod and 35 km in other area of agglomeration. Newly built Wastewater Treatment Plant started with its work in the middle of 2014. It's located by the river Sava, downstream by the city center and town bathing-place, and it's protected with mound by the river Sava. Capacity of WWTP is 80.000 PE and it takes third stage of treatment, which means successful removal of total nitrogen and total phosphor defined in Ordinance on limit values of hazardous and other substances in wastewater. WWTP Slavonski Brod is specific because of C-Tech technology (Cyclic Activated Sludge Technology). In this work, we will represent efficiency of wastewater treatment in Slavonski Brod during the last two years 2015. and 2016., through concentrations of COD, BOD, total nitrogen, total phosphor and suspended solid defined in Water permit.

## UKLANJANJE NITRATA IZ VODE IONSKOM IZMJENOM

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Visoke koncentracije nitrata u vodi, kako u površinskim tako i u podzemnim vodama, posljedica su geološkog sastava tla ili antropološkog djelovanja. Povećane koncentracije nitrata u vodi ozbiljan su problem za zdravlje ljudi uzrokujući rak probavnog sustava ili druge anomalije, a kod djece uslijed povećane konzumacije vode za piće s koncentracijom nitrata većom od 50 mg/l može doći do bolesti zvanom methemoglobinemija. Nadalje, prisutnost nitrata u vodonosnicima, može utjecati na eutrofikaciju što uključuje i rast algi te smanjenje otopljenog kisika u vodi. Prirodna i umjetna gnojiva koja se koriste u ishrani bilja, proizvodnja detergenata, nekontrolirani ispus otpadnih voda u okoliš te industrijski otpad, glavni su izvori nitrata u vodi. Nitrati su stabilni, dobro topivi ioni koji se teško uklanjaju iz vode konvencionalnim metodama kao što su koagulacija i flokuacija. Ionska izmjena pokazuje zadovoljavajuće rezultate te je iz toga razloga najčešće korištena metoda za uklanjanje nitrata iz vode. Ovim radom ispitana je mogućnost uklanjanja nitrata iz vode primjenom komercijalnih ionskih izmjenjivača: Duolite A7 i Relite A490. Ispitan je utjecaj početne koncentracije nitrata (10, 50 i 100 mg/l), vremena adsorpcije (15 do 1440 min) i mase ionskog izmjenjivača (0,1 – 0,6 g).

## NITRATE REMOVAL FROM WATER BY ION EXCHANGE

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High concentrations of nitrates in water, both in surface and in groundwater, is a consequence of geological composition of soil or human activity. Increased concentrations of nitrate in drinking water is a serious hazard to human health, causing abnormalities such as cancerous growths in human digestion system, while excessive nitrate intake via drinking water can cause methemoglobinemia in infants. Furthermore, the presence of nitrate in aquifers can stimulate eutrophication, which compromise the growth of algae and depletion of dissolved oxygen. Natural and chemical fertilizers in crop production, detergent manufacturing, uncontrolled land discharge of municipal wastewater, and industrial wastes have been identified as the main sources of nitrate in water sources. Nitrate is a stable, highly soluble ion that is difficult to remove by conventional water treatment methods such as coagulation and flocculation. Ion exchange is the most widely employed procedure used for removing nitrate from water. In this research the possibility of removing nitrates from water was examined by using commercial ion exchangers: Duolite A7 and Relite A490, respectively. The influence of the initial concentration of nitrate (10, 50 and 100 mg/l), the contact time (15 - 1440 min) and the mass of the ion exchanger (0.1 to 0.6 g) was also examined.

## **SENSOR TECHNOLOGY FOR MONITORING OF AQUATIC MEDIUM**

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Negative environmental pollution by natural and anthropogenic activities requires a quality monitoring program. Standard laboratory methods have limitations relating to the incompetence to obtain timely and appropriate data on the current state of analyzed quality of water bodies. Due to these limiting factors, research has focused on developing new technologies to provide a quality monitoring program and ensure real-time data on the status of the examined water bodies. It is extremely important to monitor quality of the studied water bodies and in the incident of pollution to take appropriate rapid and prompt measures to avoid the spreading of contamination. Fiber optic sensor (FOS) represents convenient technology for examination the physico-chemical parameters of aquatic medium and with possibility to substitute the standard laboratory instrumentation. In this paper, developed FOS for measurement of organic and inorganic pollutants in water bodies were presented. Operating principle, limit of detection and dynamic range of different sensors were discussed. Based on comparative analysis the physico-chemical parameters with standard laboratory analysis and FOS, it was established that the sensors are convenient and effective technology for monitoring of water media.

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**DETEKCIJA I VIZUALIZACIJA ULTRA RIJETKIH IZOTOPA Cd I Zn U  
RIZOSFERNIM OTOPINAMA I HRANI POMOĆU NAJNAPREDNIJIH  
TEHNIKA MASENE SPEKTROMETRIJE**

**DETECTION AND VISUALIZATION OF ULTRA-TRACE Cd AND Zn  
ISOTOPES IN RHIZOSPHERE SOLUTIONS AND FOOD BY MOST  
ADVANCED MASS SPECTROMETRY TECHNIQUES**

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Cink (kao fitonutrijent) i kadmij (kao fitotoksičan element) dijele slične/iste načine ulaska u biljku i transporta unutar biljke. U ovoj studiji je potpuno razvijena biljka rotkvice (*Raphanus sativus* L. cv. Cherry Belle) uzgajana u hranivoj otopini bila izložena vrlo slaboj (2.2  $\mu$ M) i kratkoj (24-satnoj) kontaminaciji <sup>70</sup>Zn i Cd sa ciljem detekcije i mapiranja izotopa u korijenu, jestivom plodu (hipokotilu) i nadzemnim izbojcima. Za tu svrhu su korištene jedne od najnaprednijih instrumentalnih tehnika za detekciju ultra rijetkih elemenata kao što je inductively coupled plasma mass spectrometry (ICP-MS) i high-resolution secondary ion mass spectrometry (NanoSIMS) tehnika za kemijsko *in situ* mapiranje. Nakon 24-satnog tretmana korijen rotkvice je akumulirao najviše promatranih elemenata (<sup>70</sup>Zn >180 i Cd >350  $\mu$ g/g s.t), dok je u jestivom plodu rotkvice njihov sadržaj bio i do 27x, a u lisnoj biomasi i do gotovo 200x manji. NanoSIMS kemijske karte kreirane na 1- $\mu$ m tankim sekcijama korijena, hipokotila i lisnih primordija korespondiraju vrlo dobro sa ICP-MS analizama i ukazuju na najveći sadržaj metala u epidermi korijena, te smanjenje sadržaja prema centru korijena. U preostalim tkivima skeniranog područja, obrazac distribucije Cd/Zn je bio vrlo sličan i ujednačen. Obije primijenjene tehnike su se pokazale vrlo uspješnim u detekciji ultra rijetkih izotopa (<sup>70</sup>Zn, <sup>114</sup>Cd) u otopini rizosfere, kao i njihovoj detekciji i vizualizaciji u brzo rastućim tkivima rotkvice.

**MOGUĆNOST PRIMJENE PEPELA IZ BIOMASE NA KISELIM I  
HRANIVIMA OSIROMAŠENIM POLJOPRIVREDNIM TLIMA**

**POSSIBILITY OF APPLICATION OF FLY ASH FROM BIOMASS ON  
ACID AND NUTRIENT-DEFICIENT AGRICULTURAL SOILS**

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Ulaskom u EU RH je temeljem Direktive o poticanju uporabe obnovljivih izvora energije (OIE) preuzela obvezu povećanja uporabe energije iz obnovljivih izvora do 2020. na 20 % u bruto potrošnji, u skladu s čime je 2013. usvojen Nacionalni akcijski plan za OIE. U sklopu navedenog plana, RH financijski podupire izgradnju elektrana/toplana na agro/šumsku biomasu, kao jednog od značajnih OIE. Godišnje se u RH otvori nekoliko postrojenja na biomasu, a njihov značajan nusproizvod je pepeo kojega je potrebno na odgovarajući način zbrinuti (iskoristiti). Po svome kemijskom sastavu pepeo biomase je izuzetno alkalni (pH >12) ali i bogat određenim fitonutrijentima (P, K, Ca, Mg). Veliki udio poljoprivrednih tala u svijetu i RH je prilično kiseo (pH <6) i siromašan hranivima, te je pretpostavka da bi se primjena pepela iz biomase mogla vrlo uspješno iskoristiti za kemijsko kondicioniranje tala u pogledu pH i određenih hraniva. U tu svrhu je provedeno istraživanje u kontroliranim uvjetima plastenika sa test kulturom kukuruzom, gdje su u određenim omjerima miješani tlo (iz Ap horizonta) i pepeo nastao izgaranjem šumske biomase, te su praćeni određeni vegetacijski i kemijski parametri tla i test kulture. Istraživanjem se utvrdilo da dodatak pepela značajno utječe na kemijske pedovarijable (pH, sadržaj makro/mikroelemenata), mineralni sastav korijena i nadzemnog dijela, te sve parametre rasta i prinosa test kulture.

## KARAKTERIZACIJA RUDNIČKE VODE

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Rudničke vode su potencijalna opasnost za okoliš jer mogu ozbiljno degradirati kvalitetu površinske i podzemne vode u koje se ulijevaju i ugroziti živi svijet. U ovom radu, u uzorcima rudničke vode uzetim na površinskom kopu (P.K.) rudnika ugljena „Drage“ i rudnika boksita „Vinjani“ (BiH), određene su koncentracije metala i organskog ugljika (otopljenog, sedimentiranog i površinski aktivnog) te sumpora (ukupnog i reduciranog). Na lokaciji rudnika ugljena koncentracije niza metala (Cd, Pb, U, Mn, Fe, Co, Ni) bile su povišene, a koncentracije Mn (84,3 - 55,8 µg/L) i Ni (33,1 - 30,7 µg/L) bile su veće od graničnih vrijednosti (GV) prema Pravilniku o zdravstvenoj ispravnosti vode za piće (NN 46/07). U istim uzorcima izmjerene su koncentracije urana do 33,7µg/L više od GV (30 µg/L) prema Svjetskoj zdravstvenoj organizaciji. Prema tome, ispiranjem ugljena u vodu dopijeva niz potencijalno toksičnih metala koji mogu negativno utjecati na vodene organizme. S obzirom da istraživane vode imaju pH blizak neutralnom (od 6,5 do 6,96 (P.K. „Drage“) i pH od 7,77 do 7,84, P.K. „Vinjani“) za pretpostaviti je da navedeni metali nisu vrlo pokretljivi. Na temelju vrijednosti topljivog organskog ugljika i reduciranog sumpora procijenjen je redoks potencijal promatranog vodenog sustava.

## CHARACTERIZATION OF THE MINE WATER

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Mine waters have the potential to negatively affect the quality of surrounding surface and ground water and aquatic ecosystems. In this study, in the samples of mine waters from the open pit (OP) coal mine "Drage" and a bauxite mine "Vinjani" (B&H), the concentrations of metals and organic carbon (dissolved, particulate and surfactant), as well as the sulfur (total and reduced), were measured. At the location of the coal mine, the elevated concentrations of a series of metals (Cd, Pb, In, Mn, Fe, Co, Ni) have been found, and the concentration of Mn (84.3 to 55.8 g/L) and Ni (33.1 to 30.7 g/L) were higher than the limit value (LV), according to the Ordinance on sanitary safety of drinking water (NN 46/07). In the same samples, the measured concentrations of uranium up to 33.7µg/L were higher than the LV (30 mg/L) according to the World Health Organisation. Thus, the enrichment of the natural water by numerous coal-derived potentially toxic metals can negatively

**Knjiga sažetaka / *Book of abstracts***

**Posterska priopćenja / *Poster presentations***

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affect aquatic organisms. The pH values of water from OP "Drage" were close to neutral (6.5 to 6.96), and from OP "Vinjani" were between 7.77 and 7.84. These results suggest that the mobility of metals is not significant. Based on the values of the dissolved organic carbon and reduced sulfur the redox potential of the investigated water system was estimated.

## BALLAST WATER MANAGEMENT IN TANKERS

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Marine transport allows economical transportation of large quantities of cargo in a globalized world. The gradual growth in the number of ships, and accordingly in the marine traffic becomes inevitable, considering the growth in the volume of the world marine trade in the past years. While providing the safety of the ship, the crew and the cargo in such an intense traffic, it is very important to protect the marine environment. Ships carry ballast waters, when they are not loaded, to safety manage their voyages and to have stability/strength values, similar to that when they are not loaded. Tankers in particular are the main actors in the transfer of millions of different types of living organisms, since they carry ballast waters in enormous amounts. Living organisms in the ballast water that are taken from the coastal waters where the biodiversity is at the maximum, when discharged at the destination port, become invasive in an environment where they have no predator and food stock is abundant, thus causing extensive ecological and economical problems. International Maritime Organization (IMO) stated ballast water exchange methods and the acceptable amounts of living organisms in the ballast water, after the use of onboard treatment systems, as D-1 and D-2 standards, in the “International Convention for the Control and Management of Ship’s Ballast Water and Sediments”, which aimed at controlling the transfer of living organisms. Nowadays, physical, chemical and mechanical on-board treatment systems are developed, which use the state-of-art technology and meet the standards, conducted by treatment companies, in cooperation with researchers and scientists. Ballast water reception facilities, are recommended by the Convention to be established on-shore, are considered to be a management alternative. In this study, by taking into account lower treatment costs, treatability of some of the microbiological parameters in ballast waters will be investigated and management alternatives will be presented.



## **THERMODYNAMIC STUDY OF Pb<sup>2+</sup>, Cd<sup>2+</sup> AND Ni<sup>2+</sup> ADSORPTION ON CHERRY/SWEET CHERRY KERNEL ACTIVATED CARBON**

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In this article, a thermodynamic study of the heavy metal cations adsorption on “low-cost” activated carbon was carried out. Cherry/sweet cherry kernels were thermochemical activated with phosphoric acid on 500 °C. The adsorption experiments were studied in a batch mode at the temperatures (295, 305 i 315 K), on a rotary shaker at 140 rpm, different lead, cadmium and nickel initial concentrations (5, 10, 20, 50, 100, 200, 300 and 500 mg/L), pH of 6.0, contact time of 30 min and the activated carbon dose of 2.0 g/L. Determination of enthalpy ( $\Delta H^\circ$ ), entropy ( $\Delta S^\circ$ ) and Gibbs free energy ( $\Delta G^\circ$ ) has a great importance to evaluate the type and mechanism of adsorption process. The values above 40 kJ of  $\Delta H^\circ$  for the Pb<sup>2+</sup> and Cd<sup>2+</sup> ions suggests that the adsorption is endothermic and mainly chemisorption takes place on the surface of the adsorbent. The small  $\Delta H^\circ$  value (6.42 kJ/mol) for Ni<sup>2+</sup> confirms that the adsorption is slightly endothermic and physical in nature (intra-particle diffusion). The positive value of  $\Delta S^\circ$  shows the increasing randomness at the solid/liquid interface during the adsorption of metal cations. The negative slowly increasing values of  $\Delta G^\circ$  confirms the spontaneity of adsorption process and thermodynamically favorable.

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## UPRAVLJANJE OTPADNIM VODAMA – BRIGA ZA OKOLIŠ I ZDRAVLJE LJUDI

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Cilj integralnog upravljanja vodama je osiguranje zalihe voda pogodnih za održanje ekološke funkcije okoliša i sigurnih za ljudsku potrošnju. Na području Europske unije na snazi je niz direktiva koje države članice transponiraju u nacionalno zakonodavstvo i kojima se na jedinstvenim načelima regulira upravljanje pojedinim segmentima vodne politike. Jedna od mjera za postizanje dobrog stanja voda je prikupljanje i pročišćavanje komunalnih otpadnih voda. Na područjima gdje je građenje sustava javne odvodnje tehnički i ekonomski opravdano – aglomeracijama – ulažu se značajna financijska sredstva kako bi se prikupljanjem otpadnih voda i njihovim pročišćavanjem postigla prihvatljiva i za vode neškodljiva razina kakvoće efluenta koji dospijeva u prirodne prijemnike. U okviru financijskog praćenja i provedbe projekata zaštite vode, Hrvatske vode su od 1996. pa do kraja 2016. godine, putem godišnjih Planova upravljanja vodama uložile oko 9,4 milijarde kuna, što uključujući i sredstva investitora iznosi oko 11,4 milijarde kuna. Višegodišnjim programom gradnje komunalnih vodnih građevina ukupno je na području Republike Hrvatske identificirano 767 aglomeracija. Na aglomeracijama većim od 2.000 ES utrošena su financijska sredstva u iznosu od oko 10,0 milijardi kuna. Uzimajući u obzir ukupno procijenjene buduće troškove izgradnje sustava odvodnje i pročišćavanja otpadnih voda za 281 aglomeraciju veću od 2.000 ES u iznosu od oko 22,0 milijarde kuna, može se zaključiti kako je za ispunjenje obveza i postizanje standarda koji proizlaze iz procesa pristupanja Europskoj uniji (Direktive o pročišćavanju komunalnih otpadnih voda 91/271/EEZ) u razdoblju do kraja 2023. godine, potrebno uložiti dvostruko veća sredstva u odnosu na sredstva uložena u prošlom razdoblju.

## **THE NUTRITIONAL ASPECT OF WATER'S IMPORTANCE**

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Water is an existential substance essential to life on which is based the existence of the entire living world. Each cell of the human body needs water to function properly. Water serves as a lubricant. It makes up saliva and the fluids surrounding the joints, regulates the body temperature through perspiration. It also helps prevent and relieve constipation by moving food through the intestines. Water is very important for the physiology of nutrition because it accelerates metabolism, increases energy levels, moisturizes the skin and gives vitality, helps the body get rid of harmful toxins. In order for the human body to function properly, to maintain concentration and alertness must be hydrated regularly. Insufficient water intake is usually the biggest factor for fatigue during the day. Dehydration is actually one of the main causes of constipation, kidney stones, headaches and other physical disorders. The body can lose fats and more than a half of proteins and to continue living while losing one tenth of the water causes death. Using of healthy and clean water is necessary in order to be healthy, to have a long and quality life. It is water that meets criteria set by the Decree for water classification.

## FLUORIDACIJA VODE ZA PIĆE

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Zubni karijes najraširenije je kronično oboljenje u svijetu. Fluoridi imaju karijes protektivno djelovanje, sprječavaju demineralizaciju tvrdih zubnih tkiva te istovremeno potpomažu proces remineralizacije. Mogu se primjenjivati endogeno i topikalno. Najstariji poznati način endogene primjene fluorida jest fluoridacija vode za piće. Američki Centar za kontrolu i prevenciju bolesti 1999. godine fluoridaciju vode za piće proglasio je jednim od deset najvećih javnozdravstvenih postignuća 20. stoljeća. Preporučena koncentracija fluorida u vodi za piće iznosi 0.7-1.2 mg/L. Svjetske epidemiološke studije govore o smanjenju pojavnosti karijesa kod populacije koja uzima fluoridiranu vodu za 40-49 % u mliječnoj i 50-59 % u trajnoj denticiji. Dostupnost velikom broju ljudi, bez obzira na socio-ekonomski status i niski troškovi provedbe, glavne su prednosti unosa fluorida putem vode. Kao glavni problem nameće se nemogućnost individualne kontrole dnevnog unosa fluorida, s obzirom na to da se fluoridi svakodnevno mogu dodatnim načinima unijeti u organizam, hranom, zrakom ili slučajnim gutanjem sredstava za održavanje oralne higijene. Najčešće spominjana posljedica prevelikog unosa fluorida jest dentalna fluoroza, a osim te komplikacije spominju se štetna djelovanja na želučanu sluznicu, bubrege i pojava alergija. Cilj ovog rada predstavljanje je načina fluoridacije vode za piće, prednosti i nedostataka, mogućih nuspojava te kontroverzi koje se vežu za ovaj način endogene primjene fluorida.

## FLUORIDATION OF DRINKING WATER

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Tooth decay is the most prevalent chronic disease in the world. Fluoride has a caries-protective mechanism of action, as it inhibits demineralization process of hard tooth tissues and helps tooth remineralization. Fluoride can be used topically or systemically. Fluoridation of drinking water is the oldest known form of systemic fluoride therapy. In 1999 fluoridation of water was named one of ten great public health achievements of the 20th century by The Center for Disease Control and Prevention. Recommended concentration of fluoride in drinking water varies between 0.7 and 1.2 mg/L. According to epidemiological data, reduction in dental decay in communities with fluoridated drinking water is 40-49% in primary dentition and 50-59% in permanent dentition. The greatest benefits of community water fluoridation are availability to all people in the community, regardless socioeconomic status, and cost-effectiveness. The major problem is controlling individual daily fluoride intake, because one can be exposed to fluoridation through food, air or even by accidental ingestion of dental products. The most common complications of fluoride overdose are dental fluorosis, allergies and negative impact on gastric mucosa and kidneys. The aim of this paper is to present modalities of water fluoridation, its benefits and complications, as well as controversies surrounding this practice.

## **KONCENTRACIJE NITRATA U VODI NA PODRUČJU POŽEŠKO-SLAVONSKE ŽUPANIJE ODREĐENE SPEKTROFOTOMETRIJSKOM METODOM**

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Glavni izvor nitrata u prehrani su povrće i voda za piće. Nitrati sami po sebi su relativno netoksični, opasnost predstavljaju njihovi metaboliti i reakcijski produkti kao nitriti, N-nitroso spojevi i dušikov monoksid (NO), zbog čega su sve češći predmet istraživanja. Određivanje nitrata u vodi za ljudsku potrošnju provedeno je spektrofotometrijskom metodom koja je prethodno validirana. U svrhu provjere prikladnosti metode određene su sljedeće izvedbene značajke: linearnost, granica detekcije, granica kvantifikacije, preciznost, istinitost i robusnost. Izvedbene značajke pokazale su da je metoda prikladna namjeni. U 2016. godini, prema redovitom planu monitoringa vode za ljudsku potrošnju, provedena je analiza 101 uzorka vode sa područja Požeško-slavonske županije na obavezan parametar sukladnosti nitrati. Koncentracija nitrata u analiziranim uzorcima kretala se od 0,87 mg NO<sub>3</sub><sup>-</sup>/L do 17,74 mg NO<sub>3</sub><sup>-</sup>/L, što je značajno niže od maksimalno dopuštene granice koja iznosi 50 mg NO<sub>3</sub><sup>-</sup>/L. Dobiveni rezultati ukazuju na dobru kvalitetu vode u javnoj vodoopskrbi Požeško-slavonske županije, gledajući kemijski parametar nitrati.

## **NITRATES IN WATER IN POŽEGA-SLAVONIA COUNTY AS DETERMINED BY SPECTROPHOTOMETRIC METHOD**

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Vegetables and drinking water are the most important sources of nitrates in human diet. Nitrates itself are relatively nontoxic, more toxic are their metabolites and reaction products like nitrites, N-nitroso compounds and nitric oxide (NO). Due to their health effect, the content of nitric compounds is nowadays more extensively studied. Nitrates concentration in water intended for human consumption was determined by spectrophotometric method. Firstly, performance characteristics were determined in order to evaluate fitness for purpose of selected method. Based on the results of linearity, limit of detection, limit of quantification, precision, trueness and robustness, method was fit for purpose. In 2016, according to the water quality monitoring programme, nitrates determination was performed in 101 water sample from Požega-Slavonia County and the results ranged from 0.87 mg NO<sub>3</sub><sup>-</sup>/L to 17.74 mg NO<sub>3</sub><sup>-</sup>/L. The obtained results are significantly lower than maximum prescribed value that is 50 mg NO<sub>3</sub><sup>-</sup>/L. Regarding chemical parameter nitrates, the water in public drinking water supply system in Požega-Slavonia County is safe and good quality.

## **MIKROBIOLOŠKA POPULACIJA VOĆNIH SOKOVA, GAZIRANIH NAPITAKA I VODE U BOCI, NAKON OTPIJANJA**

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U ovom radu, istražena je mikrobiološka populacija voćnih sokova, gaziranih napitaka i vode u boci, nakon otpijanja. Negazirani i gazirani napitci te voda u boci su izuzetno popularni, posebno među mladom populacijom. Česta je praksa otpijanja gutljaja izravno iz boce i ostavljanja napitka na sobnoj temperaturi. Mikroorganizmi iz usta dospijevaju u napitak gdje mogu uzrokovati njegovo kvarenje. Uzorci soka od jabuke, naranče i kruške, cola napitka te vode u boci su, nakon otpijanja, inkubirani pri sobnoj temperaturi. Mikrobiološkim analizama provedenim tijekom inkubacije (prije i nakon otpijanja te u 2., 4. i 6. danu) određen je broj aerobnih mezofilnih bakterija, bakterija mliječne kiseline, kvasaca i plijesni te koliformnih bakterija. Istovremeno, praćena je promjena pH vrijednosti te ostale senzorske promjene (zamućenje, pojava plina i fermentacije, neugodan miris). Tijekom čuvanja pri sobnoj temperaturi, dolazi do povećanja broja aerobnih mezofilnih bakterija, bakterija mliječne kiseline i kvasaca. Nije ustanovljena prisutnost koliformnih bakterija. U uzorcima s nižim pH vrijednostima napitaka, ukupni broj mikroorganizama je bio manji. pH vrijednost u uzorcima smanjuje se tijekom čuvanja pri sobnoj temperaturi. Kako bi se spriječilo umnožavanje mikroorganizama, potrebno je, nakon otpijanja, čuvati napitke pri temperaturi hladnjaka.

## **MICROBIOLOGICAL POPULATION OF SOFT AND CARBONATED BEVERAGES AND BOTTLED WATER AFTER SIPPING**

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The aim of this study was to investigate the microbial population of fruit juice drinks, carbonated beverages and bottled water, after sipping. Fruit juices and carbonated beverages are very popular, especially among younger generations. Taking a sip of drink straight from the bottle and leaving it at room temperature is very common. Microorganisms harboring mouth manage to enter into drinks where they proliferate and are, therefore, responsible for the spoilage. Samples of apple, orange and pear juices, as well as carbonated drinks and bottled water were incubated at room temperature, after sipping. Total counts of aerobic mesophilic bacteria, lactic acid bacteria, fungi and coliforms were determined before and after sipping, as well as at 2<sup>nd</sup>, 4<sup>th</sup> and 6<sup>th</sup> incubation day. Changes of pH and sensory evaluation (turbidity, gas, fermentation and odor) were also detected. Counts of total bacteria, lactic acid bacteria and yeasts were increased during incubation period. Coliforms were not detected in analyzed samples. At lower pH value samples lower counts of microorganism were detected. During incubation period, pH values of beverages declined. For microbial growth restricting, after sipping, beverages should be kept at refrigeration temperatures.

## **REMOVAL OF TWO BROMINATED MICROPOLLUTANTS ( $\alpha$ -HBCDD AND TBBPA) IN A HOSPITAL WASTEWATER IN İZMİR (TURKEY) BY SEQUENTIAL BIOLOGICAL AND REVERSE OSMOSIS PROCESSES**

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The brominated flame retardants (BFRs) from an environmental point of view has increased considerably during the last two decades. BFRs include various chemical groups, the most common being tetrabromobisphenol A (TBBPA), and hexabromocyclododecane ( $\alpha$ -HBCDD).  $\alpha$ -HBCDD is an additive flame retardant, i.e. the molecule is not chemically incorporated in the polymer. TBBPA is covalently bond and not released as easily. They are used in electronic equipment, plastics, textiles and building materials. Since their low solubilities ( $7.65 \times 10^{-6}$  –  $2.1 \times 10^{-6}$  g/L) and higher adsorption capacities (Log Kow = 5.60 , 5.90) they can not be biodegraded effectively. In this study, the  $\alpha$ -HBCDD and TBBPA in a raw hospital wastewater were biodegraded effectively using a sequential anaerobic UASB /aerobic CSTR reactor at high SRTs (58 day) at  $\alpha$ -HBCDD and TBBPA loading rates of 0.12 and 0.23 ng/L/day, respectively. Maximum  $\alpha$ -HBCDD and TBBPA yields were 87% and 89% in anaerobic UASB while the yields were calculated as 94% and 97% in aerobic CSTR. The total yields in sequential total reactors were 95% and 97% for  $\alpha$ -HBCDD and TBBPA, respectively. The methane gas percentages were recorded as 78% in the anaerobic reactor. In the treatment with sequential two RO membranes (BW30-2540 DOW Filmtec) the maximum water recovery was about 85%. The  $\alpha$ -HBCDD and TBBPA yields were 98 and 99%, respectively. Product water qualities of these membranes were found to be suitable for irrigation.

## PREPARATION AND DETECTION OF SILVER NANOPARTICLES IN AQUEOUS SOLUTIONS BY ADVANCED PULSE VOLTAMMETRIC TECHNIQUES

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The benefits of water colloids containing silver nanoparticle are well known, the application of which spans over homeopathy, alternative medicine to advanced technologies associated with contemporary modern medicine, water and air purification systems, etc. In the current work we propose a simple methodology for preparation of silver nanoparticle water colloids starting with electrolysis process, followed by redox chemistry with biomolecules such as ascorbic acids and three peptide glutathione that is used as complexing, reducing, and stabilizing agent. The morphology of silver nanoparticles has been studied with atomic force microscopy, while the properties in the liquid phase have been explored in detail by square-wave voltammetry, as one of the most advanced pulse-voltammetric techniques. As expected, a few-second electrolysis procedure in a distilled water with silver anode yielded predominantly ionic silver solution, which could be analyzed by anodic stripping square-wave voltammetry at submicromolar concentration interval of silver ions at edge plane pyrolytic graphite electrode. Following addition of ascorbic and/or glutathione a colloid of silver nanoparticle is formed, which is not prone of detection with anodic stripping voltammetry. The problem was circumvented in an excess of glutathione, causing adsorptive accumulation of silver nanoparticles at the electrode surface, thus enabling anodic oxidation and voltammetric detection of silver particles. The voltammetric properties of accumulated silver nanoparticles have been analyzed in the light of the theory of adsorptive stripping voltammetry by altering the potential modulation parameters.



**IZLOŽENOST STANOVNIŠTVA GRADA ZAGREBA  
KONTAMINANTIMA IZ VODE ZA LJUDSKU POTROŠNJU**

**POPULATION EXPOSURE OF ZAGREB CITY AREA TO  
CONTAMINANTS FROM DRINKING WATER**

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Dostupnost vode za ljudsku potrošnju smatra se glavnim preduvjetom za zdravlje, a prisutnost kontaminanata ispod najvećih dopuštenih količina jamči da neće doći do štetnog djelovanja na zdravlje potrošača tijekom njihovog života. Stoga je cilj ovoga rada bio procijeniti izloženost stanovništva grada Zagreba kontaminantima iz vode za ljudsku potrošnju, temeljem dostupnih podataka koje je u 2016. godini prikupio Gradski ured za zdravstvo Grada Zagreba za navedeno područje. Literaturni podaci pokazuju kako povećana izloženost pojedinim kontaminantima u vodi dovodi do zdravstvenih poremećaja kao što su methemoglobinemija, razni neurološki poremećaji, oštećenja kardiovaskularnog sustava, disfunkcije bubrega, osteoporoza i sl., a u iznimnim slučajevima i smrti. U radu su izneseni rezultati izloženosti koji su izračunati pomoću Excel modula „Improrisk 1.3.3.“ koji obrađuje podatke za pojedine kontaminante (nitriti, nitrati, cijanidi, kadmij, živa, aluminij, arsen, klorati i kloriti), u odnosu na konzumaciju vode odrasle populacije grada Zagreba, te uspoređuje s vrijednostima koje se odnose na zaštitu zdravlja (eng. *Health-based guidance value*, *HBGV*). Sukladno rezultatima, izloženost stanovništva grada Zagreba kontaminantima iz vode za ljudsku potrošnju nalazi se u granicama vrijednosti koje se odnose na zaštitu zdravlja.

## **OTPADNE VODE IZ PIVOVARA - OTPAD ILI SIROVINA?**

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S obzirom da od svih nusproizvoda iz pivovara, daleko najveći udio čini otpadna voda (procjenjuje se da se čak i do 7 litara otpadne vode po litri proizvedenog piva), razumljivo je da se ulažu veliki naponi prvenstveno da se ta količina smanji, a onda i da se na različite načine i u različite svrhe proizvedena količina iskoristi. Radi strožih zakonskih regulativa i sve veće svijesti za ekologiju, u današnje vrijeme sve velike pivovare imaju sustave za obradu otpadnih voda koji su najčešće kombinacija aerobnog i anaerobnog načina. Tako, osim što uvelike smanjuju negativan utjecaj otpadnih voda na okoliš, pivovare dobivaju metan kojeg koriste kao pogonsko gorivo u kotlovima za paru čime si dodatno smanjuju troškove. Budući da je to još uvijek prilično skupa tehnologija, zbog neisplativosti male pivovare u najvećem broju slučajeva nemaju takve sisteme i svoju otpadnu vodu ispuštaju u kanalizaciju bez ikakve obrade. Stoga je potrebno posvetiti pažnju drugim i alternativnim načinima korištenja i zbrinjavanja otpadnih voda kao što su npr. korištenje anaerobno obrađene otpadne vode kao medij za hidroponsko uzgajanje biljaka, uzgajanje mikroalgi u otpadnoj vodi iz pivovara, uklanjanje baznih bojila uz pomoć otpada iz pivovara i sl.

## **BREWERY EFFLUENTS - WASTE OR RAW MATERIAL?**

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Considering that of all brewery by-products, wastewater makes by far the biggest part (it is estimated that up to seven liters of water are used for every liter of beer product), it is understandable that big efforts are made to, firstly, lower this quantity and, by using different techniques and approaches, to make use of produced effluents. Because of strict legislation and the rise of ecological awareness, today all big breweries have systems for wastewater treatment which are often a combination of aerobic and anaerobic methods. In addition to greatly reducing negative impact of brewery effluents on environment, breweries obtain methane which is then used as a fuel in steam generators allowing to further reduce energy costs. As this is still rather expensive technology, due to unprofitability most small breweries don't have any wastewater treatment systems and they discharge their effluents directly to sewage system without any treatment. Therefore it is necessary to pay attention to other and/or alternative ways of usage and treatment of brewery effluents as for example using anaerobically digested brewery effluent as a medium for hydroponic crop production, growing microalgae in brewery wastewater, removal of basic dye from wastewaters utilizing brewery wastes etc.

## **THERMOCHEMICAL MODIFICATION OF APRICOT KERNELS FOR REMOVAL OF PRIORITY, HAZARDOUS PRIORITY AND EMERGING SUBSTANCES FROM AQUEOUS WASTES**

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Using of organic industrial processing waste as precursors for low-cost adsorbent has been recognized as an eco-friendly technique for wastewater decontamination. In this study, mechanically and thermally modified apricot kernels were further activated with phosphoric acid to improve its sorption of Pb<sup>2+</sup>, Cd<sup>2+</sup>, Ni<sup>2+</sup>, naproxen and chlorophenols. Physicochemical properties of the activated kernels were characterized using scanning electron microscopy (SEM), energy dispersive X-ray spectroscopy (EDX), Fourier transform infrared spectroscopy (FTIR) and Brunauer, Emmett and Teller (BET) technique. Its potential as a sorbent medium was evaluated in a batch adsorption system. Experiments were performed as a function of pH (2-9), contact time (5-60 min), temperature (295, 305 and 315 K), solute concentration (5-500 mg L<sup>-1</sup>) and adsorbent dose (0.2-10 g L<sup>-1</sup>). With the optimal process conditions the adsorption efficiency was over 95%. Sorption kinetics and isotherms fitted better with the pseudo-second-order and Langmuir models as compared with the pseudo-first-order and Freundlich models, respectively. Experimental, theoretical and simulation research on the processing, structure and properties of the obtained activated carbon has shown that chemically active and highly porous surface, little processing, excellent sorption capacity, and the abundance of feedstock for sorbents preparation, allow this material to attract and retain certain organic and inorganic pollutants in a preferential, very efficient and cost-effective way.

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## **MONITORING KONCENTRACIJE KLORIDA I SULFATA U BUNARIMA B-17 I B-18 CRPILIŠTA VINOGRADI KOD OSIJEKA**

### **MONITORING CONCENTRATION OF CHLORIDES AND SULPHATES IN THE WELLS B-17 AND B-18 WATER SUPPLY VINOGRADI NEAR OSIJEK**

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Crpilište Vinogradi nalazi se zapadno od garda Osijeka i obuhvaća 18 bunara, gdje se analiza kvalitete i zdravstvene ispravnosti vode kontinuirano provodi. Iako se monitoring kvalitete podzemne vode vodocrpilišta Vinogradi vrši jednom mjesečno u ovom radu prikazani su rezultati od 2011. do 2016. godine. Ova studija istražuje i utvrđuje promjene u koncentraciji klorida i sulfata u bunarima B-17 i B-18 tijekom višegodišnjeg monitoringa. Podaci o kretanjima koncentracije sulfata i klorida statistički su obrađeni. Tijekom 2014. godine zabilježene su minimalne koncentracije sulfata i klorida u bunarima B-17 i B-18. Vrijednost koncentracije klorida od 8,22 mg Cl<sup>-</sup>/l i sulfata od 5,68 mgSO<sub>4</sub><sup>2-</sup>/l izmjerena je u B-17, dok su bunaru B-18 izmjerene koncentracije klorida od 26,83 mg Cl<sup>-</sup>/l i sulfata od 33,83 mgSO<sub>4</sub><sup>2-</sup>/l. Značajno je da zadnjih tri godine koncentracije klorida i sulfata imaju tendenciju rasta pri čemu se narušava kvaliteta vode, iako još daleko ispod maksimalno dozvoljenih vrijednosti što se može objasniti njihovom lokacijom (neposredna blizina Brondinog kanala).

## **METHOD VALIDATION OF MICROCYSTIN-LR IN WATER**

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The worldwide occurrence of cyanobacterial blooms due to water eutrophication evokes extreme concerns. These blooms produce cyanotoxins which are hazardous to living organisms. Microcystin-LR (MC-LR) is the most toxic and the most frequently encountered toxin produced by the cyanobacteria in the contaminated water. Microcystin-LR is a potential carcinogen for animals and humans, and the International Agency for Research on Cancer has classified MC-LR as a possible human carcinogen. The water samples were sonicated at ambient temperature for 30min to break down all the algae wich may contain microcystin. After passed through a 45 µm regenerated cellulose filter membranes, the spiked samples were concentrated by Oasis HLB. Filters with planktonic material was extracted twice with methanol:acidified water (90:10, V/V) by sonication in an ultrasonic bath. The extract was centrifuged and supernatant was evaporated to 5 mL in stream of nitrogen. The concentrated extract was diluted in acidified water and clean-up by SPE procedure. The eluate evaporate near dryness, then resolved in mobile phase and analyzed by LC-MS/MS. The calibration curve of MC-LR was linear within the range of 20-400 ng/mL (0.1-2.0 µg/L). The R<sup>2</sup> was 0.9938. Average recovery (0.1; 05 and 1.0 µg/L) was 83.6±12.20. The LOQ was 0.10 µg/L.

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**REVITALIZACIJA I KAKVOĆA VODE KUPALIŠTA  
„BIZOVAČKI BAJER“**

**REVITALIZATION AND WATER QUALITY OF BRICK  
FACTORY POND „BIZOVAČKI BAJER“**

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Bizovac je jedno od rijetkih slavonskih naselja koje se može pohvaliti s dva atraktivna kupališta, Termalnom rivijerom Aquapolis u sklopu Bizovačkih toplica te kupalištem "Bizovački bajer" nastalim dugogodišnjim iskapanjem gline za potrebe tvornice opeka "Ciglana Bizovac". "Bizovački bajer" već je generacijama mladih omiljeno izletišta i kupalište, a čini ga nekoliko umjetnih jezera čija dubina seže i do 6 metara. Procjenjuje se da je ukupna vodena površina veća od 15 hektara, a kakvoću vode Bizovačkog bajera potvrđuje i raznovrsni riblji fond. Cijelo kupalište okruženo je niskom travom nekadašnjeg mjesnog pašnjaka te nekolicinom mladih nasada topole i vrba. U cilju revitalizacije i korištenja ove vodne cjeline, Općina Bizovac pokrenula je, u suradnji s mjesnim sportsko-rekreativnim društvima, pripremu projekta revitalizacije izletišta oaze "Bizovački bajer". Navedenim projektom revitalizacije ovog izletišta planira se izgradnja kompletne infrastrukture i različitih sportsko-rekreativnih sadržaja, a u okviru ovog projekta provodit će se i kontinuirani nadzor kakvoće kupališne vode "Bizovačkog bajera" u cilju očuvanja i zaštite okoliša te očuvanja ljudskog zdravlja. U ovom radu prikazani su planirani zahvati na vodnom tijelu "Bizovačkog bajera" te rezultati analiza vode "Bizovačkog bajera" koje, tijekom kupališne sezone, provodi Zavod za javno zdravstvo Osječko-baranjske županije.

## **TECHNOLOGIES FOR REMOVAL OF UV FILTERS**

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UV filters are compounds used in cosmetics and in several materials (e.g. plastics, adhesives, rubber) for prevention of damage due to sunlight irradiation. These compounds are considered to be emerging contaminants, due to their presence in the environment and the fact that the risks associated with their presence are still insufficiently researched. As a result of widespread use of UV filters, the majority of these compounds ends up in wastewater, where they are usually not removed or degraded in wastewater treatment plants (WWTPs). The consequence could be contamination of natural water resources, i.e. rivers, lakes and oceans. The removal of UV filters in WWTPs greatly depends on the implemented technology. In this paper, the removal technologies for two UV filters, benzophenone-3 ((2-Hydroxy-4-methoxyphenyl)-phenylmethanone) and octocrylene (2-ethylhexyl 2-cyano-3,3-diphenylprop-2-enoate) were researched. These two compounds were selected for research because benzophenone-3 is considered to be more hydrophilic and octocrylene more lipophilic. The best technology for removal of both of these compounds is reported to be membrane filtration, especially reverse osmosis membranes.

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**Kazalo autora / *Author index***

A

Adamović Dragan 43, 91, 97, 107  
Agbaba Jasmina 47, 54, 60, 76, 88  
Akyol Birkan 44  
Alpaslan Necdet 44  
Amić Ana 45  
Anđelić Tea 63  
Anić Vučinić Aleksandra 2  
Antov Mirjana 77  
Antunović Kazimir 34  
Apostolović Tamara 47, 76  
Atkovska Katerina 48, 87

B

Babić Hrvoje 14  
Babić Jasenka 105  
Baić Lucija 38  
Bajić Jovan 91  
Bajramović Emir 67  
Bakrač Azra 39  
Balić Tomislav 11  
Barač Branimir 3  
Batinić Branislav 91  
Bečvardi Ljiljana 11  
Benka Pavel 58  
Bezovska Viktorija 51  
Bežanović Veselin 43  
Bijelić Jelena 74  
Blazhevska Tatjana 99  
Blažić Marijana 106  
Bobar Sejit 49, 85  
Bošković Nikola 107  
Bounoughaz Moussa 41  
Bozhinovski Zoran 15, 28, 32  
Bubalo Kovačić Marina 50  
Bubalo Marina 93  
Bulog Aleksandar 24  
Buljubašić Sanel 65  
Bursić Vojislava 61, 109  
Bušić Valentina 58

C

Cekova Blagica 51, 70

Cenov Arijana 24  
Ciglencečki Irena 94  
Cliburn Matt R. 92  
Clode Peta L. 92  
Crevar Biljana 33  
Cvejić Sandra 61

Č

Čagalj Dario 105  
Čavić Aleksandra 52  
Čepić Zoran 111  
Čobanković Iva 42  
Čustović Selma 10  
Čvarković Radomir 62

Ć

Ćavar Suzana 14  
Ćirić Vladimir 58

D

Dalmacija Božo 47, 54, 60, 76, 88  
Dedić Samira 39  
Dimitrovski Dejan 32  
Drahotuski Zdenko 110  
Dubić Petra 50  
Dušak Vesna 27

DŽ

Džaferović Aida 39

Đ

Đerđ Igor 74  
Đogo Maja 52  
Đugum Jelena 68  
Đukić Marina 109  
Đurakovac Amela 53  
Đurić Simonida 58  
Đurin Bojan 7, 38  
Đurkić Tajana 54

**Kazalo autora / Author index**

---

**E**

Ergović Ravančić Maja 55  
Erhan Mustafa 28

**F**

Filipović Lana 56, 57  
Filipović Vilim 56, 57, 93  
Flanjak Ivana 101  
Fleit Ernő 86  
Frank Georg 30

**G**

Galić Ivo 94  
Gašo-Sokač Dajana 58  
Gjorgjievski Ilinka 99  
Glad Marin 24  
Glumac Nada 7  
Gotal Dmitrović Lovorka 27  
Grabić Jasna 58, 61, 109  
Grgić Marko 60  
Gross-Bošković Andrea 82  
Grozdanov Anita 48, 61  
Guagliardo Paul 92  
Gudelj Ivana 13  
Gvozdencac Sonja 109

**H**

Habuda-Stanić Mirna 15, 17, 19, 20, 29, 32,  
55, 58, 62, 68, 80, 82, 90, 108, 110  
Hajdinger Andreja 5  
Hajduk Gordana 22  
Halambek Jasna 106  
Harangozo Dora 11  
Hengl Brigita 105

**I**

Ibrahimpašić Jasmina 39  
Igrc Marina Diana 56  
Inmeler Ceyla 96  
Ivanković Anita 63  
Ivanković Ivana 50

Ivanković Predrag 63  
Ivešić Martina 16

**J**

Jahić Munir 65, 67  
Jakab Jelena 79  
Jakopec Mario 108  
Jakupi Shaban 87  
Jerković Marta 12  
Jerković Nebojša 68  
Josipović Marko 40  
Josipović Renata 83  
Jovanov Dragan 51, 70  
Jovanovski Filip 51  
Jozanović Marija 11  
Jurković Martina 19, 33  
Jurlina Davor 71

**K**

Kajtažović Azra 67  
Karl Matej 71  
Karnaš Maja 11  
Katić Ines 13  
Kenjerić Daniela 19  
Kezerle Antonija 34, 72  
Klapec Tomislav 33  
Kolarić Dario 14  
Korica Milenko 74  
Kovač Sanja 38  
Kovač Tihomir 33, 80  
Kovač-Andrić Elvira 75  
Kovačević Srđan 111  
Kragulj Isakovski Marijana 47, 54, 60, 76  
Kralj Edgar 20  
Kralj Ksenija 20  
Kralj Marika 14  
Kranjčec Filip 56, 93  
Kraševac Marija 11  
Krčmar Dejan 47, 88  
Krivohlavek Adela 16  
Kukić Dragana 77  
Kukučka Andrej 78  
Kukučka Miroslav 78  
Kukučka Stojanović Nikoleta 78

Kuna Lucija 79  
Kuvendziev Stefan 15, 28, 32, 48, 87

L

Landeka Dragičević Tibela 1  
Leko-Kos Marija 4  
Lešić Stjepanka 71  
Lisichkov Kiril 15, 28, 32, 48, 70, 87, 104  
Lončarić Ante 80  
Lučić Lavčević Magdi 81  
Lušić Dražen 24

LJ

Ljatif Mahi 15, 28, 48  
Ljayifi Eyup 28  
Ljubić Nataša 72

M

Magdić Damir 82  
Majdančić Meho 40  
Majstorović Jerina 63  
Makić Halid 39  
Maletić Snežana 54, 60, 76  
Maloić Mario 56  
Marinkovski Mirko 15, 28, 32, 48, 87  
Markoska Vesna 70  
Marković Milenija 52  
Marković Monika 40  
Martinez Sanja 41  
Mastanjević Kristina 34  
Mateljak Zoran 68  
Matijević Bojan 106  
Matijević Leonard 105  
Matijević Marko 71, 100  
Matijević Mato 101  
Maurović Nada 56  
Medverec Knežević Zvonimira 83  
Medvidović-Kosanović Martina 11  
Mehović Munir 49, 85  
Melicz Zoltán 86  
Memedi Hamdije 87  
Menkinoska Marija 99  
Mihajlović Ivana 52, 91

Mikac Nevenka 94  
Milinković Dragana 90  
Mirceski Valentin 104  
Molnar Jazić Jelena 54, 76, 88  
Musić Valerija 16  
Mustać Ivan 56

N

Nadih Martina 83  
Nađ Lucija 7  
Nakić Domagoj 2  
Nastić Nataša 77  
Nevistić Ante 20  
Nikšić Korana 89  
Novoselić Edon 4  
Nujić Marija 17, 29, 80, 90

O

Obradović Dino 36  
Obrovski Boris 52, 91  
Omanović Tea 79  
Ondrašek Gabrijel 50, 92, 93  
Opačak Danijela 83  
Orlović-Leko Palma 94  
Ovuka Jelena 61

P

Paić Angelina 108  
Pala Ayşegül 96  
Pap Sabolč 43, 97, 107  
Pašić Melita 108  
Paurević Marija 75  
Pavelić Ana 89  
Pavelić Mara 98  
Pavlova Valentina 99  
Pavlović Hrvoje 34, 102  
Pavlovska Martina 99  
Pehlivaner Gökçe 103  
Pejakić Marija 100  
Penava Antonio 81  
Penava Ariana 101  
Petošić Dragutin 56  
Petrić Jasenka 105

**Kazalo autora / Author index**

---

Petrović Aleksandra 109  
Petrović Danijela 63  
Podravac Dijana 33, 102  
Pofuk Dunja 13  
Popović Aleksandra 109  
Prodanović Jelena 77  
Ptiček Siročić Anita 7

**R**

Radonić Jelena 43, 97, 107, 111  
Raguž Lučić Nikola 79  
Rajs Vladimir 91  
Reka Arianit A. 87  
Rengel Zed 92  
Romić Davor 50, 92, 93  
Romić Željka 108  
Rončević Srđan 60, 76, 88  
Rožac Vlatko 17, 30  
Ruseska Gordana 48

**S**

Sakač Nikola 11  
Sak-Bosnar Milan 11  
Santo Vera 14, 20, 110  
Savić Radovan 93  
Schwen Andreas 57  
Sekulić Mirjana 53  
Selec Hrvoje 27  
Smolić Martina 79  
Sokolić Darja 19  
Spasojević Jelena 60  
Sponza Delia Teresa 103  
Stević Filip 17, 62  
Stojanov Leon 104  
Stražanac Danijela 105  
Sučić Hrvoje 14  
Suver Josip 26

**Š**

Šag Matej 17  
Šarić Goran 106  
Šarkanj Bojan 33  
Šćiban Marina 77

Šikić Sanda 16  
Šikić Sandra 9  
Šiljeg Mario 2  
Šimunić Ivan 56  
Školka Anastazija 17  
Šolević Knudsen Tatjana 107  
Šoštarić Jasna 40  
Španja Save 9  
Šperac Marija 36  
Špoljarić Maronić Dubravka 17  
Šrajter Gajdošik Martina 75

**T**

Tadić Igor 3  
Tadić Lidija 5, 12, 45  
Tatić Mladen 61  
Tolić Sonja 16  
Tompić Teuta 22  
Toromanović Merima 39  
Touabi Noura 41  
Tričković Jelena 47, 61, 76  
Tubić Aleksandra 47, 54, 60, 88  
Turk Dunja 22  
Turk Sekulić Maja 43, 97, 107, 111

**V**

Vasić Vesna 77  
Včev Aleksandar 79  
Velić Darko 34  
Velić Natalija 34, 72, 102  
Vešligaj Turkalj Jelena 108  
Vojinović Miloradov Mirjana 52, 91  
Vouk Dražen 2  
Vrabec Denis 4  
Vrdoljak Martina 71  
Vukić Lušić Darija 24  
Vuković Dora 110  
Vuković Gorica 109  
Vuković Srećko 110

**W**

Watson Malcolm 88  
Weninger Thomas 57

|                     |                                  |
|---------------------|----------------------------------|
| Y                   | Zobundžija Dora 58               |
|                     | Zovko Mira 13                    |
| Yilmaz Baris 44     | Zovko Monika 50, 92, 93          |
| Z                   | Ž                                |
| Zavadlav Sandra 106 | Živančev Nevena 43, 52, 107, 111 |
| Zemunac Radoš 109   | Žuna Pfeiffer Tanja 17           |

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