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# WATER FOR ALL

21-22 March 2019  
Osijek, Croatia

BOOK OF ABSTRACTS





**8. međunarodna konferencija**

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## **VEZA VODE & ENERGIJE - VEZA ISTOKA I ZAPADA**

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Mjerila moći neke države su razvijena ekonomija, stabilna politička situacija, veličina vojske, .... Međutim, bez vode i energije ne da nema stabilne i jake države, nego nema života! Zapadna civilizacija, bez obzira na razvijenost, nažalost ima probleme oko količine i kakvoće vode. Istočna isto tako. Tko ima više problema, tko manje, tko ih efikasnije rješava, .... Teško je dati odgovor. Ali nije teško započeti zajedničku suradnju na rješavanju tih problema. Uzbekistan i Tajland dvije su zanimljive i egzotične azijske zemlje. Svaka od njih ima specifične probleme oko vode i energije, baš kao i Hrvatska. Tijekom međusobne suradnje i posjeta, donesen je (zajednički!) stav da si možemo pomoći. Korištenje obnovljivih izvora energije, metode racionalnog korištenja vode, povećanje energetske učinkovitosti, .... Mnogo toga možemo naučiti i vidjeti na primjeru Azije.

*Ključne riječi: voda, energija, održivost, Uzbekistan, Tajland*



## CONNECTION OF WATER & ENERGY - CONNECTION OF EAST AND WEST

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Measures of power of any state are developed economy, a stable political situation, size of the army, .... However, without water and energy there is no any stable and strong state, but also there is no life! Western civilization, regardless of its development, unfortunately has problems with quantity and quality of the water. Eastern also. Who has more problems, who less, who can handle them more efficiently, .... It is difficult to answer on this. But it is not difficult to start joint collaboration regarding solving these problems. Uzbekistan and Thailand are two interesting and exotic Asian countries. Each of them has specific water and energy problems, just like Croatia. During mutual collaboration and visit, it was enact (joint) attitude that we can help to each other. Using of renewable energy sources, rational water usage methods, increasing of energy efficiency, .... Much can be learned and seen in example from Asia.

*Keywords: water, energy, sustainability, Uzbekistan, Tajland*



## **MEĐUNARODNI INSTRUMENTI KAO PODRŠKA JEDNAKO DOSTUPNE ZDRAVSTVENO ISPRAVNE VODE ZA LJUDSKU POTROŠNJU ZA SVE - EUROPSKA PERSPEKTIVA**

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Milijuni ljudi u Europskoj Regiji Svjetske zdravstvene organizacije (SZO) konzumiraju kontaminiranu vodu. Svakoga dana 14 ljudi umire od dijareje, uzrokovane upotrebom neodgovarajuće vode za ljudsku potrošnju, lošom higijenom i sanitarnim uvjetima. U kućanstvima 57 milijuna ljudi nema opskrbe vodom iz vodovoda, a 21 milijun nema pristup osnovnoj vodoopskrbi. Također, 36 milijuna ne posjeduje osnovne sanitarne uvjete. Ovakvo stanje zahtjeva aktivnosti za unaprjeđenje i to ne samo u Europi nego i širom svijeta. Zemlje članice Ujedinjenih Naroda su usvojile Agendu 2030 za Održivi Razvoj sa setom od 17 Ciljeva Održivog Razvoja. Postizanje univerzalne i ravnopravno dostupne zdravstveno ispravne vode za ljudsku potrošnju, higijene i sanitarnih uvjeta je središnje mjesto u Cilju 6, kao i u dijelovima Cilja 3 koji je posvećen zdravlju. U 2017. zemlje Europske Regije SZO su usvojile Ostravsku Deklaraciju u kojoj su se obavezale na djelovanje u cilju osiguranja sveobuhvatne, pravedne i održive opskrbe zdravstveno ispravne vode za ljudsku potrošnju i odgovarajuće sanitarne i higijenske uvjete za sve i na svakom mjestu. 1999. godine europske države su usvojile Protokol o vodi i zdravlju koji je podržan zajednički od SZO i UNECE. Protokol je vrlo učinkovit alat za podršku vođenja politika u ovom području. On zahtjeva od svih zemalja uspostavljanje nacionalnih ciljeva i implementacijske planove za vodu, sanitarne uvjete i zdravlje.

*Ključne riječi:* univerzalna i ravnopravna dostupnost zdravstveno ispravne vode za ljudsku potrošnju, međunarodni instrumenti, Ciljevi Održivog Razvoja, Ostravska Deklaracija, Protokol o vodi i zdravlju



## **INTERNATIONAL INSTRUMENTS AIMING TO SUPPORT THE EQUITABLE ACCESS TO SAFE DRINKING WATER FOR ALL – THE EUROPEAN PERSPECTIVE**

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Millions of people in the WHO European Region drink contaminated water. Every day 14 people die of diarrhea due to inadequate water, sanitation and hygiene. 57 million people do not have piped water at home and 21 million people still lack access to basic drinking-water services. Moreover 36 million people do not enjoy access to basic sanitation. This situation is calling for an action, not only in Europe, but world-wide. Member States of the United Nations adopted the 2030 Agenda for Sustainable Development with a set of 17 Sustainable Development Goals. Achieving universal and equitable access to safe and affordable drinking-water, sanitation and hygiene for all is in the core of the Goal 6 as well as in the parts of the Goal 3 which is dedicated to health. In 2017, Member States in the WHO European Region agreed to the Ostrava Declaration, committing them to act and ensure universal, equitable and sustainable access to safe drinking-water, sanitation and hygiene for all and in all settings. In 1999, European Member States adopted the Protocol on Water and Health, which is jointly supported by WHO and UNECE. It provides an effective policy tool, calling on countries to establish national targets and implementation plans related to water, sanitation and health.

*Keywords:* universal and equitable access to safe water, international instruments, Sustainable Development Goals, Ostrava Declaration, Protocol on Water and Health



## **INTEGRATED ASSET MANAGEMENT – WHY WE ARE WHERE WE ARE TO-DAY, AND WHERE WILL WE BE IN NEAR FUTURE?**

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This presentation is aimed to give a general message on the way asset management has been practiced since «modern» urban water systems were established in 1850's. The author has followed the development by being a partner in several national (Norwegian) and international (EU) projects since 1975. He has coordinated three EU projects on asset management since 2001 and been a lead partner in several recent international projects. The presentation will provide several examples on technical developments as well as planning routines. Asset management has a history, which began before the term asset management was invented for urban water systems, in fact it existed from the beginning of modern water services, defined by pipelines and water treatment systems. The activities related to management has shifted from time period to time period, however, a common factor has been good handcraft on building pipelines, use of materials with long durability as well as treatment systems with high efficiency. We can distinguish the 170 years passed since modern urban water systems appeared in 1850's into three periods:

1950- 1970 **Sanitation period**, clean water to consumers and no pollution in vicinity of households. The technological development comprises pipe materials, knowledge of needed strength and important degradation mechanisms of the pipeline materials.

1970-2000 **Environment concern period**, where the environmental impact of sanitary systems has been focused. Here the efforts have been to collect as much wastewater as possible, reduce losses via CSO's by separating wastewater and stormwater and capacitate treatment plants to minimize pollution loads to receiving waters.

2000-2020 **Resilience, risk management, sustainable performance and green economy**, with focus on measurement of risk and resilience related to water supply, environmental impact and capacity to meet impact of climate changes. A large portion of the water infrastructure is already built but it is necessary to provide a regular upgrade and a professional operation and maintenance. Several technologies have been developed to support this development.

The rapid development of digital systems including new sensors, wireless transmission systems, tools for analyzing collected information (extended SCADA, machine learning) is going to provide a revolution within rehabilitation planning, by enabling the city engineer to take better solutions and perform actions more correct and timely that have been possible until now.

We are more aware of principles for good governance, and groups of stakeholders will be given more influence in the future, for example via «Communities of Practice» or more extensive agreements between groups of users. It is expected that management will be improved and that this will result in better reliability and resilience of water services and cost savings.

*Keywords:* water management, urban water systems, water supply system, sewerage



**Usmena priopćenja / *Oral lectures***

**Poljoprivreda i vodni resursi /**  
***Agriculture and Water Resources***





## ENVIRONMENTAL FATE OF THREE PHARMACEUTICAL OCCURRING IN WASTEWATER USED IN AGRICULTURAL IRRIGATION IN CENTRAL MEXICO

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The environmental fate of ibuprofen, primidone and triclocarban in an irrigation system reusing wastewater was studied at lab-scale through photodegradation, biodegradation and soil column transport experiments, which simulated the conditions of the field. Samples of wastewater used for irrigation, a long-term irrigated soil as well as surface and groundwater were taken from the irrigated area for these experiments. Results showed that the three compounds are susceptible of being photo and biodegraded in the matrices tested; the order at which compounds were degraded by both processes was ibuprofen>triclocarban>primidone. Compounds showed higher rate of photodegradation in surface water than in wastewater and soil, while biodegradation was more rapid in wastewater and soil than in natural waters. Primidone was more susceptible to be photodegraded than biodegraded in all of the tested matrices. In the transport experiments, ibuprofen was the most mobile compound, while primidone and triclocarban were more strongly retained onto the soil, presumably by sorption onto the organic domain in the solid matrix. ibuprofen resulted to be retained and degraded in the soil matrix as it passes through the first 60 cm depth of the soil profile, therefore it is considered as an important topic to evaluate the occurrence and environmental fate of the by-products produced of this compound.

*Keywords:* environmental fate, pharmaceuticals, wastewater reuse



## **GROUNDWATER PROTECTION AND POLLUTION CONTROL: TRACE METALS MOBILITY AND TRANSPORT IN SOIL**

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Environmental protection and pollution control in the water-soil-plant continuum are emerging as topics of particular interest in the last few decades, for the both, scientific and public sector. One of the reasons for such attention is that the numbers of potentially harmful substances introduced in the environment are rising, and especially of those originating from agricultural practices and industry. Anthropogenic inputs of TMs to agricultural soils are mostly through organic waste amendments (sewage sludge, bio-waste, municipal waste), agro-chemicals, fertilizers, atmospheric deposition and accidental inputs; whilst main output fluxes are leaching and TMs removed by crops. Most of the substances applied in agricultural production are useful in the soil surface layer, but they can cause pollution and degradation of natural resources due to their leaching into deeper soil layers and groundwater. Mobility and transfer of soil solutes (including TMs) is usually closely linked with the water flow through soil vadose zone. If TMs are found in their mobile form (species) in the soil solution, they can be transported through soil profile simultaneously with water flow, thus posing a risk for groundwater pollution. Therefore, TMs chemical speciation modelling approach is widely used in studies of soil and groundwater contamination and risk assessment.

*Keywords:* solute transport, trace metals speciation, leachate, groundwater contamination



## OCJENA SPECIFIČNE RANJIVOSTI VODONOSNIKA NA NITRATE I LINDAN NA ŠIREM PODRUČJU REGIONALNOG CRPILIŠTA „ISTOČNA SLAVONIJA“ PREMA EUROPSKIM EKOLOŠKIM STANDARDIMA

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Vodonosnici na području istočne Slavonije, pripadaju aluvijalnim naslagama rijeke Bosne, u kojima se nalazi crpilište „Istočna Slavonija“ Sikirevci. U radu se definira geografska površina vodonosnog horizonta Velika Kapanica te analizira krovina pokrovne naslage u smislu zaštite podzemnih voda te se prikazuju rezultati istraživanja provedenih na temelju terenskog rekognosciranja i prikupljenih podataka sa područja Federacije Bosne i Hercegovine i Republike Hrvatske. Utvrđeno je da podzemna voda koja se crpi na zdencima priljevnog područja sadrži vrijednosti željeza, mangana, prirodnog amonijaka i arsena viših od MDK za pitku vodu sukladno zakonskoj regulativi, a koji su posljedica prirodnih reduktivnih uvjeta u vodonosnoj sredini. Europski ekološki standardi među najvišima su u svijetu te je upravo „europskim pristupom“ procjene specifične ranjivosti i prema protokolu koji je predložen u sklopu projekta COST Action 620 te primjenom COP metode određena ocjena specifične ranjivosti vodonosnika na nitrate i lindan.

*Ključne riječi:* europski ekološki standardi, ocjena specifične ranjivosti vodonosnika, regionalno crpilište "Istočna Slavonija"



**EVALUATION OF SPECIFIC VULNERABILITY OF THE AQUIFERS ON  
NITRATES AND LINDANE IN THE REGIONAL AREA OF THE  
REGIONAL WELL FIELD "EASTERN SLAVONIA" ACCORDING TO  
EUROPEAN ECOLOGICAL STANDARDS**

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Aquifers in the area of eastern Slavonia belong to the alluvial deposits of the river Bosna, where the "Eastern Slavonia" well field Sikirevci is based. This paper defines the geographic surface of the aquifer Velika Kapanica and analyzes the roof covering of groundwater in terms of groundwater protection and presents researches conducted on the basis of field recognition and data collected from the territory of the Federation of Bosnia and Herzegovina and the Republic of Croatia. European ecological standards are among the highest in the world so the "European approach" is being used for assessing specific vulnerability and the protocol proposed under the COST Action 620 project and using the COP method to assess the specific vulnerability of the aquifers on Nitrate and Lindane.

*Keywords:* European ecological standards, evaluation of specific vulnerability of the aquifer, regional well field "Eastern Slavonia"



## ANALIZA MOGUĆNOSTI NAVODNJAVANJA ZADARSKOG ZALEĐA KORIŠTENJEM VODE IZ HIDROTEHNIČKIH SUSTAVA NA SLIVU RIJEKE ZRMANJE I LIČKOM PLATOU

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Analizom je obuhvaćeno 17.561 ha poljoprivrednih površina na području Zadarske županije, koje su podijeljene u 13 funkcionalnih cjelina. Potrebne količine vode za navodnjavanje predmetnih površina u sušnoj godini iznose 46,5 mil. m<sup>3</sup>. U tom obimu, na ovom prostoru, su kao mogući izvori identificirani slivovi Ličkog platoa i sliv rijeke Zrmanje. Pri bilanciranju raspoloživih količina vode uvaženi su zahtjevi svih „korisnika“ u slivu i to prema prioritetima, ekološki, vodoopskrbni, energetske i navodnjavanje. Analiza mogućnosti zahvaćanja vode za navodnjavanje na slivu rijeke Zrmanje je usmjerena na lokacije planiranih višenamjenskih hidrotehničkih sustava HE Ervenik i HE Zrmanja. Pregradni profil HE Žegar je izostavljen u ovoj analizi zbog značajnih gubitaka vode koji se javljaju na uzvodnoj dionici. Proizvodni potencijal HE Ervenik u prosječnoj godini iznosi 41 GWh, a na HE Zrmanja 28 GWh. Budući da je pregradni profil HE Ervenik pozicioniran najuzvodnije te je visinski povoljniji u odnosu na navodnjavane površine, a za što je, iskazano kroz utrošak energije u prosječnoj godini, potrebno oko 25 GWh, a to je 17 GWh manje u odnosu na vlastitu proizvodnju. Pregradni profil HE Zrmanja je visinski nepovoljniji u odnosu na navodnjavane površine, jer je za dobavu istih količina vode potrebno utrošiti 38 GWh električne energije što premašuje njenu prosječnu godišnju proizvodnju za 10 GWh. Sveukupni investicijski troškovi prve opcije iznosili bi 5,6 milijardi kuna, a operativni i pogonski troškovi 1,75 kn/m<sup>3</sup> distribuirane vode za navodnjavanje. Dok bi investicija u drugu opciju bila niža, odnosno 5,1 milijardi kuna, ali s višim operativnim i pogonskim troškovima od 2,08 kn/m<sup>3</sup> distribuirane vode. Za vode sliva Ličkog platoa se može konstatirati da su većim dijelom već i danas iskorištene u sustavu RHE Velebit, a mogućnost korištenja preostalog vodnog potencijala je ograničena kako u pogledu njena akumuliranja tako i transfera do površina za navodnjavanje. Jedina moguća opcija korištenja voda s Ličkog platoa bi bila zahvaćanje prethodno korištene vode u RHE Velebit, odnosno iz akumulacije Razovac. Zahvat vode iz akumulacije Razovac visinski približno odgovara zahvatu na HE Zrmanja stoga im je prosječni godišnji zahtjev za energijom identičan i iznosi oko 38 GWh. Sveukupni investicijski troškovi ove opcije su najniži i iznose 4,9 milijardi kuna, međutim, zbog nemogućnosti pokrića pogona iz vlastite proizvodnje, operativni i pogonski troškovi su izuzetno visoki i iznose 2,91 kn/m<sup>3</sup> distribuirane vode. Usporedbom sveukupnih troškova ovih opcija u razdoblju od 50 godina, zahvat vode na pregradnom profilu HE Zrmanja se pokazao kao optimalna opcija kojom se osigurava navodnjavanje značajnog dijela poljoprivrednih površina Zadarske županije.

*Ključne riječi:* Zadarska županija, Zrmanja, Lički plato, višenamjenski hidrotehnički sustav, navodnjavanje

### WATER POTENTIAL FROM HYDRO-TECHNICAL SYSTEMS IN ZRMANJA RIVER BASIN AND LIKA PLATO FOR IRRIGATION PURPOSE IN THE ZADAR COUNTY





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The analysis included 17.561 ha of agricultural land in the Zadar County area, which were divided into 13 functional units. In the dry year irrigation water requirements of the scope area are 46.5 million m<sup>3</sup>. Available water sources are basins Lika plato and river Zrmanja basin. According to the priorities all “users” in the basin were taken into account, ecological, water supply, energy and irrigation. Available water for irrigation from river Zrmanja is directed at the two locations of planned multipurpose hydro technical systems HE Ervenik and HE Zrmanja. In the profile of the HE Žegar analysis was omitted due to significant water losses on the upstream section. The production capacity in the average year is 41 GWh on the HE Ervenik and 28 GWh on the HE Zrmanja. Since the HE Ervenik profile is located higher upstream and it is at a suitable elevation compared to the irrigated area, expressed as energy consumption in the average year it is needed 25 GWh, which is 17 GWh less compared to its own production capacity. HE Zrmanja profile is located lower according to the irrigated area and it is necessary 38 GWh of energy for the same amount of water, which exceeds its average annual production capacity for 10 GWh. The total investment costs of the first option are 5,6 billion HRK, while operation and maintenance costs are 1.75 HRK/m<sup>3</sup> of distributed water for irrigation. While the investment in the second option is lower and it is 5.1 billion HRK, but with higher operation and maintenance costs of 2.08 HRK/m<sup>3</sup> of distributed water. Available waters from the Lika plato today are used in the RHE Velebit hydro energy system. Additional water amount is limited both in terms of its accumulation and distribution to the irrigation area. The only solution for using water from Lika plato basin is pre-used water in the RHE Velebit reservoir Razovac. Elevation of the Razovac reservoir is approximately equal to the HE Zrmanja profile, therefore the average annual energy demand is 38 GWh. The total investment costs of this option are the lowest with the amount of 4.9 billion HRK, but there is no capacity to cover the energy consumption from own production so operation and maintenance costs are 2.91 HRK/m<sup>3</sup> which is extremely high. Comparing the total costs of these options through the 50 year period, the HE Zrmanja profile is indicated as an optimal option which provides multipurpose system with ability to ensure irrigation of a significant part of the agricultural area of the Zadar County.

*Keywords: Zadar county, Zrmanja, Lika plato, multipurpose hydro technical system, irrigation*



## KORIŠTENJE VODE U POLJOPRIVREDI

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Poljoprivreda je prema svjetskim podacima najveći korisnik vode u odnosu na industriju i domaćinstva sa udjelom od 70 %. Prema FAO podacima i predviđanjima za razdoblje od 1950 – 2030. godine potrošnja vode u poljoprivredi je u stalnom porastu. Povećanje broja stanovnika u svijetu a time i sve veća potreba za hranom, te sve veća pojava sušnih godina ima za posljedicu intenziviranje poljoprivredne proizvodnje, a time i veće korištenje vode u poljoprivredi. Stočarstvo i navodnjavanje su najveći potrošači vode u poljoprivredi. U Europi poljoprivreda koristi 30 % vode u poljoprivredi a u Hrvatskoj to je tek 2 %, što nažalost daje sliku stanja u stočarstvu i primjeni navodnjavanja. Osim što je veliki korisnik vode, poljoprivreda je i veliki potencijalni zagađivač nitratima i pesticidima i to površinskih i podzemnih voda. Voda je u biljnoj proizvodnji u vrlo složenim, dinamičkim, fizikalnim, biokemijskim odnosima u tlu. Voda u poljoprivredi dolazi iz oblaka, zadržava se u tlu, biljke je usvajaju i ispuštaju u atmosferu. Složen je proces određivanja potrebnih količina vode za rast i razvoj biljaka i dodatno je potrebno uložiti znanje, rad, financijska sredstva i primijeniti tehniku da bi se osigurali optimalni uvjeti za rast i razvoj biljaka bez obzira da li se radi o suvišku ili manjku vode u tlu. Stočarske govedarske farme su veliki potrošači vode gdje se potrebe za vodom kreću i do 150 litara vode/grlu/danu.

*Ključne riječi:* poljoprivreda, voda, navodnjavanje, stočarstvo



## **THE USE OF WATER IN AGRICULTURE**

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In accordance with the global data, agriculture is the largest water user, compared to the industry and households, with a share amounting to 70%. Pursuant to the FAO data and anticipations for the 1950–2030 period, water consumption in agriculture has been permanently increased. An increase in the number of inhabitants worldwide, thus creating an ever so prominent food demand and an increasing phenomenon of drought years, eventuates in an intensification of agricultural production and an increased water usage in agriculture hereby. In Europe, agriculture consumes 30% of water, amounting to only 2% in Croatia, which unfortunately portrays the picture of a cattle breeding status and irrigation. In addition to being a major water consumer, agriculture is also a large-sized potential polluter by nitrates and pesticides when it comes to the surface and subterranean waters. In plant production, water is the very complex, dynamic, physical and biochemical relations in the soil. Water in agriculture arrives from the clouds, is kept in the soil, is absorbed by the plants and released by them in the atmosphere. Complex is a process of determination of necessary water quantities for a plant growth and development, so it is necessary to invest additional knowledge, labor, and finances and apply the technical resources to provide the optimal conditions for the plant growth and propagation, irrespective of a fact whether it pertains to a water surplus or water scarcity in a soil. The cattle breeding farms are major water consumers, where a water need may amount to even 150 liters per head or per day.

*Keywords:* agriculture, water, irrigation, cattle breeding



## VODA - TEMELJ ŽIVOTA NA PLANETU ZEMLJA

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Usprkos činjenici da voda pokriva 70,8 % površine Zemlje predviđa se da će do 2030. god. čak 30-35 % ljudi na raspolaganju imati manje od 1000 m<sup>3</sup> po glavi godišnje, tako da su izgledni još veći problemi nedostatka vode u svijetu nego ih danas imamo. Hrvatska raspolaže s 32.800 m<sup>3</sup>/stan/god i po opskrbljenosti vodom je na 8. mjestu u svijetu i 3. mjestu u Europi. Dakle, prema opskrbljenosti vodom Hrvatska spada među bogate zemlje. Od ukupne potrošnje, oko 10 % vode se koristi u domaćinstvu, oko 20 % u industriji i energetici, a najviše – 66 % u poljoprivredi. Pri korištenju potrebno je poduzimati mjere koje će na nekim mjestima spriječiti, a na nekim ublažiti nedostatak vode. U tu svrhu potrebno je sustavno uvoditi racionalnu potrošnju i štednju vode i razvijati svijest ljudi o potrebi i značaju štednje. Zatim valja uvesti prečišćavanje svih otpadnih voda i njihovo ponovno korištenje za odgovarajuće namjene. Pri čuvanju i raspodjeli vode posebno je značajna poznata deklaracija UN: VODA JE PRIRODNO DOBRO NA KOJE IMA PRAVO SVAKO LJUDSKO BIĆE NA ZEMLJI. Dakako, ovu deklaraciju trebamo svi poštivati i u životu primjenjivati.

*Ključne riječi:* voda, poljoprivreda, Ujedinjeni narodi (UN)

**WATER - THE BASIC OF LIFE ON THE PLANET EARTH**



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Despite the fact that water covers 70.8% of the Earth's surface, it is anticipated that by 2030, as many as 30-35% of people have less than 1000 m<sup>3</sup>/person/year, which would be below of minimal requirements. Croatia has 32,800 m<sup>3</sup>/person / year and water supply is ranked 8<sup>th</sup> in the world and 3<sup>rd</sup> place in Europe. Therefore, according to the supply of water Croatia is among the rich countries. Of the total consumption, about 10% of water is used in households, about 20% in industry and energy, and up to 66% in agriculture. When using it, it is necessary to take measures that will prevent some places, and to some extent alleviate the lack of water. To this end, it is necessary to systematically introduce rational consumption and water saving and to raise awareness of the need and importance of savings. Then clean all wastewater and reuse it for proper use. Conservation and distribution of water is especially important in the UN declaration: WATER IS NATURALLY GOOD ON WHICH EVERY HUMAN BEING HAS THE RIGHT. Of course, this declaration should be respected and applied in the life.

*Keywords:* water, agriculture, United Nations (UN)

**Prerada vode za piće i obrada  
otpadnih voda /  
*Drinking Water and Wastewater Treatments***





## REUSE OF MUNICIPAL WASTEWATER FOR AGRICULTURAL IRRIGATION BY MEMBRANE PROCESSES

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Climate change and population growth associated with increased need for food have become global problems in the supply of water for agricultural purposes. Nowadays, when all water supplies have to be considered, municipal wastewater (MWW) become valuable source of water. For a safe reuse, treated MWW should comply with the quality criteria defined by the guidelines for water use in irrigation (World Health Organization (WHO), European Union (EU)). The aim of this work was to evaluate MWW treated with membrane bioreactor (MBR), nanofiltration (NF), and reverse osmosis (RO) for its reuse in agricultural irrigation. The reclaimed MWW was characterized for the main physico-chemical and microbiological parameters. An additional focus was the detection and removal of compounds from the Watch List of contaminants of emerging concern (CEC). MBR effluent demonstrated a stable and suitable quality with regards to the decrease of turbidity (99.8%), total suspended solids (TSS, 100%), chemical oxygen demand (COD, 96%), and removal of dissolved organic carbon (DOC, 88%), but low decrease of conductivity (10%). Additional treatment with NF/RO significantly decreased conductivity and concentration of ions in permeate streams. MBR-NF/RO system completely removed all detected CECs. This study was showed that MWW treated with coupled membrane processes could be helpful for production of water which satisfies all standards for agricultural irrigation.

*Keywords:* municipal wastewater, reuse, irrigation, membrane processes





## **ADSORPTION OF Cd(II) FROM AQUEOUS SOLUTION BY MODIFIED Ca-BENTONITE CLAY**

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In this study, the adsorption capacity of thermally (TAB) and acid-activated Ca-bentonite with HCl (KABh) and H<sub>2</sub>SO<sub>4</sub> (KABs) was investigated in the treatment of aqueous solution containing cadmium ions. The effect process variables such as various concentrations of adsorbates was also investigated. By atomic absorption spectrophotometer were analyzed the remaining concentrations of Cd(II) ions. Wastewater is simulated by using stock solutions prepared from certified reference materials in different concentration ranges, and the adsorption process was carried out at a constant adsorbent dosage, contact time, mixing rate and ambient temperature. The highest efficiency of removal Cd(II) ions in the amount of 97, 60% at a concentration of 2 mg/l was achieved using TAB, while for KABh and KABs the efficiency was 96,96% and 94,78% at 0,5 mg/l. Adsorption capacity of clay was followed order: TAB>KABh>KABs. Adsorption isotherm of TAB, KABh and KABs was expressed in terms of Freundlich kinetic model, and the resulting experimental datas fitted well for mentioned isotherm which has shown that bentonite is a good adsorbent for Cd(II) ions. Further, the Freundlich constant n of 1 confirm the suitability of this model to describe the process of adsorption of Cd(II) ions from aqueous solution.

*Keywords:* aqueous solution, adsorption capacity, Ca-bentonite, Cd(II) ions, adsorption



## ADVANCED OXIDATION TREATMENTS OF OLIVE MILL WASTEWATER

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New and innovative advanced oxidative processes for wastewater treatments are currently in the focus of scientific research and development for possible industrial implantation. The main aim of this study was to investigate the effect of cold plasma treatment, high intensity ultrasound and UV radiation with addition of additives: H<sub>2</sub>O<sub>2</sub>, TiO<sub>2</sub>, FeCl<sub>3</sub>x 6H<sub>2</sub>O on degradation and removal of complex organic compounds from olive mill wastewater (OMWW). Olive mill wastewater represents a potential ecological problem when it is raw disposed into the environment, because its high organic load. OMWW samples (with and without additives) were treated by high-voltage plasma discharge at frequencies 60 Hz and 120 Hz in combination with pumped gases (nitrogen, air and oxygen) for 30 minutes, by UV radiation for 30 minutes and 10 minutes by high intensity ultrasound. Physico-chemical parameters of quality, chemical oxygen demand (COD), and total dissolved carbon (TOC) were determined. The results have shown the efficacy of plasma treatment in degradation of organic compounds as well as degradation and reduction of polyphenolic compounds. Reduction of color and total dissolved carbon occurred in all treated samples, mostly with the addition of FeCl<sub>3</sub>x 6H<sub>2</sub>O. Treatment with UV radiation and ultrasound proved to be the most efficient resulting in the 50% reduction of organic compounds after 10-minute treatment.

*Keywords:* wastewater, cold plasma, OMWW, ultrasound, UV radiation



## PRIMJENA ELEKTROKOAGULACIJE ZA KONDICIONIRANJE VODA

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Pristup čistoj vodi za piće osnovno je ljudsko pravo. Prema *Direktivi o kakvoći vode za piće (98/83/EZ)*, kako bi bila zdravstveno ispravna, voda za piće ne smije sadržavati mikroorganizme, parazite i tvari koje ugrožavaju ljudsko zdravlje te mora ispunjavati minimalne zahtjeve vezane uz mikrobiološka i kemijska svojstva, radioaktivnost te fizikalna svojstva. Kondicioniranje vode je proces postizanja zdravstvene ispravnosti vode za ljudsku potrošnju, a provodi se na objektima opremljenim pripadajućom elektrostrojarskom opremom, tzv. uređajima za kondicioniranje vode. Iako su učinkoviti, konvencionalni procesi obično koriste nekoliko složenih uređaja povezanih u jednu funkcionalnu cjelinu, koji su nerijetko skupi za održavanje, a sama postrojenja zauzimaju velike površine. Stoga je cilj ovog rada predstaviti metodu elektrokoagulacije (EK) kao alternativnu mogućnost postojećim konvencionalnim procesima kondicioniranja vode. U radu će se prikazati primjeri dosadašnjih istraživanja primjene procesa EK, s koncentracijom na utjecaj pojedinih operativnih parametra, kao što su pH, temperatura, materijal elektrode i sl., na učinkovitost uklanjanja onečišćavala kao što su *Escherichia coli* te povišene koncentracije željeza, arsena, mangana, amonija i dr. Također, napraviti će se i ekonomska analiza koja, s ekonomskog aspekta, prikazuje kada je opravdano koristiti EK u procesu kondicioniranja.

*Ključne riječi:* elektrokoagulacija, kondicioniranje vode, operativni parametri



## APPLICATION OF ELECTROCOAGULATION FOR WATER CONDITIONING

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Access to clean drinking water is basic human right. According to the Council Directive 98/83/EC on the quality of water intended for human consumption, drinking water shall be wholesome and clean if it is free from any micro-organisms, parasites and substances which in numbers or concentrations constitute a potential danger to human health, whereby must meet minimum requirements regarding microbiological and chemical properties, radioactivity and physical properties. Water conditioning is a method of removing altering minerals, chemicals and contaminants from a water source and it is carried out on facilities equipped with the corresponding electro-mechanical equipment. Although efficient, conventional processes typically use several complex devices connected to a single functional unit, which are often expensive to maintain and occupy large areas. Therefore, the aim of this paper is to present the electrocoagulation (EC) method as an alternative to conventional water conditioning process. The examples of previous studies of the EC process application is presented in this paper. The focus of the paper is the influence of the certain operational parameters such as pH, temperature, electrode material, etc., on the efficiency of pollutant removal such as *Escherichia coli* and elevated concentrations of iron, arsenic, manganese, ammonia and others. Also, an economic analysis is made, which, from an economic point of view, shows when it is justified to use the EC in the conditioning process.

*Keywords:* electrocoagulation, water conditioning, operative parameters



## **LEACHATE COMPOSITION AND EFFECTS TO THE ENVIRONMENT**

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Knowledge of the landfill leachate generation is a prerequisite for the planning of a leachate management strategy. An assessment of the leachate generation rate cannot be prepared in the absence of the waste disposal plan. An understanding of the potential for the leachate generation and quality is essential at the conceptual design stage. Water balances are used to assess likely leachate generation volumes. Parameters used include waste volumes, input rates and absorptive capacity, effective and total rainfall, infiltration and other site parameters. A control of leachate quantity and quality is the basis for stable, long-term landfill and leachate treatment plant operation. Proper characterization of leachate, supported by studies (bench test or pilot plants) is helpful to select a reliable leachate treatment facility that can effectively accommodate variable influent characteristic. Leachates are composed of organic substances, inorganic substances and many others that are undesirable because of their negative effect on the environment and human life. In this paper should be given an overview of the main characteristic of leachate as well approach to the adequate managing of the leachate in the aim to prevent pollution into surrounding ground and surface waters.

*Keywords:* sanitary landfill, waste, leachate, treatment



## PRIMJENA NOVIH TEHNOLOGIJA - SIGURNA I POUZDANA DEZINFEKCIJA VODE SUKLADNO DOMAĆIM ZAKONIMA I MEĐUNARODNIM STANDARDIMA

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Za dezinfekciju vode, međunarodne institucije preporučuju, umjesto plinskog klora, koristiti proizvode, koji nisu klasificirani kao opasni. Prema CLP/GHS direktivama, plinski klor je opasna kemikalija: H331, H319, H335, H315, H400. „SIGMA“ je razvila uređaj **HLOROGEN**<sup>®</sup>, koji postupkom elektrolize proizvodi otopinu natrijevog hipoklorita 1 % ekvivalentnog klora (Cas No: 7681-52-9) na mjestu potrošnje. Natrijev hipoklorit s <5 % ekvivalentnog klora je neopasan prema **Direktivi o opasnim supstancama** (the Dangerous Substances Directive) **67/548/EEZ**, te izmjenama i dopunama **Direktivi o opasnim preparatima** (Dangerous Preparation Directive) **88/379/EEC** i **CLP/GHS** direktivi. Uređaj **OksiHLOROGEN**<sup>®</sup>, na mjestu potrošnje, iz soli i vode uz pomoć električne energije proizvodi mješavinu ekvivalentnog klora i klor dioksida, koji dezinficira vode sa sadržajem organskih tvari (isključuje stvaranje organoklornih spojeva). Efikasno je dezinfekcijsko sredstvo i jak oksidans, sposoban neutralizirati tvari neorganskog porijekla (amonijak, sulfidi željeza i mangana), uzročnike boje, mirisa i okusa vode, te huminske tvari. Alternativa je klor dioksid, koji prema CLP/GHS direktivi nosi oznake opasnosti: H270, H330, H314, H400, EUH006.

*Ključne riječi:* voda, klor, elektroliza, dezinfekcija, natrijev hipoklorit



## USE OF NEW TECHNOLOGY – SAFE AND RELIABLE DRINKING WATER DISINFECTION ACCORDING TO DOMESTIC AND INTERNATIONAL STANDARDS

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For water disinfection international institutions recommend, instead of chlorine gas, its derivatives are used which have not been categorized as hazardous/toxic substances. According to CLP/GHS Directives the chlorine gas is classified as extremely dangerous chemical: H331, H319, H335, H315, H400. Sigma ltd. has developed **HLOROGEN**<sup>®</sup> device that by electrolysis produce solutions of sodium hypochlorite with 1% of equivalent chlorine; (CAS No: 7681-52-9), at the place of consumption. According to the **Dangerous Substances Directive 67/548/EEC** and subsequent amendments of the **Dangerous Preparations Directive 88/379/EEC** and **CLP/GHS** directives, solution of sodium hypochlorite in concentrations of less than 5% is considered to be harmless. **OksiHLOROGEN**<sup>®</sup> device at the place of consumption from salt and water, with the help of electrical energy, produces a mixture of equivalent chlorine and chlorine dioxide that disinfect the water with presents of organic substances (exclude formation of organic chloride compounds). It is an effective disinfectant and a strong oxidizing agent, capable, to neutralize the admixtures of organic origin (ammonic, sulfides of iron and manganese), agents for color, odor and taste of water, as well as humic substances. The alternative is chlorine dioxide which according to the CLP/GHS Directive has the following marks: H270, H330, H314, H400, EUH006.

*Keywords:* water, chlorine, disinfectant, sodium hypochlorite, mixed disinfectant



## POSTUPAK PROČIŠĆAVANJA OTPADNIH VODA NA UPOV-u CENTAR U ZADRU

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Postrojenje za pročišćavanje otpadnih voda Centar u Zadru projektirano je za 100.000 ekvivalentnih stanovnika (ES). Kao tehnološko rješenje drugog stupnja pročišćavanja odabran je jednostupanjski ('konvencionalni') uređaj s aktivnim muljem uz odvojenu stabilizaciju mulja. »Drugi stupanj« pročišćavanja sastoji se od niza bioloških, kemijskih i fizikalnih procesa koji imaju funkciju uklanjanja većine organskih tvari prisutnih u vodi, a obuhvaća primjenu bioloških i/ili drugih postupaka pročišćavanja kojima se u otpadnim vodama smanjuje koncentracija suspendirane tvari i BPK<sub>5</sub> influenta za 70-90 %, a koncentracija KPK za najmanje 75 %. Ovom prezentacijom predočit će se postupak pročišćavanja otpadnih voda na UPOV-u Centar sa rezultatima pročišćavanja otpadnih voda na UPOV-u od početka rada do danas. Prezentacija će obuhvatiti probleme s kojima su se djelatnici UPOV-a susretali u početku rada, rješavanje istih te stabilizaciju u radu UPOV-a. Također će se prikazati štete koje su uzrokovane poplavom u rujnu 2017. godine, ciljevi i način sanacija UPOV-a od šteta uzrokovanih poplavom i ponovno uspostavljanje postupka pročišćavanja otpadnih voda.

*Ključne riječi:* postupak pročišćavanja otpadnih voda, Zadar, Hrvatska





## **WASTE WATER TREATMENT PROCESS IN THE WWTP CENTAR IN ZADAR**

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Wastewater Treatment Plant Centar in Zadar is designed for 100,000 equivalents (ES). As a technological solution of the second stage of purification was selected a single stage ('conventional') device with active sludge with separate sludge stabilization. The second stage of purification consists of a series of biological, chemical and physical processes that have the function of removing most organic substances present in water and encompassing biological and / or other purification processes which reduce the concentration of suspended matter and BPK5 influenza in wastewater by 70-90%, and concentration of KPK for at least 75%. This presentation will present the wastewater treatment process at the WWTP Centar with the results of wastewater treatment at WWTP from the beginning of operation to date. The presentation will cover the problems faced by WWTP staff at the beginning of work, solving them and stabilizing the work of WWTP. It will also show the damage caused by the flood in September 2017, the goals and the way of repairing WWTP from flood damage and re-establishing the wastewater treatment process.

*Ključne riječi: wastewater treatment, Zadar, Croatia*



## FEASIBILITY OF THE THP SLUDGE TREATMENT PROCESSES ON EXISTING AND NEW WWTPs

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The THP process is a pre- or post-treatment of sewage sludge combined with anaerobic digestion at the WWTPs, so it can be easily applied on existing or new WWTPs. With respect to existing worldwide experiences it is a question up to which capacity of WWTP application of the THP process becomes feasible. On one hand integration of the THP process increases the investment and O&M costs, but on the other hand it increases the biogas production, reduces the volumes of anaerobic digesters, reduces the sludge quantities and improves sludge characteristics that leads to further reduction of sludge management costs. The THP process on WWTPs might be implemented in two basic ways - the first is to apply it in front of the digesters which are going to be built, and the second one is to apply it after the existing anaerobic digesters. This paper gives a brief description of methodology and results of its application on existing and new WWTPs. Additionally, through cost-benefit analysis the feasibility of the THP process at the WWTP Osijek is thoroughly investigated for both cases, either for its implementation at new WWTP or as additional upgrading once when the WWTP will be put in operation.

*Keywords:* wastewater, treatment, sludge, THP, WWTP, Osijek



## **PROŠIRENJE VODOOPSKRBNOG SUSTAVA VODOVODA-OSIJEK NOVIM IZDVOJENIM POGONIMA**

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Vodoopskrbni sustav Vodovoda-Osijek snabdijeva se vodom iz izvorišta Crpilište Vinogradi koje se sastoji od 18 zdenaca dubine 130 m do 180 m, vodozahvata Pampas na rijeci Dravi, te izvorišta Crpilište Dalj koje se sastoji od 4 zdenca dubine od 100-150 m. Širova voda s izvorišta Crpilišta Vinogradi i vodozahvata Pampas se transportira na preradu do pogona proizvodnje vode Nebo pustara, a voda s izvorišta Crpilište Dalj obrađuje se na izdvojenom pogonu proizvodnje vode Dalj. Osnovna nit vodilja proširenja vodoopskrbnog sustava novim izdvojenim pogonima je racionalizacija troškova te regionalizacija i restrukturiranje cijelog sustava vodoopskrbe kako bi se što bolje ostvarili projekti i postigli standardi na koje smo se obvezali ulaskom u EU. Zato smo u postupku proširenja, u novim pogonima odlučili nadograditi konvencionalnu tehnologiju obrade sa sustavom membranske filtracije, s ciljem postizanja vrijednosti arsena ispod 10 µg/l. S tim ciljem pristupilo proširenju vodoopskrbnog sustava Osijek, da bi se osigurala voda odgovarajuće kvalitete, te da odabrani tehnološki postupak zadovoljava i još dva nužna kriterija: dostupan nivo ulaganja i cijenu vode koja će biti dostupna potrošačima.

*Ključne riječi:* vodoopskrbni sustav, izdvojeni pogoni, arsen, dostupnost potrošačima



## **WIDENING OF THE WATER SUPPLY SYSTEM OF VODOVOD - OSIJEK THROUGH NEW SEPARATED PLANTS**

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The water supply system of Vodovod-Osijek is supplied with water from the water source Vinogradi, which consisting of 18 wells 130 to 180 m deep, the Pampas water intake on the Drava River and the water source Dalj, which consists of 4 wells of depth of 100-150 m. Raw water from the water source Vinogradi and the water from water intake Pampas are transported to the processing plant Nebo pustara, and the water from the water source Dalj is being processed at a separate water production plant Dalj. The basic strand of the water supply system expansion with new separate plants is cost rationalization and regionalization and restructuring of the entire water supply system to better realize the projects and meet the standards we are obliged to enter into the EU. That is why we are in the expansion process, in new plants, decided to upgrade the conventional technology with membrane filtration technology, with the aim of achieving arsenic values below 10 µg/l. With this in mind, the water supply system of Osijek has been extended to ensure adequate water quality and that the chosen technological process meets two other criteria: the available investment level and the price of water that will be available to consumers.

*Keywords:* water supply system, separate drives, arsenic, availability to consumers

**Upravljanje vodnim resursima /**  
***Water resources management***





## **THE INCLUSION OF SMALL WATERWORKS INTO PUBLIC WATER SUPPLY SYSTEMS IN CROATIA**

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According to official data, about 87% of the population in Croatia are supplied with water through public water supply systems. The rest of the population is supplied from individual water supplies or small (also called 'local') waterworks that supply 50 or more inhabitants (or deliver more than 10 cubic meters per day). These small waterworks are ordinarily managed by consumers who have also funded their construction. Water comes from sources that are not registered in the monitoring system by the national water agency, therefore these waterworks are characterized by the absence of a legal entity registered for providing water services and the lack of water permits and concessions granted by the national water agency, making them formally illegal. The problem of including small waterworks in the public water supply systems is complex with multiple factors involved. There are technical criteria that small waterworks must meet, but the problem is the lack of technical documentation, which is why the technical characteristics, such as water supply lines, profiles, lengths, etc., are not known. Water quality represent the greatest risk because water is supplied to consumers without any processing, often even without disinfection. This paper presents problems and possible solutions for including small waterworks into public water supply.

*Keywords:* small waterworks, local waterworks, public water supply systems



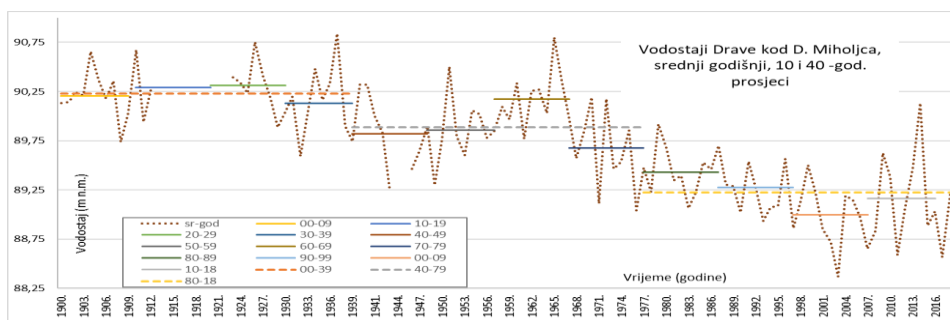
## O HIDROLOGIJI KROZ ISTRAŽIVANJA VODOSTAJA DONJE DRAVE

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Osijek se razvija uz korito rijeke Drave i njegovi građani neposredno doživljavaju svoju rijeku. Zato puno o njoj znaju, većinom iz bogatog iskustva, ali bez sustavnog praćenja hidroloških podataka ovaj suživot bi svakako bio drugačiji. U radu se predstavlja nekoliko primjera vezanih uz istraživanja vodostaja koja ukazuju na važne elemente hidroloških opažanja i značajne osobine donje Drave. Nešto nizvodnije od Osijeka Drava se ulijeva u Dunav. Kontinuirana praćenja vodostaja na području sutoka ovih rijeka relativno su duga, datiraju s kraja pretprošlog stoljeća. Za primjer, dat je osvrt na hidrološku stanicu D. Miholjac, koja je uspostavljena 1890. godine, ali nisu joj svi izvorni podatci vodostaja istovrsni. Ukazuje se na potrebu dobre pripreme (usklađivanja) podataka za povećanje pouzdanosti narednih analiza. Zbog malih padova korita u ovom području, najnižvodnije hidrološke postaje Drave su pod usporom voda Dunava. Ilustrirano je to krivuljama promjene vodostaja tijekom nekoliko godina. S obzirom na maksimanu oscilaciju Dunava od preko 8,5 m, uspor ponekad doseže i do D. Miholjca, ali zbog malog utjecaja može se za referentnu postaju koristiti postaja Belišće. Promjene vodostaja pokazuju periodičko ponavljanje. Lako shvatljiva je ona na godišnjoj razini, ali uočljive su i druge, dužeg perioda. Na primjerima iz blizine Osijeka predstavljeni su prosječni godišnji režim vodostaja i neka odstupanja od njega te periodične promjene godišnjeg režima vodostaja u par varijanti.



Zaključno se napominje da su ažurno registrirani vodostaji indikator opasnosti od poplava, prema kojima se poduzimaju primjerene protupoplavne aktivnosti. Kroz, dijelom prikazano, praćenje i izučavanje vodostaja upoznat je karakter donje Drave i njezin međuodnos s Dunavom. Analize ukazuju na produbljenje korita Drave tijekom razmatranog dugogodišnjeg razdoblja. Primjetno je ranije pojavljivanje viših vodostaja kao i veća raspršenost pojavljivanja maksimalnih vrijednosti.

*Ključne riječi:* vodostaji, donja Drava, uspor, vodni režim



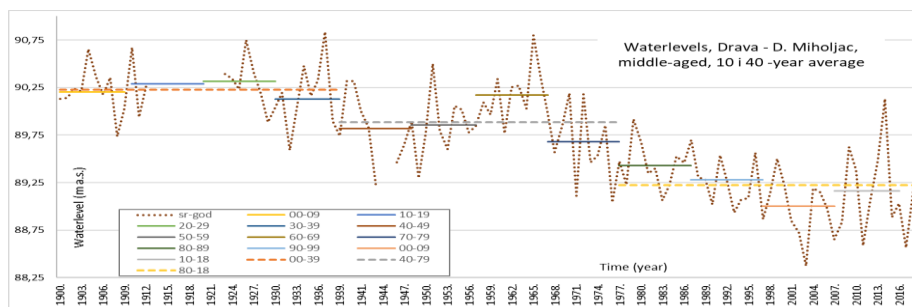


## ABOUT HYDROLOGY THROUGH RESEARCH OF LOWER DRAVA WATERLEVELS

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Osijek is developing along the river Drava and its citizens are directly experiencing their river. So they know a lot about her mostly from a rich experience, but without the systematic monitoring of hydrological data this coexistence would certainly be different. This paper presents several examples of waterlevels research that point to important elements of hydrological observation and significant characteristics of the lower Drava. Something downstream from Osijek Drava flows into the Danube. Continuous waterlevels monitoring in the area of these rivers is relatively long, dating back from the late 19th century. For example, a review of hydrological station D. Miholjac was given, which was established in 1890, but not all original water data are equivalent to each other. It points to the need for good preparation (alignment) of data to increase the reliability of the further analysis. Due to the small falls in the area, the most downstream hydrological stations of the river Drava are under subdued influence waters river Danube. It is illustrated by the waterlevels change curves over several years. Due to the maximum oscillation of the Danube of over 8,5 m, the backwater sometimes reaches to D. Miholjac, but due the small influence the station Belišće can be used for reference station. Waterlevels changes show a periodic repetition. It is easily understood at the annual level, but other, longer periods are also evident. Examples from the vicinity of Osijek are the average annual water regime and some deviations from it and the periodic changes of the annual water regime in a few variants.



Finally, it is noted that the up-to-date waterlevels are a flood hazard indicator according to which appropriate anti-flooding activities are being undertaken. Throughout, partly shown, monitoring and studying water levels, the character of the lower Drava and its relationship with the Danube are known. The analyzes indicate the deepening of the Drava riverbed during the considered long-term period. The earlier occurrence of higher water levels and higher dispersion of the occurrence of maximum values are noticed.

*Keywords:* waterlevels, lower Drava, backwater, water regime



## SMART HYDRO ENERGY HYBRID SYSTEM

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Smart Hydro Energy Hybrid System (SHEHS) is a hybrid energy system, which represents an interconnection of a small hydroelectric (HE) power plant and a solar photovoltaic (PV) power plant. The Critical Period Method (CPM) is used for system sizing. If the total energy production is lower than the energy demand, a critical period should be defined by the biggest difference between demand and production. The period (day) in which that difference appears is called the critical period. If this period (day) is met (satisfied), all the remaining days of the year are also met (satisfied). Any possible breaks in energy production, caused by a reduction in expected river flow rates or insolation (in case of the cloudiness), will be reduced to a minimum. Use of such a hybrid system guarantees the production of electricity throughout the year. By building such a hybrid system, it comes to the realization of the Smart City and enables energy stability and security. Despite the fact that Croatia has great potential with regard to the large number of available watercourses and solar energy, such hybrid system has never been applied. Matter of fact, CPM has never been applied in world.

*Keywords:* hybrid energy system, hydroelectric power plant, solar photovoltaic power plant, Critical Period Method, Smart City



## UTJECAJ KLIMATSKIH PROMJENA/VARIJACIJA NA POJAVE EKSTREMNIH HIDROLOŠKIH PRILIKA NA KRŠKIM IZVORIMA – PRIMJER IZVORIŠTA VODOOPSKRBE U ISTRI

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Klimatske prilike, a posebno klimatske promjene i varijacije uvelike utječu ne samo na dinamiku istjecanja podzemnih voda na krškim izvorima, nego i mogućnost osiguravanja njihove vodoopskrbe namjene. Tako se sve učestalije javljaju pojave izrazito dugotrajnih sušnih razdoblja, kao i pojava velikih voda praćenih s ekstremnim mutnoćama. Dobar primjer pojava takvih ekstremnih prilika i njima izazvanim problemima u vodoopskrbi pružaju izvori vodoopskrbe na području Istre u uvjetima postojećeg stanja, kao i u uvjetima prognoziranih promjena klimatskih prilika (oborina i temperature). U radu će biti prikazani karakteristični primjeri pojava dugotrajnih sušnih razdoblja s jedne strane, te pojava mutnoća s druge strane, na važnijim krškim izvorima uključenim u vodoopskrbni sustav na području Istre. Prikazati će se rezultati regionalnog funkcioniranja pojedinih izvorišta vodoopskrbe, modeliranja pojava takvih stanja, kao i procjene utjecaja klimatskih promjena s nekoliko scenarija na hidrološke značajke vodnog režima analiziranih izvora. Korišteni su modeli strojnog učenja – regresijskih stabala odlučivanja i neuronskih mreža. Prikazani rezultati ukazuju na potrebu operativnog upravljanja izvorištima vodoopskrbe, te aktivnog procesiranja informacija o stanju i mogućim promjenama hidroloških prilika, kako bi se optimiziralo korištenje vodnih resursa u kritičnim hidrološkim prilikama.

*Ključne riječi:* krški izvori, vodoopskrba, klimatsko modeliranje, male vode, ekstremne mutnoće



## **IMPACT OF CLIMATE CHANGE/VARIATIONS ON EXTREME HYDROLOGICAL EVENTS AT KARST SPRINGS – EXEMPLIFIED BY SOURCES OF WATER SUPPLY IN ISTRIA**

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Climate conditions, in particular climate change and variations, have a significant impact not only on the dynamics of groundwater discharge at karst springs, but also on the ability to make sure that their water supply purpose is fulfilled. In such circumstances, exceptionally long dry spells are becoming more and more frequent, as well as high water events accompanied by extreme turbidity. A good example of such extreme events and the problems they cause to water supply comes from water supply sources in the Istria region at present conditions, as well as at conditions of forecasted climate change events (rainfall and temperatures). The paper will present the characteristic examples of prolonged dry spells on the one hand and the occurrence of turbidity on the other hand at major karst springs included in the water supply system in Istria. It will present the results of the regional operation of individual sources of water supply, modelling of such events, as well as the impact assessment of climate change with several scenarios on the hydrological characteristics of the water regime of the analysed sources. Machine learning models – decision regression trees and neural networks are used. The presented results indicate the need for operational management of water supply sources and for active processing of information about the condition and possible change of hydrological events in order to optimize the use of water resources during critical hydrological events.

*Keywords:* karst springs, water supply, climate modelling, low waters, extreme turbidity



## **SUSTAV ZAŠTITE OD POPLAVA GRADA OSIJEKA**

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Obrana od poplava, regulacija vodotoka i melioracijski zahvati na vodnom području sliva Drave i Dunava imaju dugu i bogatu tradiciju zahvaljujući činjenici da borba čovjeka na ovim prostorima traje stoljećima kako bi se plodna nizinska područja zaštitila od brdskih voda Krndije, Papuka i Bilogore s jedne i velikih voda Mure, Drave i Dunava s druge strane. Počeci organiziranog vodnog gospodarstva u Hrvatskoj upravo vezani za ove prostore osnivanjem «Društva za regulaciju rijeke Vuke» 1876. godine na čelu s biskupom J. J. Strossmayerom. Izgradnja prvih dunavskih nasipa datira još od 18. stoljeća s ciljem zaštite nizinskog dijela Baranje od Mohača do Draža. Nepovoljne meteorološke prilike i nasipi neodgovarajućih dimenzija na vodnom području Dunava rezultirali su pojavom katastrofalnih poplava u 1964., 1965., 1966. i 1972. godini. Poslije ovih poplava, a naročito poslije poplave 1965. godine, dolazi do značajnih ulaganja sredstava i intenziviranja izgradnje novih nasipa i rekonstrukcija postojećih u cilju zaštite ugroženih područja, tako da je danas većina nasipa jača i viša, s većim stupnjem sigurnosti za obranu od poplava.

*Gljučne riječi:* obrana od poplava, Dunav, Drava, Osijek, Hrvatska



## OSIJEK FLOOD PROTECTION SYSTEM

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Flood protection, watercourse regulation and melioration activities in the water catchment area of the Drava and Danube basin have a long and rich tradition due to the fact that man's struggle in this region has lasted for centuries in order to protect the fertile lowland areas from the mountain waters of Krndija, Papuk and Bilogora and high water of the Mura, the Drava and the Danube. The beginnings of the organized water economy in Croatia were precisely tied to these premises by the establishment of «Društva za regulaciju rijeke Vuke» in 1876, led by Bishop J. J. Strossmayer. The construction of the first Danube embankments dates back to the 18th century with the aim of protecting the lower part of Baranja from Mohacs to Draž. Adverse meteorological conditions and embankments with inadequate dimensions in the Danube basin have resulted in catastrophic flooding in 1964, 1965, 1966 and 1972. After these floods, and especially after the flood in 1965, significant investments were invested and the intensification of the construction of new embankments and the reconstruction of existing ones in order to protect the vulnerable areas, so today most of the embankments are stronger and higher, with a greater degree of safety for flood protection.

*Keywords:* flood protection, Danube, Drava, Osijek, Croatia

**Monitoring kakvoće voda /**  
*Monitoring of water quality*







## **THE CURRENT STATUS AND ECOLOGICAL RISK ASSESSMENT IN SEDIMENT OF SPREČA RIVER**

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Concentration of heavy metals (Cd, Co, Cr, Cu, Ni and Pb) was determined in sediment samples collected along the Spreča River stream. Samples were taken at 12 positions from springhead to confluence into the Bosna River. The pH value, electrical conductivity and content of organic matter were also measured. Samples were acid digested and analyzed by atomic absorption spectrophotometer. The sediments were found to be contaminated with Cr, Cu and Ni which has been attributed mainly to dispersion from major urban and industrial areas. A high concentration of chromium and nickel were found in the sediment samples downstream from Lukavac town. The relatively high content of organic matter is closely related to the high organic matter flux to sediments from direct discharge of domestic and industrial wastewaters. The ecological risk assessment in sediments was carried out by the ecological risk index (ERI) proposed by Hakanson (1980). Results showed that the ERI posed by heavy metals is considerable in Spreča River sediment from Lukavac to Dobož especially near industrial facilities.

*Keywords:* sediment, heavy metals, contamination, ecological risk assessment



## **EFFICIENT MONITORING OF CHANGING OF DRINKING AND WASTE WATER QUALITY PARAMETERS BY USING SPATIAL DATABASE AND APPLICATION OF RAPS**

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Nowadays, most of communal utilities continually and automatically follow changes of the drinking and waste water quality within their area of activity. Different control systems and applications are used for this purpose. Efficient monitoring also should imply analysis of water quality parameters, i.e. range of changes, trends, etc. Rescaled Adjusted Partial Sums (RAPS) method is very suitable method for visualisation and determination of the readily apparent features, which may be hidden from the common time series plots of values. Paper will show different approach for tracking and analysis of the drinking and waste quality parameters via combination of open source spatial database PostgreSQL and open source GIS software. Mentioned approach has not yet been used in communal utilities. Main advantages of this modern system are high efficiency of water quality monitoring on large set of data, and all open source programs are free of charge. However, application of this system would require further education of employees in communal utilities. All analysis and results are obtained for real locations.

*Keywords:* drinking and waste water, quality, spatial database, GIS, RAPS



## **POTENCIJALNO PRISUSTVO TEŠKIH METALA U VODAMA NA PODRUČJU MAGLAJA I ZAVIDOVIĆA**

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Zagađenje vode teškim metalima uzrokovano industrijskim aktivnostima i tehnološkim razvojem predstavlja ozbiljan zdravstveni i ekološki problem zbog toga što su toksični, nisu biorazgradivi, akumuliraju se u živim sistemima i imaju dugo poluvrijeme života u svim sredinama. Za razliku od rijeke Krivaje koja svojim većim tokom protiče kroz prirodne ljepote i ruralna područja, rijeka Bosna cijelim svojim tokom je recipijent otpadnih voda iz domaćinstava većeg broja gradova, industrijskih otpadnih voda i komunalnih ispusta. Pored toga deponije svojim procjednim vodama značajno utiču na kvalitet vodotoka i životne sredine. Cilj ovog rada je bio utvrditi potencijalno prisustvo teških metala arsena (As), olova (Pb) i žive (Hg) atomskom apsorbcionom spektrofotometrijom. Odrediti kategoriju površinskih voda, utvrditi razliku između njih i ispitati zdravstvenu ispravnost gradskog vodovoda Zavidovići. Rezultati ukazuju na prisustvo teških metala u vodi u granicama koje ne mogu prouzrokovati poremećaj ekološke ravnoteže. Vodotok Bosne kod Maglaja je klasificiran u III-IV klasu a Krivaju u Kovačima, općina Zavidovići, u I-II klasu. Rezultati su potvrdili i zdravstvenu ispravnost vode za piće. Potrebno je pratiti unos polutanata u vodene sisteme tokom dužeg vremenskog perioda i u različitim periodima kako bi utvrdili izvor onečišćenja i preduhitrili eventualne posljedice po ekosistem i zdravlje čovjeka.

*Ključne riječi:* životna sredina, onečišćenje vode, teški metali, arsen, olovo, živa, atomska apsorbciona spektrofotometrija



## POTENTIAL PRESENCE OF HEAVY METALS IN WATER IN THE AREA MAGLAJ AND ZAVIDOVIĆI

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Water pollution of heavy metals caused by industrial activities and technological development represents a serious health- and environmental problem because of their toxic and non-biodegradable effect, they accumulate in living systems and they have long duration of lifetime in all environments. In comparison with river Krivaja which flows through natural beauty and rural areas with its bigger part of its flow, river Bosna with all own flow is a recipient of waste water from homes of several cities, industrial waste water and utility waste. In addition to landfills, its steep water directly affective on quality of the watercourse and environment. The goal of this work is to determine potentially present of heavy metals arsenic (As), lead (Pb), mercury (Hg) with atomic absorption spectrophotometry. Determine the category of surface waters, determine the difference between them and examine health safety of water infrastructure supply in Zavidovici. The results indicate the presence of heavy metals within limits that they can't caused disturbance of ecological balance. The watercourse of river Bosna in Maglaj classified in III-IV class and river Krivaja in Kovaci, municipality Zavidovici classified in I-II class. The results confirmed health safety of drinking water. It is necessary to monitor the intake of pollutants in water systems during the long time term in different periods to determine the source of pollution and forestall possible consequences of the ecosystem and public health.

*Keywords:* environment, ater pollution, heavy metals, arsenic, lead, mercury, atomic absorption spectrophotometry



## **IDENTIFICATION AND FATE OF PETROLEUM TYPE POLLUTANT IN THE COASTAL SEDIMENTS OF THE RIVER VRBAS (BANJA LUKA, BOSNA AND HERZEGOVINA)**

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The organic substance of the coastal sediments of the Vrbas river (in the vicinity of the heating plant, the city of Banja Luka), as a potential source of petroleum type pollutants, was investigated. Samples were taken in the immediate vicinity of the plant, and at various distances from it. In organic extracts biological markers, *n*-alkanes, isoprenoidal aliphatic alkanes and polycyclic alkanes of the type of sterane and terpane, were analyzed in detail. Crude oil as the most mature form of the organic substance of the geosphere has the characteristic distribution of these biological markers. Therefore, the results of the gas-chromatographic mass spectrometric (GC-MS) analysis of these hydrocarbons can be used as a forensic tool to determine the presence of petroleum pollutants in the environment. On the other hand, the differences in the distribution in samples taken from different locations from the pollution site may indicate a way of migrating the pollutant through sedimentary formations using water. The conclusions reached have a fundamental meaning in terms of defining the migration mechanism. On the other hand, the practical significance of these investigations consists in estimating the intensity of changes in the pollutant under conditions that prevail in river coastal sediments.

*Keywords:* petroleum pollutant, biological markers, river sediments, migration



## **ECOLOGICAL MAP OF THE CITY OF ZAGREB – WATER FOR HUMAN CONSUMPTION**

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Environmental map of the City of Zagreb was implemented in 2017 as web GIS application "Ecological map of the City of Zagreb". The ecological map represents an interactive operating tool with an innovative approach in which the data is presented in a simple visual way, easily understood to all citizens of Zagreb and interested parties while full-scale analysis results are available to professional services. Project combines different data on the state of the environment, such as water, air and soil quality data, meteorological information and pollen allergy level. As far as water is concerned, the data from the monitoring of water for human consumption are shown on the map, and historical data are also presented in order to monitor whether a place has any problems with the quality of water. The most interesting places are, of course, facilities such as kindergartens, schools, hospitals and water reservoirs, where regular (111 places) and additional and expanded (39 places) analysis is carried out. If unsatisfactory results occur, they are marked in red. Along with each unsatisfactory result, the actions taken and the results of repeated analyzes have been carried out after re-sampling and testing. The results are presented in accordance with the requirements of Annex 4, the new Directive on water for human consumption. The project was implemented in cooperation of the Andrija Stampar Teaching Institute of Public Health, Faculty of Agriculture University of Zagreb, Institute for Medical Research and Occupational Health, Meteorological and Hydrological Institute of Croatia and the City of Zagreb.

*Keywords:* ecological map, water quality, Zagreb, web GIS application



## **PRAĆENJE STANJA VODA NA PODRUČJU SANACIJSKOG ODLAGALIŠTA OTPADA – SLUČAJ PIŠKORNICA**

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Sanacijom odlagališta komunalnog otpada kontinuirano se smanjuju štetni učinci nepropisno i neadekvatno odloženog otpada u okolišu. Osobito je važno pratiti i procijeniti potencijalno onečišćenje površinskih i podzemnih voda te smanjiti rizike za ljudsko zdravlje. Cilj ovog rada je procijeniti djelotvornost sanacije odlagališta otpada Piškornica provedene u razdoblju od 2005. do 2012. godine. Prije i nakon sanacije analizirane su podzemne vode iz piezometara (P2, P3, P4 i P5) na lokaciji odlagališta i površinske vode iz vodotoka Gliboki (uzvodno i nizvodno od odlagališta). Rezultati analiziranih parametara (KPK, BPK<sub>5</sub>, elektrovodljivost, željezo) pokazali su u svim analiziranim uzorcima podzemne vode iz piezometara značajan pad vrijednosti ( $p < 0,05$ ) i do 82 % (BPK<sub>5</sub> u P5) nakon sanacije. Utvrđena je i razlika u koncentraciji pokazatelja među piezometrima, a najznačajniji pad vrijednosti analiziranih pokazatelja utvrđen je u uzorcima vode iz piezometra P5 koji je najbliže i nizvodno od tijela odlagališta i u kojem su vrijednosti pokazatelja prije sanacije odlagališta bile najveće. Ispitivanjem vodotoka Gliboki nije utvrđena statistički značajna razlika ( $p < 0,05$ ) uzvodno i nizvodno od odlagališta niti prije i nakon sanacije. Ostali mjereni pokazatelji ukazuju na varijabilnost u obje vrste voda. Numerički model toka podzemne vode i pronosa zagađenja je pokazao da niti u najgorem scenariju odnosno u slučaju najvećeg mogućeg crpljenja (420 l/s) trenutnog kapaciteta crpilišta Ivanščak smještenog 5-6 km od odlagališta, neće doći do zagađenja podzemne vode. Rezultati su pridonijeli odlukama u gospodarenju vodama te izradi plana daljnjeg monitoringa voda na području odlagališta.

*Ključne riječi:* odlagalište otpada, sanacija, monitoring voda, numerički model



## MONITORING OF WATERS STATUS ON THE AREA OF THE WASTE LANDFILL – CASE STUDY PIŠKORNICA

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The remediation of the municipal waste landfill continuously reduces the harmful effects of improperly and inadequately disposed waste in the environment. It is especially important to monitor and assess potentially contamination of surface and groundwater and reduce the risks on human health. The aim of this paper is to evaluate the efficiency of the remediation of waste landfill of Piškornica implemented in the period from 2005 to 2012. Groundwater from piezometers (P2, P3, P4 and P5) at the location of the landfill and surface water from the Gliboki stream (upstream and downstream from the landfill location) were analyzed, before and after the remediation. The results of the analyzed parameters (KPK,  $BPK_5$ , electroconductivity, iron) showed significant decrease in values ( $p < 0.05$ ) and up to 82% ( $BPK_5$  in P5) after remediation in all analyzed groundwater samples from piezometers. There was also a difference in the concentration of indicators among the piezometers, and the most significant decrease in the value of the analyzed indicators was determined in the water samples from piezometer P5, which is nearest and downstream from the landfill body, and where the values of the indicators before the landfill remediation were greatest. Significant difference ( $p < 0.05$ ) was not found at the upstream and downstream locations of the Gliboki stream basin before and after remediation. Other measured indicators indicate the variability of both types of water. The numerical model of the groundwater flow and transfer of pollutant shows that groundwater pollution will not occur even in the worst scenario respectively in the case of the largest possible pumping (420 l/s) of the current capacity of the Ivanščak source located 5-6 km from the landfill. The results contributed to decisions on water management and to the making of a plan for further monitoring of waters on landfill area.

*Keywords:* waste landfill, remediation, monitoring of waters, numerical model





## **INTEGRALNA PROCJENA EKOLOŠKOG STATUSA RIJEKE LIŠTICE**

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Ekološki status definiran je Okvirnom direktivom o vodama – ODV (2000/60/EZ) kao mjera kvalitete strukture i funkcije ekosustava površinskih voda. Osim bioloških elementa (zajednice planktona, bentosa i nektona) procjena ekološkog statusa obuhvaća i hidro-morfološke i fizikalno-kemijske elemente, koji podržavaju funkcioniranje zajednica te njihovu raznolikost. U radu je prikazana procjena ekološkog statusa Lištice, krške ponornice, čije se vode koriste za vodoopskrbu Širokog Brijega te natapanje poljoprivrednih površina u krškoj depresiji - Mostarskom blatu. Istraživanja sprovedena tijekom 2016. godine obuhvatila su zajednice fitobentosa, makrofitske vegetacije i makroskopskih beskralješnjaka, uz analize fizikalno-kemijskih i kemijskih pokazatelja vode. Uzorkovanje materijala i analize parametara vode obavljeno je na tri postaje duž longitudinalnog profila rijeke, u sezonama proljeće, ljeto i jesen, a provedene su prema propisanoj standardnoj metodologiji za ODV-om propisane elemente vodnog tijela. Za rijeku Lišticu utvrđen je ukupno dobar ekološki status, ali su uočena i određena odstupanja od istog u pojedinim sezonama kao posljedica antropogenih pritisaka.

*Ključne riječi:* ekološki status, Okvirna direktiva o vodama, Lištica, Bosna i Hercegovina



## INTEGRAL ASSESSMENT OF ECOLOGICAL STATUS OF THE LIŠTICA RIVER

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The ecological status is defined by the Water Framework Directive - WFD (2000/60/EC) as a measure of the quality of the structure and function of surface water ecosystems. In addition to biological elements (plankton, benthos and nekton communities), the assessment of ecological status also includes hydro-morphological and physico-chemical parameters, that support the functioning communities and their diversity. In this paper we present assessment of ecological status of the Lištica river, karstic sink-hole river, which water is being used for drinking in Široki Brijeg and also for irrigation agricultural surfaces in karstic depression-Mostarsko blato. Researchs were performed in 2016 and included communities of phytobenthos, macrophytes and invertebrates as well as physical and chemical conditions of water. The samples were taken on three sites during longitudinal profile of river in spring, summer and autumn seasons. Samples were collected according to the WFD methodology. A good ecological status has been determined for the Lištica river, but some deviations have been also determined in certain seasons as a consequents of anthropogenic pressures.

*Keywords:* ecological status, Water Framework Directive, Lištica, Bosnia and Herzegovina



## **ODREĐIVANJE KLOROALKANA U VODI METODOM PLINSKE KROMATOGRAFIJE S MASENOM SPEKTROMETRIJOM (GC-MS/MS)**

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Kratkolančani poliklorirani alkani ili skraćeno kloroalkani su vrlo složene tehničke smjese polikloriranih n-alkana s duljinom ugljikovodičnog lanca od C<sub>10</sub> – C<sub>13</sub> i sadržajem klora između 49 i 70 %. Dobivaju se kloriranjem n-alkana i nisu prirodno prisutni u okolišu. Zbog njihovih fizikalnih svojstava kao što su viskoznost i otpornost gorenju, koriste su u različite svrhe kao npr. aditivi za maziva, PVC plastifikatori i usporivači gorenja u bojama, ljepilima i brtvilima. Zbog višeg tlaka pare i topljivosti u vodi, kloroalkani imaju visoki potencijal ispuštanja u okoliš u koji dospjevaju putem proizvodnje, skladištenja ili uporabe. Postojani su u okolišu te je utvrđena njihova toksičnost i kancerogenost za vodene i kopnene organizme. Ovim radom opisana je metoda određivanja kloroalkana u vodi za ljudsku potrošnju, podzemnim, površinskim i otpadnim vodama. Uzorci vode za ispitivanje pripremaju se ekstrakcijom tekuće-tekuće i pročišćavanjem kromatografijom na stupcu, a identifikacija i kvantifikacija se provodi tehnikom plinske kromatografije s masenom spektrometrijom (GC-MS/MS). Prema važećim zakonskim propisima Republike Hrvatske propisani su standardi kakvoće okoliša za kloroalkane u površinskim vodama kao i maksimalno dozvoljena koncentracija u otpadnim vodama. Validacijom metode je dokazana njena primjenjivost namjenjenoj svrsi i zadovoljenje zahtjeva regulative te je metoda akreditirana u skladu s normom HRN EN ISO/IEC 17025:2017.

*Ključne riječi:* kloroalkani, SCCPs, C<sub>10</sub>-C<sub>13</sub>, voda, određivanje, GC-MS/MS



## **DETERMINATION OF SHORT-CHAIN POLYCHLORINATED ALKANES (SCCPs) IN WATER BY GAS CHROMATOGRAPHY-MASS SPECTROMETRY (GC-MS/MS)**

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Short-chain polychlorinated alkanes or paraffins (SCCPs) are highly complex technical mixtures of polychlorinated n-alkanes having a C10-C13 hydrocarbon chain length and a chlorine content between 49 and 70%. They are obtained by chlorination of n-alkanes and they are not naturally present in the environment. Because of their physical properties such as viscosity and burn resistance, they are used for various purposes, such as lubricant additives, PVC plasticizers and flame retardants in paints, adhesives and sealants. Due to higher vapour pressure and water solubility, SCCPs have high potential of releasing into the environment during their production, storage or usage. They are persistent in the environment and their toxicity and carcinogenicity have been determined for aquatic and terrestrial organisms. This paper describes the method for determination of SCCPs in water for human consumption, underground, surface and waste water. Test water samples are prepared by liquid-liquid extraction and purification by column chromatography. Identification and quantification are performed by gas chromatographic mass spectrometry technique (GC-MS/MS). According to the regulations of the Republic of Croatia, environmental quality standards of SCCPs for surface water and maximum allowable concentration in wastewaters are prescribed. Validation of the method has proved its applicability to the intended purpose and compliance with regulatory requirements. The method is accredited according to HRN EN ISO/IEC 17025:2017.

*Keywords:* chloroalkanes, SCCPs, C10-C13, water, determination, GC-MS/MS



## **KAKVOĆA VODE NA BRODOVIMA**

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Zbog sve većeg razvoja nautičkog turizma, kakvoća voda za piće na brodovima ima sve značajniju ulogu. Cilj ovog rada bio je analizirati rezultate kakvoće vode za piće na različitim vrstama brodova u Primorsko-goranskoj županiji, u petnaestogodišnjem razdoblju od 2002. do 2016. godine. Ukupno je analizirano 478 uzoraka, na osnovne mikrobiološke i fizikalno-kemijske pokazatelje, pri čemu su korištene standardne ISO metode. Korelacijska analiza rezultata pokazala je uglavnom dobru korelaciju različitih mikrobioloških parametara, te nešto slabiju korelaciju između fizikalno-kemijskim i mikrobioloških parametara. Statistički značajna razlika u kakvoći vode za piće na brodovima uočena je po godinama, mjesecima, sezonama, a također i po vrsti subjekta koji dostavlja vodu na analizu. Svi mikrobiološki pokazatelji, izuzev ukupnih koliformnih bakterija, u promatranom razdoblju imaju silazan trend. Broj izraslih kolonija (UBB) i *P. aeruginosa* imaju najveći porast u listopadu, kao i indikatori fekalnog onečišćenja (*E. coli* i enterokoki), koji se u povišenim koncentracijama pojavljuju i tijekom ljeta. Uzorci dostavljeni od strane brodogradilišta generalno su bolje kakvoće u odnosu na uzorke dostavljene od strane brodarskih agencija. U cilju efikasnije kontrole kakvoće vode za piće i unaprjeđenja zaštite potrošača, potrebno je rutinski ispitivati koncentraciju rezidualnog klora i prisutnost *Legionella*.

*Ključne riječi:* kakvoća vode, brodovi, mikrobiološko onečišćenje, plan sigurnosti vode, dezinfekcija



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Due to the increasing development of nautical tourism, the quality of drinking water on boats has an increasingly important role. The aim of this paper was to analyze the results of water quality on different types of vessels in the Primorje-Gorski Kotar County, during the 15-year period from 2002 to 2016. A total of 478 samples were analyzed on the basic microbiological and physical-chemical indicators, using standard ISO methods. The results of testing of water quality showed that there was a statistically significant difference between years, months, seasons as well as between the type of operator that supplies the water to the analysis. All microbiological indicators, with the exception of total coliform bacteria, have a downward trend. The number of colonies (HPC – heterotrophic plate count) and *P. aeruginosa* has the highest increase in October, as well as indicators of fecal contamination (*E. coli* and enterococci), which appear in elevated concentrations during the summer. Samples delivered by shipyards are of better quality than those delivered by shipping agencies. In order to effectively control the quality of drinking water as well as improvement of the consumer protection, measurement of the residual chlorine concentration and *Legionella* detection should be routinely investigated.

**Keywords:** water quality, ships, microbiological contamination, water safety plan, disinfection

**Vodooskrbni sustavi i odvodnja /**  
*Water supply and sewage systems*







## **DEFINIRANJE VODNIH GUBITAKA NA REGIONALNOM VODOOPSKRBNOM SUSTAVU OSIJEK KORISTEĆI NAPREDNE HIDRAULIČKE MODELE**

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Ovim se radom prikazuju metode definiranja vodnih gubitaka koristeći napredne hidrauličke modele na primjeru Regionalnog vodoopskrbnog sustava Osijek. Rezultati prikazani ovim radom proizašli su iz projekta „Uspostava tehničkog informacijskog sustava vodoopskrbe na području Osijek – Čepin – Dalj i izrada programa upravljanja gubicima vode“. Svrha ovoga rada je na stvarnom primjeru prikazati metode određivanja, analize te prostornog definiranja vodnih gubitaka s primjenom u naprednom hidrauličkom modelu. Hidraulički model prikazan ovim radom omogućuje neposredno povezivanja više izvora podataka u svrhu kvalitetnog hidrauličkog proračuna te naknadne analize rezultata. Svi analizirani rezultati, proizašli iz hidrauličkog modela, u potpunosti prikazuju stvarno stanje na Regionalnom vodoopskrbnom sustavu Osijek po pitanju potrošnje vode, vodnih gubitaka i tlakova na sustavu. Na ovaj način, računalna simulacija koja kvalitetno prezentira stvarno stanje, omogućuje svim korisnicima uvid u stanje vodoopskrbnog sustava te precizno donošenje odluka za sve buduće aktivnosti.

*Ključne riječi:* vodni gubitak, hidraulički model, EPANET, WaterCAD, Regionalni vodoopskrbni sustav Osijek



## **DEFINITION OF WATER LOSSES IN REGIONAL WATER SUPPLY SYSTEM OF OSIJEK USING ADVANCED HYDRAULIC MODELS**

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This paper presents methods of defining water losses using advanced hydraulic models on the example of the Osijek regional water supply system. The results presented in this paper have come from the project "Establishment of a technical information system for water supply in the area of Osijek - Čepin - Dalj and the development of water loss management programs". The purpose of this paper is to present a realistic example of the method of determination, analysis and spatial definition of water losses using the advanced hydraulic model. The hydraulic model illustrated by this work enables the immediate connection of multiple data sources for the purpose of a high quality hydraulic calculation and subsequent analysis of the results. All analysed results, derived from the hydraulic model, fully represent the actual situation in Osijek regional water supply system regarding water consumption, water losses and system pressures. In this way, a computer simulation that represents current state of water supply system in a high quality way, enables all users to gain insight into the water supply system condition and enables them to make accurate decisions regarding all future activities.

*Keywords:* water loss, hydraulic model, EPANET, WaterCAD, Osijek regional water supply system



## **PROBLEMATIKA ODRŽAVANJA VAKUUMSKOG KANALIZACIJSKOG SUSTAVA**

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Kanalizacijski sustav je neophodan dio svakog naselja koji doprinosi zaštiti okoliša i ljudi. Postoji više vrsta kanalizacijskih sustava. Pored standardnih sustava (mješoviti, razdjelni te ostali), postoje i alternativni, nestandardni sustavi, a jedan od njih je i vakuumski kanalizacijski sustav. Kako bi bilo koji kanalizacijski sustav ispravno funkcionirao i uspješno obavljao svoju zadaću, potrebno je pravilno i redovito održavanje. Općenito, održavanjem se smatra niz aktivnosti kojima se postiže da izgrađene građevine omogućuju adekvatnu uporabu i funkcionalnost za projektiranu namjenu. Budući da je u Republici Hrvatskoj jako puno malih, ruralnih naselja za koja nije isplativo graditi standardne kanalizacijske sustave, počinju se primjenjivati nestandardni kanalizacijski sustavi. S obzirom na to da su ovi sustavi relativno novi i slabo se primjenjuju, ne postoji općepoznata praksa, pravila za uporabu, održavanje istih te, ono najvažnije, ne postoje iskustva korisnika i ljudi zaduženih za upravljanje radom i održavanjem. U radu će se prikazati općenite karakteristike i dijelovi vakuumskih kanalizacijskih sustava. Dat će se preporuke za održavanje i navesti troškovi održavanja iz autorima dostupne literature.

*Ključne riječi:* kanalizacijski sustav, održavanje, troškovi, vakuumski kanalizacijski sustav



## **MAINTENANCE ISSUES OF THE VACUUM SEWER SYSTEM**

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A sewer system is an indispensable part of every settlement which contributes to the protection of the environment and people. There are many types of sewer systems. In addition to the standard sewer systems (mixed, separated, etc.), there are the alternative, non-standard systems, and one of them is a vacuum sewer system. In order for a sewer system to function correctly and to perform its tasks successfully, it needs to be maintained properly and regularly. Generally speaking, maintenance is considered to be a series of activities performed in order to achieve that constructed buildings allow an adequate use and functionality for the purpose they were designed for. Since there are many small, rural settlements in the Republic of Croatia for which it is not profitable to build standard sewage systems, non-standard sewage systems are increasingly used. Considering these systems are relatively new and still rarely used, there is no general practice or rules for use and maintenance of the same, and, most importantly, there is no user experience or people responsible for managing the work and maintenance. The paper will present the general characteristics and parts of vacuum sewer systems. Maintenance recommendations will be given and maintenance costs specified making reference to the literature available to the authors.

*Keywords:* sewer system, maintenance, costs, vacuum sewer system



## **DOSTUPNOST ZDRAVSTVENO ISPRAVNE VODE ZA LJUDSKU POTROŠNJU U OSJEČKO-BARANJSKOJ ŽUPANIJI – POSLIJE DOMOVINSKOG RATA DO SADA**

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Razvitak vodoopskrbe predstavlja jedan od bitnih elemenata infrastrukturnog razvitka jedinica lokalne samouprave i Županije u cjelini. Razvijen vodoopskrbni sustav i dostupnost kvalitetne i zdravstveno ispravne vode za ljudsku potrošnju na cijelom području, predstavlja temeljnu pretpostavku gospodarskog razvitka i integralni dio životnog standarda. Opskrba zdravstveno ispravnom vodom za ljudsku potrošnju i odgovarajuća sanitacija, temelj su sprječavanja bolesti, koje se prenose onečišćenom vodom. Kemijski, fizikalni i mikrobiološki pokazatelji koji definiraju kakvoću vode za piće ovise o kakvoći vode na izvorištu, uključujući: vrstu obrade, metodu dezinfekcije, tehničko stanje objekta i razvodne mreže vodoopskrbnog sustava. Cilj rada je dati prikaz sadašnjeg stanja vodoopskrbe i usporediti ga sa stanjem iz 1996. godine. Opskrbljenost vodom stanovništva Županije, iz javnih vodoopskrbnih sustava, iznosi 85 % (mogućnost 98,5 %), što je nešto više od prosjeka Republike Hrvatske, dok je opskrbljenost javne i lokalne vodoopskrbe prije dvadesetak godina iznosila 77,5 % i to pretežno vodom nezadovoljavajuće zdravstvene ispravnosti. Smanjen je broj lokalnih vodovoda priključivanjem na javni vodoopskrbni sustav te su smanjene koncentracije pojedinih parametara, poglavito arsena. Sustavno ulaganje u vodoopskrbne sustave vidno je rezultiralo poboljšanjem stanja i osiguravanjem bolje dostupnosti zdravstveno ispravne vode za ljudsku potrošnju, na području Županije.

*Ključne riječi:* dostupnost vode, vodoopskrba, voda za ljudsku potrošnju, Osječko-baranjska županija



## AVAILABILITY OF WHOLESOME WATER FOR HUMAN CONSUMPTION IN OSIJEK - BARANJA COUNTY – AFTER THE HOMELAND WAR UNTIL PRESENT DAY

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The development of water supply is one of the essential elements of the infrastructure development of local self-government units and the County as a whole. A developed water supply system and the availability of quality and wholesome water for human consumption throughout the area is a fundamental condition premise for economic development and a better living standard. Supply of wholesome water for human consumption and adequate sanitation are the basis for preventing diseases which are transmitted with contaminated water. Chemical, physical and microbiological indicators that define the quality of drinking water depend on the quality of water in the wellspring, which includes: the type of treatment, the disinfection method, the technical condition of the facility and the distribution network of the water supply system. The main goal of this paper is to present the current state of water supply and compare it with its state in 1996. 85% of population in the county is supplied with water by the public water system, which is slightly above the average of the Republic of Croatia, while 20 years ago it was 77,5% of population with water of predominantly unsatisfactory quality. The number of local waterworks has been reduced by connecting to the public water supply system and the concentration of some parameters has been reduced, especially arsenic. Systematic investment in water supply systems has resulted in the improvement of the situation and it helped to ensure better access to wholesome water for human consumption in the County.

*Keywords:* water availability, water supply, water for human consumption, Osijek-Baranja County

**Voda i zdravlje /**  
***Water and health***







## UTJECAJ VRSTE MATERIJALA VODOVODNIH CIJEVI NA KVALITETU PITKE VODE: KRATKI PREGLED

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Voda je osnova života na Zemlji te je potrebna svakom živom biću. Pitka voda za ljudsku upotrebu dobiva se iz različitih izvora, na različite načine. Voda sadrži kemijski potpis onog materijala s kojim dolazi u doticaj. Osnovni način na koji pitka voda dolazi u kontakt s materijalom cijevi je prilikom distribucije pitke vode uličnim cjevovodima do zgrada, ili pak u kućnoj vodovodnoj instalaciji pomoću koje se pitka voda razvodi do prostorija u zgradi. Pitka voda, u kućnoj instalaciji, se distribuira različitim vrstama cijevi, odnosno cijevima napravljenim od raznih materijala. Neki od tih materijala su HDPE (polietilen visoke gustoće), PVC (polivinil-klorid), PE (polietilen), čelik, olovo, itd. Za određene vrste materijala cijevi, iz autorima dostupne literature, navest će se prednosti i nedostaci svake cijevi u smislu upotrebe za instalaciju pitke vode te općenito karakteristike cijevi. Također, prikazat će se mogući utjecaj različitih materijala od kojih su vodovodne cijevi napravljene na zdravlje čovjeka te epidemiološki, kemijski i mikrobiološki pregled kvalitete takve vode. Na kraju rada, dat će se zaključak o kvaliteti pitke vode ovisno o tome kojim se cijevima pitka voda distribuira.

*Ključne riječi:* kvaliteta pitke vode, materijal cijevi, vodovodne cijevi, zdravlje



## IMPACT OF VARIOUS MATERIALS USED IN WATER SUPPLY PIPES ON THE QUALITY OF DRINKING WATER: A SHORT REVIEW

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Water is the basis of life on Earth and it is vital for every living being. Drinking water for human use comes from different sources and it is supplied in different ways. Water contains a chemical signature from the material it comes into contact with. The most important way in which drinking water comes in contact with the pipe material is water distribution through street water pipes that deliver water to buildings, or in an in-home water supply system by which drinking water is being distributed to the rooms of the building. Drinking water in home water supply systems is transported using various types of pipes, which are made of different materials. Some of these materials are HDPE (high density polyethylene), PVC (polyvinyl chloride), PE (polyethylene), steel, lead, etc. The advantages and disadvantages of each type of pipe, in terms of their use for the distribution of drinking water and pipe characteristics in general, will be shown, using the literature available to the authors. The possible impact of different water pipe materials on human health and the epidemiological, chemical, and microbiological quality inspection of such water will be investigated and presented. The most suitable material for water supply pipes, in terms of ensuring optimal drinking water quality, will be determined in the conclusion at the end of the paper.

**Keywords:** drinking water quality, pipe material, water supply pipes, health



## NATURAL MINERAL WATERS AND NATURAL SPRING WATERS

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The primary purpose of the EU natural mineral water legislation is to protect the health of consumers, to prevent consumers from being misled, to ensure fair trading and to facilitate the functioning of the internal market. There are different categories of waters intended for human consumption, such as natural mineral waters, natural spring waters, table waters and tap water. Natural mineral waters may be distinguished from ordinary drinking water by their purity at source and their constant level of minerals. Spring waters are intended for human consumption in their natural state. Both categories should be bottled at source and placed on the market just as the prepacked food. Natural mineral waters are subject to an authorization procedure carried out by the competent authorities of the EU countries or by European Economic Area (EEA) countries. In Croatia competent authority is Ministry of Agriculture. Specificity for the Croatian market is recognition procedure for natural spring water too. The lists of natural mineral waters officially recognized by the EU countries of the EU and of the EEA (Iceland and Norway) are published by the European Commission in the Official Journal of the European Union. Furthermore, the list of natural mineral and natural spring water officially recognized in Croatia is published in the "Official Gazette". The list shall contain the trade name of the product, name of origin, place of origin and the use of country of origin. These lists are regularly updated. It is prohibited to market natural mineral water, as well as natural spring water, from one and the same spring under more than one trade description. Also, all indications attributing to a natural mineral water properties relating to the prevention, treatment or cure of a human illness are prohibited. Member States may adopt special provisions regarding indications (both on packaging or labels and in advertising) concerning the suitability of a natural mineral water for the feeding of infants. For the first time, in Croatian ordinance would be prescribed parameters which operators must fulfil to label a natural mineral water as suitable for the preparation of infant food.

*Keywords:* natural mineral water, natural spring water, recognition



## CONTRIBUTION OF BEVERAGES TO TOTAL WATER INTAKE IN CROATIA

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Water is a crucial nutrient comprising 60% of human body weight. It is well documented that water plays an essential role in the healthy functioning of the body, including regulation of body temperature, transport, digestion and absorption of nutrients, and excretion of wastes. Water imbalance in the body is associated with adverse health consequences from mild thirst to severe dehydration, delirium, and even death. Plain water intake is the major contributor to total water intake but water may also be consumed from daily consumption of foods and beverages. The aim of the study was to evaluate water intake from beverages, to combine it with plain water intake and to compare it with EFSA recommendation. For the purpose of assessment juices, soft drinks, juice concentrates, coffee, tea, milk and yogurts are taken into account, because they represent significant part of liquid intake, according to national food consumption data. The results show that intake of water from beverages was 14% and 17% for men and women, respectively. If we combine this with previously calculated plain water intake, the total intake from water and beverages was around 54% and 67% for men and women, respectively. Reported water consumption was below recommendations. Higher water intakes were suggestive of better diet quality.

*Keywords:* water intake, beverages, Croatia, adults



## RE-EMERGING WATERBORNE PATHOGENS

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Water is essential element for all living feature including microorganisms. Many microbes can survive and replicate in different type of water with minimal nutrients and can be transferred to humans. Therefore, water could serve as a niche for transmission of many infectious diseases. As the epidemiology of waterborne diseases is changing, there is a growing global public health concern about new and reemerging infectious diseases. New microbial pathogens have emerged, and some have spread worldwide. In the last decades, industrialization, population growth and climate change have influenced the water resources and new or reemerging waterborne disease. Some of the microorganisms that has reemerged are pathogens such as *Legionella pneumophila* and *Francisella tularensis*. They are both gram negative bacterium, and cause serious disease in humans. These bacteria are able to survive in different types of water by various mechanisms. They life cycle, adaptation to aquatic environment and human cells are peculiar and is still under intensive research. In this lecture the interesting aspect of environmental persistence, pathogenesis of the disease and mechanisms of infection will be presented.

*Keywords: re-emerging waterborne pathogens, Francisella, Legionella*



## BIZOVAC I TERMALNA VODA

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Sedamdesetih godina 20. stoljeća tvrtka INA d.d. provodila je intenzivna istraživanja na području Općine Bizovac jer su preliminarna istraživanja ukazivala na potencijalno bogata izvorišta nafte i plina. U većini istražnih radnji procjene naftno-geoloških stručnjaka su se pokazale točne te je, u to vrijeme, na području Bizovca niknulo više bušotina na kojima je započelo danonoćno crpljenje nafte. Provodeći istražnje radnje i otvarajući bušotinu Bizovac-1 i Bizovac-2, naftno-geološki stručnjaci su nemalo ostali iznenađeni kada je 31. 8. 1970. iz saponice na bušotini umjesto nafte potekla termalna voda s temperaturom od 96,8 °C. Uzorci vode dostavljeni su u analitički laboratorij, a analize su pokazale da bizovačka termalna voda pripada grupi jodnih slanih hipertermi, odnosno skupini visoko mineraliziranih termalnih voda sa sadržajem joda iznad 1 mg/L. Vijest o otkriću ljekovite vode brzo se proširila među Bizovčanima te su se stanovnici Bizovca i okolnih mjesta već nekoliko dana nakon otkrića termalne vode kupali u obližnjim poljskim kanalima gdje se ispuštala novootkrivena termalna voda. Komercijalizacija ljekovite bizovačke termalne vode započela je 1974. godine kad je sagrađen prvi otvoreni bazen i prateći smještajni objekt koji se, tijekom sljedećih desetljeća pokazao nedostatan za sve goste Bizovca željne uživanja i liječenja u bizovačkoj termalnoj vodi. Stoga je 1990. godine sagrađen i otvoren hotel Termia s Poliklinikom za medicinsku rehabilitaciju. Ponuda hotela dodatno je osnažena 1997. godine izgradnjom suvremenog kupališnog kompleksa Aquapolis kojeg tijekom ljetnih mjeseci posjeti nekoliko tisuća kupača. Otkriće termalne vode promijenilo je budućnost Bizovca, te su Bizovac i Bizovačke toplice danas, uz najljepšu hrvatsku narodnu nošnju, simbol i povezanosti vode i zdravlja.

*Ključne riječi:* termalna voda, Bizovačke toplice, Bizovac, Hrvatska

## BIZOVAC AND THERMAL WATER



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During the 1970s INA d.d., Croatian multinational oil company, conducted many biotechnical investigations in the area of eastern Croatia in order to find new sources of oil since the preliminary researches indicated existence of significant deposits of oil and gas. The significant number of drills were made in the area of the municipality of Bizovac and in the most investigative actions, geologists' estimates proved to be accurate. At that time several oil wells were open in the area of Bizovac, and so called pump jack pendants started the daytime crushing of oil in the fields of Bizovac. But conducting investigative actions and opening the bores the Bizovac-1 and Bizovac-2, the petroleum geologist were very surprised when on August 31 1970 directly from the nozzle on the well instead of the oil, a thermal water flowed with the temperature of 96.8 °C. The thermal water flowed from bore pipe in the regular intervals. The water samples were delivered to the analytical laboratory and analyses shown that according to balneological classification, thermal water from Bizovac belongs to a group of the iodine hyperthermal waters with iodine content more than 1 mg/L. The news about discover of therapeutic thermal water spread rapidly among the population of Bizovac, as well as throughout the Slavonia, and several days after the discovery of the thermal waters, the inhabitants of Bizovac and surrounding villages were bathed in nearby canals where the thermal water from the wells was discharged. The commercialization of the therapeutic thermal water was begun in 1974 when the first outdoor swimming pool, with was accommodation facility, was built. The following decades shown the insufficiency of accomadation capacity, and, therefore, in 1990, the hotel Termia with the Polyclinic for Medical Rehabilitation was opened. The construction of the Aquapolis Aquapark during the 1997 additionally made the Bizovac Thermal Spa (Bizovačke toplice) more attractive for tourists. The several thousand tourists visit Bizovac and enjoys in healing benefits of Bizovac's thermal water. The discovery of thermal water has changed the future and the population lifestyle in the Bizovac, and nowadays Bizovac, along with the most beautiful Croatian folk costume, is the symbol of the connection between water and health.

**Keywords:** thermal water, Bizovačke toplice, Bizovac, Croatia

**Posterska priopćenja / *Poster presentations***



**Poljoprivreda i vodni resursi /**  
***Agriculture and Water Resources***





## **THE POSSIBLE IMPACT OF AGRICULTURE ON THE GROUNDWATER QUALITY, AN EXAMPLE OF KARST FIELD DUGOPOLJE**

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More than 25% of the world's population relies on karst aquifers for their water supply. Karst aquifers are known for their sensitivity to pollution due to thin soil cover, concentrated infiltration, swallow holes and concentration of flow in the epikarst and vadose zones. Different agricultural practices can be a source of high levels of heavy metals in soils. They can have an impact on plant health, soil biological processes and enter the human body through biomagnification processes. Since soil is Earth's largest natural filter it also has a protective function being a significant factor in retardation and attenuation of potential pollution on its way to groundwater. Dugopolje is a typical karst field located on the northern slopes of the Mosor mountain. The area consists of mesozoic and kenozoic carbonate and clastic rocks. The soils are brown and red soils on limestones and dolomites. Because of the intensive tectonics, area is intensively karstified with couple of active swallow holes. A tracer test carried out from Colića abyss has proven direct connection between river Jadro and Dugopolje field. Since Jadro spring provides about 300.000 inhabitants with drinking water it is very important to minimize any possible negative impact human activities can have on groundwater quality. This paper analyses the physical - chemical indicators of soils from Dugopolje and compares them with values obtained from deep boreholes from the same area in attempt to determine the impact the agriculture has on groundwater quality.

*Keywords:* karst aquifer, groundwater, agriculture, heavy metals



## **ARSENIC CONTAMINATION OF SEAWATER AND FISH FROM BAR REGION (MONTENEGRO)**

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Arsenic (As) has been classified by the International Agency for Research into Cancer (IARC) as a human carcinogen, because of increased cancer incidences at certain sites in people exposed to As at work, environment or through their diet. Arsenic is widely distributed in nature and commonly associated with the mines and ores such as lead, copper and gold. Elemental arsenic rarely occurs, therefore it is usually found in four oxidation states: As(-III), As(0), As(III), and As(V). In natural waters, As is frequently found in inorganic form as oxyanions of trivalent arsenite or pentavalent arsenate. The average As concentrations in the open seawater are typically around 1.5 mg/L and usually show little variation. However, the concentrations are variable in the coastal seawater, as they are conditioned by the river inputs and salinity or redox gradients. The water was sampled twice a year at three localities, on two depths. The fish were collected from the daily catch of the local fisherman by the random principal choice. The As contaminations of water samples and fish muscle tissue were tested applying Atomic Absorption Spectroscopy (HG/CV-AAS) by the Thermo electron S2 AA System. Arsenic was not detected only once during the study, at locality Sutomore, in January, from the water sampled in the open seawater. The highest As concentration was obtained in the water sampled in the same period, but at Volujica locality (3.43 µg/dm<sup>3</sup>). The presence of As was detected in all seven prospected fish species. The highest concentrations and above MAC were obtained in muscle tissue of two skate species, *Raja montagui* (3.05 mg/kg) and *R. miraletus* (2.47 mg/kg). Regarding the proven risk of As on human health and the environmental conditions, continuous monitoring of water, sediment and fish should be implemented in order to asses As concentrations and if possible, reduce it sources in seawater.

**Keywords:** arsenic, marine water, sediment, contamination



## INFLUENCE OF PH ON THE ADSORPTION OF ORGANIC POLLUTANTS ON MICROPLASTIC ISOLATED FROM PERSONAL CARE PRODUCTS

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Microplastics have been recognized as transport vector for heavy metals and organic pollutants in aquatic ecosystems. Therefore, microplastics are concerned as emerging contaminants in aquatic environments. In this study, the influence of aquatic matrix pH value on the interaction formation between two different groups of organic pollutants (chlorinated phenols and halogenated pesticides) on microplastics isolated from two personal care products has been investigated. Based on the obtained results, it can be concluded that the change of pH value in the aquatic matrix affects the formation of interactions between ionizable organic pollutants such as chlorinated phenols and all types of microplastics. The highest percentage of interaction between chlorinated phenol and selected microplastics was observed at pH 7 (45-55%) for both tested microparticles. On the other hand, at pH 10 and pH 4 the percentage of interaction formed between phenols and microplastics was lower and ranged between 15-35%. In case of non-ionizable organic pollutants, such as halogenated pesticides, the change in pH value doesn't have a significant impact on formation of interactions with selected microplastics. The obtained results also showed that adsorption of non-ionizable organic pollutants depend on hydrophobic/hydrophilic properties and size of the molecules, as well as the properties of microplastics. The results of this study provide significant information on the behavior of chlorinated phenols and halogenated pesticides in the presence of different types of microplastics with change in the pH value of the real water matrix.

*Keywords:* microplastic, personal care products, chlorinated phenols, halogenated pesticides, pH

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## **DYNAMICS OF SURFACE RUNOFF AND AGROCHEMICALS CONCENTRATION FROM SLOPED VINE GROWING POSITON UNDER DIFFERENT PRECIPITATION INTENSITY**

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South and southwest hillslope terrains are favorable areas for vine cultivation, but because of the slope they are susceptible to erosion and surface runoff, especially after intensive precipitation. The study was conducted at the Jazbina experimental station located in Zagreb County (UniZG Faculty of Agriculture, Department of Viticulture and Enology), with a pronounced slope (~20%) and inter-row grass mulch practice. Surface runoff collectors were set up in the inter-row of the 20 years old Pinot Blanc vineyard, where phosphorus, potassium, copper-sulfate and herbicide (glyphosate) were applied. Data were acquired from the automatic meteorological station (Pinova), and in addition to the natural precipitation, different intensity precipitation events were simulated as well. Immediately after precipitation, volume of surface runoff was measured and samples were taken for the analyses in an accredited laboratory (MELILAB, UniZG Faculty of Agriculture, Department of Soil Amelioration) and at the Institute for Medical Research and Occupational Health (Zagreb). Results confirm that at the investigated vineyard terrain precipitation intensity significantly affects surface runoff, as well as its chemical composition, i.e. herbicide and macro/microelement concentration. To prevent negative (agro)ecological impacts (e.g., surface and/or groundwater pollution), agrochemicals in vineyards should be applied in accordance with the sustainable agriculture guidelines.

**Keywords:** P, K, CuSO<sub>4</sub>, glyphosate, surface runoff, vineyard



## **BOTTOM ASH FROM BIOMASS COGENERATION PLANTS: A SOURCE OF RAW MATERIALS AND SUBSTRATE FOR WASTEWATERS TREATMENT**

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Some of the most advanced biomass-fueled cogeneration plants (BFCP) applies bubble fluidized bed technology, i.e. controlled addition of the quartz sand ( $\text{SiO}_2$ ) fraction to catalase and improve combustion process. Besides of biomass conversion into the heat and electricity, as a main by-product (waste) of BFCP is a bottom ash, i.e. inorganic alkaline material comprised of mixed ash/ $\text{SiO}_2$  fractions. An assumption is that by means of separation of bottom ash to certain  $\text{SiO}_2$  and ash fractions is possible to (re)use such materials, e.g. in civil engineering ( $\text{SiO}_2$ -enriched fractions), agriculture and/or waste water treatments (ash fraction). In preliminary study preformed with BFCP bottom ash, 7 fractions (F) with different ash/ $\text{SiO}_2$  portions were separated, confirming F4 (0,5-1 mm) as the most dominant (>50%) fraction. In the second study, certain amount of F1 fraction (<0,125 mm) was mixed with a liquid effluents from animal farms (manure). Results show that addition of F1 markedly raised the manure pH reaction (from 6.7 to 11,8) and changed its electrical conductivity. Considering strong alkaline medium of F1 fraction ( $\text{pH}>12$ ) further studies are needed to elucidate its potential for using such substrate as a soil amendment (e.g. on acid soils) and/or substrate for wastewaters (e.g. agricultural/municipal waste waters).

*Keywords:* biomass ash, agricultural effluents, agriculture, acid soils



## **LJEKOVITE VODE SREBRENICE U FUNKCIJI RURALNOG RAZVOJA**

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Rad se bavi potencijalima koji mogu obnoviti život na području Srebrenice, Bosna i Hercegovina. Mineralna voda izvorišta Guber u Srebrenici koristila se kao lijek za liječenje kožnih oboljenja, još prije dolaska Rimljana. Godine 1886. izvršena su prva naučna istraživanja mineralnih izvora na području opštine Srebrenica, kada su bečki istraživači zabilježili postojanje 48 mineralnih izvora. Godine 1956. Savezno ministarstvo za zdravlje SFRJ i Komisija za lijekove Saveznog zavoda iz Beograda je vodu Crni Guber proglasilo lijekom. Cilj rada je bio istražiti potencijale za mogući ruralni razvoj koje pružaju ljekevite vode Srebrenice, kao što su: razvoj zdravstvenog turizma, povećanje smještajnih kapaciteta, integrisanje poljoprivrednih proizvođača i drugih djelatnosti. Povećanjem novouposlenih radnika, kućnih budžeta ali i ukupnim privrednim razvojem Srebrenice, voda bi ponovo mogla obnoviti život na ovom području.

*Ključne riječi:* Srebrenica, ljekevite vode, ruralni razvoj





## **HEALING WATERS OF SREBRENICA IN FUNCTION OF RURAL DEVELOPMENT**

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The paper deals with potentials that can restore life in Srebrenica, Bosnia and Herzegovina. The mineral water of the Guber spring in Srebrenica was used as a remedy for the treatment of skin diseases, even before the arrival of the Romans. In 1886, the first scientific research of mineral resources in the Srebrenica municipality was carried out, when the Viennese researchers recorded the existence of 48 mineral springs. In 1956 Federal Ministry of Health of the SFRJ and Medicines Commission of the Federal Bureau from Belgrade have declared the water of Crveni Guber a medicine. The aim of this paper was to explore the potential for possible rural development provided by healing waters of Srebrenica, such as: development of health tourism, increase of accommodation capacities, integration of agricultural producers and other activities. By increasing newly employed workers, home budgets, and the overall economic development of Srebrenica, water could regain life again in this area.

*Keywords:* Srebrenica, medical waters, rural development

**Prerada vode za piće i obrada  
otpadnih voda /  
*Drinking Water and Wastewater Treatments***





## ANALYSIS OF LEACHATE FROM NON-SANITARY LANDFILL AND ASSESSMENT OF REMOVAL EFFICIENCY OF CAFFEINE USING MATERIAL AND SUBSTANCE FLOW ANALYSIS

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Leachate from the non-sanitary municipal solid waste landfill was collected in order to perform the physico-chemical (*temperature, pH value, conductivity, COD, BOD<sub>5</sub>, NH<sub>4</sub><sup>+</sup>-N, SO<sub>4</sub><sup>2-</sup>, P<sub>tot</sub>, orthophosphates, turbidity and suspended solids*) and microbiological (*number of aerobic heterotrophs, total number of coliform bacteria, total number of faecal coliform bacteria, number of intestinal enterococci*) analysis. Obtained results indicate that the landfill is in methanogenic phase of waste decomposition as well as the presence of two species of microorganisms, *Escherichia coli* and *Klebsiella pneumoniae*. In addition, a semi-quantitative screening analysis of collected samples were performed using QP2010-Ultra GC-MS. The 16 organic compounds were identified of which 5 belong to the group of pharmaceuticals: *Caffeine, 22-Tricosenoic acid, 4-Methylthiomorpholine-1,1-dioxide, 2,6,10,14-Hexadecatetraen-1-ol, 3,7,11,15-tetramethyl-, acetate, (E,E,E)-, 1,2-Bis(trimethylsilyl)benzene*. A software package *STAN* was used to perform material and substance flow analysis. The scenario modelling was performed to assess the removal efficiency of selected technologies from the aspect of reducing the concentration of *Caffeine* because of its well-known negative effects on humans and environment as well. Technologies for leachate treatment which were observed within the Scenario 1 are: *Hybrid wetland system, Membrane bioreactor (MBR) and Reverse osmosis (RO)*. The modelling results indicate the high removal efficiency of *Caffeine* concentration (99.99%).

**Keywords:** Landfill leachate, Pharmaceuticals, Caffeine, STAN

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## THE REMOVAL OF NEONICOTINOID INSECTICIDE IMIDACLOPRID IN AN ANNULAR PHOTOREACTOR

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Heterogeneous photocatalysis has recently attracted an increasing interest of scientists and experts who deal with the waste water and air treatment. An important area of application is removal of persistent organic pollutants, which can not be easily destroyed by conventional methods. Among these pollutants are neonicotinoid insecticides, which are widely used all over the world and currently are included in the watch list of substances of the European Commission within the Water Framework Directive. Therefore, there is a need to study their influence on the environment and to develop appropriate technologies for their removal. In this work, the photolytic and photocatalytic degradation of neonicotinoid insecticide imidacloprid in an annular photoreactor with recirculation under different working conditions (irradiation source, pH, type and concentration of the catalyst) was studied. The photolytic degradation was examined using lamps that emit UVA, UVC and sun light. The photocatalytic experiments in the suspension involved the use of commercial titanium dioxide (TiO<sub>2</sub> P25, *Degussa/Evonik*), commercial TiO<sub>2</sub> P25 pre-treated with UVC irradiation and nitrogen-doped TiO<sub>2</sub> (produced by Cinkarna Celje). The catalysts were characterized using XRD, UV/Vis-DRS, BET and SEM/EDX analysis. The most efficient photocatalyst was then immobilized on the glass woving fibre, using peroxotitanic acid as a binder. The degree of imidacloprid degradation was determined using high performance liquid chromatography (HPLC). According to the obtained results, UVC-treated TiO<sub>2</sub> showed the best efficiency among the examined catalysts in the slurry reactor using lamp that emit sun irradiation. The degradation rate increases with the increase in the catalyst concentration. The immobilized UVC-treated catalyst gave satisfying results in terms of stability, activity and reuse.

*Keywords:* heterogeneous photocatalysis, neonicotinoid insecticides, imidacloprid, annular reactor

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## **REMOVAL OF METHYLENE BLUE DYE FROM PRINTING INDUSTRY SIMULATED SAMPLE USING THE ALTERNATIVE ADSORBENT IN THE CONTINUOUS FIXED-BED COLUMN**

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The printing industry uses different types of paints and solvents in its production process. Large amounts of water are used to wash printing machines, which results in the production of dye-containing wastewater with hazardous consequences on the environment. One of the dominant components that is often detected in the wastewater samples of the printing industry is methylene blue (MB). This research aimed to study the efficiency of commercial adsorbent in removing MB from the aqueous solution, soldered with a specific concentration, using the continuous fixed-bed adsorption column. During research and adsorption process, 30 cm long with 2 cm diameter column was used. The layer height of the commercial adsorbent was 3 cm, MB flow was 5 mlmin<sup>-1</sup> and initial, soldered, concentration of MB was 10 mgL<sup>-1</sup>. The entire experiment was carried out at 25 °C temperature, with an aqueous solution pH value of 5.60 and conductivity of 15μScm<sup>-1</sup>. The column data were fitted by the Thomas, Clark and modified dose-response models. Thermal and acidic treatment of commercial adsorbent, as a condition for a more efficient process, has not been studied. The results were implied that commercial activated carbon might be suitable as an adsorbent material for adsorption of MB from an aqueous solution.

*Keywords:* adsorption, dynamic system, waste water treatment



## **SIMPLIFIED COLLECTIVE ALTERNATIVE SOLUTION FOR WATER TREATMENT INTENDED FOR HUMAN CONSUMPTION IN SMALL COMMUNITIES – SALTA-z**

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The National Foundation of Health (Funasa) of Brazil has the mission of promoting actions and initiatives for the development of sanitation and promotion of environmental health in Brazilian municipalities of up to 50 thousand inhabitants. It was developed by this Foundation the Collective Alternative Treatment of Water for Human Consumption - SALTA-z, which seeks to reach the drinking water standard for human consumption, according to the parameters of the World Health Organization (WHO). SALTA-z performs uptake at the source (in wells or rivers), chlorination, decantation and filtration with the Zeolite element. This collective solution for water treatment has low cost, easy deployment and monitoring. The whole phase to implement this solution is made in a participatory way, in which the community participates from its implantation until the monitoring. Given the similarity of socio-environmental characteristics of Brazilian and other cities in development, and communities around the world, Funasa presents this solution as a possibility of cooperation to be developed by other developing countries with the objective of promoting the improvement of the quality of water for human consumption in low-income communities, with a view to improving environmental health.

*Keywords:* water treatment, simplified solution for water treatment, SALTA-z



## REMOVAL OF TARGET PRIORITY POLLUTANTS FROM WATER USING ADVANCED OXIDATION PROCESSES

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The presence of a large number of organic pollutants in the environment presents a significant risk to the quality of both surface and groundwater. In the field of water policy, priority substances such as different chlorinated pollutants are substances which present a significant risk towards the aquatic environment due to their acute or chronic toxicity, persistence and bioaccumulation potential (*Directive 2013/39/EU*). This paper presents data relating to the application of advanced oxidation processes (AOPs) to treat priority pollutants which are not susceptible to conventional treatment techniques due to their high chemical stability and/or low biodegradability (*Dewil et al., 2017*). Laboratory research indicates that the ultraviolet (UV) activation of hydrogen peroxide (UV/H<sub>2</sub>O<sub>2</sub> process) or persulfate (UV/S<sub>2</sub>O<sub>8</sub><sup>2-</sup> process) in order to produce highly reactive free radicals (hydroxyl (HO<sup>•</sup>) or sulfate (SO<sub>4</sub><sup>•-</sup>)) led to the almost complete oxidative degradation of trichlorobenzene and alachlor (up to 99%) in different water types. Significantly higher degradation efficiencies of both pollutants were achieved using advanced oxidation processes than compared to UV photolysis alone. The efficiency of the hydroxyl radical based or sulfate radical based AOPs applied for degradation of trichlorobenzene and alachlor depends to a large extent on the content and characteristics of the natural organic matter present, the water alkalinity and pH.

*Keywords:* priority pollutants, advanced oxidation processes, UV/H<sub>2</sub>O<sub>2</sub> process, UV/S<sub>2</sub>O<sub>8</sub><sup>2-</sup> process

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## IMPACT OF INFLUENT NITROGEN CONCENTRATION ON GRANULE SIZE AND STABILITY

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An attractive technology for biological nutrient removal from wastewater is aerobic granular sludge. Many factors have influence to granule formation and stability: substrate composition, organic loading rate, settling time, dissolved oxygen, pH and temperature, anaerobic degradation within granules, outgrowth of filamentous organisms, functional loss of strains and extracellular polymeric substances, aeration intensity, reactor configuration. COD/N ratio plays an important role in granule size in an N removal aerobic granule system.

*Keywords:* aerobic granule, granule stability, granule size, nutrient removal



## **USPOREDBA UČINKOVITOSTI UREĐAJA ZA PROČIŠĆAVANJE OTPADNIH VODA ISTOČNE HRVATSKE**

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Sustavi za pročišćavanje otpadnih voda jedan su od najboljih načina kako zaštititi prirodu, životinje pa tako i čovječanstvo od različitih toksičnih tvari. Danas, u 21. stoljeću, zahtjevi za pročišćavanjem otpadnih voda su vrlo visoki te je prilikom ispuštanja pročišćenih otpadnih voda u recipijente, vodne resurse, potreban visok stupanj pročišćavanja istih. Kako bi se postigla što veća učinkovitost pročišćavanja otpadne vode te kako bi se postigle što niže vrijednosti pokazatelja kakvoće pročišćene otpadne vode (suspendirane tvari, KPK, BPK5, koncentracije fosfora, dušika i ostalih štetnih tvari), potrebno je izabrati adekvatnu tehnologiju i proces, kao i vrstu uređaja za pročišćavanje otpadnih voda. Predmet ovog rada je prikaz primijenjenih tehnologija i usporedba učinkovitosti uređaja za pročišćavanje otpadnih voda na području istočne Hrvatske, a to su uređaji za pročišćavanje otpadnih voda u Belom Manastiru (pročišćavanje aktivnim muljem te nitrifikacijom i denitrifikacijom), Valpovu i Belišću (pročišćavanje aktivnim muljem), Donjem Miholjcu („Orbal Proces Trening“), Našicama (BIOCOS®), Slavonskom Brodu (SBR postupak), Vinkovcima (produžena aeracija) te biljni uređaj u Vinogradcima. Prikazom rezultata analiza ulazne nepročišćene i izlazne pročišćene otpadne vode za 2016. i 2017. godinu na sljedeće parametre: suspendirana tvar, KPK, BPK5, ukupni dušik i ukupni fosfor prikazan je postotak učinkovitost pročišćavanja otpadnih voda svakog navedenog uređaja kao i usporedba učinkovitosti svih opisanih uređaja po navedenim parametrima.

*Ključne riječi:* obrada otpadnih voda, uređaj za pročišćavanje otpadne vode, istočna Hrvatska



## COMPARISON OF EFFICIENCY OF WASTEWATER TREATMENT PLANTS IN EASTERN CROATIA

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Wastewater treatments are of the most efficient way for ecosystem and nature protection from various toxic substance, and nowadays, the technical and efficient requirements for wastewater treatments are very high and demanding in the case of wastewater discharging into the recipient, water resource. In order to achieve the highest efficiencies in removal and reduction of quality parameters values with the lowest possible price, adequate technology and process should be selected as well as the type of wastewater treatment plant. This paper present an overview of the applied technologies and comparison of the efficiency of wastewater treatment plants (WWPs) in the Eastern Croatia. The technologies and efficiencies of following WWPs are presented: WWP in Beli Manastir (active sludge purification and nitrification and denitrification), WWP in Valpovo and Belišće (treatment with active sludge), WWP in Donji Miholjac (Orbal Process Training), WWP in Našice (BIOCOS®), WWP in Slavonski Brod (SBR), WWP in Vinkovci (active sludge) and WWP in Vinogradci (Surface Flow Treatment Wetland). Following parameters were determined in influents and effluents of WWPs during the 2016 and 2017: suspended matter, KPK, BPK5, total nitrogen and total phosphorus and the removal percentages of above mentioned parameters were is compared.

**Keywords:** wastewater treatment, wastewater treatment plant, eastern Croatia



## **ULTRAFILTRACIJA KAO METODA ZA UKLANJANJE TENZIDA IZ OTPADNIH VODA**

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Tenzidi, površinski aktivne tvari smanjuju površinsku napetost vode i drugih tekućina. Prema načinu djelovanja dijele se na: anionske, kationske, neionske i amfoterne površinski aktivne tvari. Imaju široku primjenu u različitim industrijama poput metalne, tekstilne, prehrambene, papirne te industrije za proizvodnju deterdženata. Zbog negativnog utjecaja na ljude, ribe i vegetaciju, otpadne vode koje sadrže tenzide potrebno je prije ispuštanja u okoliš obraditi. Tehnologije membranske separacije sve više se upotrebljavaju pri obradi otpadnih voda i predstavljaju učinkovitu alternativu procesima poput adsorpcije, ionske izmjene i pješčanih filtera. Jedan od membranskih procesa, proces ultrafiltracije koristi se i za uklanjanje tenzida iz otpadnih voda. Cilj ovog rada je prikazati upotrebu ultrafiltracije kao metode za uklanjanje tenzida iz otpadnih voda.

*Ključne riječi:* ultrafiltracija, otpadna voda, membrane, deterdženti



## **SURFACTANT WASTEWATER REMOVAL BY ULTRAFILTRATION**

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Surfactant, also called surface active agents reduce surface tension in water and other liquids. By their behavior in solutions they are classified as: anionic, cationic, non ionic or amphoteric. They are widely used in many industrial applications such as metal processing, textile, food, paper and detergent industry. Due to their harmful effect to humans, fish and vegetations, wastewater having surfactants need to be treated before discharging into environment. Membrane technologies are widely used in wastewater treatments. In this technology, membranes are used in different applications. They provide effective alternatives to related technologies such as adsorption, ion exchangers, and sand filters. One of the membrane technology, ultrafiltration is used for surfactant wastewater removal. The aim of this paper is to present ultrafiltration as successful method for surfactant removal.

*Keywords:* ultrafiltration, waste water, membranes, detergents



## **OBRADA OTPADNE VODE PREHRAMBENE INDUSTRIJE**

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Suvremeno doba obilježeno je sve većom potrošnjom vode u industriji i urbanim sredinama. Svakom upotrebom vode iz brojnih vodoopskrbnih sustava za različite namjene dolazi do promjene njezinih fizikalnih, kemijskih i bioloških svojstava pri čemu nastaju velike količine otpadnih voda. Ispuštanjem takve vode u prirodni recipijent dolazi do onečišćenja čime se narušava ravnoteža vodnih ekosustava. Kako bi se primijenio odgovarajući proces pročišćavanja otpadnih voda i kako bi učinak pročišćavanja bio što bolji važno je poznavati vrstu i sastav otpadne vode. Prehrambena industrija je poznata kao veliki potrošač vode i ujedno kao generator velikih količina otpadnih voda onečišćenih biološki lako ili teško razgradivim tvarima. Velika potrošnja vode je uvjetovana strogim higijenskim uvjetima i visokom kontrolom kvalitete proizvoda. Prosječna potrošnja vode u odnosu na proizvod često je u omjeru 10:1. Zbog toga je potrebno otpadne vode prikupiti te na prikladan način pročistiti i ispustiti u prijemnik kako ne bi došlo do štetnih posljedica za okoliš. Obrada otpadnih voda i izgradnja uređaja za pročišćavanje u okviru industrijskog pogona prije ispuštanja u gradski kanalizacijski sustav su od velikog značaja kada je u pitanju očuvanje okoliša.

*Ključne riječi:* otpadne vode, prehrambena industrija, obrada otpadnih voda



## WASTEWATER TREATMENT GENERATED FROM FOOD INDUSTRY

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The modern era is characterized by increasing water consumption in the industry and in the urban environments. Each use of water from a number of water supply systems for different uses results in a change in its physical, chemical and biological properties, resulting in large amounts of wastewater. By releasing such water into natural recipients pollution occurs which can be harmful to biodiversity. In order to apply appropriate and efficient wastewater treatment process it is very important to know the nature and composition of wastewater. The food industry is known as a large consumer of water and also as a generator of large quantities of wastewater, which can be contaminated with biologically easily or heavily biodegradable substances. High water consumption is conditioned by strict hygienic conditions and high product quality control. The average water consumption in relation to the product is often 10: 1. Therefore, it is necessary to employ appropriate wastewater treatment processes before being discharged into the environment. Wastewater treatment and construction of industrial wastewater treatment plants are of great importance when it comes to environmental protection.

*Keywords:* wastewater, food industry, wastewater treatment



## **ANALIZA OTPADNE VODE U KLAONICAMA**

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U ovom radu proučavane su otpadne vode triju klaonica tijekom vremenskog perioda od tri godine. Ispust otpadne vode dviju klaonica bio je u prirodni recipijent, a ispušt otpadne vode treće klaonice u gradski kolektor. Analitički je praćena temperatura vode i okolnog zraka, boja, miris, pH, KPK, BPK5, ukupna ulja i masti, anionski detergentski, ukupni dušik, ukupni fosfor, taložne tvari, te ukupni klor. Prema dobivenim rezultatima analize određivano je može li se otpadna klaonička voda ispuštiti u za to predviđeni recipijent ili je potrebno njeno odležavanje u lagunama. Otpadne vode klaonica koje su ispuštane u prirodni recipijent prikazale su više vrijednosti ispitanih analitičkih parametara nego otpadna voda klaonice koja je ispuštana u gradski kolektor. Vrijednosti KPK i BPK u sve 3 godine bile su iznad maksimalno dozvoljene koncentracije [( >125 mg O<sub>2</sub>/L) KPK, (>25 mg O<sub>2</sub>/L) BPK]. Vrijednosti ukupnih ulja i masti su iznad maksimalno dozvoljene koncentracije (43,0 mg/L) samo u jednom slučaju, dok su ostali podaci (pH, anionski detergentski) ispod maksimalno dozvoljene koncentracije. Prema dobivenim rezultatima može se reći da analizirane klaoničke otpadne vode pripadaju u biološki razgradive otpadne vode.

*Ključne riječi:* otpadna voda, lagune za pročišćavanje, KPK, BPK5





## **ANALYSIS OF WASTEWATER IN SLAUGHTERHOUSES**

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In this paper, the quality of wastewater from three different slaughterhouses was determined. The research included three years time period. Water from two objects was discharged in natural recipient, and from the third object wastewater was collected in city wastewater collector. Temperature of water and the air, colour, odour, pH, COD, BOD<sub>5</sub>, total oils and fats, anion detergents, total nitrogen, total phosphorus, sedimentary substances and total chlorine were determined. According to the results it was determined if wastewater can be discharged into the recipient or it must settle in lagoons. Wastewaters discharged to natural recipients had higher levels of tested parameters than wastewater discharged to city collector. COD and BOD levels in all three years had values above legally permissible concentrations [( >125 mg O<sub>2</sub>/L) COD, (>25 mg O<sub>2</sub>/L) BOD]. Total oils and fats value exceeded maximum levels only once, while other parameters were below maximum permissible concentration. Slaughterhouses wastewater are in the group of biodegradable wastewater.

*Keywords:* wastewater, lagoon, COD, BOD<sub>5</sub>



## **THE EFFECT OF DIFFERENT NANOCATALYSTS FOR PHOTOCATALYTIC DEGRADATION OF METHYLENE BLUE**

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The aim of this study is to investigate photodegradation of Methylene Blue (MB) in water by using ZnO and TiO<sub>2</sub> nanoparticles. Adsorption and photocatalytic oxidation studies were carried out by using produced TiO<sub>2</sub>, commercial TiO<sub>2</sub> and commercial ZnO nanoparticles. In order to evaluate performance tests, MB solution of 5 mg/L was used. 0.05, 0.1 and 0.2 g nanoparticles were weighed and placed in 50 mL solution. The samples were mixed in the dark for 2 hours for establishing adsorption-desorption equilibrium. Photocatalytic operation was conducted by UV light in the designed box. After photocatalytic degradation test, each sample was taken for measurement of absorbance by using Shimadzu UV-Vis spectrophotometer. As a result of the photocatalytic tests it is noted that the highest color removal efficiency was obtained in the samples both produced TiO<sub>2</sub> commercial TiO<sub>2</sub> catalysts. Almost all of MB was removed completely.

*Keywords:* Nanoparticles, TiO<sub>2</sub>, Photocatalytic Degradation, Methylene Blue, UV Lamp



## THE STATISTICAL AND TECHNICAL EVALUATION OF THE WASTEWATER TREATMENT PLANT OF SUMMER SITES

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The aim of this study is technical and statistical evaluation of wastewater treatment plants existing summer sites in Izmir City. The study is carried out in a period from August to September 2018. Within the scope of the study for surrounding areas of Izmir City the treatment plant for 150 summer sites were investigated and listed. The treatment plants were analyzed by taking the necessary permissions and visiting them at their current location. It has been determined that most of the wastewater embedded in underground called as a package treatment system were used in summer sites for many reasons such as smell and noise control. Many parameters have been considered within the scope of the study such as installed power of the plant, influent waste water flow and pollutant concentration, the properties of the sludge, sludge disposal methods, effluent water parameters, the method and location of effluent water discharge, operation period of the wastewater treatment plant. As a result of this study, it has been found that the low cost package treatment systems were preferred, generally. The most energy required systems were blowers. In order to provide clean and smooth environment, use of central wastewater treatment plants are more suitable than the use of package treatment systems.

*Keywords:* summer sites, wastewater, wastewater treatment plant, package treatment



## THE EFFECTIVENESS OF NOVEL CHLORINE DIOXIDE IN DRINKING WATER DISINFECTION

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The presence of *E.coli* in drinking water is not very common, however drinking water polluted with *E. coli* can lead to infection and could cause serious illness. Water contamination can lead to adverse health effects, including gastrointestinal illness, reproductive problems, and neurological disorders. More than 200 diseases are derived from polluted water. The main objective of present research was to evaluate the effectiveness of novel chlorine dioxide for the inactivation of *E. coli* in drinking water. Chlorine dioxide is made of two compounds: liquid sodium chlorite and solid sodium-peroxodisulphate »in situ«. Chlorine dioxide composition is in accordance with German water treatment regulation (TrinkwV 2001). In this experiments different concentrations of chlorine dioxide were added at different temperatures in order to determine the optimal conditions for *E. coli* removal from drinking water. Results show that optimal dose is 0.2 mg/L of chlorine dioxide at room temperature, while the same dose was effective at increased temperatures at 30 °C and 40 °C. The contact time was less than 1 m.

*Keywords:* drinking water disinfection, *E.coli*, chlorine dioxide



## REMOVAL OF SYNTHETIC DYE USING A LOW-COST ADSORBENT: COLUMN STUDIES

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Brewers' spent grain (BSG) has been investigated as a low cost adsorbent for the removal of synthetic dye Congo red (CR) from aqueous solution using columns. The results revealed that BSG can rapidly remove azo dye CR from water. Continuous flow operations were used to obtain breakthrough curves. Different experimental conditions were tested: BSG particle size (100-400  $\mu\text{m}$  and 500-600  $\mu\text{m}$ ), column diameter (13 and 18 mm) and bed height (2 and 4 cm) at dye concentration 50 mg/L, while the dye solution flow rate was kept constant (8 mL/min). The results showed 58% CR removal during the first few minutes. Maximum saturation capacity was 54.73 mg/g.

*Keywords:* low cost adsorbent, Congo red, adsorption, column studies



## AMOXICILLIN REMOVAL BY H<sub>2</sub>SO<sub>4</sub>-ACTIVATED CARBON PRODUCED FROM HAZELNUT SHELLS

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The aim of this study was to investigate the adsorptive removal of amoxicillin (AMX) from aqueous solutions using H<sub>2</sub>SO<sub>4</sub>-activated carbon produced from hazelnut shells (AC-HS). Characterisation of the AC-HS was performed by N<sub>2</sub> adsorption and desorption isotherms, scanning electron microscope (SEM), Fourier transform infrared spectroscopy (FTIR) and pH<sub>pzc</sub>. A batch technique was used for the investigation of AMX adsorption on AC-HS and the concentration of AMX was monitored by UHPLC. The experimental adsorption data were modelled using appropriate kinetic (pseudo-first order, pseudo-second order and Elovich) and isotherm (Freundlich and Langmuir) models. The maximum adsorption capacity of AMX onto AC-HS was 10.18 mg/g. AMX adsorption onto AC-HS increased from 77 to 87% with the increase of temperature from 25 to 45 °C. Overall, the obtained results indicate that waste lignocellulosic material (*i.e.* hazelnut shells) could be a promising non-hazardous adsorbent, which can be used for the removal of AMX from water.

*Keywords:* lignocellulosic material, activated carbon, amoxicillin, adsorption



## CENTRALIZIRANI ILI DECENTRALIZIRANI SUSTAV OBRADE OTPADNIH VODA – KAKO DO PRAVE ODLUKE?

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Dobra priključenost stanovništva na sustave odvodnje te obrada otpadnih voda neke su od temeljnih postavki održivosti u upravljanju vodnim resursima nekog područja. Pri tome dominiraju centralizirani sustavi za obradu otpadnih voda. Ipak, decentralizirani sustavi za manje aglomeracije koji se grade u suradnji s lokalnom upravom sve više su prepoznati kao alternativa velikim centraliziranim sustavima i kao prikladan način za osiguravanje učinkovite obrade otpadnih voda, uz istovremeno smanjenje troškova i mogućnost ponovne uporabe pročišćene vode. Pravilan odabir stupnja centralizacije, odnosno decentralizacije sustava za obradu otpadnih voda neke aglomeracije ovisi o cijelom nizu čimbenika, koje treba uzeti u obzir prilikom odabira: demografski, tehnološki, ekonomski, okolišni, socijalni, itd. U radu se analizira problematika odabira centraliziranog ili decentraliziranog sustava odvodnje otpadnih voda uzimajući u obzir njihove specifičnosti, kao i specifičnosti same aglomeracije za koju se sustav razmatra.

*Ključne riječi:* otpadna voda, decentralizirani sustav obrade otpadnih voda, centralizirani sustav obrade otpadnih voda



## **CENTRALIZED OR DECENTRALIZED WASTEWATER TREATMENT SYSTEM - HOW TO REACH THE RIGHT DECISION?**

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Good connectivity of the population to the sewerage systems and wastewater treatment are some of the fundamental sustainability elements in the management of water resources in a certain area. Centralized systems for wastewater treatment dominate in this sense. Nevertheless, decentralized systems for smaller agglomerations built in co-operation with local government are increasingly recognized as an alternative to large centralized systems and are perceived as an adequate way to ensure efficient wastewater treatment, while reducing costs and enabling reuse of the purified water. The proper selection of the degree of centralization or decentralization of the wastewater treatment system of a certain agglomeration depends on a variety of factors to be considered when selecting: demographic, technological, economic, environmental, social, etc. This paper analyzes the issues of selecting a centralized or a decentralized wastewater treatment system taking into account their specificities, as well as the specificities of the agglomeration itself for which the system is being considered.

**Keywords:** wastewater, decentralized wastewater treatment system, centralized wastewater treatment system





## BIOLOGICAL NUTRIENT REMOVAL IN SEQUENCING BATCH REACTOR WITH ANOXIC/OXIC CONFIGURATION

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In an anoxic/oxic process the effectiveness of phosphate accumulating organisms (PAOs) and nitrifiers and denitrifiers for N and P removal at different C/P ratios was investigated. Sodium acetate was used as a sole source of carbon. The anoxic/oxic biological nutrient removal process was performed at configuration: 2 h anoxic phase (addition of sodium acetate), followed by aerobic phase (addition of PO<sub>4</sub>-P and NH<sub>4</sub>-N). The anoxic/oxic process resulted in a simultaneous removal of C, N and P as a result of PAOs activity, nitrifiers and denitrifiers, and ordinary heterotrophs activity. PAOs cluster was proven by FISH method. Poly-P was detected in microbial cells.

*Keywords:* anoxic/oxic regime, N and P removal, PAOs, nitrifiers, denitrifiers



## **TREATMENT OF THE OLIVE POMACE LEACHATE WASTEWATER**

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Disposal of the olive mill wastes is serious threat to the environment in the Mediterranean countries. Storage of this energy valuable material on the open surfaces, expose it to runoff, leaching and fast wastewater production occurs. This leachate has to be characterized and treated to prevent environmental pollution. Production, characterization and treatment of the olive pomace leachate have been investigated in laboratory scale. Monitoring of production of the leachate has shown rapid elution in the first 12 hours, with decrease content of pollutants up to complete experiment. That means high solubility of harmful components in water and serious threat in case of uncontrolled disposal of the olive pomace in nature. In eluted wastewater have been determined COD (2447.70 mg O<sub>2</sub>/l), BOD<sub>5</sub> (724.8 mg O<sub>2</sub>/l), Kjeldahl nitrogen (11.2 mg N/l), pH (4.34) and turbidity (72.8 NTU). Decrease of the high COD and BOD<sub>5</sub> values is performed with aeration during 4 days, where removal efficiency was 41% and 30% respectively. Treatment has been continued with flocculation and coagulation where maximal achieved removal efficiency was 58% of initial COD.

*Keywords:* wastewater, leachate, olive pomace, aeration, coagulation



## SOLID-PHASE EXTRACTION OF NEONICOTINOIDS RESIDUE FROM WATER: COMPARISON BETWEEN EXTRACTION CARTRIDGES

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Neonicotinoids are nowadays the most widely used insecticides in the world and include imidacloprid, thiamethoxam, acetamiprid, thiacloprid and clothianidin, as well as the metabolite 6-chloro nicotinic acid. The Commission Implementing Decision (EU) 2018/840 of 5 June 2018 established the watch list of substances for Union-wide monitoring in the field of water policy pursuant to Directive 2008/105/EC of the European Parliament and of the Council and repealing the Commission Implementing Decision (EU) 2015/495. This Decision establishes additional substances and their maximum acceptable method detection limits like oxadiazon (8.8 ng/L), methiocarb (10 ng/L) and neonicotinoids (9-500 ng/L). During the pesticides extraction from water, the solid-phase extraction (SPE) column was used. Bakerbond spe<sup>TM</sup> SDB-1 Solid Phase Extraction Columns (J.T. Baker<sup>TM</sup>, USA) and Bond Elut Plexa (Agilent Technologies, USA) were evaluated for the SPE of neonicotinoids (imidacloprid, thiamethoxam, acetamiprid, thiacloprid and clothianidin) from water. The comparison of the results of these two types of columns, was performed by spiking water samples at two levels (0.05 and 0.1 µg/L) in in three replicates. The Bakerbond<sup>TM</sup> column with styrene-divinylbenzene (SDB) copolymer/ 6 mL capacity, 200 mg bed weight) quantitatively adsorbed these pesticides, with the obtained recoveries: 36.9% for imidacloprid, 43.2% for tiacloprid, 119.3% for clothianidin, 64.6% for acetamiprid and 53.6% for thiamethoxam. Using Bond Elut Plexa (60mg, 3 mL) with the unique polymeric architecture with a nonretentive, hydroxylated, amide-free surface and a nonpolar PS-DVB core for retaining small molecules, the obtained recoveries were 66.9% for imidacloprid, 72.9% for tiacloprid, 103.4% for clothianidin, 67.4% for acetamiprid and 45.2% for thiamethoxam. Both colums have low recovery values for thiametoxam, while the highest values were obtained by Bond Elut Plexa for thiacloprid, imidacloprid and acetamipri. Great recoveries were achieved for clothuanidin using both SPE columns. Those recoveries were obtained by the use of calibration prepared in mobile phase ranging from 0.01 to 0.1 µg/L. Those results poin out the necessity of matrix-mached calibration.

**Keywords:** neonicotinoids, SPE extraction, water, LC-MS/MS

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## KONDICIONIRANJE VODE ZA LJUDSKU POTROŠNJU IZ AKUMULACIJSKOG JEZERA “BUTONIGA”, ISTRA

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Akumulacijsko jezero Butoniga smješteno je na istoimenoj glavnoj lijevoobalnoj pritoci rijeke Mirne, a nastalo je izgradnjom brane 1988. godine u cilju stvaranja zaliha i korištenja vode za potrebe vodoopskrbe. Akumulacijsko jezero prikuplja vodu rijeke Butoniga, njenih pritoka Dragućki i Račićki potok te oborinske vode okolnog područja. Slijev se proteže između 40 i 500 m nadmorske visine, a ukupni obujam akumulacije „Butoniga“ iznosi 19,7 milijuna m<sup>3</sup>. Kapacitet prerade vode pogona „Butoniga“ i vodoopskrbe je 1000 l/s, a proces kondicioniranja vode čini niz sljedećih postupaka i tehnoloških procesa: (i) zahvaćanje vode iz jezera, (ii) predtretman predozoniranjem, (iii) koagulaciju, flokulaciju i flotaciju (iv) brzu filtraciju, (v) glavno ozoniranje (vi) sporu filtraciju te (vii) dezinfekciju i korekciju pH vrijednosti. Prerađena voda se nakon obrade putem vodoopskrbnog sustava Istarski vodovod d.o.o. distribuira se stanovnicima Pazina, Poreča i Rovinja te dijelu stanovništva grada Pule. Cilj ovog rada je prikaz tehnološkog procesa i učinkovitosti kondicioniranja površinske vode akumulacijskog jezera Butoniga te opis vodoopskrbnog sustava Istarskog vodovoda.

*Ključne riječi:* kondicioniranje vode, vodoopskrbni sustav, Istra, Butoniga



## **DRINKING WATER TREATMENT PLANT AT BUTONIGA ACCUMULATION LAKE, ISTRIA**

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The Butoniga accumulation lake is located on the main left bank of the river Mirna, and it was built by the dam construction in the year 1988. The accumulation lake was constructed with the aim to obtain water reservoir for Istrian water supply system. The reservoir collects the water of the Butoniga River, its tributaries Dragučki and Račički potok, as well as the precipitation from the surrounding area. The slope extends between 40 and 500 m above sea level, and the total volume of the Butoniga reservoir is 19.7 million m<sup>3</sup>. The water treatment capacity of the "Butoniga" is 1000 l/s and implies a following technological processes: (i) catching water from the lake, (ii) pretreatment by pre-ozonation, (iii) coagulation, flocculation and flotation (iv) rapid filtration, (v) ozonation (vi) slow sand filtration and (vii) disinfection and pH correction. After treatment, the processed water is distributed via water supply system Istarski vodovod d.o.o. to the consumers and residents of towns Pazin, Poreč, Rovinj and part of the population of town of Pula. The aim of this paper is to present the technology and efficiency of drinking water treatment plant at the Butoniga accumulation lake. The water supply system of the Istria, Istarski vodovod d.o.o, will be also described.

*Keywords:* water conditioning, water supply system, Istria, Butoniga



## **OCCURRENCE OF NUTRIENTS, HEAVY METALS AND MICROPLASTICS IN SOME WASTEWATER TREATMENT PLANTS' OUTPUTS IN ISTRA REGION**

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Agriculture is highly dependent on the climate and is one of the sectors which are the most affected by observed climate changes in the last decades. Climate change induced intensification and prolongation of droughts could significantly affect the agricultural socio-economic potential of Mediterranean regions such as Region of Istria. Hydrological plans based on water saving, efficiency and reuse can maintain water resource availability for multiple uses. This study aims at investigating the occurrence and fate of nutrients, heavy metals and microplastics in four wastewater treatment plants (WWTPs) in Istria region (WWTPs: Roč, Prhati, Kanfanar, Sveti Lovreč). Samples were taken from the output of the selected WWTPs in three sampling events (May, June and July) in 2018. Collected samples were analyzed for: pH, electrical conductivity, nutrients, dissolved organic carbon, heavy metal concentration (As, Ba, Cu, Zn, Cd, Cr, Ni, Pb, Hg) and microplastics (MPs) in two size fractions: 50 µm-300 µm and > 100 µm. Based on the results of the three sampling events, it could be seen high variability in nutrients concentration as well as heavy metals concentrations (Cu and Ni). MPs were found in all samples and their average abundance ranged from  $12 \pm 2100 \text{ L}^{-1}$  (50 µm-300 µm).

*Keywords:* irrigation, water quality, nitrogen, droughts, climate change



**Upravljanje vodnim resursima /**  
***Water resources management***





## MOGUĆNOSTI I PREDNOSTI KORIŠTENJA GEOTERMALNIH VODA

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Geotermalne vode predstavljaju dvije trećine od ukupno procijenjenih obnovljivih izvora energije u svijetu, a njihovo je korištenje poznato iz davne povijesti, posebno iz rimskih vremena. Promatrajući geotermijski potencijal Republika Hrvatska se može podijeliti na dva različita prostora koja dijeli južni dio savske depresije: Panonski i Dinarski prostor. Zahvaljujući pozitivnoj toplinskoj anomaliji u Panonskom prostoru su prosječni temperaturni gradijent i gustoća toplinskog toka znatno viši od europskog prosjeka, stoga se u ovom području nalazi većina izvora geotermalne vode, uz mogućnost pronalaženja novih izvora dok su u Dinarskom prostoru prosječni temperaturni gradijent i gustoća toplinskog toka niži od svjetskog prosjeka. Unatoč pozitivnim preduvjetima geotermalna voda se nije koristila u skladu sa svojim mogućnostima. Većinom se koristila za rekreaciju i terapiju, a nešto manje za uzgoj riba, sanitarnu vodu, te za zagrijavanje vode i prostora. Razvojem naftne industrije i ispitivanjem pojedinih geotermalnih bušotina stvoren je tehnološki preduvjet za iskorištavanje geotermalne vode, za grijanje, proizvodnju voća i povrća u staklenicima, a u pogon je puštena i prva hrvatska geotermalna elektrana, čime se trendovi korištenja vrlo polako okreću u pozitivnom smjeru.

*Ključne riječi:* geotermalne vode, obnovljivi izvori energije, mogućnost korištenja

## POSSIBILITIES AND ADVANTAGES OF GEOTHERMAL WATER EXPLOITATION



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Geothermal water represents two thirds of the total estimated renewable energy sources in the world, and their usage are known from ancient history, especially from old Romans. According to the geothermal potential, the Republic of Croatia can be divided into two different parts that are divided by southern part of the River Sava depression: Pannonian and Dinarics part. With the help of positive thermal anomaly, in the Pannonian part are average temperature gradient and thermal flow density noticeably higher than the European average, therefore are most geothermal water springs located in this area, with the possibility of discovering new springs. Temperature gradient and thermal flow density in the Dinarics part are lower of the world average. Despite the positive preconditions, the geothermal water was not used accordance with its capabilities. It was mostly used for recreation and therapy, and a little less for fish farming, sanitary water and for water and space heating. Development of oil industry and examination of some geothermal boreholes created technological precondition for geothermal water exploitation, for heating and production of fruit and vegetables in greenhouses. The first Croatian geothermal power plant has been finished, wherewith is the usage trend turned in a positive direction.

*Keywords:* geothermal water, renewable energy sources, possibility of exploitation



## ASSESSMENT OF SURFACE AND GROUNDWATER QUALITY IN THE PROTECTED AREA OF LAKE ZOBNATICA USING MULTIVARIATE STATISTICAL METHODS

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The paper presents a review of two research years (2018-2019) in monitoring of surface and ground water quality in the protected area of Zobnatoca lake. Standard laboratory methods were used in the analysis of the key physico-chemical parameters: pH, dissolved oxygen, anions - nitrites ( $\text{NO}_2^-(\text{aq})$ ) and nitrates ( $\text{NO}_3^-(\text{aq})$ ), orthophosphates ( $\text{PO}_4^{3-}(\text{aq})$ ) and ammonium nitrogen cation ( $\text{NH}_4^+-\text{N}(\text{aq})$ ), total nitrogen, sulfates ( $\text{SO}_4^{2-}(\text{aq})$ ), chlorides ( $\text{Cl}^-(\text{aq})$ ), fluorides ( $\text{F}^-(\text{aq})$ ), conductivity, and cations of metals (nickel ( $\text{Ni}^{2+}(\text{aq})$ ), iron ( $\text{Fe}^{2+}(\text{aq})$ ), zinc ( $\text{Zn}^{2+}(\text{aq})$ ), chromium ( $\text{Cr}^{6+}(\text{aq})$ ), copper ( $\text{Cu}^{2+}(\text{aq})$ ). Multivariate statistical methods, principal component (PCA) and cluster analysis (CA), were applied to assess the water quality. PCA was used to evaluate chemical parameters that have the greatest impact on the deterioration quality of the aquatic media. The CA group observed locations and determines which location has negative load. Statistical interpretation of the results obtained with standard laboratory analyzes identified possible sources of contamination. Release of inorganic and organic pollutants during the anthropogenic activities may cause contamination of aquatic environment.

**Keywords:** PCA, CA, monitoring, water quality

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## **EVALUATION OF LEACHATE POLLUTION INDEX OF URBAN MUNICIPAL LANDFILL SITE IN NOVI SAD, SERBIA**

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Leachate samples were collected during the one year monitoring campaign, on municipal solid waste landfill in Novi Sad, Serbia. Determination of T, pH, EC, DO, BOD<sub>5</sub>, COD, NO<sub>2</sub>-N, NO<sub>3</sub>-N, NH<sub>4</sub>-N, Tot N, Tot P, B, SO<sub>4</sub><sup>2-</sup>, KMnO<sub>4</sub>, and cations of metals (Ca, Mg, Na, K, B, Cr, Ni, Zn, Fe, Cd, Pb and Al) was performed in order to evaluate the leachate pollution index (LPI) (Kumar and Alapat 2005). Due to the obtained values, only 7 parameters (pH, total dissolved solids, BOD<sub>5</sub>, COD, iron, zinc, and lead) were used for the purpose of calculation of LPI, which resulted in the reduced value of total pollution index. The obtained LPI value was 6,87 and was lower than value obtained within the previous study from the similar landfill site in Croatia (8,53) (Matešić et al., 2016). In addition the obtained LPI value is lower than 35 which indicates the low potential of contamination, as well as the relatively constant quality status of the leachate on landfill site in Novi Sad. The future monitoring programs should include all 18 prescribed parameters for LPI evaluation in order to obtain the overall value of the contamination index.

*Keywords:* leachate, municipal solid waste landfill, LPI

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**Monitoring kakvoće voda /**  
*Monitoring of water quality*



## SPEKTROFOTOMETRIJSKO I KROMATOGRAFSKO ODREĐIVANJE ANIONA I KATIONA U UZORCIMA KONZUMNE VODE

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Kvaliteta vode se ispituje prema preporukama, smjernicama i pravilnicima mjerodavnih ustanova i zavoda na međudržavnoj i državnoj razini. Pitka voda je bistra i potpuno prozirna, bez mirisa i boje. Analiza vode obuhvaća čitav niz fizikalnih (temperatura, boja, mutnoća, miris, okus, pH, ...), kemijskih (kalcij, magnezij, kalij, litij, natrij, amonijak, fluorid, klorit, bromat, klorid, nitrit, klorat, bromat, nitrat, fosfat, sulfat, ...) i bakterioloških parametara, te toksičnih tvari (aluminij, arsen, berilij, cijanidi, kadmij, krom, nikal, olovo, pesticidi, selenij, vanadij, živa, bakar, cink, ...). U ovom su radu spektrofotometrijski i kromatografski proučavani pojedini kemijski parametri u uzorcima konzumne vode iz vodovodne mreže u Osijeku. Promatrana voda uzorkovana je na 6 različitih lokacija (tri blizu Vodovoda i tri udaljene od Vodovoda). Spektrofotometrijskom analizom određivana je koncentracija mangana i željeza. Drugi dio rada obuhvaćao je analizu konzumne vode ionskom kromatografijom. Određivale su se i uspoređivale koncentracije pojedinih aniona (fluorida, fosfata, klorida i bromida) i kationa (kalcija, magnezija, kalija, natrija). Cilj istraživanja bio je praćenje koncentracije ispitivanih kationa i aniona u određenom vremenskom periodu te uspoređivanje dobivenih vrijednosti sa zakonskim regulativama. Kako bi se upotpunilo istraživanje, određivana je i pH vrijednost navedenih uzoraka. Dobiveni rezultati ispitivanih parametara nisu pokazali značajnija odstupanja od zakonom propisanih vrijednosti.

*Ključne riječi:* spektrofotometrija, kromatografija, konzumna voda, anioni, kationi



## SPECTROPHOTOMETRIC AND CHROMATOGRAPHIC DETERMINATION OF ANIONS AND CATIONS IN THE DRINKING WATER SAMPLES

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Water quality is determined according to the recommendations, guidelines and books of regulations of relevant agencies and institutions on the interstate and state level. Drinking water is clear and totally transparent with no smell and color. Water analysis includes the whole range of physical (temperature, color, abstruseness, smell, flavor, pH, ...), chemical (calcium, magnesium, potassium, lithium, sodium, ammonia, fluoride, chlorite, bromate, chloride, nitrate, chlorate, bromate, nitrate, phosphate, sulphate, ...) and bacteriological parameters and toxic compounds (aluminum, arsenic, beryllium, cyanide, cadmium, chromium, nickel, lead, pesticides, selenium, vanadium, mercury, copper, zinc, ...). In this study some chemical parameters were studied in drinking water samples from the Osijek water supply network with spectrophotometry and chromatography. Samples of the studied water were taken from 6 different locations (three locations near Vodovod and three locations far away from Vodovod). Spectrophotometric analysis was used to determine concentration of manganese and iron. The second part of this study included drinking water analysis with ionic chromatography. Concentrations of several anions (fluoride, phosphate, chloride and bromide) and cations (calcium, magnesium, potassium and sodium) were determined and the obtained concentrations were compared. The aim of this study was to monitor concentrations of the studied cations and anions in a determined time period and to compare the obtained results with law regulations. In order to complete this investigation, pH values of the studied water samples were also determined. The obtained results of the studied parameters didn't show significant deviation from values determined by law.

*Keywords:* spectrophotometry, chromatography, drinking water, anions, cations





## ESTIMATION OF ANTIBACTERIAL ACTIVITY OF SELECTED ANTIBIOTIC PRODUCTS

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Antibacterial resistance is currently a major global issue. Antibacterial agents, together with antibiotic-resistant bacteria have been widely detected in different environmental compartments. The activity of antibacterial agents on bacteria may differ based on bacterial species or strain. Due to serious infections caused by multidrug-resistant bacteria, in 2014, the World Health Organization identified antimicrobial resistance as one of the most critical challenges and serious threats to the global public health. Thus, currently, antibacterial agents are regarded as emerging environmental contaminants, with possible implications for human health and ecological status of the environment. The present study aimed to determine the antibacterial activity as well as minimum inhibitory concentrations of azithromycin, erythromycin and tulathromycin against *Bacillus subtilis*, *Pseudomonas aeruginosa* and *Escherichia coli*, respectively. Disc diffusion assay was used to determine antibacterial activity on selected bacteria. Three different concentrations of antibacterial agents were used 40, 80 and 800 mg/L. From obtained results of disc diffusion method, it can be concluded that azithromycin, erythromycin and tulathromycin inhibited the growth of *B. subtilis* at all examined concentrations. The growth of *E. coli* was not inhibited by any of examined antibacterial agents and growth of *P. aeruginosa* was not inhibited by erythromycin, but with azithromycin and tulathromycin was inhibited at all examined concentration.

*Keywords:* Antibacterial activity, *Bacillus subtilis*, *Pseudomonas aeruginosa*, *Escherichia coli*, azithromycin, erythromycin and tulathromycin

### *Acknowledgments*

This study was funded by Croatian Science Foundation through project entitled Modeling of Environmental Aspects of Advanced Water Treatment for Degradation of Priority Pollutants (MEAoWT) (IP-09-2014-7992).



## CHEMICAL AND MICROBIOLOGICAL ANALYSIS OF RIVER LASVA PARAMETERS

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Due to industrial activities and the use of agrochemicals, an inadequate chemical and microbiological quality of irrigation water has been identified. The aim of this paper was to examine the chemical and microbiological quality of irrigation water (IW) from the river Lasva (Bosnia and Herzegovina). Fifteen samples of IW were taken in the spring, summer and autumn of 2017 at five locations (Santici, Donji Sakici, Dolac, Merdani and Lasva) in the valley of the Lasva River. From chemical parameters, the pH value was determined potentiometrically (Matlab Taleb 5410, USA), the nitrite and nitrate concentration was determined using the Hach DR / 2000 (UV) UV / VIS spectrophotometer, and the AAS method was used for the determination of metals. Total coliform bacteria and faecal streptococci were determined by MPN method, nutrient agar was used for identification of mesophilic and psychophilic bacteria, ceftrimid agar for *Pseudomonas sp.*, SS agar for *Salmonella spp.*, and sulphite agar for fecal *Clostridium* species. The results showed that the pH value is optimal for irrigation purposes. The content of Fe, Zn, K, nitrite and nitrate in all samples was below the maximum allowed concentration. The presence of pathogenic bacteria was detected in most of the samples. Only the water sample from the Santici locality can be considered adequate and appropriate for irrigation purposes, while other samples are characterized by poor microbiological quality. These studies confirm the importance of microbiological characteristics in the assessment of water used for irrigation.

*Keywords:* water quality, irrigation water, river Lasva



## ORGANOKLORNA KONTAMINACIJA SEDIMENTA TIJEKOM RURALNOG, URBANOG I INDUSTRIJSKOG UTJECAJA NA AKVATIČNI SUSTAV (DUNAV, SRBIJA)

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Prostorna distribucija različitih organoklornih spojeva (PCB i OCP (DDT, HCB i HCH)) ispitana je u kolektiranim uzorcima sedimenta rijeke Dunav na području Srbije. Dobivene koncentracije su bile relativno niske u usporedbi s drugim akvatičnim sedimentima širom svijeta. Rezultati su pokazali širok opseg koncentracija ( $\mu\text{g}/\text{kg}$  suhe težine) sa sljedećim redoslijedom:  $\Sigma_6\text{DDTs}$  (0.70-16.65) >  $\Sigma_7\text{PCBs}$  (0.25-3.54) >  $\Sigma_5\text{HCH}$  (0.04-2.28) > HCB (0.06-0.62), s dominacijom o, p'-DDT. Relativno veće  $\Sigma\text{DDT}$  koncentracije i visoke DDT/DDE + DDD vrijednosti na dva mjesta uzorkovanja u blizini industrijskih gradova ukazuju na trenutnu upotrebu DDT-a. Kompozicijske analize su pokazale da su heksa- i hepta-PCB dominantni za PCB. Rezultati dobiveni u ovom istraživanju ukazuju da je PCB kontaminacija akvatičnog sustava proistekla iz ne-točkastog taloženja, kao što je atmosferska depozicija i površinsko otjecanje, za manje klorirane kongenere, ali i točkastih izvora, kao što su industrijski izvori stacionirani duž toka rijeke, za visoko klorirane kongenere. OCP potiču uglavnom od starih ostataka i nove upotrebe pesticida u poljoprivredi i akvakulturi. Dobiveni rezultati doprinose oskudnoj regionalnoj bazi podataka za organoklorne spojeve u slijevu rijeke Dunav.

*Ključne riječi:* Sediment Dunava, PCB, DDT, HCB, HCH

### Zahvala

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## **ORGANOCHLORINE CONTAMINATION IN SEDIMENTS COLLECTED FROM A RURAL-, URBAN- AND INDUSTRIAL-IMPACTED AQUATIC SYSTEM (DANUBE, SERBIA)**

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The spatial distribution of various organochlorinated compounds (PCBs and OCPs (DDTs, HCB and HCHs)) were investigated in sediments of Serbian's stretch of Danube River. Obtained concentrations were appeared to be relatively low in comparison with other rivers sediment worldwide. The results demonstrated a wide range of concentrations ( $\mu\text{g}/\text{kg}$  dry weight) with the following decreasing order:  $\Sigma_6\text{DDTs}$  (0.70-16.65) >  $\Sigma_7\text{PCBs}$  (0.25-3.54) >  $\Sigma_5\text{HCH}$  (0.04-2.28) > HCB (0.06-0.62), with a dominance of o,p' -DDT. Relatively higher  $\Sigma\text{DDT}$  concentrations and high DDT/DDE + DDD ratios in two sampling locations near the industrial cities indicates a current DDT usage, probably linked to public health emergencies. Compositional analyses indicated that hexa- and hepta-PCBs were dominant for PCBs. Our results indicated that the contamination with PCBs came from nonpoint deposition, such as atmospheric contribution and surface runoff, for light chlorinated congeners and point source deposition, such as the industrial sources along river flow, for highly chlorinated congeners, whereas OCPs originate mainly from old residuals and new usage of pesticides in agriculture and aquaculture. These results contribute to the sparse regional database for organochlorinated compounds in the Danube basin.

**Keywords:** Danube sediment, PCBs, DDTs, HCB, HCHs

### *Acknowledgements*

This investigation was financed by the Ministry of Education, Science and Technological Development, Republic of Serbia (III46009 and TR34014).



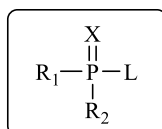
## ORGANOPHOSPHATE PESTICIDE IN WATER

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Pesticide pollution of surface water and groundwater has been recognized as a major problem in many countries because of their persistence in aquatic environment and potential adverse health effects. Pesticides in the streams are a potential concern for human health if they affect a drinking water source or occur where there is a recreational use such as bathing and swimming. They also are a potential concern for aquatic life and ecosystems in all streams. Although the primary issue for groundwater is drinking water quality, groundwater may also play a role as a source of pesticides contamination to surface water sources. Organophosphate (OP) compounds are a group of pesticides that includes some of the most toxic chemicals used in agriculture. OP compounds are esters, anhydrides or halides of fully substituted phosphorous, phosphonic or phosphinic acid. For these compounds central the phosphorus atom must form five bonds,  $R_1$  and  $R_2$  may be alkyl, alkoxy, alkylthio, aryl, aryloxy, mono- or dialkylamino groups. The leaving group L is attached to the phosphorous atom with the weaker bond.



X: O or S

$R_1, R_2$ : alkyl, alkoxy-, alkylthio-, aryl-,  
aryloxy-, mono- and dialkylamino group

L: -F, -CN, -SR<sub>3</sub>, -OR<sub>3</sub>

OP toxicity is due to the ability of these compounds to inhibit an enzyme, acetyl cholinesterase at cholinergic junctions of the nervous system. This review will deal with the chemical structure of OP compounds, its health impacts, poisoning, metabolism of OPs, pesticides analysis, and major modes and pathways for degradation of organophosphate pesticides.

**Keywords:** organophosphate pesticides, poisoning, pesticides analysis, degradation



## **INFLUENCE OF KEY PROCESS PARAMETERS FOR DEGRADATION OF ATRAZINE BY USING PHOTOOXIDATIVE AOP**

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Since the day when pesticides were created and began to use them, they became pollutant because of their extremely low biodegradability. Although, pesticides have a lot of positive properties, once they enter into the aquatic system, they become a problem. Due to these harmful effects, both on humans and on the flora and fauna, some pesticides are listed on the list of priority substances of Directive 2013/39/EU with purpose to be continuously monitored in the aquatic environment. Therefore, there is a need for finding effective, but also environmentally acceptable methods for their removal. Methods for the primary and secondary wastewater treatment processes are not effective for the removal of pesticides, so Advanced Oxidation Processes (AOP) are showing better efficiency and their potential increases. The aim of this paper was to apply the photolysis and photooxidation processes with the addition of oxidants (hydrogen peroxide and sodium persulphate) in the continuous flow reactor for the removal of pesticide atrazine from model water. The influence of process parameters (flow and concentration of oxidants) on the efficacy of atrazine removal was examined. By using a combination of a full factor plan and the response surface method (RSM), it was found that the maximum removal of atrazine (78.11%) is achieved by applying a vacuum UV/PS process at a flow rate of 0.6 L/min and a persulphate concentration of 2 mM, which is in accordance with the values of developed RSM model (78.68%). Also, it has been shown that both process parameters, flow and concentration of oxidants have a significant effect on the effectiveness of the removal of atrazine.

*Keywords:* advanced oxidation processes, atrazine, photooxidation, RSM modeling

### *Acknowledgements*

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## **WASTEWATER OF DAIRY LIVNO**

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Dairy Livno is one of the largest dairies in Bosnia and Herzegovina, its main activity is buying milk and production of dairy products with special emphasis on the production of hard cheese (Livno cheese). Livno dairy as a major milk processor and potential polluter with a large amount of technological waste water, 60 m<sup>3</sup> to 100 m<sup>3</sup>, is of particular importance for monitoring. Since the drainage is located in the catchment area of the river Cetina, and any accidental situation (sudden and relatively large pollution usually caused by human factor) is directly reflected on the hydrological and biological potential of Cetina River. Waste water monitoring is carried out according to the Regulation on the conditions of wastewater discharge into the environment and the public sewerage system (Official Gazette of FB&H, No. 101/15). The dairy makes six annual tests on the basis of flow (wastewater monitoring). Testing the quality parameters of technological waste water is done by analytical methods in accordance with BAS EN ISO standards. The paper analyzes the parameters of wastewater technology according to legal regulations over the last two years (2017-2018). A total of 12 laboratory tests were observed and were found to comply with the requirements of the Regulation.

*Keywords:* waste water, monitoring, quality parameters



## QUALITY OF THE DUMAN WATER SOURCE

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The Duman water source is located in the area of Livno and it is the basis of the water supply system of urban and peripheral urban areas. It runs under the rocky edge of Crvenica, which belongs to the mountain mass of Kruzi-Cincar. The amount of water of this source depends on the season and the amount of rainfall, and during the year it varies from a maximum flow rate of 4800 L/s to a minimum of 370 L/s. During the last two years the physicochemical and microbiological parameters of the water quality of the mentioned source have been monitored according to BAS EN ISO standards, and the obtained values are compared with the climatological picture i.e. by the amount of rainfall in the mentioned period. During the rainy season, when water flow is increased, the occurrence of water cloudiness and the increased number of fecal coliform bacteria have been reported. Water turbidity values in the examined period ranged from 0.01 to 1.25 nephelometric units of turbidity (NTU), whereas according to the Ordinance on the health of drinking water of Federation of Bosnia and Herzegovina the value of NTU should not exceed 1. Depending on the amount of rainfall, there were also marked changes in the microbiological parameters of water quality. The total number of coliform bacteria per 100 mL was between 20 and 200 while the Ordinance on the health of drinking water allowed the total number of faecal coliform bacteria 0/100 ml. These results may be due to dirt impurities from the surface or surface of underground flow during flow as well as limestone substrates and the inability of natural filtration, and such water represent a constant potential danger to consumers and require a very strict control regime.

*Keywords:* water quality, physicochemical parameters, microbiological parameters, climatological image





## MIKROBIOLOŠKA ISPRAVNOST BUNARSKIH VODA NA PODRUČJU KOPRIVNIČKO-KRIŽEVAČKE ŽUPANIJE U 2018.

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Bunari su iskopine ili bušotine kreirane u zemlji kopanjem, bušenjem ili pobijanjem da bi se pristupilo podzemnim vodama. Prije izgradnje vodoopskrbne mreže, bunari su se koristili kao izvori pitke vode za namirivanje potreba mnogih domaćinstava u Koprivničko-križevačkoj županiji. Danas stanovništvo županije bunarsku vodu koristi uglavnom kao pitku vodu za životinje, dok se u nekim mjestima županije još uvijek koristi i kao izvor pitke vode za ljude. Tijekom 2018. godine u Veterinarskom zavodu Križevci u Laboratoriju za mikrobiologiju hrane i hrane za životinje analizirano je 287 uzoraka bunarskih voda. Od ukupnog broja pretraženih uzoraka, 69 (24 %) uzoraka bilo je nesukladno prema Pravilniku o parametrima sukladnosti i metodama analize vode za ljudsku potrošnju (NN 125/2017). S obzirom na činjenicu da je gotovo jedna četvrtina svih analiziranih uzoraka nesukladna te da zdravstveno neispravna voda može uzrokovati razne bolesti u čovjeka, važno je kontinuirano provoditi uzorkovanje i mikrobiološku analizu bunarske vode, naročito u mjestima gdje se koristi kao izvor pitke vode. Također, važno je redovito provoditi postupak dezinfekcije i educirati stanovništvo o važnosti iste.

*Ključne riječi:* bunarska voda, zdravstvena ispravnost, Koprivničko – križevačka županija



## **MICROBIOLOGICAL CORRECTNESS OF WELL WATER IN THE KOPRIVNIČKO KRIŽEVAČKA COUNTY IN 2018**

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Wells are excavations or boreholes created in the ground by digging, drilling or driving to access groundwater. Prior to the construction of the water supply network, wells were used as sources of drinking water to supply the needs of many households in Koprivnica-Križevci County. Today, the county's population mainly use well water as drinking water for livestock, while in some localities it is still used as a source of drinking water for people. 287 samples of well water were analyzed during 2018 in the Veterinary Institute Križevci, in Laboratory for Microbiology of Food and Animal Feed. Out of the total number of samples tested, 69 (24%) of the samples were inconsistent with the Regulation on Conformity Parameters and Water Analysis Methods (NN 125/2017). Given that almost one quarter of all analyzed samples are non-conforming and that health-defective water can cause various diseases in humans, it is important to continually conduct sampling and microbiological analysis of well water, especially in places where it is used as a source of drinking water. It is also important to regularly carry out the disinfection process and educate the population on the importance of the disinfection.

*Keywords:* well water, health safety, Koprivnica-Križevci County



## LEVELS OF RARE EARTH ELEMENTS IN DRINKING WATER

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The mobility of rare earth elements (REEs) in water is low. However, natural (weathering processes) or human origins (the use of phosphate fertilizers) may lead to elevated concentrations of REEs in surface waters and groundwater. This study presents the results of analyses of the concentration of rare earth elements (REEs) in drinking water in the three settlements: Vladislavci, Čepin, Dalj (water from wells) and towns: Osijek, and Našice (public water supply system) located in eastern Croatia. Concentration of 13 rare earth elements: La, Ce, Pr, Nd, Sm, Eu, Gd, Dy, Ho, Er, Tm, Yb and Lu in 67 water samples were analysed by inductively coupled plasma mass spectrometry (ICP-MS). Mean concentrations of the REEs in analysed water samples ranged over 2 orders of magnitude, from less than 0,001 to 0,055  $\mu\text{gL}^{-1}$ . From all measured REEs, La and Ce had highest concentrations in most of the investigated locations. Analyzed water displayed variations with  $\sum\text{REEs}$  ranging from 0,019  $\mu\text{gL}^{-1}$  (Čepin), 0, 038  $\mu\text{gL}^{-1}$  (Osijek) 0,065  $\mu\text{gL}^{-1}$  (Našice), 0,090  $\mu\text{gL}^{-1}$  (Vladislavci) to 0,20 4  $\mu\text{gL}^{-1}$  (Dalj). No significant difference in mean REEs concentrations between water samples from wells and municipal water was observed (Mann –Whitney test,  $p=0,30$ ).

**Keywords:** rare earth elements, water, ICP-MS, Croatia



## **KAKVOĆA VODE ODVODNOG KANALA KARAŠICA KOD POPOVCA (13. R.KM) U RAZDOBLJU OD 2006. DO 2015. GODINE**

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Na području Baranje formirani su brojni vodotoci i kanali čija je glavna uloga odvodnja suvišnih voda s poljoprivrednog zemljišta, a kanal Karašica glavni je odvodni kanal. Stoga su u svrhu određivanja kakvoće vode kanala kod mjesta Popovac (13. r.km) istraženi u razdoblju 2006.-2015. godine režim kisika, organske i hranjive tvari te mikrobiološki pokazatelji, a u 2015. godini makrofitska vegetacija. Količina otopljenog kisika u vodi bila je veća u hladnijem dijelu godine (proljeće i jesen) i značajno se smanjivala ljeti uslijed pojačane mikrobiološke razgradnje organske tvari, uz povećane koncentracije amonij-N. S druge strane, količina nitrata bila je najveća u proljetnim mjesecima, što je pogodovalo razvoju makrofitske vegetacije. Tako je u proljeće 2015. godine bio razvijen submerzni tip vegetacije s 90 % pokrovnosti, dok je tijekom ljeta prevladavala slobodno-plivajuća vrsta *Lemna gibba*, a ukupna pokrovnost makrofita bila je smanjena (40%). Tijekom 2006. i 2012. godine utvrđene su najveće vrijednosti kemijske i biološke potrošnje kisika. Srednje vrijednosti ukupnog fosfora (3,947-0,666 mgP/L) i ortofosfata (1,194-0,323 mgP/L) su se smanjivale od 2006. do 2015. godine, međutim one su i dalje visoke i podržavaju povećanje eutrofizacije. Kakvoća vode bila je vrlo promjenjiva tijekom pojedinih godina i ovisila je o promjenama klimatskih parametara i jakom antropogenom utjecaju.

*Ključne riječi:* kakvoća vode, Odvodni kanal Karašica, makrofita, eutrofizacija



## WATER QUALITY OF THE DRAINAGE CANAL KARAŠICA NEAR POPOVAC (13TH R. KM): A TEN-YEAR ANALYSIS (2006-2015)

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The primary function of the drainage canal Karašica in Baranja is to drain surplus runoff waters from the surrounding agricultural land. A ten-year analysis (2006-2015) of the variations on water quality parameters (oxygen, organic matter, the nutrient regime, microbiological indicators, macrophyte vegetation) was conducted in the canal at the site Popovac (13th r. km). The amount of dissolved oxygen in the water was higher in the colder part of the year and decreased significantly in the summer due to intensified microbiological degradation of organic matter and increased ammonium-N concentration. The amount of nitrate was the highest in the spring months, favoring the development of macrophyte vegetation. Thus, in the spring of 2015, a submerged vegetation type with 90% coverage was developed, while the free-floating *Lemna gibba* prevailed during the summer when the overall coverage of the macrophytes was reduced (40%). During 2006 and 2012, the highest values of chemical and biological oxygen consumption were determined. The mean values of total phosphorus (3.947-0.666 mg/L) and orthophosphates (1.194-0.323 mg/L) have decreased from 2006 to 2015 but remained high indicating eutrophication. Water quality was variable over the years and was dependent on the changes in climate parameters as well as strong anthropogenic impacts.

*Keywords:* water quality, Drainage canal Karašica, macrophytes, eutrophication



## **UTJECAJ POLJOPRIVREDNIH I KOMUNALNIH OTPADNIH VODA NA RAST VODENE LEĆE *L. MINOR* L.**

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Poljoprivreda i urbanizacija značajno utječu na kvalitetu površinskih voda. Drenažni kanal Karašica u Baranji glavni je prijemnik slivnih voda poljoprivrednog područja i komunalnih otpadnih voda, a unos raznih onečišćujućih tvari u ovaj vodotok ovisi o sezonskim promjenama klimatskih parametara. Tijekom jedne godine mjesečno su na dvije postaje (S1 – pod utjecajem poljoprivrednih voda i S2 – pod utjecajem komunalnih otpadnih voda) uzimani uzorci vode za laboratorijske analize hranjivih tvari, organskih tvari, teških metala, pesticida, bakterijske kontaminacije, klorofila-a fitoplanktona i izvođenje Lemna testa za istraživanje utjecaja utvrđenog onečišćenja na rast vodene leće (*Lemna minor* L.). Na postaji S2 Odvodnog kanala Karašica utvrđene su manje srednje vrijednosti otopljenog kisika u vodi i klorofila fitoplanktona. Istodobno su utvrđene veće vrijednosti koncentracija hranjivih tvari i organske tvari te ukupnih koliforma, fekalnih koliforma i bakterije *Escherichia coli*, nego na postaji S1. S druge strane, vrijednosti organoklorovih pesticida i njihovih produkata razgradnje bili su viši na postaji S1. Fizikalno-kemijske karakteristike uzoraka vode s ove postaje pokazale su se stresnim za rast *L. minor* i dobro su korelirale s biomarkerima, kao što su sadržaj karotenoida i klorofila te peroksidacija lipida.

*Ključne riječi:* kakvoća vode, Odvodni kanal Karašica, Lemna-test, inhibicija rasta



## **INFLUENCE OF AGRICULTURAL AND COMMUNAL WASTEWATERS ON THE GROWTH OF *L. MINOR* L.**

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In the Baranja county agricultural practice and urbanization significantly affect surface water quality. The drainage canal Karašica is the main recipient of the agricultural and communal wastewaters, and the input of various pollutants into this watercourse depends on the seasonal changes in the climate parameters. Water was sampled monthly during one year at two distinctive sites on the drainage canal (S1 – influenced by agricultural runoff and S2 – by communal wastewaters) for laboratory analyses of nutrients, organic substances, heavy metals, pesticides, bacterial contamination, phytoplankton chlorophyll, and Lemna test, which was used to estimate the effect of determined contamination on the growth of *Lemna minor* L. At the site S2, lower average values of dissolved oxygen and phytoplankton chlorophyll concentration in the water was determined. At the same time, higher nutrient concentrations and organic matter as well as total coliforms, fecal coliforms and *Escherichia coli* were determined. On the other hand, organochlorine pesticides and their degradation products were higher at the site S1. Physicochemical characteristics of water samples from this site proved to be stressful for the growth of *L. minor* and correlated well with biomarkers like carotenoid and chlorophylls content and lipid peroxidation.

**Keywords:** water quality, drainage canal Karašica, Lemna test, growth inhibition



## ODREĐIVANJE ANIONA I KATIONA U UZORCIMA PRERAĐENE I NEPRERAĐENE VODE UPORABOM SPEKTROFOTOMETRIJE, IONSKE KROMATOGRAFIJE I VOLTAMETRIJE

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Voda je osnovni preduvjet života i predstavlja vrijednost koja nema cijenu. Pitka voda je sve dragocijenija, no zalihe pitke vode se smanjuju zbog rasta populacije, velikih zagađenja i klimatskih promjena. Kako bi se ispunili zahtjevi za postizanje ispravnosti potrebna je analiza vode. Analiza vode je određivanje fizikalno-kemijskih, organoleptičkih, mikrobioloških i drugih svojstava vode kako bi se mogla utvrditi njezina zdravstvena ispravnost. Uzimanje uzorka vode koja služi za određivanje svojstava mora se vršiti prema zakonom propisanim postupcima. Svrha redovitih ispitivanja je dobivanje osnovnih podataka o fizikalno-kemijskoj i mikrobiološkoj kvaliteti vode za ljudsku potrošnju te podataka o učinkovitosti rada postrojenja. Naše istraživanje je bazirano na spektrofotometrijskoj analizi prerađene i neprerađene vode u trajanju od 5 tjedana. Spektrofotometrijskom analizom određivana je koncentracija mangana, željeza i amonijaka u vodi. Drugi dio rada bazira se na kromatografskoj analizi gdje su određivane koncentracije amonijevih ( $\text{NH}_4^+$ ), nitratnih ( $\text{NO}_3^-$ ), nitritnih ( $\text{NO}_2^-$ ), sulfatnih ( $\text{SO}_4^{2-}$ ) iona, te ione arsena ( $\text{As}^{3+}$  i  $\text{As}^{5+}$ ). Za određivanje iona arsena ( $\text{As}^{3+}$ ) su također korištene ciklička i diferencijalna pulsna voltimetrija sa modificiranom i nemodificiranom elektrodom od staklastog ugljika. Cilj istraživanja je određivanje koncentracije navedenih kationa i aniona u prerađenoj i neprerađenoj vodi. Dobivene vrijednosti uspoređene su sa zakonskim regulativama.

*Ključne riječi:* prerađena i neprerađena voda, određivanje aniona i kationa, spektrofotometrija, kromatografija





## DETERMINATION OF ANIONS AND CATIONS IN THE PROCESSED AND UNPROCESSED WATER SAMPLES BY USING SPECTROPHOTOMETRY, ION CHROMATOGRAPHY AND VOLTAMMETRY

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Water is the basic requirement for life and represents a value which has no price. Drinking water is more and more valuable, since the reserves of drinking water are decreasing because of the growth of the population, high pollution and climate changes. In order to fulfil demands regarding water safety, the analysis of water is needed. Water analysis includes determination of physico-chemical, organoleptic, microbiologic and other properties of water to determine water health safety. Sampling of water samples used to study water properties must be done according to the procedures regulated by law. The aim of regular water analysis is to get basic data regarding physico-chemical and microbiological water quality for human consumption as well as data regarding the efficiency of facility work. Our study was based on spectrophotometric analysis of processed and unprocessed water in 5 weeks time period. Spectrophotometric analysis was used to determine concentrations of manganese, iron and ammonia in water. The second part of our work is based on chromatographic analysis where concentrations of ammonium ( $\text{NH}_4^+$ ), nitrate ( $\text{NO}_3^-$ ), nitrite ( $\text{NO}_2^-$ ), sulphate ( $\text{SO}_4^{2-}$ ) ions and arsenic ions ( $\text{As}^{3+}$  and  $\text{As}^{5+}$ ) were determined. For determination of arsenic ion ( $\text{As}^{3+}$ ), cyclic and differential pulse voltammetry with modified glassy carbon electrode were also used. The aim of this study was determination of concentrations of the listed anions and cations in processed and unprocessed water samples. Obtained values were compared with law regulations.

**Keywords:** processed and unprocessed water, determination of anions and cations, spectrophotometry, chromatography



## SORPTION BEHAVIOUR OF ORGANOPHOSPHORUS PESTICIDES ON DANUBE RIVER SEDIMENT

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This work studies the sorption behavior of organophosphorus pesticides - OPP (chlorfenvinphos and chlorpyrifos-methyl) on Danube river sediment under non-equilibrium conditions in order to investigate the risk from infiltration of these pollutants into underground water wells. Organic carbon and organic matter contents were 0.24% and 1.02%, respectively. The Danube sediment consists mainly of sand (~80%). The contents of silt and clay (< 2  $\mu\text{m}$ ) were about 4% and 5.5%, respectively. Danube sediment represents a typical sandy aquifer material with low organic carbon content. The breakthrough curves of nonsorbing tracer (thiourea) were symmetrical S-shaped curves, indicating the absence of physical non-equilibrium processes in porous media. The breakthrough curve obtained for both investigated OPPs was not fully identical with the breakthrough curve of thiourea, indicating a slight non-equilibrium sorption. Retardation coefficients ( $R_d$ ) for chlorfenvinphos was 6.2. In the case of chlorpyrifos-methyl 8 h passed before 40% of the initial concentration was detected in the eluate. Under the same conditions,  $R_d$  for chlorpyrifos-methyl was two times higher ( $R_d \sim 15$ ) compared to chlorfenvinphos. Chlorpyrifos-methyl has shown a significant step of biodegradation with  $\lambda = 4.15$ . Higher retardation obtained for chlorpyrifos-methyl was expected as a consequence of higher hydrophobicity ( $\log K_{OW} = 4.31$ ) compared to chlorfenvinphos ( $\log K_{OW} = 3.8$ ). The obtained transport parameters indicate that with increasing molecular hydrophobicity the retardation coefficient increases, which is consistent with the higher sorption affinity of hydrophobic chlorpyrifos-methyl on the Danube geosorbent.

*Keywords:* organophosphorus pesticides, Danube river sediment, chlorfenvinphos, chlorpyrifos-methyl

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## SPATIAL CHARACTERIZATION OF SURFACE WATER QUALITY IN KOSOVO

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In this paper statistical and chemometric data analysis (Factor Analysis and Cluster Analysis) for spatial classification of water quality indicators was performed. The used data for analysis were obtained by measuring the 34 parameters that indicate the quality of the surface water of Ibri river basin in Kosovo, during the year 2017. All parameters were experimentally determined according to standard methods for water analysis in Kosovo Environmental Protection Agency. Ibri river basin has 18 monitoring stations, three of which belongs to the Iber River (Location 1), while the other monitoring stations are positioned at different stations at the rivers: Sitnica (Location 2), Llapi (Location 3), Prishtevka (Location 4), Gracanka (Location 5), Drenica (Location 6) and the river Shtime (Location 7). By applying the chemometric data analysis (FA/PCA) classification for all water quality parameters was identified. Cluster analysis for spatial classifications showed that different locations may be generally grouped into main clusters (groups). The first group consisted of location 1,3,7, while second groups consist of location 2 and 6. Location 4 and Location 5 with large distances are separately placed and connected with other groups. Routine monitoring programs of the water quality generate complex multidimensional data set. Since, the data obtained had multivariate nature and several of the variables were correlated, multivariate statistical data analysis methods can be used for the interpretation of the data. Multivariate statistical technique for evaluation and interpretation of large complex data set presents a necessity and usefulness for planning program of effective water and human health protection.

*Keywords:* spatial characterization, surface water quality, chemometric data analysis



## **FIZIKALNO-KEMIJSKA KVALITETA PODZEMNE I KONDICIONIRANE VODE NA CRPILIŠTU „BIKANA“ VIROVITICA**

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Grad Virovitica se opskrbljuje vodom za piće koja se dobiva kondicioniranjem podzemne vode na vodocrpilištu „Bikana“. Crpilište se nalazi u sjevernom dijelu grada te obuhvaća šest zdenaca. Monitoring kvalitete crpljene podzemne vode provodi se kontinuiranom analizom kakvoće i zdravstvene ispravnosti. U ovom radu prikazane su vrijednosti koncentracije željeza, mangana, amonijaka te utroška kalijevog permanganata tijekom redovitog monitoringa podzemnih voda u 2018. godini. Dobivene su vrijednosti potom uspoređene s fizikalno-kemijskim parametrima vode nakon procesa kondicioniranja. Rezultati ovog istraživanja ukazuju da na kemijski sastav ispitivanih podzemnih voda značajno utječu karakteristični redukcijски uvjeti vodonosne sredine, uslijed kojih je zabilježena pojava povećanih koncentracija željeza, mangana i slobodnog amonijaka. Kakvoća podzemne neprerađene vode, ne mijenja se značajno te je pod snažnim utjecajem geološkog profila vodonosnika. Iako su prethodna istraživanja pokazale da podzemna voda s crpilišta „Bikana“ zadovoljava mikrobiološke, ali ne i fizikalno-kemijske standarde, potrebno je ukazati na primjenu odgovarajuće tehnološke obrade, kako bi voda koja se javnim vodoopskrbnim sustavom distribuira bila u skladu s odredbama Pravilnika o usklađenosti parametara i metodama analize vode za ljudsku potrošnju (Narodne novine 125/2017).

*Ključne riječi:* podzemna voda, fizikalno-kemijska kvaliteta, kondicioniranje vode, crpilište „Bikana“



## PHYSICO-CHEMICAL QUALITY OF THE GROUNDWATER AND CONDITIONED WATER AT THE „BIKANA“ WELL FIELD IN VIROVITICA

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The city of Virovitica is supplied with drinking water obtained by conditioning the groundwater at the „Bikana“ well field. The pumping station is located in the northern part of the city and comprises of six wells. The quality of groundwater is controlled regularly, almost on daily basis. In this study, the concentrations of iron, manganese, ammonia and potassium permanganate consumption were determined in groundwater during the regular monitoring in 2018. The obtained results were compared to the physico-chemical parameters of conditioned water. Consequently, the parameters indicate that the chemical composition of the groundwater significantly depends on the characteristic reductive conditions in its aquifers, causing presence of increased concentrations of iron, manganese and free ammonia. The quality of untreated groundwater does not change remarkably and is strongly influenced by the geological structure of the aquifer. Although the previous studies showed that groundwater from the „Bikana“ well field is microbiologically safe, but does not satisfies physico-chemical standards, it is crucial to point out that the application of appropriate technology is necessary in order to obtain safe drinking water which will be in accordance with the Regulations of parameters compliance and analysis methods of water for human consumption (Official Gazette 125/2017).

*Keywords:* groundwater, physico-chemical quality, water conditioning process, „Bikana“ well field



## **MUTNOĆA BUNARSKE I VODOVODNE VODE NA PODRUČJU OSJEČKO-BARANJSKE I VUKOVARSKO-SRIJEMSKJE ŽUPANIJE**

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Mutnoća vode optičko je svojstvo i ukazuje na čistoću vode. Uzrokovana je prisutnošću netopljivih koloidnih tvari kao što su: silikatna kiselina, aluminijev ili željezov hidroksid, suspendirane čestice gline, čestice mulja, otopljene obojene organske tvari iz otpadnih voda, mikroorganizmi ili planktoni. Visoka koncentracija suspendiranih tvari u prirodnim vodama smanjuje prodiranje svjetlosti, usporava proces fotosinteze, povećava temperaturu voda što utječe na smanjenje koncentracije otopljenog kisika i život u vodi. Vode koje su pročišćavane metodom taloženja ili koagulacije, mogu biti mutne od viška koagulanata. Mutnoća vode može se odrediti usporedbom svjetlosnih efekata koji se javljaju prolaskom svjetlosti kroz uzorak i standard. Izražava se u nefelometrijskim jedinicama mutnoće NTU (engl. *Nephelometric Turbidity Units*) ili FTU jedinicama (engl. *Formazin Turbidity Unit*). Cilj ovog rada je bio odrediti mutnoću bunarske i vodovodne vode na području Osječko-baranjske i Vukovarsko-srijemske županije, usporediti dobivene vrijednosti i procijeniti kvalitetu ispitivanih voda. Uzorci vodovodnih voda imali su vrijednosti mutnoće koje su znatno manje od granične vrijednosti u svim ispitanim uzorcima što je rezultat mehaničkog pročišćavanja ovih voda prije upuštanja u vodovodnu mrežu. Bunarske vode se ne pročišćavaju te su stoga vrijednosti mutnoće voda na nekim lokacijama bile veće od graničnih što može biti posljedica sastava tla i promjene vodostaja podzemnih voda tijekom uzorkovanja.

*Ključne riječi:* optičko svojstvo, suspendirane tvari, mutnoća vode, turbidimetrija



## **TURBIDITY IN WELL WATERS AND MUNICIPAL WATERS IN OSIJEK-BARANJA COUNTY AND VUKOVAR-SRIJEM COUNTY**

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Turbidity is the optical property of water. It is a vital indicator of water quality. Turbidity is caused by the presence of insoluble colloidal solids in water, such as: silicic acid, ferrous hydroxide, aluminium hydroxide, suspended clay particles, mud particles, soluble colored organic matter from wastewater, and microorganisms or plankton. High levels of suspended particles in open waters can reduce the amount of light, decrease the photosynthesis capacity and increase water temperature, which can consequently result in reduced levels of dissolved oxygen and negatively affect the aquatic life. Waters treated with settling processes or flocculation/coagulation can be turbid due to excessive amounts of coagulants. Turbidity of water can be determined by comparison of the intensity of light scattered by the sample in specific conditions with the intensity of light scattered by standard reference suspension under the same condition. Measurement units for turbidity are NTU (Nephelometric Turbidity Units) or FTU (Formazin Turbidity Unit). The aim of this work is to determine turbidity in well water and municipal water in Osijek-Baranja County and Vukovar-Srijem County, to compare the results and determine the quality of tested waters. All tested samples of municipal water showed significantly lower turbidity values than the reference range due to mechanical water treatment. Since well waters are not treated, samples from several sites measured higher turbidity levels than the reference range, which could be influenced by soil composition or changes in ground water flow rates.

*Keywords:* optical property, suspended solids, turbidity, turbidimetry



## **PROČIŠĆAVANJE OTPADNIH VODA NA PODRUČJU GRADA KOPRIVNICE**

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S obzirom na sve veći porast stanovništva, urbanizaciju i gospodarski razvoj, količina otpadne vode, kao i razina onečišćenja, globalno rastu. Upravljanje otpadnim vodama uvelike je zanemareno, a takve su vode i podcijenjene kao potencijalno pristupačan i obnovljiv izvor vode i energije. Kako je velik dio Hrvatske porozan krški prostor, pročišćavanje otpadnih voda jedini je način očuvanja velikih zaliha pitke vode. Osnovna uloga uređaja za pročišćavanje otpadnih voda je pročišćavanje vode do stupnja kakvoće koji osigurava da otpadna voda neće pogoršati i ugroziti prirodno stanje okoliša. Centralni uređaj za pročišćavanje otpadnih voda grada Koprivnice pročišćava otpadne vode uključujući i treći stupanj pročišćavanja, koji predstavlja proces obrade mulja aerobnom stabilizacijom, dehidriranjem i MID – MIX tehnologijom pri čemu nastaje kemijski inertan prah, koji se može iskoristiti u građevini ili odlagati na odlagalište bez utjecaja na okolinu. U ovom radu analizirani su fizikalno – kemijski pokazatelji kakvoće otpadnih voda (KPK, BPK<sub>5</sub>, ukupni dušik, ukupni fosfor, suspendirana tvar) na uzorcima otpadnih voda uzetih nakon pročišćavanja na uređaju za pročišćavanje na području grada Koprivnice tijekom 2014., 2015. i 2016. godine. Rezultati su pokazali da su vrijednosti fizikalno-kemijskih pokazatelja unutar granice dozvoljenih vrijednosti što ukazuje na efikasan rad uređaja za pročišćavanje.

*Ključne riječi:* otpadne vode, pročišćavanje, fizikalno-kemijski pokazatelji





## **WASTEWATER TREATMENT IN THE AREA OF KOPRIVNICA CITY**

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Due to increase of population, urbanization and economic development, the amount of wastewater, as well as pollution levels, are growing globally. Wastewater management is largely neglected, and such water is underestimated as a potentially accessible and renewable source of water and energy. A porous karst covers the significant area of Croatia and the wastewater treatment is the only way to preserve large quantities of potable water. The basic role of wastewater treatment plants is to purify water to a degree of quality that ensures that wastewater will not deteriorate and endanger the natural state of the environment. The central wastewater treatment plant of the city area of Koprivnica purifies wastewater including the third stage of purification, which represents the process of sludge treatment by aerobic stabilization, dehydration and MID - MIX technology, creating a chemically inert powder that can be used in the building or disposed of on a landfill without impact to the environment. In this paper, we analysed the physical - chemical indicators (COD, BOD<sub>5</sub>, total nitrogen, total phosphorus and suspended matter) of wastewater samples from wastewater treatment plant in Koprivnica city during three-year period (2014-2016). The results were within the limits of permitted values, indicating efficient purification of waste water.

*Keywords:* wastewater, treatment, physical-chemical indicators



## **ELECTROANALYSIS OF HEAVY METALS IN WATER**

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Water is very important for human health. Heavy metal ions are the cause of environmental pollution from led of petrol, industry, leaching metal ions from soil into lakes and rivers by acid rain. Therefore, the development of electrochemical methods and their application in the determination of heavy metal ions such as zinc, copper, cadmium and lead in water are of great interest. The present development electroanalytical methods (polarography, voltammetry, stripping chronopotentiometry) in the heavy metal analysis of water showed rapidness, robustness, selectivity, low detection limits and low cost of devices. The Croatian legislation on water for human consumption prescribed the maximum permissible concentration of heavy metals in water (Zn 3000  $\mu\text{g/L}$ ; Pb 10  $\mu\text{g/L}$ ; Cd 5,0  $\mu\text{g/L}$ ; Cu 2,0  $\text{mg/L}$ ). The aim of this work is to present different electrochemical techniques and their improvement in the determination of copper, zinc, cadmium and lead in water.

*Keywords:* electrochemical methods, heavy metals, legislation, water



**Vodooskrbni sustavi i odvodnja /**  
*Water supply and sewage systems*



## PRIMJENA OTPADNOG MULJA IZ SOLVAY PROCESA U UKLANJANJU TEŠKIH METALA IZ INDUSTRIJSKIH OTPADNIH VODA

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Industrijske otpadne vode visokog sadržaja teških metala i niske pH vrijednosti često zahtijevaju velike količine kemijskih sredstava za tretman prije ispuštanja u prirodne recipijente, što je dovelo do povećanog istraživanja prirodnih materijala i industrijskih nusprodukata kao alternativnih sorbenata za uklanjanje teških metala. Otpadni mulj iz Solvay procesa proizvodnje natrijevog karbonata, zbog visokog sadržaja pH i kalcijevog karbonata, ima potencijal za uklanjanje teških materijala iz otpadnih voda. U ovom radu je istražena efikasnost uklanjanja teških metala iz otpadnih voda koje potiču iz industrije galvanizacije, koristeći otpadni mulj iz Solvay procesa. Rezultati eksperimenata sugeriraju da se ispitivani mulj može koristiti kao efikasno niskotroškovno sredstvo za precipitaciju i sorpciju teških metala, kao i za neutralizaciju kiselih otpadnih voda. Glavni nedostatak mulja je sadržaj soli u njegovom sastavu, što nameće uslov ispuštanja tretirane vode u slane recipijente.

*Ključne riječi:* tretman otpadne vode, teški metali, niskotroškovni sorbenti, otpadni mulj



## **APPLICATION OF WASTE SLUDGE FROM SOLVAY PROCESS FOR REMOVAL OF HEAVY METALS FROM INDUSTRIAL WASTEWATER**

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Industrial wastewater of high content of heavy metals and low pH, often require large quantities of chemical agents for treatment prior to discharge into natural recipients, which has led to the increased research of natural materials and industrial by-products as alternative sorbents for the removal of heavy metals. Waste sludge from the Solvay process of sodium carbonate production, due to its high pH and calcium carbonate content, has the potential for removing heavy metals from wastewater. In this paper the efficiency of removal of heavy metals from wastewater originating from electroplating industry was investigated, using the waste sludge from the Solvay process. The results of the experiments suggest that the tested sludge can be used as an effective low-cost agent for precipitation and sorption of heavy metals, as well as for the neutralization of acid waste water. The main disadvantage of the used sludge is the salt content in its composition, which imposes a requirement to discharge treated water to saline recipients.

*Keywords:* wastewater treatment, heavy metals, low-cost sorbents, waste sludge



## PREGLED STANJA VODNIH USLUGA NA PODRUČJU OPĆINE BUGOJNO

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Općina Bugojno se snabdijeva pitkom vodom iz gradskog vodovodnog sustava koji koristi oko 64 % stanovništva. Starost i oštećenost vodovodne mreže rezultira značajnim gubicima vode koji se procjenjuju na oko 60-70 %. U ruralnim područjima općine postoje 32 lokalna vodovoda iz kojih se vodosnabdijeva oko 20 % stanovništva. Dio grada je priključen na kanalizacijski sustav koji koristi oko 35 % stanovništva. Navedeni podaci za općinu Bugojno ne odstupaju od stanja u sektoru vodnih usluga na razini BiH. Pokrivenost stanovništva javnim uslugama vodosnabdijevanja u BiH iznosi oko 75 %, a odvodnjom otpadnih voda 41%. Prosječni gubici vode u BiH iznose 59 %, a samo 15 % stanovništva je priključeno na postrojenja za prečišćavanja otpadnih voda. Kvalitet vodnih usluga bilježi negativan trend i zbog smanjenja kvaliteta vode za piće. Tijekom 2017. godine na području Bugojna je za ispitivanje zdravstvene ispravnosti vode za piće ukupno uzeto 132 uzorka. Za mikrobiološku analizu uzeto je 83 uzorka iz gradskog vodovoda i svi uzorci su odgovarali propisanim standardima, dok je sa lokalnih vodovoda analiziran 31 uzorak te je utvrđeno da su četiri (12,9 %) uzorka bila mikrobiološki neispravna. Za kemijsku analizu uzeto je ukupno 18 uzoraka, šest uzoraka iz gradskog vodovoda i 12 uzoraka iz lokalnih vodovoda te nije bilo neispravnih uzoraka. Pregled stanja vodnih usluga u općini Bugojno ukazao je na slične probleme koji postoje u cjelokupnom sustavu na državnoj razini.

*Ključne riječi:* voda za piće, zdravstvena ispravnost, vodosnabdijevanje

## WATER SERVICES REVIEW IN BUGOJNO MUNICIPALITY



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Municipality of Bugojno is supplied with drinking water from urban water supply system which is used by 64% of the population. The age and damage of the water supply network results in significant water loss estimated at about 60-70%. In rural areas of municipality there are 32 local water supply systems, which are used by 20% of the population. Part of the town is connected to a sewerage system that is used by 35% of the population. The mentioned data for the municipality do not deviate from the situation in the water services sector in BiH. The coverage of the population by public water supply services in BiH is about 75% and wastewater drainage is about 41%. The amount of the average water losses in BiH is about 59%, and only 15% of the population is connected to wastewater treatment plants. Quality of water services has a negative trend also due to decrease in quality of drinking water. In 2017, in the area of Bugojno, 132 samples were taken for testing the health safety of drinking water. For microbiological analysis 83 samples were taken from urban water supply system and all samples corresponded to the prescribed standards, while 31 samples from local water facilities were analysed and four (12.9%) samples were microbiologically incorrect. For chemical analysis a total of 18 samples were collected, six samples from urban water supply and 12 samples from local water facilities, and there were no defective samples. A review of the situation of water services in municipality of Bugojno indicated similar problems that exist in the overall system at the state level.

*Keywords:* drinking water, health safety, water supply





## UTJECAJ ISPIRANJA VODOOPSKRBNE MREŽE NA KAKVOĆU VODE ZA LJUDSKU POTROŠNJU

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Voda za ljudsku potrošnju mora ispunjavati parametre propisane Pravilnikom o parametrima sukladnosti, metodama analize, monitoringu i planovima sigurnosti vode za ljudsku potrošnju te načinu vođenja registra pravnih osoba koje obavljaju djelatnost javne vodoopskrbe (NN broj 125/17). Pravna osoba koja obavlja djelatnost javne vodoopskrbe obvezna je osigurati da voda za ljudsku potrošnju koja se isporučuje korisnicima/potrošačima bude ispravna u svakom dijelu vodoopskrbne mreže. Opskrba stanovništva zdravstveno ispravnom vodom je složen zadatak koji ovisi o mnogo čimbenika, a najvažniji su: sanitarno-tehnički i higijenski uvjeti u vodoopskrbnim objektima i pratećoj infrastrukturi. Vodovod-Osijek redovito održava svoju vodoopskrbnu mrežu na način da provodi dva puta godišnje ispiranje vodoopskrbne mreže. Cilj ovog rada je statističkom obradom analitičkih izvješća o kakvoći vode za ljudsku potrošnju uzorkovanoj iz vodoopskrbne mreže grada Osijeka i prigradskih naselja tijekom desetogodišnjeg razdoblja (2008. - 2018. godine) utvrditi učinkovitost ispiranja gradske vodoopskrbne mreže te utvrditi kakvoću vode koja se distribuirala potrošačima putem vodoopskrbne mreže. Analizirali su se dobiveni podaci o koncentraciji željeza ( $\mu\text{gFe/l}$ ), mutnoći vode ( $^{\circ}\text{NTU}$ ) i boji vode ( $^{\circ}\text{Pt Co}$  skale). Korelacijom i grupiranjem dobivenih podataka ovisno o dijelu godine (prije i nakon ispiranja mreže) utvrdila se i ovisnost kakvoće vode u vodoopskrbnom sustavu o udaljenosti od pogona za proizvodnju vode kao i količini protoka i potrošnje vode.

*Ključne riječi:* vodoopskrbna mreža, kakvoća vode, ispiranje vodoopskrbne mreže



## **EFFECTS OF WATER DISTRIBUTION SYSTEM FLUSHING OPERATIONS ON DRINKING WATER QUALITY**

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Water for human consumption must meet the parameters prescribed by the Code of Conformity Parameters, methods of analysis, monitoring and water security plans for human consumption, and the manner of keeping a register of legal entities performing public water supply ("NN" No. 125/17). The legal person performing public water supply service is obliged to ensure that the water for human consumption delivered to consumers is adequate in every part of the water supply network. Healthy drinking water supply is a complex task that depends on many factors, and the most important ones are: sanitary, technical and hygienic conditions in water supply facilities and associated infrastructure. Vodovod-Osijek regularly maintains its water supply network in a way that conducts rinsing of the water supply network two times a year. The aim of this paper is to determine the effectiveness of rinsing the city water supply network and to determine the quality of water distributed to consumers through the water supply network by statistical analysis of the analytical reports on the quality of water for human consumption sampled from the Osijek water supply network and suburban settlements during the ten-year period (2008-2018). The obtained data on iron concentration ( $\mu\text{gFe} / \text{l}$ ), water turbidity ( $^{\circ}\text{NTU}$ ) and water color ( $^{\circ}\text{Pt Co}$  scale) were analyzed. By correlation and grouping of the data obtained, depending on the part of the year (before and after rinsing of the network), the dependence of the water quality in the water supply system on the distance from the water production plants as well as the amount of water flow and consumption was determined.

*Keywords:* water supply, water quality, rinsing of the water supply network



## **PRIMJENA NATRIJEVOG HIDROKSIDA KAO PRECIPITACIONOG SREDSTVA ZA UKLANJANJE BAKRA I NIKLA IZ VODE**

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Vode visokog sadržaja teških metala mogu imati negativne efekte na sve žive organizme koji ih konzumiraju, ili obitavaju u njima, uključujući mikrororganizme, biljke, životinje i ljude. Hemijska precipitacija je najčešće korišten postupak za uklanjanje teških metala iz vode, a na raspolaganju su različiti hemijski reagensi koji se mogu koristiti kao precipijenti: natrijev hidroksid, kalcijev hidroksid, natrijev karbonat, kalcijev karbonat, itd. Količina i kvalitet nastalog precipitata ima direktan uticaj na efikasnost uklanjanja teških metala iz vode. U ovom radu je istraživana uticaj natrijevog hidroksida kao precipitacionog sredstva na efikasnost i uklanjanje bakra i nikla iz njihovih monokomponentnih vodenih otopina visokih i niskih inicijalnih koncentracija metala.

*Ključne riječi:* teški metali, obrada vode, natrijev hidroksid, bakar, nikal



## **APPLICATION OF SODIUM HYDROXIDE AS A PRECIPITATING AGENT FOR REMOVAL OF COPPER AND NICKEL FROM WATER**

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Water of high content of heavy metals can have negative effects on all living organisms that consume or live in them, including microorganisms, plants, animals and humans. Chemical precipitation is the most commonly used method for removing heavy metals from water, and various chemical reagents are available which can be used as precipitants: sodium hydroxide, calcium hydroxide, sodium carbonate, calcium carbonate, etc. The amount and quality of the resulting precipitate has a direct effect on the efficiency of removing heavy metals from water. In this paper, the influence of sodium hydroxide as a precipitating agent on the efficiency and removal of copper and nickel from their monocomponent aqueous solutions of high and low initial concentrations of metals was investigated.

*Keywords:* heavy metals, water treatment, sodium hydroxide, copper, nickel



## **ANALYSIS OF THE CURRENT IMPLEMENTATION AND GUIDELINES FOR IMPROVING THE QUALITY OF THE WATER SUPPLY SYSTEM IN ACCORDANCE WITH THE LEGISLATIVE FRAMEWORK IN THE REPUBLIC OF CROATIA**

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The Republic of Croatia is obliged to provide a sustainable water supply system in accordance with the legislation stemming from the guidelines and directives of the European Union. The current water supply system in the Republic of Croatia, for the most part, does not meet the regulatory standards of the current legislative framework. The biggest problems are related to: pipeline deterioration, poor maintenance and large losses of the entire system and poor quality of delivered water to end consumers. In addition, there are a large number of settlements of more than 50 residents who do not have adequate access to water, which further aggravates the demographic picture of rural parts of the Republic of Croatia and is necessary for global problem solving. This paper provides a cross-section of the legislative framework that needs to be ensured through the implementation of the water supply system improvement as well as an overview of the main problems encountered by water supply providers. Furthermore, the paper elaborates the framework guidelines for solutions to these problems, which include: the increase in the number of people connected to the water supply system, reconstruction of the existing system, improvement of water supply management by uniting water supply providers, water loss reduction, the application of new network control systems through the implementation of investment projects co-financed by EU funds.

*Keywords:* water supply systems, legislative framework, EU funds, water quality, water supply system improvement

**Močvarna staništa /**  
*Wetlands*





## **EFFECTS OF PARTICULATE MATTER ON THE ECOSYSTEM OF KOPAČKI RIT**

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Kopački rit Nature Park situated between two rivers, the Drava and the Danube, has been protected area since 1967. Particulate matter (PM<sub>10</sub> i PM<sub>2.5</sub>) concentration have been measured and monitored in the Kopački rit area from 2012 until 2017. Particulate matter is divided into two major groups – less than 2.5 μm (PM<sub>2.5</sub>) and less than 10 μm (PM<sub>10</sub>). Particulates larger than 10 μm sediments readily under the Earth's gravitational force. Particulate matter has negative influence on human health especially in connection with respiratory problems. It is, therefore, necessary to measure their concentrations. Larger particles have influence on upper and smaller on lower respiratory tract. However, particulate matter may also be suspended in the water; major part of PMs originates from water. If so, they can influence acidity of water (by lowering pH), change nutrient balance, affect biodiversity and contribute to acid rain. Accordingly, it is not unusual to measure PM concentration in water samples. Data on airborne particulate matter does not show considerable diurnal variations. Measured concentrations are, most often, within legal limits. Occasionally, readings exceeded limits especially during winter and/or night. There is very good linear dependence between PM<sub>10</sub> and PM<sub>2.5</sub> concentrations.

*Keywords:* particulate matter, water & air pollution, monitoring, health issues





## SURADNJA NA PODRUČJU PLANIRANOG PENLATERALNOG UNESCO REZERVATA BIOSFERE MURA-DRAVA-DUNAV

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Javna ustanova Agencija za upravljanje zaštićenim prirodnim vrijednostima na području Osječko – baranjske županije, Županijska 4/III, 31000 Osijek, Hrvatska

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**Nositelj projekta:** Međunarodni fond za zaštitu prirode, Ured Austrija (WWF Austrija), a ostali projektni partneri su: Državni ured Styria, Odjel za zaštitu prirode (Austrija), Institut za zaštitu prirode (Slovenija), Općina Velika Polana (Slovenija), Javne ustanove za zaštitu prirode Koprivničko-križevačke županije, Virovitičko-podravske županije i Osječko-baranjske županije (Hrvatska), NP Balathon felvideki (Mađarska), WWF Adria (Hrvatska), Vojvodina šume (Srbija) i Institut za zaštitu prirode Vojvodine (Srbija).

**Sažetak:** Projekt se financira iz prekograničnog INTERREG Danube Transnational Programma. Javna ustanova Agencija za upravljanje zaštićenim prirodnim vrijednostima na području Osječko – baranjske županije sudjeluje na projektu kao partner br. 6.

**Ukupni budžet projekta:** 2.154.000,00 €, od čega aktivnosti javne ustanove: 100.000,00 €, a omjer sufinanciranja je 85 % EU, a 15 % partneri.

**Vrijeme provedbe projekta:** 2,5 godine, a planiran završetak je 30. lipanj 2019. godine.

Projektom se istražuju Čaplje (*Ardenidae*) na NATURA 2000 području Aljmaškog rita i cijele Osječko- baranjske županije.

U sklopu istraživanja izrađeni su Akcijski planovi za područje Aljmaškog rita i za područje Regionalnog parka Mura - Drava u Osječko-baranjskoj županiji.

U sklopu projekta provedene su slijedeće aktivnosti s ciljem podizanja razine svijesti javnosti o značaju zaštićenog područja, kao što su:

- fotografije Čaplji i područja provedbe projekta,
- slikovnice za djecu
- River S'cool na području stare Drave u mjestu Sarvaš

River S'cool čini mrežu edukativnih programa i objekata koji će imati svi partneri u projektu duž budućeg UNESCO Rezervata Biosfere Mura-Drava-Dunav. Kako bi škole bile uniformirane na području UNESCO Rezervata Biosfere Mura-Drava-Dunav, izraditi će se četiri zajednička elementa (jarbol, učionica na otvoren, smjerokaz /putokaz i infoable).

- Pored toga Javna ustanova će postaviti jednu osmatračnicu za ptice.

*Ključne riječi:* Zaštita prirode, Osječko-baranjska županija, COOP MDD, monitoring, čaplje



## **TRANSBOUNDARY MANAGEMENT PROGRAMME FOR THE PLANNED 5-COUNTRY BIOSPHERE RESERVE “MURA-DRAVA- DANUBE”, ACRONIM: COOPMDD**

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**Lider of project:** International Fund for Nature Protection, Office of Austria (WWF Austria) and other project partners are: Styria State Office, Nature Protection Department (Austria), Institute for Nature Protection (Slovenia), Municipality of Velika Polana (Slovenia), Public (Croatia), NP Balathon Uplands (Hungary), WWF Adria (Croatia), Vojvodina Forests (Serbia) and Institute for Nature Protection of Vojvodina (Serbia).

**Abstract:** The project is funded from the cross-border INTERREG Danube Transnational Program. Public institution for nature protection in Osijek Baranja County participates in the project as partner no. 6th.

**Total budget of the project:** 2.154.000,00 €, of which Public institution activities: 100.000,00 €, and the co-financing ratio is 85% EU and 15% partners.

**Project implementation time:** 2.5 years, and the planned completion is 30 June 2019.

The project explores the Heron (Ardenidae) on the NATURA 2000 area of Aljmaški rit and the entire Osijek-Baranja County.

Within the framework of the research, the Action Plans for the area of the Aljmaški rit and for the area of the Mura - Drava Regional Park were created in the Osijek - Baranja County.

As part of the project, the following activities were carried out with the aim of raising public awareness of the importance of the protected area, such as:

- Photographs Heron and Areas of Project Implementation,
- Picture books for children
- River S'cool in the area of the Old Drava in Sarvaš

River S'cool is a network of educational programs and facilities that will have all project partners along the future UNESCO Biosphere Reserve Mura-Drava-Danube. In order for the schools to be uniformed in the area of the UNESCO Mura-Drava-Danube Biosphere Reserve, four common elements (mountaineering, open class, direction / roadmap and infoable) will be created.

- In addition, the Public Institution will set up a bird watch.

*Keywords:* Nature Conservation , COOP MDD, monitoring, Heron's



## SUKCESIJSKE PROMJENE PLITVIČKIH JEZERA

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Plitvička jezera su najveći i najstariji nacionalni park Hrvatske, koji je proglašen nacionalnim parkom 1949. godine. Na UNESCO-vu listu svjetske baštine uvršteni su 1979. godine, prvenstveno zbog fenomena stvaranja sedrenih barijera. U današnje vrijeme su u unutrašnjem dijelu Parka vidljive velike promjene s obzirom na ekološku sukcesiju koja se odnosi na zaraštavanje nekadašnjih pašnjaka, travnjaka i livada. Sukcesijske su promjene povezane u prvom redu s raseljavanjem stanovništva koje je prije Domovinskog rata živjelo u mjestima unutar Parka kao što su Plitvički Ljeskovac, Bijela Rijeka, Končarev Kraj, Uvalica, Čorkova Uvala itd. Stanovništvo tog kraja koje je nekada živjelo i od stočarstva, a ne isključivo turizma, ispašom stoke i košnjom livada održavalo je ove prirodne površine od zaraštavanja. Pored toga, stanovnici su bili zaposleni i kao lugari u šumama Parka i sjećom su održavali prohodnost šume. Promjene u krajobrazu, koje su iz godine u godinu sve uočljivije, prvenstveno u brzom širenju šumske vegetacije, osim što dovode do gubitka raznolikosti staništa, neminovno dovode i do smanjenja toka Crne i Bijele rijeke, koje su najvećim dijelom izvor vode za Plitvička jezera. Gubitkom različitih tipova staništa, nepovratno ćemo izgubiti i brojne životinjske i biljne vrste karakteristične za livade košanice, pašnjake i travnjake, ali ono što je također neprocjenjivi gubitak je smanjenje pojedinih riječnih tokova (osobito Bijele rijeke). Stoga bi se upravljanje Parkom i turistička djelatnost, osim samog središta Nacionalnog parka, trebala usmjeriti i na njegove izvorne dijelove, posebno politikom održivog razvoja, koja mora uključivati suživot lokalnog stanovništva, njegov aktivan angažman u životu Nacionalnog parka, ali i dalekosežnijom politikom zaštite prirode i okoliša kada je riječ o ovom neprocjenjivom vodenom bogatstvu.

*Ključne riječi:* Plitvička jezera, zaraštavanje, sukcesijske promjene

## SUCCESSIVE CHANGES OF PLITVICE LAKES



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Plitvice Lakes are the largest and oldest national park in Croatia, which was declared a national park in 1949. In 1979 Plitvice Lakes National Park was added to the UNESCO World Heritage List, primarily due to the phenomenon of the creation of sedge barriers. Today, in the interior of the Park, there are great changes in the ecological succession concerning pastures, lawns and meadows becoming overgrown. Successive changes are primarily related to the displacement of the population that before the Homeland War lived in places such as Plitvice Ljeskovac, Bijela Rijeka, Končarev Kraj, Uvala, Čorkova Uvala, etc. The population of that area, which once lived from cattle breeding, not only from tourism, maintained these natural areas from becoming overgrown by livestock grazing and mowing. In addition, the inhabitants were also employed as foresters in the Park and maintained passable forests with logging. Changes in landscape, which are more noticeable year after year, primarily in the rapid spread of forest vegetation, besides causing the loss of habitat diversity, inevitably lead to the reduction of the flow of the Black and White River, which are mostly a source of water for Plitvice Lakes. With the loss of various habitat types, we will irretrievably lose many animal and plant species characteristic of meadows, pastures and lawns, but what is particularly invaluable is the reduction of certain river flows (especially the White River). Park management and tourism, apart from the center of the National Park itself, should also focus on its original parts, in particular through the policy of sustainable development, which must include the coexistence of the local population, its active engagement in the life of the National Park, and more far-reaching nature and environment protection policy when it comes to this invaluable water wealth.

*Keywords:* Plitvice Lakes, overgrowing, successive changes



## MONITORING VIDRE (*LUTRA LUTRA L.*) I DABRA (*CASTOR FIBER L.*) U PARKU PRIRODE KOPAČKI RIT U SKLOPU PROJEKTA NATURAVITA

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U sklopu elementa projekta 7 Zaštita vodnih i o vodama ovisnih ekosustava na projektnom području u projektu NATURAVITA (Razminiranje, obnova i zaštita šuma i šumskog zemljišta u zaštićenim i Natura 2000 područjima u dunavsko - dravskoj regiji) planirana je aktivnost Javne ustanove „Park prirode Kopački rit“ monitoring vidri i dabrova. Kako vidra i dabar predstavljaju glavne indikatorske vrste sisavaca vodenih i močvarnih staništa, potrebno je utvrditi karakteristike njihovih populacija kao što su brojnost, disperzija, distribucija, odnos spolova i mladih jedinki, biološki potencijal te stanje pojedinih teritorija/jazbina/obitelji ovisno o uvjetima na mikrostanjima. Planirano trajanje monitoringa je 3 godine (od 2020. do 2022.). Jedna od planiranih metoda praćenja vidri i dabrova je pomoću GPS uređaja koji bi se, kod vidri, postavio u obliku malog ruksaka na leđa, a kod dabra bi se priljepio na korijen repa jer je fiksacija klasičnih GPS ogrlica oko vrata ovih vrsta životinja problematična zbog toga što su njihovi vratovi nešto širi od glave pa postoji velika mogućnost da će je životinja vrlo brzo skinuti. Na ovaj način očekuje se dugotrajnije nošenje GPS uređaja koji bi se tijekom aktivne faze životinje nalazio iznad vode dok pliva i tako detektirao lokaciju na kojoj se nalazi. Za svaku vrstu planirano je po pet GPS uređaja, a željeno vrijeme praćenja je oko godinu dana s po četiri detekcije lokacije dnevno. Lokacije se ne mogu detektirati u vodenom mediju te u jazbinama u kojima životinje budu dok miruju, no uređaj će biti postavljen tako da šalje podatke o njihovoj lokaciji tijekom njihove aktivne faze, kako bi se dobili što konkretniji podaci i kako bi se uštedjelo na bateriji. Osim GPS praćenja, monitoring će uključivati i ostale metode utvrđivanja prisutnosti vidri i dabrova na projektnom području. Ostale metode za detekciju dabrova uključivat će vizualna zapažanja promatrača životinje, pronalazak lešine, pronalazak znakova aktivnosti hranjenja životinje (izgrižena stabla i grane), otkrivanje prisutnosti pomoću mirisa, pomoću izmeta, otkrivanje tragova, jazbina i konstrukcijskih aktivnosti. Za dokaze o prisutnosti vidre koristit će se metode opažanja životinje, pronalazak lešina, pronalazak izmeta, otisaka stopala, ostataka hrane, skloništa iznad zemlje te brloga pod zemljom. Ovim istraživanjem dobit će se bolji uvid u biologiju ovih vrsta, njihovo ponašanje i rasprostranjenost te odnos prema staništu u kojem se nalaze, a ujedno i uvid u kvalitetu močvarnih i vodenih staništa i uslugama koje pruža te koje utječu na kvalitetu života organizama koji u njima žive, posebice vidri i dabrova.

*Ključne riječi:* Kopački rit, NATURAVITA, monitoring, vidra, dabar



## **MONITORING OF EUROPEAN OTTER (*LUTRA LUTRA* L.) AND EUROPEAN BEAVER (*CASTOR FIBER* L.) IN KOPAČKI RIT NATURE PARK AS A PART OF NATURAVITA PROJECT**

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As a part of Naturavita project Mine Clearance, Regeneration and Protection of Forests and Forest Land in Protected Areas and Natura 2000 Sites in the Danube-Drava Region; Project objective 7 Protection of water and water dependent ecosystems within the project area, Public Institution Kopački rit planned activity is monitoring of European otter and European beaver. The best indicator species to research wet habitats conditions are otters and beavers and it's very important to define their characteristics like number of specimens, their dispersion, distribution, sex relation, number of young animals, biological potential and condition of every territory/den/family depending on microhabitat conditions. Planned time of monitoring is three years (from 2020 to 2022). One of planned tracking methods for these animals is using GPS devices. On otters, device will be settled on their backs like small "backpack", and on beavers it will be glued on base of their tale because fixation of regular GPS collars in these animals is very problematic and the main reason is that their necks are wider than head and there is a big possibility that animal will take it off. Using this kind of methodology, expected results are that the animal will longer "wear" the device and whole time, during active phase of animal and when it swims, it will be above water detecting its location. For every species, five GPS devices are planned, to track them through one year with four position fixes per day. Locations can't be detected in water and in dens where the animals are during their inactive phase, but devices will be programmed to send data about their locations during their active phase to get better data and to save the battery. Except GPS tracking, monitoring will include other methods of conducting otter and beaver presence in project area. Other methods for beaver detection will include visual observation, findings of dead animals, finding feeding activity marks (gnawing trees and branches), presence detecting through scent marks, finding faeces, tail or paw prints, dens and construction activities. Other methods for otter detection will include visual observation, findings of dead animals, finding faeces, paw prints, food remains, shelters beneath and burrows under the ground. With this survey, we will get better insight in biology of these species, their behaving, distribution and relation to their habitat and, on the other hand, insight in water dependent ecosystem habitat quality and their contribution of life quality of species that live in these habitats, especially otters and beavers.

*Keywords:* Kopački rit, NATURAVITA, monitoring, otter, beaver



## THE JELAS FIELD – A SIGNIFICANT ORNITHOLOGICAL AREA

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The Jelas field has been protected in the category of significant landscape since 1995. An enormous area of 20.800 ha is located on the territory of Slavonski Brod and the municipalities of Oriovac, Bebrina, Sibirj and Brodski Stupnik. The boundaries of the protected area are the northern boundary of the Zagreb-Slavonski Brod highway, from the bridge on the river Orlava to the Sloboda channel, to the freeway to the river pass to Mrsunja, and from Mrsunja to the Sava river pass. The construction of the "Jelas" fish farm with a total of 2.300 ha of areas distributed in 24 fishing ponds of different sizes and more than 20% of the area covered with cattail and reed (*Typha latifolia* and *T. angustifolia*, *Phragmites communis*) enabled the "return" of a large number of species to their "old home". The Jelas field is an area rich in ornithological fauna characteristic of the area between Sava and Drava. Up until now, 230 bird species have been registered on the "Jelas" fish farm, of which there are 122 species of nesting birds, and over 280 species in the wider area. During bird migration, fish farming is an important station for many species of wildlife because it provides a wealth of food and peace for rest.

**Keywords:** Jelas field, ornitofauna, birds

**Voda i zdravlje /**  
***Water and health***







## NANOČESTICE U PROČIŠĆAVANJU VODE ZA PIĆE

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Voda je esencijalna za ljudski život i zdravlje, ona čini 70 % ljudskog tijela i 71 % ukupne površine našeg plavog planeta. Unatrag nekoliko desetljeća voda za piće se sve rjeđe može pronaći u prirodi, mnogi izvori pitke vode su zagađeni što zbog industrije i ostalog ljudskog djelovanja, a što zbog mikroorganizama. Iako na Zemlji ima 71 % vode samo 2,5 % pripada slatkoj vodi. Danas se izvori pitke vode smatraju nacionalnim bogatstvom ne samo zbog svoje ljepote i rijetkosti nego i zbog funkcionalnosti budući da trenutno u svijetu postoji manjak prirodne pitke vode. Pročišćavanje vode za piće danas je nužnost, međutim različite tvari koje se koriste za pročišćavanje vode mogu imati štetno djelovanje na ljudski organizam u neprimjerenim količinama. Razvojem biotehnologije sve učestalije se u raznim područjima koriste nanočestice pa tako postoji i potencijal korištenja nanočestica u pročišćavanju vode za piće. Cilj ovog rada je istražiti koje su potencijalne mogućnosti korištenja nanočestica u pročišćavanju vode, kakva je njihova učinkovitost u usporedbi s drugim metodama pročišćavanja, koje vrste nanočestica su optimalne za korištenje u pročišćavanju vode, koji je učinak i postoji li potencijalno štetnost za ljudsko zdravlje od strane nanočestica te koje su posljedice sinteze nanočestica za okoliš i postoji li ekološki prihvatljiv način njihove sinteze.

*Ključne riječi:* nanočestice, pročišćavanje vode, voda za piće, zdravlje, kvaliteta vode



## NANOPARTICLES IN PURIFICATION OF POTABLE WATER

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Water is essential for human life and health, it makes up to 70% of the human body and 71% of the total surface of our blue planet. In the recent decades potable water has become scarce in nature, many sources of drinking water are polluted due to industry, other human activities, or because of microorganisms. Although there is 71% of water on Earth only 2.5% belongs to fresh water. Potable water sources today are considered a national asset not only because of its beauty and rarity but also because of functionality because there is currently a lack of natural drinking water in the world. The purification of drinking water is a necessity today, however, the various substances used for water purification can have an adverse effect on the human body in inappropriate quantities. With the development of biotechnology, nanoparticles are increasingly used in various areas, so there is also the potential for using nanoparticles in the purification of drinking water. The aim of this paper is to explore the potential uses of nanoparticles in water purification, their efficacy compared to other purification methods, which types of nanoparticles are optimal for use in water purification, their effect and potential harm to human health and what are the consequences of the nanoparticle synthesis for the environment and whether there is an ecologically acceptable method to synthesize them.

**Keywords:** nanoparticles, water purification, potable water, health, water quality



## ZDRAVSTVENA ISPRAVNOST VODE ZA PIĆE NA PODRUČJU UNSKO-SANSKOG KANTONA U PETOGODIŠNJEM RAZDOBLJU

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Cilj rada je prikazati trend kretanja kvaliteta vode za piće na području Unsko-sanskog kantona u petogodišnjem razdoblju. Obradeni su i interpretirani rezultati monitoringa zdravstvene ispravnosti vode za piće na području Kantona u razdoblju od 2014. do 2018. godine, (broj mikrobiološki ispitanih uzoraka N=8515, broj fizikalno -kemijski ispitanih uzoraka N=7947). Rezultati monitoringa zdravstvene ispravnosti vode za piće pokazuju da se procenat mikrobiološki neispravnih uzoraka kreće od 20,00 % u 2018. do 30,91 % u 2014. godini. Procenat fizikalno-kemijski neispravnih uzoraka kreće se od 11,02 % do 15,23 %. Najveći udio u ukupnom broju mikrobiološki neispravnih uzoraka je s područja općina Sanski Most, Bužim i Ključ. U pogledu fizikalno-kemijske neispravnosti prednjače Bužim, Ključ i Bihać. Najbolje stanje zdravstvene ispravnosti vode je u Bosanskoj Krupi, gdje se postotak neispravnih uzoraka kreće oko 8 %. Istovremeno je to općina sa najvećim brojem analiza, što se ne podudara sa veličinom vodoopskrbnog sistema i brojem potrošača. Osiguranje zdravstveno ispravne vode za piće jedan je od osnovnih preduslova dobrog zdravlja. Zavod za javno zdravstvo Bihać vrši analize vode za piće, prati sanitarno-tehničke uvjete na vodoopskrbnim sistemima, kao i kretanje bolesti koje se mogu dovesti u vezu sa vodoopskrbom. S obzirom na neujednačene uvjete, različit pristup menadžmenta JP koja se bave vodoopskrbom, trend kretanja zdravstvene ispravnosti vode za piće znatno varira od općine do općine. Glavni razlog zdravstvene neispravnosti vode za piće je fekalno onečišćenje, a od zadanih kriterija najčešće odstupaju ukupan broj koliformnih bakterija, prisutnost *E.coli* i enterokoka, mutnoća vode, koncentracija rezidualnog klora i potrošnja KMnO<sub>4</sub>.

*Ključne riječi:* zdravstvena ispravnost vode za piće, fekalno onečišćenje, vodoopskrba



## HEALTH SAFETY OF DRINKING WATER AT THE UNA-SANA CANTON AREA IN THE FIVE-YEAR PERIOD

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The aim of the paper is to show drinking water quality trends in the Una-Sana Canton area during the five-year period. The results of monitoring the health safety of drinking water in the Canton area were processed and interpreted during period of 2014-2018 (the number of microbiologically tested samples N=8515, the number of physicochemically tested samples N=7947). The results of monitoring the health safety of drinking water show that the percentage of defective microbiological samples is ranging from 20,00% in 2018. to 30,91% in 2014. The percentage of physicochemically defective samples is ranging from 11,02% to 15,23%. The largest share in the total number of microbiologically defective samples is from the areas of municipalities Sanski Most, Bužim and Ključ. In terms of physicochemically defects Bužim, Ključ and Bihać are leading. The best state of the health safety of drinking water is in Bosanska Krupa, where the percentage of defective samples is around 8%. At the same time, it is the municipality with the largest number of analyses, which does not match the size of the water supply system and the number of consumers. Safe drinking water is one of the basic prerequisites of good health. The Public Health Institute Bihać performs drinking water analyses, monitors the sanitary-technical conditions in water supply systems, as well as the range of diseases that can be related to water supply. Given the unequal conditions, the different approaches of the management of public companies which deal with water supply, the trend of ranging the health safety of drinking water varies greatly from municipality to municipality. The main cause of health defects in drinking water is fecal contamination, and the most common criteria are the total number of coliform bacteria, the presence of E.coli and enterococci, water turbidity, residual chlorine concentration and KMnO<sub>4</sub> consumption.

*Keywords:* health safety of drinking water, fecal contamination, water supply



## **SIGURNOST NA VODI, PROJEKT CRVENOG KRIŽA I FAKULTETA ZA ODGOJNE I OBRAZOVNE ZNANOSTI**

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Svjetska zdravstvena organizacija navodi utapanje kao treći vodeći uzrok nenamjernih ozljeda u svijetu, a prema podacima Hrvatskog zavoda za javno zdravstvo, utapanje je četvrti uzrok smrtnosti nakon padova, prometnih nesreća i otrovanja. U Hrvatskoj oko stotinu ljudi godišnje umre od posljedica utapanja. Mala djeca i muške odrasle osobe su pod najvećim rizikom. Obrazovanje studenata je osnovna misija Fakulteta za odgojne i obrazovne znanosti, a edukacija građana je je ključna sastavnica Hrvatskog Crvenog Križa u strategiji sprječavanja utapanja. Kako se svatko može naći u situaciji da postane slučajni spasilac, a osobito učitelji razredne nastave u svome radu s učenicima mlađe školske dobi, osmišljen je zajednički projekt koji se redovito provodi od 2011. godine. Cilj provedenih radionica *Slučajni spasilac* je podučiti studente o postupcima prevencije nesreća na vodi, uočavanju opasnosti pri boravku uz vodu, općenitim postupcima i priručnim sredstvima spašavanja na vodi te postupcima prve pomoći. Projektom *Sigurnost na vodi* podiže se svijest javnosti o opasnostima i rizicima povezanim s vodom te kodovima sigurnosti na vodi, a što kao prevencija značajno doprinosi smanjenju broju nesretnih događanja na vodi i rizika od utapanja. U sklopu projekta provede se radionice za studente Učiteljskoga studija, a od 2018. i za studente Kineziologije. Od 2019. godine planiramo ovaj edukacijski projekt provoditi i sa studentima Ranoga i predškolskog odgoja.

*Ključne riječi:* sigurnost na vodi, utapanje, prva pomoć, Crveni križ, studenti



## **WATER SAFETY JOINT PROJECT OF RED CROSS AND FACULTY OF EDUCATION**

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The World Health Organization states that drowning is the third leading cause of unintentional injuries in the world, and according to data from the Croatian Public Health Institute, drowning is the fourth cause of mortality after falling, traffic accidents and poisoning. In Croatia about a hundred people per year, die from the drowning. Small children and adult males are at greatest risk. Education of students is the main mission of the Faculty of Education, and education of citizens is a key role of the Croatian Red Cross in the strategy of drought prevention. As everyone can find themselves in a situation of becoming an unintentional rescuer, especially schoolteachers in their work with younger schoolchildren, a joint project was designed in 2011. Objectives of the workshops *The Unintentional Rescuer* is to coach students about water accident prevention procedures, water hazard dangers, general procedures in water rescue and the first aid procedures. *The Water Safety* project promotes public awareness of water hazards and risks as well as water safety codes, which, as prevention, significantly contributes to reducing the number of accidents in water and the risk of drowning. Workshops for Primary School Teacher students of the second year were carried out; and from 2018 for Kinesiology students too. From 2019, the project is planned to be extended to Early and Pre-school Education students.

*Keywords:* water safety, drowning, first aid, Red Cross, students



## **INFECTIOUS RISKS RELATED TO USE OF THE DENTAL UNIT WATER**

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The water used in dental practice needs to run long distance, from local waterways to the dental unit, where it is used for the proper work of the dental instruments and mouth rinsing. According to the literature, water in dental units is colonized with microorganisms. These microorganisms form a biofilm on the inside of the waterline tubing, which is a potential source of the free-floating microorganisms in dental unit water. That may be a risk for patients and the dental team because they are exposed to aerosol and water generated by the dental unit. Microorganisms that have been isolated from dental unit water are gram-positive bacteria (*Actinomyces* sp., *Lactobacillus*, *Mycobacterium*, *Staphylococcus aureus*, etc.), gram-negative bacteria (*Fusobacterium*, *Legionella*, *Pseudomonas*, etc.), fungi (*Candida albicans*, *Aspergillus*, etc.), and protozoa (*Giardia*, *Microsporidium*, etc.). Studies have shown that immunocompromised patients are at risk for infection from the dental unit water. To prevent infection transmission we use different chemical and nonchemical methods. The objective of this paper is to present infectious risks related to use of the dental unit water, microorganisms founded in biofilm formed in dental unit waterlines as well as their pathogenic potential, and methods used for reducing the risk for infection.

**Keywords:** dental unit water, infection, biofilm, Legionella





## VODA, HRANA I ENERGIJA - KLJUČ ZA ODRŽIVI RAZVOJ

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Jedan od ciljeva održivog razvoja je „Voda za sve do 2030. godine“. To znači da je potrebno iznaći rješenje za milijarde ljudi, koji još uvijek nemaju pristup zdravstveno ispravnoj vodi kako bi osigurali zdravu vodu, a time za zdravlje i sigurnu hranu. Porastom broja stanovnika na Zemlji, gospodarskim rastom i promjenom načina prehrane povećava se potražnja za vodom, proširuju se poljoprivredna područja, povećava se industrijska proizvodnja, a time i količina otpadnih voda. Najveći potrošač svjetskih vodenih resursa upravo je poljoprivreda koja troši četvrtinu ukupne energije potrebne upravo za prehranu stanovništva. U suvremenoj poljoprivrednoj i industrijskoj proizvodnji hrane, kako bi proizveli zdravstveno ispravnu hranu i sačuvali okoliš, proizvođači kontinuirano, prema važećoj zakonskoj regulativi, prate kvalitetu i zdravstvenu ispravnost vode s jedne strane te se usredotočuju na upravljanje vodnim resursima i zaštitom ekosustava s druge strane. Prema World Wild Foundation-u zahtjevi ljudi za resursima imaju utjecaj na zdravlje ekosustava, a upravo zdravlje ekosustava utječe na sposobnost osiguravanja istih. Hrana, voda i energetska sigurnost usko su povezani, međuovisni i značajni za opstojnost ekosustava. U radu će biti prikazane mjere koje se provode u poljoprivredno-prehrambenom lancu poput preciznog navodnjavanja i reupotrebe vode koje posredno utječu na bioraznolikost, a ključ su održivog razvoja.

*Ključne riječi: zdravstveno ispravna voda, sigurna hrana, održivi razvoj*

**WATER, FOOD AND ENERGY – KEY FOR**



## **SUSTAINABLE DEVELOPMENT**

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One of the aims of sustainable development is "Water for all up to 2030". This means that it is necessary to find a solution for billions of people, who still do not have access to drinking water to ensure healthy water, and therefore health and safe food. With the increase of world population, economic growth and the change in diet, water demand is increased, agricultural areas are expanded, industrial production is increased, and thus the amount of wastewater. The largest consumer of the world's aquatic resources is the farming that consumes a quarter of the total energy needed precisely for production of food. In modern agricultural and industrial food production, in order to produce health-related food and preserve the environment, manufacturers continuously, according to current legislation, monitor the quality and health of the water on the one hand, and management of water resources and ecosystem protection on the other. According to the World Wild Fondation, the demands of people for resources have an impact on ecosystems' health, and precisely the health of the ecosystem affects the ability to provide them. Food, water and energy security are closely linked, interdependent and significant for the existence of ecosystems. The paper will show measures implemented in the agri-food chain, such as the precise irrigation and reuse of water that indirectly affect biodiversity, and the key to sustainable development.

*Keywords:* drinking water, safe food, sustainable development



## KOMPARACIJA ZDRAVSTVENE ISPRAVNOSTI VODE ZA PIĆE IZ GRADSKOG I LOKALNIH VODOVODA NA PODRUČJU KANTONA SARAJEVO

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Cilj rada je komparacija zdravstvene ispravnosti vode za piće iz gradskog vodovoda i vode za piće iz lokalnih vodovoda na području Kantona Sarajevo u periodu 2016.-2018. godina, a koji su pod kontrolom J.U. Zavod za javno zdravstvo Kantona Sarajevo. Akcenat je na nužnosti poboljšanja sanitarno-higijenskih uslova na lokalnim vodnim objektima, što će posljedično dovesti do poboljšanja zdravstvene ispravnosti vode za piće na istim. Trogodišnje kontinuirano praćenje vode na mjestu krajnjeg potrošača obuhvatio je nadzor nad sanitarno-tehničkim i higijenskim prilikama gdje je vršena organoleptička, mikrobiloška i fizičko-hemijska analiza vode, te interpretacija rezultata analiza. Laboratorijska analiza uzoraka vode pokazala je da jedan dio uzoraka vode uzetih sa lokalnih vodovoda ne odgovara važećem Pravilniku o zdravstvenoj ispravnosti vode za piće. Analiza dobijenih rezultata ukazuje na neophodnost sistemskog kontinuiranog sanitarno-higijenskog nadzora, kako bi u konačnici kvaliteta vode sa lokalnih vodovoda dostigla kvalitet vode iz gradskog vodovoda.

*Ključne riječi:* zdravstvena ispravnost vode, gradski vodovod, lokalni vodovod



## **COMPARISON OF SAFETY OF DRINKING WATER FROM CITY WATERWORKS AND LOCAL WATER SUPPLIES IN THE AREA OF CANTON SARAJEVO**

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The aim of the study is a comparison of the safeness of drinking water from the city waterworks and drinking water from local water supplies in the area of Sarajevo Canton in the period 2016-2018. which are under the control of Public Health Institute of Sarajevo Canton. The accent is on the necessity of improving sanitary-hygienic conditions on the local water facilities, which will consequently lead to improvements to the safety of drinking water. Continuously three-year monitoring of water at the ultimate consumer point included the supervision of the sanitary-technical and hygienic conditions which included microbiological, organoleptic and physical-chemical analysis of the water and the interpretation of the results of the analysis. Laboratory analysis of water samples showed that one part of the water samples taken from the local water supply did not match the valid regulations of the safety of drinking water. The analysis of the obtained results indicate the need for a systematic and continuous monitoring of the hygienic-sanitary conditions so that in the end the quality of the water from the local water supplies reach the same quality of water from the municipal waterworks.

*Keywords:* safety of drinking water, city waterworks supply, local water supply



## KEMOMETRIJSKA ANALIZA SASTAVA PODZEMNIH VODA OSJEČKO-BARANJSKE ŽUPANIJE

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Na području Osječko-Baranjske županije, na površini od 4152 km<sup>2</sup>, nalaze se 264 naselja. Voda za piće lokalnom stanovništvu osigurava se iz 21 županijskog vodocrpilišta. U ovom radu su rezultatima deskriptivne statističke analize prikazane osnovne karakteristike uzoraka podzemnih voda. Rezultati pokazuju vrlo ujednačene vrijednosti temperature i pH u uzorcima vode iz 21 vodocrpilišta. Usporedbom rezultata i propisanih dopuštenih vrijednosti utvrđene su povišene koncentracije željeza, mangana, amonijaka i arsena, te povišene vrijednosti mutnoće i boje u pojedinim uzorcima. Izmjerene vrijednosti analizirane su i kemometrijskim metodama. Faktorskom analizom dobivena je korelacijska matrica koja prikazuje odnose među izmjerenim vrijednostima analiziranih svojstava i koncentracija. Klusterskom analizom kreirani su klasteri i dendogrami sa sličnim vrijednostima i promjenama u uzorcima. Analiza glavnih komponenti otkrila je 11 značajnih međusobnih veza i sličnosti između svojstava i koncentracija. Kumulativno, one uzrokuju 95,76 % varijabilnosti unutar analiziranog seta podataka i zbog njih se uzorci podzemnih voda u Panonskoj Hrvatskoj međusobno značajno razlikuju.

*Ključne riječi:* Podzemna voda, Panonska Hrvatska, deskriptivna statistika, kemometrijska analiza



## **CHEMOMETRIC ANALYSIS OF UNDERGROUND WATERS IN OSIJEK-BARANJA COUNTY**

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There are 264 settlements in the area of Osijek-Baranja County, on the surface of 4152 km<sup>2</sup>. Drinking water to the local population provided by 21 county water wells. In this paper, the results of descriptive statistical analysis reveal the basic characteristics of groundwater samples. The results show uniform values of temperature and pH in water samples from 21 water traps. By comparing of the results and the prescribed permissible values, elevated concentrations of iron, manganese, ammonia and arsenic were found, as well as elevated values of turbidity and color in certain samples. The measured values were also analyzed by chemometric methods. Factor analysis yields a correlation matrix showing relationships between measured values of analyzed properties and concentrations. Cluster analysis produced clusters and dendograms with similar values and changes in samples. The analysis of major components revealed 11 significant relationships and similarities between properties and concentrations. Cumulatively, they cause 95.76% variability within the analyzed data set and because of that, groundwater samples in Pannonian Croatia differ significantly among them.

*Keywords:* Underground water, Pannonian Croatia, descriptive statistics, chemometric analysis



## MATEMATIČKI MODELI ZA PROCJENU SADRŽAJA ARSENA U PODZEMNIM VODAMA OSJEČKO-BARANJSKE ŽUPANIJE

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Sliv podzemnih voda Panonske Hrvatske čini cjelinu sa slivom susjedne Mađarske i Srbije. Na području Osječko-Baranjske županije, na površini od 4152 km<sup>2</sup>, nalaze se 264 naselja. Pojedini uzorci podzemnih voda na ovom području sadrže povišene koncentracije željeza, mangana, nitrata i organskih tvari. Analize pokazuju da se u podzemnim vodama pojavljuje i arsen. U ovom radu izrađeni su matematički modeli koji povezuju sadržaj arsena s kemijskim sastavom podzemne vode. Modeli se temelje na rezultatima analiza kakvoće podzemnih voda iz vodocrpilišta Osječko-baranjske županije. Usporedbom izvedenih prediktivnih matematičkih modela zaključeno je da linearni model nije primjenjiv jer ne može precizno utvrditi pojavnost arsena na temelju ostalih vrijednosti svojstava i sastava vode. Među polinomnim modelima najveću F-test vrijednost (0,964) i najveću R<sup>2</sup> vrijednost (0,980) pokazao je model izveden višestrukom polinomnom regresijom primjenom metode najmanjih kvadrata. Prediktori potrebni za izvođenje navedenog modela su izmjerene vrijednosti elektrovodljivosti, te koncentracije amonijaka, hidrogenkarbonata, natrija, fosfata i anionskih tenzida.

*Ključne riječi:* Podzemna voda, Panonska Hrvatska, prediktivni model, PLSR



## **MATHEMATICAL MODELS FOR ASSESMENT OF ARSENIC CONTENT IN UNDERGROUND WATERS IN OSIJEK-BARANJA COUNTY**

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The underground watercourse in Pannonian Croatia forms a whole with the basin of neighboring Hungary and Serbia. In the area of Osijek-Baranja County, on the surface of 4152 km<sup>2</sup>, there are 264 settlements. Some groundwater samples in this area contain elevated concentrations of iron, manganese, nitrate and organic matter. Analysis shows that arsenic also appears. In this paper, mathematical models were created with the aim of linking the arsenic content with the chemical composition of groundwater. The models were based on the results of the analysis of groundwater quality in the Osijek-Baranja County water wells. Comparison of derived predictive mathematical models concluded that linear model is not applicable because it can not accurately determine the occurrence of arsenic based on other values of properties and composition of water. Among the polynomial models, the highest F-test value (0.964) and the highest R<sup>2</sup> value (0.980) were determined for a model derived by multiple polynomial regression using the least squares method. The predictors required for the performance of the above model were measured values of conductivity, ammonia, hydrogen carbonate, sodium, phosphate and anionic surfactants.

*Keywords:* Underground water, Pannonian Croatia, predictive model, PLSR





## ISPRAVNOST I UPOTREBA BUNARSKIH VODA NA PODRUČJU JELISAVCA I NAŠIČKE BREZNICE

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Uvođenjem gradske vodoopskrbne mreže na području grada Našice, pitka voda je postala dostupna velikom broju stanovnika i uvelike je zamijenila korištenje bunarskih voda. Međutim, u pojedinim izvangradskim naseljima bunarske vode se i dalje koriste. Istraživanje korištenja bunarske vode na području dvaju Našičkih naselja, Jelisavcu i Našičkoj Breznici provedeno je u razdoblju od studenog 2018. do veljače 2019. godine. Anketirani su stanovnici u ukupno 100 domaćinstava u Jelisavcu i 101-om domaćinstvu u Našičkoj Breznici. Utvrđeno je da u naselju Jelisavac, od 100 ispitanika, 88 koristi vodu iz bunara, dok u naselju Našička Breznica, od 101-og ispitanika bunarsku vodu koristi njih čak 98. Analizu kvalitete bunarske vode provodi svega 19 ispitanika u Jelisavcu, a u Našičkoj Breznici 35. Vrlo mali broj ispitanika kontrolira kvalitetu bunarske vode, ali njih ukupno 116 provodi redovitu preventivnu dezinfekciju bunara, koristeći u tu svrhu vapno i sredstva na bazi klora. Korištenje bunarske vode u različite svrhe i dalje je vrlo rašireno među stanovništvom na području naselja u okolici grada Našice. Stoga je nužno provoditi redovitu analizu kvalitete bunarske vode i očuvati podzemne vode.

*Ključne riječi:* pitka voda, bunari, naselja, kontrola kvalitete vode, dezinfekcija



## **THE USE AND SAFETY OF WELL WATER IN THE AREA OF THE SETTLEMENTS JELISAVAC AND NAŠIČKA BREZNICA**

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With the introduction of the water supply network in the area of the city of Našice, tap water became available to a large number of inhabitants, and it greatly replaced the use of well water. However, the well water is still being used in some suburban settlements. A well water use survey was conducted in the area of the city of Našice in two settlements, Jelisavac and Našička Breznica in the period November 2018 to February 2019. The survey was performed in 100 households in Jelisavac, and 101 households in Našička Breznica. The analysis showed that in Jelisavac, 88 of 100 respondents used well water, while in Našička Breznica, well water was used by 98 of 101 respondents. Only 19 well owners in Jelisavac and 35 households in Našička Breznica surveyed performed water quality control. Despite the small number of well owners controlling the water quality, 116 carried out preventive disinfection of water wells using lime or chlorine-based disinfectants. The survey showed that well water usage is still very common in the suburban settlements of the area of Našice. Hence, it is very important to perform the well water quality monitoring and to protect and preserve groundwater resources.

*Keywords:* well water, settlements, water quality control, disinfectants



## UNOS TEKUĆINE KOD OBOLJELIH OD ARTERIJSKE HIPERTENZIJE

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Kardiovaskularne bolesti su vodeći uzrok smrti u Hrvatskoj te uzrokuju 50 % svih smrti od kroničnih nezaraznih bolesti. Hipertenzija je oko 6 puta češća u pretilih nego u ljudi s normalnom tjelesnom masom. Prema Nacionalnoj strategiji razvoja zdravstva 2012.-2020. smrtnost od kardiovaskularnih bolesti u Hrvatskoj gotovo je najviša u Osječko-baranjskoj županiji. Brojna istraživanja pokazala su nužnost i povoljne učinke adekvatne hidracije na regulaciju krvnog tlaka, no ista ukazuju da je i dalje hidracija na nezadovoljavajućoj razini. Kod oboljelih od arterijske hipertenzije ispitivali smo prehrambene navike pomoću FFQ testa i standardiziranih upitnika o prehrani te unos tekućine. Anketa je obuhvaćala 56 osoba (m = 32, ž = 24) u dobi od 33 do 87 godina. 57 % ispitanika uz arterijsku hipertenziju boluje od neke druge kronične nezarazne bolesti (dijabetes, hiperlipidemija, gastritis..). Najviši indeks tjelesne mase iznosio je 46,1 (prosječni ITM = 29,5). 63,8 % ispitanika ne konzumira svakodnevno svježe voće, a 48,1 % ne konzumira svakodnevno povrće u obliku salata. Više od 1,5 L vode na dan konzumiralo je 45,4 % ispitanika dok je manje od 1 L vode na dan unosilo 26,2 % ispitanika. 5,9 % ispitanika izjavilo je kako uopće ne pije vodu. 89,9 % ispitanika svakodnevno pije kavu. 29,8 % ispitanika izjavilo je kako svakodnevno unosi minimalno 0,2 L alkoholnih pića. S obzirom na rastuću pandemiju pretilosti kao i oboljenja od nezaraznih kroničnih bolesti dobiveni rezultati su očekivani. Mayo Clinic navodi preporuku nezavisne znanstveno-stručne ustanove Institute of Medicine da je dnevna potreba tekućine za muškarce 3,0 L, a za žene 2,2 L. Naša skupina oboljelih od arterijske hipertenzije ne unosi tekućinu dovoljno s obzirom na preporuke

*Ključne riječi:* unos tekućine, arterijska hipertenzija

## DIETARY LIQUID INTAKE AND ARTERY HYPERTENSION



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Cardiovascular diseases are the leading cause of death in Croatia, causing 50% of all deaths from chronic non-communicable diseases. Hypertension is about 6 times more common in obese people than people with normal body mass. According to the National Strategy for Health Care Development 2012.-2020. the mortality rate of cardiovascular diseases in Croatia is almost the highest in the Osijek-Baranja County. Numerous studies have shown the necessity and beneficial effects of adequate hydration on blood pressure regulation, but the same suggests that the hydration continues to be unsatisfactory. In the case of patients with arterial hypertension, we studied dietary habits using FFQ test and standardized nutrition and fluid intake questionnaires. The survey included 56 people (m = 32, ž = 24) between the ages of 33 and 87. The results show that 57% respondents with arterial hypertension suffer from some other chronic non-communicable disease (diabetes, hyperlipidemia, gastritis ...). The highest body mass index was 46.1 (average ITM = 29.5). 63.8% of respondents do not consume fresh fruit daily, and 48.1% do not consume daily vegetables in salad form. More than 1.5 L of water per day consumed 45.4% of respondents while less than 1 L of water per day consumed 26.2% of respondents. 5.9% of respondents said they did not drink water at all. 89.9% of respondents daily drink coffee. 29.8% of the respondents stated that they had to drink at least 0.2L of alcoholic drinks every day. Considering the growing pandemics of obesity as well as non-chronic diseases, the received results were expected. The Mayo Clinic suggests the recommendation of an independent Institute of Medicine that the daily need for men is 3.0 L and for women 2.2 L. Our group of patients with arterial hypertension does not inject liquid sufficiently with regard to the recommendations.

**Keywords:** liquid intake, artery hypertension



## PREDICTION OF GROUNDWATER HARDNESS IN SLAVONIA USING ARTIFICIAL NEURAL NETWORK MODELS

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Water hardness is an important parameter for water quality determination and suitability for human consumption and agriculture purposes. Hard water is usually defined as water which contains calcium and magnesium salts principally in a form of bicarbonates, chlorides and sulfates with possible presence of ferrous ions. According to the literature, several epidemiological investigations have demonstrated the relation between risk for cardiovascular disease and other health problems with the use of hard water enriched with calcium and magnesium ions. Most water of the Slavonian region is classified as hard water which may lead to health, plumbing and structural issues. Therefore it is essential to investigate potential causes of water hardness to be able to quickly estimate water hardness parameter. This could be useful for both convenient, and also for economic reasons due to expensive analytical equipment and materials. In this study, two artificial neural network models (ANNs) have been developed in order to predict water hardness in Slavonian region covering data recorded over the last five years, between 2014. and 2018. For that purpose, a feed-forward multilayer backpropagation neural network (FFBP-ANN) and radial basis function (RBF) neural network were created varying activation functions, the number of neurons in the hidden layer and spread constant for RBFNN model. The ANNs have been trained and tested on divided and normalized dataset in the range from -1 to 1 and from 0 to 1 in order to scale-up the inputs and output parameters. The overall performance of the developed ANN predictive models was evaluated based on the obtained mean squared error (MSE) and correlation coefficient (R) parameters. Determination of the best performing model was based on the AAD (Average absolute deviation) parameter. The obtained results showed the superior performance of FFBP-ANN model compared to RBFNN. However, both models were found to be useful tools for water hardness prediction.

**Keywords:** water hardness, Slavonia, artificial neural networks, prediction



## PRELIMINARY RESEARCH RESULTS ON THE INFLUENCE OF CONSUMER ANTIBIOTICS ON UNICELLULAR ALGAE AND CYANOBACTERIA

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Research on the influence of consumer antibiotics on unicellular algae and cyanobacteria found in water habitats was conducted through the framework of science and art research project that explored contemporary pharmaceutical pollution of water. In project framework microdoses of Amoxicillin, Clindamycin and Penicillin-Streptomycin antibiotics on tested algae (*Spirulina platensis*, *Haematococcus* sp., *Nostoc* sp., *Chlorella* sp. and *Euglena gracilis*) and cyanobacteria (*Oscillatoria animalis*, *Anabaena cylindrica* and *Gloeocapsa* sp.) showed inhibitory effect on growth of all green – chlorophyll containing species. Only exception was red *Haematococcus* sp. algae (containing carotenoid pigments) whose growth was not inhibited but increased. Research was conducted in laboratory setting under controlled conditions. Algae were cultivated in test tubes at constant temperature of 24 °C, and under 12-12 light period. The growth was monitored in period of 7 days, using Hach DR/2010 spectrophotometer. The research on long term influence of antibiotics is ongoing.

**Keywords:** pharmaceutical pollution, consumer antibiotics, growth inhibition, algae, cyanobacteria



**Studentski rad / *Student work***





## UTJECAJ SELENA NA SADRŽAJ GLUTATIONA I ANTIOKSIDACIJSKU AKTIVNOST U STANICAMA ALGE *MONORAPHIDIUM CF.* *CONTORTUM*

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Selen (Se) je element u tragovima koji se u prirodi pojavljuje u brojnim organskim i anorganskim oblicima. Dosadašnja istraživanja pokazala su dvojak učinak Se na živi svijet – djeluje kao esencijalan mikronutrijent, ali i kao toksični element, u ovisnosti o koncentraciji, kemijskom obliku te drugim parametrima okoliša. Potencijalna toksičnost leži u sposobnosti bioakumulacije od strane primarnih producenata, posebice mikroalga, koje osiguravaju transport Se duž hranidbenih lanaca u vodenim ekosustavima. U kontekstu navedenog, cilj istraživanja bio je utvrditi učinak različitih koncentracija selenita (5, 25, 50 i 100 mg/L) na rast kulture jednostanične zelene alge *Monoraphidium cf. contortum*, aktivnost antioksidacijskog enzima glutation S-trasferaze (GST), sadržaj ukupnih topljivih fenola i ukupnog glutationa (tGSH) te ukupan sadržaj reaktivnih kisikovih tvari (ROS) tijekom različitih vremenskih perioda izlaganja (24, 48 i 72 sata). Tretmani većim koncentracijama Se rezultirali su inhibicijom rasta alga i pojačanim stvaranjem ROS-a u stanicama. Također, selenit je uzrokovao povećanje ukupne koncentracije topljivih fenola, smanjenje koncentracije tGSH te povećanje aktivnosti GST-a. Tretman najnižom koncentracijom selenita imao je pozitivan učinak na rast alga i smanjenje sadržaja ukupnog ROS-a u stanicama. Učinak Se na antioksidacijski odgovor ovisio je o primijenjenoj koncentraciji i vremenu izlaganja selenitu.

*Ključne riječi:* selenit, oksidacijski stres, antioksidacijski odgovor, glutation, zelene mikroalge



## THE EFFECT OF SELENIUM ON GLUTATHIONE CONTENT AND ANTIOXIDANT ACTIVITY IN *MONORAPHIDIUM* CF. *CONTORTUM*

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Selenium (Se) is a trace element that appears in nature in many organic and inorganic forms. Previous investigations showed a dual impact of Se on the living world - it acts as an essential micronutrient, but also as a toxicant, depending on its concentration, chemical form and other environmental parameters. Potential toxicity lies in the ability of its bioaccumulation by primary producers, particularly microalgae, which provide its transport along the food chains in aquatic ecosystems. In the context of the above, the study aimed to determine the effect of different selenite concentrations (5, 25, 50 and 100 mg/L) on the growth of unicellular green alga *Monoraphidium* cf. *contortum*, the activity of antioxidant enzyme glutathione S-transferase (GST), the content of total soluble phenols and total glutathione (tGSH) and the total content of reactive oxygen species (ROS) during different periods of treatment (24, 48 and 72 hours). The results showed the inhibiting effect of higher Se concentrations on algal growth and enhanced ROS generation in cells. Also, selenite treatment induced an increase in the content of total soluble phenols, a decrease in the content of tGSH and increased GST activity. Treatment with the lowest concentration of selenite had a positive effect on algal growth and reduced the total content of ROS in cells. The effect of Se on the antioxidative response in algal cells depended on the applied concentration and time of exposure to selenite.

*Keywords:* selenite, oxidative stress, antioxidative response, glutathione, green microalgae



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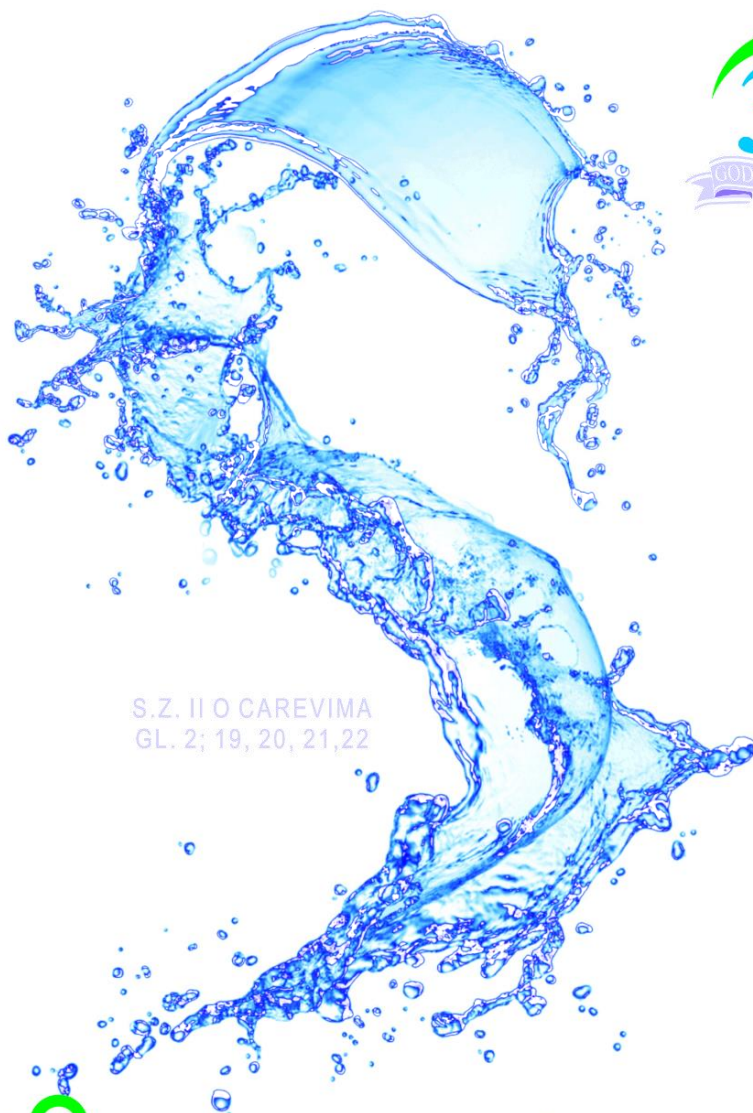

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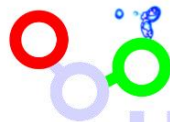


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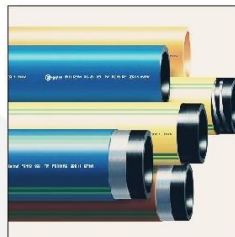
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Široki spektar djelatnosti obuhvaća izradu studijske dokumentacije za projekte koji se financiraju iz EU fondova, kao i studije utjecaja na okoliš i elaborate zaštite okoliša iz područja hidrotehnike i zbrinjavanja otpada.

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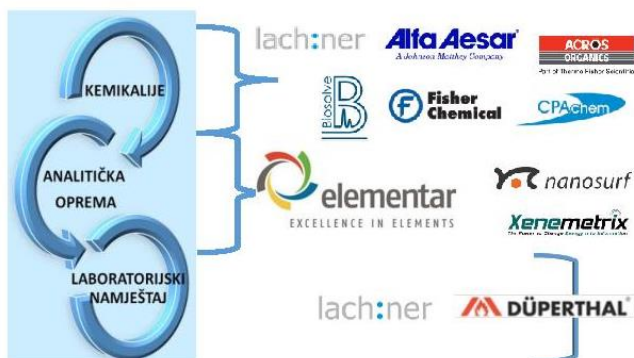




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Ispitivanje sastava eluata otpada.

Određivanje pH, pKCl, ukupnog CaCO<sub>3</sub>, NO<sub>3</sub><sup>-</sup>, NO<sub>2</sub><sup>-</sup>, NH<sub>4</sub><sup>+</sup>, fosfora i kalija, humusa, teških metala i drugih kemijskih svojstava tla.



Pokazatelji koji se mjere u uzorcima vode, eluata tla i sedimenata:

- ✓ atomskom apsorpcijskom spektrometrijom: Al, As, B, Ba, Ca, Cd, Co, Cr, Cu, Fe, Hg, K, Li, Mg, Mn, Mo, Na, Ni, Pb, Se, Si, Sr, Ti, V, Zn
- ✓ amonijak, nitriti, nitrati, ukupni dušik
- ✓ bromidi, fenoli, fluorida, fosfati, jodidi, kloridi
- ✓ silikati, sulfidi, sulfati, sulfiti
- ✓ suspendirana tvar, mutnoća, KPK
- ✓ alkalitet, ukupna tvrdoća, karbonatna tvrdoća, nekarbonatna tvrdoća, kalcijeva tvrdoća, magnezijeva tvrdoća
- ✓ slobodni CO<sub>2</sub>, konc. otopljenog kisika i zasićenost kisikom
- ✓ pH, električna vodljivost, ukupna otopljena tvar
- ✓ trasiranje podzemnih tokova (konc. natrijevog fluoresceina)
- ✓ ukupni organski ugljik i ukupni dušik - TOC/DOC/TN
- ✓ razaranje tla zlatotopkom
- ✓ ekstrakcija izmjenjivih kationa iz tla amonijevim acetatom i kalijevim kloridom



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Trgovačko društvo Izvor – ing d.o.o. osnovano je 2013. g. za građenje, nadzor i projektiranje. Najznačajnija područja djelatnosti su:

1. Projektiranje - hidrotehničke građevine, plovni putevi, vodovod i kanalizacija, inženjerske građevine, trgovački centri, tvornice, poljoprivredni objekti
2. Nadzor nad izvođenjem svih vrsta radova
3. Vođenje projekata – sufinanciranih iz EU fondova

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