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NAJNOVIJA DOSTIGNUĆA U FOTOKATALITIČKOJ RAZGRADNJI ORGANSKIH ONEČIŠĆUJUĆIH TVARI U VODAMA

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Kemijska složenost organskih onečišćujućih tvari u prirodnim vodama, poput lijekova, agrokemikalija i boja, zahtijeva primjenu novih i naprednijih načina njihova uklanjanja iz voda u odnosu na konvencionalne metode njihova pročišćavanja. Jedna od takvih metoda je fotokatalitička razgradnja. U ovom radu su opisani mehanizmi razgradnje štetnih organskih spojeva pomoću poluprovodničkih materijala s aktivnim fotokatalitičkim svojstvima uz djelovanje UV ili vidljivog zračenja te metode i odabir komponenata za pripravu najnovijih fotokatalizatora, njihova stabilnost kao i učinkovitost uklanjanja organskih onečišćujućih tvari. U radu su također opisane prednosti i nedostatci fotokatalitičkih metoda, kao i smjernice za buduća istraživanja u ovom području.

Ključne riječi: fotokataliza, organske onečišćujuće tvari, boje, lijekovi, pesticidi

RECENT ACHIEVEMENTS IN PHOTOCATALYTIC DEGRADATION OF ORGANIC WATER CONTAMINANTS

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The chemical complexity of organic contaminants (drugs, agrochemicals and dyes) requires new more advanced ways to remove them from water compared to the conventional treatment methods used. One such method is photocatalytic degradation. In this paper, the mechanism of degradation of harmful organic compounds using semiconductor materials with photocatalytically active properties in the presence of UV or visible radiation will be explained. Methods and selection of components for the preparation of the latest developed photocatalysts, their stability as well as the percentage of contaminant removal will be discussed. The discussion will also cover the advantages and drawbacks of photocatalytic methods, as well as future research in this area.

Keywords: photocatalysis, organic water contaminants, dyes, drugs, pesticides

UPRAVLJANJE PODZEMNIM VODAMA U REPUBLICI HRVATSKOJ

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Podzemna voda je jedinstven i nezamjenjiv prirodni resurs ograničenih količina i neravnomjerne prostorne i vremenske raspodjele. Za potrebe javne vodoopskrbe godišnje se zahvaća 435 milijuna m^3 podzemne vode na 467 vodocrpilišta, što je 91,2 % ukupno zahvaćenih količina. Za ostale potrebe zahvaća se oko 154 milijuna m^3 podzemne vode na 2913 vodozahvata. Za potrebe izrade planova upravljanja vodnim područjima određena su osnovna i grupirana tijela podzemne vode, uspostavljen monitoring podzemnih voda, donesena je Uredba o standardu kakvoće voda, analizirani pritisci i određeno kemijsko i količinsko stanje tijela podzemne vode. Na vodnom području rijeke Dunav je izdvojeno 20, a na Jadranskom vodnom području 13 grupiranih vodnih tijela podzemne vode. Ocjena kemijskog stanja navedenih vodnih tjela provedena je primjenom sljedećih testova „Zaslanjenje ili druga intruzija“, „Površinske vode, „Kopneni ekosustavi ovisni o podzemnim vodama“, „Zaštitne zone izvorišta vode za piće (DWPA)“ i „Opća ocjena kakvoće“. Za količinsko stanje podzemnih voda korišteni su testovi „Zaslanjenja ili druga intruzija“, „Površinske vode“, „Kopneni ekosustavi ovisni o podzemnim vodama“ i „Bilanca voda“. Navedenim testovima utvrđeno je dobro kemijsko stanje svih podzemnih voda u panonskom dijelu Hrvatske, osim na Varaždinskom području, dok na krškom području su samo tijela Južna Istra i Boljkovac-Golubinka u lošem stanju. Na Dunavskom vodnom području sva tijela podzemnih voda su u dobrom količinskom stanju, a na Jadranskom vodnom području samo je tijelo Bokanjac-Boljkovac u lošem stanju.

Ključne riječi: javna vodoopskrba, podzemne vode, test ocjene stanja, kemijsko i količinsko stanje tijela podzemne vode

GROUNDWATER MANAGEMENT IN CROATIA

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Groundwater is a unique and irreplaceable natural resource of limited quantities unevenly distributed in space and time. For the needs of the public water supply, 435 million m^3 of groundwater is abstracted annually at 467 water abstraction sites, accounting for 91.2% of the total abstracted quantities. For other needs, around 154 million m^3 of groundwater is abstracted annually at 2,913 water abstraction sites. In order to prepare the river basin management plans, basic groundwater bodies were designated and grouped, groundwater monitoring was established, the Regulation on water quality standard was adopted, pressures were analyzed, and the chemical and quantitative status of groundwater bodies was identified. In the Danube and Adriatic river basin districts, 20 and 13 grouped groundwater bodies respectively were designated. The following tests were used for the assessment of groundwater chemical status: “Saline or other intrusions”, “Surface water”, “Groundwater dependent terrestrial ecosystems”, “Drinking water protection areas (DWPA)” and “General quality assessment”. The groundwater quantitative status was assessed using the following tests: “Saline or other intrusion”, “Surface water”, “Groundwater dependent terrestrial ecosystems”, and “Water balance”. In the Pannonian part of Croatia, the chemical status of all water bodies, except for the body “Varaždin area”, is assessed as good, and in the karst region, only the bodies “Southern Istria” and “Boljkovac-Golubinka” has a poor status. In the Danube river basin district, all the groundwater bodies have good quantitative status, and in the Adriatic river basin district, only the body “Bokanjac-Boljkovac” has a poor status.

Keywords: public water supply, groundwater, status assessment test, groundwater body chemical and quantitative status

VODNO GOSPODARSTVO JUČER, DANAS, SUTRA

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Vodno gospodarstvo u Republici Hrvatskoj financira se iz više različitih izvora, a najznačajnije je EU financiranje. Kroz Operativni program Konkurentnost i kohezija 2014.-2020. (OPKK) i Nacionalni plan oporavka i otpornosti 2021.-2026. (NPOO) planiraju se financirati projekti ukupne vrijednosti 12,8 milijardi kuna, dok je za Višegodišnji financijski okvir 2021.-2027. usuglašavanje u tijeku. EU sredstva dala su novi zamah vodnome gospodarstvu te je od 2016. vidljivo povećanje dostupnosti i poboljšanje kvalitete vode za ljudsku potrošnju, povećanje broja stanovnika s mogućnošću priključenja na sustave javne odvodnje te povećanje stupnja pročišćavanja otpadnih voda. Povećao se i broj točaka na kojima je kvaliteta vode za kupanje izvrsna, i na moru i na kopnenim vodama. Unatoč svemu, na Mediteranu se ispušta čak 60 % nepročišćenih otpadnih voda sa značajnim pritiscima od turizma. S ciljem objedinjavanja poslova monitoringa površinskih i podzemnih voda kao i drugih poslova neophodnih za dobro upravljanje vodama i za izvještavanje Europske komisije o stanju voda u Republici Hrvatskoj na jednom mjestu u posebnoj stručno-znanstvenoj instituciji u 2022. godini osnovan je Institut za vode „Josip Juraj Strossmayer“.

Ključne riječi: upravljanje vodama, Republika Hrvatska

WATER MANAGEMENT IN CROATIA – YESTERDAY, TODAY, TOMORROW

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Water management in Republic of Croatia is financed from several different sources, but EU funding is the most important. Through the Operational Program Competitiveness and Cohesion 2014-2020. and the National Recovery and Resilience Plan 2021-2026. it is planned to finance projects worth a total of 1,7 billion EUR while for the Multiannual Financial Framework 2021-2027. the reconciliation is still in progress. EU funds have given new impetus to water management, and since 2016 there has been an increase in the availability and quality of water for human consumption, an increase in the number of inhabitants with the possibility of connecting to public sewerage systems and an increase in the degree of wastewater treatment. The number of points where the quality of bathing water is excellent, both at sea and on land, has also increased. Despite everything, as much as 60% of untreated wastewater is still discharged in the Mediterranean with significant pressures from tourism. In order to unite surface and groundwater monitoring activities, as well as other activities necessary for good water management and for reporting to the European Commission on the state of water in Croatia, the Josip Juraj Strossmayer Water Institute was established in the year 2022 as a special professional-scientific institution.

Keywords: water management, Republic of Croatia

ULOGA I VAŽNOST VODE U POLJOPRIVREDI

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Neupitna je važnost vode u životu čovjeka, biljaka i životinja. Od ukupne količine vode tek je 1 % slatke vode pristupačno čovjeku za korištenje. Gospodarenje vodama podrazumijeva slijedeće djelatnosti: zaštitu od štetnog djelovanja voda (zaštita od poplava), zaštita voda od zagađenja i korištenje voda. Na globalnoj razini poljoprivreda je najveći korisnik svježe slatke vode, s udjelom od 70 %, a na europskoj razini je to 30 %. U Hrvatskoj je nakon Domovinskog rata (sustavi navodnjavanja su bili devastirani ili otuđeni) navodnjavanih površina bilo za 10 000 ha manje u odnosu na stanje prije Domovinskog rata. Hrvatski stručnjaci, uz dva međunarodna konzultanta, napisali su Nacionalni projekt navodnjavanja i gospodarenja poljoprivrednim zemljištem i vodama u Republici Hrvatskoj (NAPNAV), u kojem su dali stručne smjernice i okvire za osiguranje realizacije održivog sustava navodnjavanja. Planirane površine navodnjavanja prema NAPNAV-u su 65 000 ha (6,5 % obradivih površina). Realizacijom NAPNAV-a do 2022. godine omogućeno je navodnjavanje na 13 000 ha, a za 90-tak lokacija izrađuju se studijske dokumentacije koje bi u narednom razdoblju omogućile navodnjavanje na 124 000 ha.

Ključne riječi: voda, čovjek, poljoprivreda

THE ROLE AND IMPORTANCE OF WATER IN AGRICULTURE

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The significance of water in the life of a human being, plants, and animals is unquestionable. Out of the total water quantity, barely one percent of freshwater is accessible to human consumption. Water management implies the following activities: (1) protection from a harmful effect of water (flood protection), (2) water protection, and (3) water consumption. On a global scale, agriculture is the largest freshwater consumer, with a seventy percent share, being represented by thirty percent at the European level. In Croatia, the irrigated areas subsequent to the Homeland War amounted to ten thousand hectares less than with regard to those in a situation prior to the Homeland War (as the irrigation systems were devastated or misappropriated). The Croatian experts, with the assistance of two international consultants, drafted the National Project of Irrigation and Land and Water Management in the Republic of Croatia (NAPNAV), in which they provided the guidelines and frameworks to assure the realization of a sustainable irrigation system. Pursuant to the NAPNAV, the planned irrigation areas amount to sixty-five thousand hectares (i.e., to 6.5% of arable land). The realization of the NAPNAV up to the year 2022 facilitated the irrigation of thirteen thousand hectares, and study documentation is being drawn up for approximately ninety locations, which would enable the irrigation of 124,000 ha in the forthcoming period.

Keywords: water, man, agriculture

Usmena priopćenja / *Oral lectures*

Poljoprivreda i vodni resursi / *Agriculture and Water Resources*

CLIMATE CHANGE IMPACTS ON WATER BALANCE COMPONENTS IN BOSNIA AND HERZEGOVINA AND CROATIA

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The climate of Southeastern Europe, where Bosnia and Herzegovina and Croatia are located, is changing in line with the global trends. The spatial and seasonal distribution of precipitation is changing, while the temperatures increased 0.4-0.8 °C on average compared to 1961-1990 average, most notably during summer (1.0-1.2 °C). Depending on the different climate change scenarios, the temperatures in this area are projected to further increase by 1.7-4.0 °C. In order to understand the effects of climate change on regional water resources, it is important to assess the impacts of these changes on the components of the water balance. The aim of this study was to determine and compare the severity of changes in annual water balance between two climate periods (1961-1990 and 1991-2020). The results indicate that climate change has a different temporal and spatial effect. All areas showed a positive trend in mean air temperature (0.29-0.36 °C per decade), reference evapotranspiration (5.96-32.14 mm per decade) and soil moisture deficit (2.75-31.63 mm per decade), while precipitation, total runoff, amount of snow and actual evapotranspiration vary depending on the location and time period. The key characteristic of the 1991-2020 period compared to 1961-1990 is the greater variation of all components of the water balance.

Keywords: climate change, soil water balance, soil moisture deficit, evapotranspiration

THE IMPACT OF AGRICULTURAL PRODUCTION ON THE GROUNDWATER IN THE BOKANJAC-POLIČNIK CATCHMENT AREA

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Groundwater is the main source of drinking water in the Republic of Croatia where over 90% of water supply is from groundwater reserves. Also, 50% of the state territory are karst aquifers which are high quality groundwater reservoirs. Due to their hydrogeological structure, they are very vulnerable to anthropogenic influences. Therefore, they require protection measures defined based on the results of detailed hydrogeological research, among which are methods for groundwater vulnerability assessment. Such methods assume that the natural chemical, biological and physical properties of an area may, to some extent, contribute to the protection of groundwater from external impacts. The KAVA method was applied in the Bokanjac - Poličnik catchment area and results will be presented in this paper. KAVA is multiparameter method, uses four parameters: cover deposits, infiltration impact, aquifer conditions and precipitation impact, and can assess the intrinsic vulnerability of aquifers and/or springs. Result of the assessment are maps made using GIS tools. In addition, a hazard map and risk map for groundwater contamination under the influence of agricultural production were prepared. The comprehensive analysis conducted in this way indicates the parts of the basin that pose a threat to the groundwater quality of this area.

Keywords: karst aquifers, vulnerability, hazard, risk, KAVA method, GIS

KVALITETA VODE ZA NAVODNJAVANJE I KRITERIJI/STANDARDI U HRVATSKOJ - DOPRINOS OKOLIŠU I INDUSTRIJI

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Kvaliteta vode koja se koristi za navodnjavanje, trebala bi zadovoljavati propisane kriterije. Pokazatelji koji se najčešće utvrđuju su električna vodljivost (EC), ukupne otopljene soli (TDS), rezidualni natrij karbonat (RSC) i omjer apsorpcije natrija (SAR). Voda može sadržavati i štetne tvari bez obzira dali se navodnjavanje provodi iz površinskih voda ili podzemne vode. Porijeklo onečišćenja mogu biti otpad, netretirane otpadne vode ili intruzija slanih voda. Korištenje vode loše kvalitete, može uzrokovati probleme u tlu kao što je alkalitet, salinitet, povećana koncentracija natrija, toksičnost i sl. U Koprivničko-križevačkoj županiji (KKŽ) a i u cijeloj Hrvatskoj, navodnjavanje je za sada slabo zastupljeno u poljoprivredi. Obzirom na klimatske promjene i trendove jako suhih i vrućih sezona, od sve većeg značaja je provođenje navodnjavanja. Prema rezultatima utvrđivanja kvalitete podzemne vode za navodnjavanje u KKŽ, vrijednosti pokazatelja su zadovoljavajuće (EC=<0,7 dS/m; TDS=<450 mg/l; RSC=<1,25 meq/l; SAR=<3,0 meq/l) za korištenje u poljoprivredi. Međutim, obzirom da u Hrvatskim propisima nema standarda i kriterija koji bi definirali kvalitetu vode, rezultati su uspoređeni sa europskim/svjetskim standardima. Ispitivanja kvalitete vode i donošenje standarda/kriterija u Hrvatskoj mogli bi pridonijeti budućem razvoju poljoprivrede u sve češće nepovoljnim klimatskim uvjetima te spriječiti onečišćenje okoliša. To bi osiguralo i efikasniji uzgoj bilja što pridonosi i proizvodnji u vlastitoj prehrambenoj industriji.

Ključne riječi: kvaliteta vode za navodnjavanje, poljoprivreda, kriteriji i standardi, okoliš, industrija

IRRIGATION WATER QUALITY AND CRITERIA/STANDARDS IN CROATIA - CONTRIBUTION TO THE ENVIRONMENT AND INDUSTRY

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The water quality used for irrigation should meet the prescribed criteria. The most commonly determined indicators are electrical conductivity (EC), total dissolved salts (TDS), residual sodium carbonate (RSC) and sodium absorption ratio (SAR). Water can also contain harmful substances, regardless of whether irrigation is carried out from surface water or groundwater. The origin of the pollution can be waste, untreated wastewater or saltwater intrusion. The use of poor water quality can cause soil problems such as alkalinity, salinity, increased sodium concentration, toxicity, etc. In Koprivnica-Križevci county (KKŽ) and throughout Croatia, irrigation is currently poorly represented in agriculture. Given the climate change and the trends of very dry and hot seasons, the implementation of irrigation is of increasing importance. According to the results of determining the groundwater quality for irrigation in KKŽ, the values of the indicators are satisfactory (EC = <0.7 dS/m; TDS = <450 mg/l; RSC = <1.25 meq/l; SAR = <3.0 meq/l) for use in agriculture. However, since there are no standards and criteria in Croatian regulations that would define water quality, the results are compared with European/world standards. Water quality testing and the adoption of standards/criteria in Croatia could contribute to the future development of agriculture in increasingly unfavorable climatic conditions and prevent environmental pollution. This would ensure more efficient cultivation of plants, which also contributes to production in our own food industry.

Keywords: irrigation water quality, agriculture, criteria and standards, environment, industry

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Usmena priopćenja / *Oral lectures*

PROVEDBA NACIONALNOG PROJEKTA NAVODNJAVANJA I GOSPODARENJA POLJOPRIVREDNIM ZEMLJIŠTEM I VODAMA NA PODRUČJU OSJEČKO-BARANJSKE ŽUPANIJE

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U cilju organiziranja navodnjavanja, te okrupnjavanja poljoprivrednog zemljišta, izmjenu strukture poljoprivredne proizvodnje, uvođenje dohodovnih kultura, osiguraju preduvjeti za primjenu novih tehnologija u uvjetima navodnjavanja Vlada Republike Hrvatske 17. studenog 2005. godine donijela je Nacionalni projekt navodnjavanja i gospodarenja poljoprivrednim zemljištem i vodama (udaljnjem tekstu: NAPNAV), a čija provedba bi trebala rezultirati boljim korištenjem prirodnim resursa za učinkovitiju poljoprivrednu proizvodnju. Prema NAPNAV-u svaka županije izrađuje svoje planove navodnjavanja, te je u skladu s navedenim Skupština Županije 11. ožujka 2006. godine donijela Plan navodnjavanja područja Osječko-baranjske županije ("Županijski glasnik" broj 3/06.). Plan navodnjavanja Županije predstavlja opsežan i sustavno izrađen planski dokument koji je osnova za daljnje detaljnije rješavanje konkretnih projekata navodnjavanja na pojedinim lokacijama Županije. NAPNAV na području naše Županije provodi se već dugi niz godina u suradnji s Hrvatskim vodama i nadležnim ministarstvom. Tijekom provedbe NAPNAV-a na području Županije izrađena je projektna dokumentacije za pojedine sustav navodnjavanja u kojima su utvrđeni budući korisnici, ishođene su lokacijske, odnosno građevinske dozvole. Na području Osječko-baranjske županije u tijeku je gradnja četiri sustava navodnjavanja, od kojih su tri financirana u cijelosti iz Programa ruralnog razvoja Republike Hrvatske, a to su: Sustav navodnjavanja mala šuma-Veliki vrt, Sustav navodnjavanja Poljoprivredni institut Osijek i Sustav navodnjavanja Budimci-Krndija. Ukupan obuhvat navedenih sustava navodnjavanja iznosi 854,50 ha Četvrti sustav navodnjavanja koji se gradi na području Županije je Sustav navodnjavanja Puškaš obuhvata 925 ha, čije izgradnje je investitor Hrvatske vode, a Županije je sufinancijer. Izgradnjom ovih sustava navodnjavanja, kao i drugih planiranih sustava navodnjavanja stvorit će se uvjeti za stabilnu poljoprivrednu proizvodnju u sve izraženijim uvijenima klimatskih promjena, kao i uvjeti za promjenu sjetvene strukture površina i prelazak na radno intenzivne proizvodnje, odnosno razvoj povrtlarske i voćarske proizvodnje. Ključne riječi: Nacionalni projekt navodnjavanja I gospodarenja poljoprivrednim zemljištem i vodama, sustav navodnjavavanja, Osječko-baranjska županija,

Ključne riječi: voda, navodnjavanje, Osječko-baranjska županija

IMPLEMENTATION OF THE NATIONAL IRRIGATION PROJECT AND AGRICULTURAL LAND MANAGEMENT AND WATERS IN THE AREA OF OSIJEK-BARANJA COUNTY

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To organize irrigation and consolidation of agricultural land, change the structure of agricultural production and the introduction of income crops, and provide prerequisites for the application of new technologies in irrigation conditions, the Government of the Republic of Croatia adopted the National Project for Irrigation and Management of Agricultural Land and Water (hereinafter: NAPNAV) on 17 November 2005, the implementation of which should result in better use of natural resources for more efficient agricultural production. According to NAPNAV, each county prepares its irrigation plans, and per the above, the County Assembly adopted the Irrigation Plan of the Osijek-Baranja County on March 11, 2006 ("County Gazette" No. 3/06). The County Irrigation Plan is a comprehensive and systematically prepared planning document that is the basis for further detailed solutions to specific irrigation projects at individual locations in the County. NAPNAV, in our County, has been implemented for many years in cooperation with Croatian Waters and the competent ministry. During the implementation of the NAPNAV in the County, project documentation was prepared for individual irrigation systems in which future users were identified, and location and construction permits were obtained. In the area of Osijek-Baranja County, four irrigation systems are being built, three of which are fully financed by the Rural Development Program of the Republic of Croatia, namely: Small Forest Irrigation System-Large Garden, Irrigation System Agricultural Institute Osijek and Irrigation System Budimci- Krndija. The total coverage of these irrigation systems is 854.50 ha. The fourth irrigation system being built in the County is the Puškaš Irrigation System, which covers 925 ha, the investor being Hrvatske vode, and the County is a co-financier. The construction of these irrigation systems and other planned irrigation systems will create conditions for stable agricultural production in the increasingly pronounced twists of climate change, as well as conditions for changing the sowing structure and transition to labor-intensive production and development of vegetable and fruit production.

Keywords: National project of irrigation and agricultural land and water management, irrigation system, Osijek-Baranja County

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

OBRADA I ZBRINJAVANJE PROČIŠĆENIH OTPADNIH VODA IZ SEPARATORA ULJA I PROIZVODNJA MODIFICIRANIH OPEKA

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U ovom radu ispitana je učinkovitost pročišćavanja otpadnih voda iz separatora ulja hibridnim postupkom, odnosno kombinacijom elektrokemijskih (EK) i naprednih oksidacijskih procesa (NOP). Obje metode postale su predmet brojnih istraživanja jer pročišćavaju otpadnu vodu koristeći električnu struju umjesto kemijskih reagensa i mikroorganizama koji mogu biti ekonomski i operativno nepovoljniji. Prema dosadašnjim istraživanjima, elektrokoagulacija je pokazala visoku učinkovitost pročišćavanja uz niske troškove izgradnje, pogona i održavanja. NOP imaju široku primjenu u obradi otpadnih voda, a njihova svrha je oksidacija organske tvari do završih produkata CO_2 i H_2O. U radu je ispitana učinkovitost pročišćavanja u ovisnosti o materijalu elektroda, jakosti struje, otopljenom kisiku, električnoj vodljivosti, pH-vrijednosti, temperaturi, KPK vrijednoste te koncentraciji ukupnih ugljikovodika ili mineralnih ulja. Također je ispitana mogućnost primjene nastalog otpadnog mulja kao djelomične zamijene gline u proizvodnji opeka. Proizvedene su četiri serije opeka s ugrađenom pročišćenom vodom i djelomičnom zamjenom dijela gline muljem generiranog hibridnim postupkom pročišćavanja. Proizvedenim opekama određena su geometrijska svojstva, ravnost, obujam i postupak šupljina, tlačna čvrstoća, otpornost na zamrzavanje i odmrzavanje, vodoupojnost, početno upijanje vode te fizikalno-kemijska i mehanička svojstva. Zadovoljavajuća učinkovitost uklanjanja KPK i mineralnih ulja iz otpadne vode ukazuje na opravdanu primjenu ovog procesa u pročišćavanju otpadnih voda.

Ključne riječi: otpadne vode, oborinske vode, separator ulja, elektrokemijski procesi, elektrokoagulacija, napredni oksidacijski procesi, opeka

TREATMENT AND DISPOSAL OF TREATED WASTEWATER FROM OIL SEPARATORS FOR RAINFALL RUNOFF AND PRODUCTION OF MODIFIED BRICKS

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In this study, wastewater from oil separators was treated by the ombination of electrochemical (EC) and advanced oxidation processes (AOP) since those methods can have economical and operational benefits due to a high treatment performance with low construction, operation, and maintenance costs. In this study, the efficiency of wastewater treatment by a combination of EC and AOP was investigated due to electrode materials, current, dissolved oxygen, electrical conductivity, pH, water temperature, chemical oxygen demand (COD) and total hydrocarbons or mineral oils. The possibility of sludge usage as a partial substitute for clay in brick production has been also investigated by the production of four series of bricks with embedded purified water and partial replacement of part of the clay with sludge. The manufactured bricks were determined on the basis of geometric properties, flatness, volume and course of voids, compressive strength, resistance to freezing and thawing, water absorption, initial water absorption, and physicochemical and mechanical properties such as soluble salt content, etc. Satisfactory efficiency was obtained in the removal of COD and mineral oils from oil separator effluents, proving and justifying the application of this process for the treatment of this type of effluents.

Keywords: wastewater, rainwater, oil separator, electrochemical processes, electrocoagulation, advanced oxidation processes, brick

IZGRADNJA POSTROJENJA ZA PROČIŠĆAVANJE OTPADNIH VODA GRADA OSIJEKA

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Za Vodovod Osijek d.o.o. 2012. godine tvrtka Hidroing d.o.o., Osijek projektirala je Uređaj za pročišćavanje otpadnih voda grada Osijeka kapaciteta 170.000 ekvivalent stanovnika (ES). Realizacija postrojenja za pročišćavanje otpadnih voda je kroz „Projekt Osijek“, a sufinanciran je od EU, Hrvatskih voda, Grada Osijeka i Općine Čepin. Ugovor s novim izvođačima koju čine zajednica ponuditelja ING-GRAD i GH-Holding za izgradnju Postrojenja za Pročišćavanje Otpadnih Voda je potpisan u kolovozu 2021. s rokom dovršetka travanj 2024. PPOV je uređaj veličine 170.000 (ES) s III. stupanjem pročišćavanja s ispustom u recipijent rijeku Dravu. Odabrana tehnologija je konvencionalna s aktivnim muljem, a uređaj se sastoji od 29 objekata koji zajedno čine jednu cjelinu. U ovom radu opisan je projekt izgradnje i rada novog postrojenja za pročišćavanje otpadnih voda grada Osijeka 170.000 ES te realizacija od njegovog početka ugovaranja do trenutnog izvođenja radova. Opisana je odabrana tehnologija pročišćavanja otpadne vode.

Ključne riječi: pročišćavanje otpadnih voda, izgradnja, tehnologija, radovi

CONSTRUCTION OF A WASTEWATER TREATMENT PLANT IN THE CITY OF OSIJEK

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For Vodovod Osijek d.o.o. In 2012, the company Hidroing d.o.o., Osijek designed the Wastewater Treatment Plant of the city of Osijek with a capacity of 170,000 population equivalent (PE). The realization of the wastewater treatment plant is through the "Project Osijek" and co-financed is from the EU, Croatian Waters, the City of Osijek and the Municipality of Čepin. Contract with new contractors they make the community of bidders ING-GRAD and GH-Holding for the construction of the wastewater treatment plant was signed in August 2021 with a deadline of April 2024. The WWTP is a 170,000 (PE) unit with III. stage of treatment with discharge into the recipient river Drava. The selected technology is conventional with activated sludge, and the device consists of 29 objects that together form one whole.

Keywords: wastewater treatment plant, construction, technology, works

UTJECAJ KVALITETE ELEKTRIČNE ENERGIJE NA POUZDANOST I STABILNOST RADA POGONA PROIZVODNJE VODE VODOVOD-OSIJEK

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Problemi vezani uz kvalitetu električne energije prisutni su u većini industrija. Za kvalitetu električne energije na mjestu priključka odgovorni su operator sustava i korisnik mreže. Obzirom da pogon za proizvodnju vode za ljudsku potrošnju mora trajno raditi, nužna je pouzdana i trajna opskrba električnom energijom zadovoljavajuće kvalitete sukladno HRN EN 50160:2012. Također, elektromagnetski povratni utjecaj trošila korisnika na elektroenergetsku mrežu mora biti unutar dozvoljenih vrijednosti propisanih Mrežnim pravilima distribucijskog sustava (NN 74/18, 52/20). Niskonaponska elektroenergetska mreža pogona proizvodnje vode Nebo Pustara sadrži osjetljiva elektroenergetska i elektronička trošila, stoga navedena oprema zahtjeva električnu energiju zadovoljavajuće kvalitete. Također, navedena trošila imaju nelinearnu strujno – naponsku karakteristiku pa su i sami izvor štetnosti lošeg utjecaja na kvalitetu električne energije. U svrhu spriječavanja neželjenih događaja s negativnim utjecajem na rad pogona proizvodnje vode, uzrokovanih lošom kvalitetom električne energije te svođenje nedopuštenog povratnog utjecaja nelinearnih trošila na elektroenergetsku mrežu, instaliran je analizator parametara kvalitete električne energije *PCube3* u trafostanici Nebo Pustara. Stoga, sukladno analizi parametara kvalitete električne energije opisane su poduzete radnje u elektroenergetskoj mreži korisnika i operatora sustava radi povećanja pouzdanosti i stabilnosti rada pogona proizvodnje vode i vodoopskrbe u cijelosti, smanjivanje negativnog utjecaja na rad i opremu pogona, kao i svođenje nedopuštenog povratnog djelovanja trošila korisnika na elektroenergetski sustav na dozvoljenu razinu.

Ključne riječi: kvaliteta električne energije, voda za ljudsku potrošnju, pouzdanost i stabilnost rada pogona proizvodnje vode i vodoopskrbe, Nebo Pustara, PCube3

INFLUENCE OF POWER QUALITY ON PRODUCTION RELIABILITY AND STABILITY OF WATER TREATMENT PLANT VODOVOD – OSIJEK

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Power quality issues are pervasive throughout most industries. The system operator and the network user are responsible for the power quality at the point of common coupling (PCC). Since the water treatment plant must operate permanently, a reliable and permanent power supply of satisfactory quality is necessary in accordance with HRN EN 50160:2012. Also, the electromagnetic feedback of the load consumption on the power grid must be within the permitted values prescribed by the Grid Code of the distribution system (NN 74/18, 52/20). Low-voltage power grid of the water treatment plant Nebo Pustara contains sensitive electric and electronic loads, therefore these loads requires power supply of satisfactory quality. Also, these loads have non-linear voltage/current characteristic and they are a source of power quality negative effects. In order to prevent adverse events with a negative impact on the operation of water treatment plant, caused by poor power quality, and reduce the impermissible impact of non - linear loads on the power grid, a power quality analyzer *PCube3* was installed at Nebo Pustara power sub - substation. In accordance with the power quality analysis, the actions taken in the user and distribution power grid are described in order to increase the production reliability and stability of water treatment plant and water supply, reducing the negative impact on plant operation and equipment and reducing the impermissible feedback of non – linear loads.

Keywords: power quality, water for human consuption, production reliability and stability of water treatment plant and water supply, Nebo Pustara, PCube3

PRIMJENA ELEKTROKOAGULACIJE ZA DEZINFEKCIJU I OBRADU VODE ONEČIŠĆENE ARSENOM I KROMOM

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U Hrvatskoj je i dalje značajan broj korisnika lokalnih vodovoda. Karakteristika voda lokalnih vodovoda uobičajeno je zdravstvena neispravnost. Kao najčešći razlog neispravnosti vode navodi se mikrobiološko onečišćenje te povišene koncentracije teških metala. Najčešći postupak kojim se provodi dezinfekcija vode u pripremi vode za piće je dezinfekcija spojevima na bazi klora. Međutim, time kao nusprodukti reakcije klora i organske tvari, nastaju klorirani ugljikovodici i nitrozamini, a koji mogu biti izrazito kancerogeni. Akumulacija ovih nusprodukata, zajedno s akumulacijom teških metala u organizmu, povećavaju rizik od negativnih učinaka na zdravlje. Alternativna metoda kondicioniranja voda, je elektrokoagulacija. Elektrokoagulacijom se pomoću električnog polja i žrtvujućih elektroda stvaraju koagulanti u cilju izdvajanja, agregiranja i taloženja onečišćenja iz vode. Ova se metoda pokazala uspješnom za uklanjanje teških metala iz voda, ali i kao postupak dezinfekcije. Cilj ovog rada je primjena elektrokoagulacije za uklanjanje arsena i kroma te dezinfekciju sirove vode opterećene *Escherichiom coli.* Ispitivanja su provedena u šaržnom reaktoru, uz 2 elektrode (1 anoda i 1 katoda) pri naponu od 62 V. Ispitana je učinkovitost procesa ovisno o materijalu elektrode (Fe, Al, Cu i grafit) i vremenu trajanja tretmana. Osim grafitnih, sve elektrode su pokazale 100 % učinkovitost uklanjanja As i Cr, dok se učinkovitost dezinfekcije razlikovala.

Ključne riječi: obrada voda, elektrokoagulacija, teški metali, dezinfekcija

APPLICATION OF ELECTROCOAGULATION FOR DISINFECTION AND TREATMENT OF WATER CONTAMINATED WITH ARSENIC AND CHROME

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In Croatia, a significant percentage of people use local water supply systems. These systems suffer from poor water quality. The most common contaminations are microbiological contamination and elevated concentrations of heavy metals. The most common procedure for disinfecting water is disinfection with chlorine-based compounds. As a by-product of chlorine and organic matter carcinogenic chlorinated hydrocarbons and nitrosamines are formed. The accumulation of these by-products, together with the accumulation of heavy metals in organisms, increases the risk of adverse effects on health. Electrocoagulation is an alternative method of raw water conditioning. Electrocoagulation creates coagulants using an electric field and sacrificial electrodes to separate, aggregate and precipitate contaminants. This method has proven successful for removing heavy metals, but also as a disinfection method. In this study electrocoagulation was used for the removal of arsenic and chromium and disinfection of raw water enriched with Escherichia coli. The process took place in a batch reactor, with 2 electrodes (1 anode and 1 cathode) at 62 V. The efficiency depended on the electrode material (Fe, Al, Cu and graphite) and the duration of the treatment. Except for graphite, all electrodes showed 100 % efficiency for As and Cr removal, while disinfection efficiency differed.

Keywords: water treatment, electrocoagulation, heavy metals, disinfection

THE REMOVAL OF NEONICOTINOID INSECTICIDES IN A FLATE-PLATE PHOTOREACTOR

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The excessive and systematic use of neonicotinoids over several years has led to the destruction of beneficial insect populations and ultimately threatens the foundations of the food chain. Due to the environmental risks posed by their use, there is a need to develop techniques and methods to prevent the bioaccumulation of insecticides and other undesirable persistent compounds in the environment, to allow their complete degradation, and create favorable conditions for environmental remediation. In the last decade, heterogeneous photocatalysis, also known as "green" technology or energy-saving technology, has been increasingly studied due to its environmental compatibility and sustainability. The aim of this study was to investigate the photolytic and photocatalytic degradation of neonicotinoids in an aqueous solution. Acetamiprid and thiacloprid, two widely used insecticides, were used as model components. Experiments were performed in a flat-plate photoreactor under conditions of recirculation of the reaction mixture over an immobilized photocatalyst layer (TiO_2 modified by urea) using two artificial lamps for simulation of solar irradiation (2.4% UVB and 12% UVA; 300-700 nm). The catalyst used was characterized by XRD, UV/Vis-DRS, BET, and SEM /EDX analysis. For most measurements, the reaction mixture was sonicated for 15 minutes immediately prior to charging the reactor. The study focused on the influence of the pH of the initial solution on the efficiency of photocatalytic and photolytic degradation. It was found that photocatalytic degradation of the two model components was most effective under acidic operating conditions, i.e., at pH 4.5, while photolysis resulted in their minimum degradation. It was also observed that pretreatment of the reaction mixture with ultrasound promoted photocatalytic degradation, while in the case of photolytic degradation, the application of ultrasound did not contribute to better degradation.

Keywords: heterogeneous catalysis, neonicotinoid insecticides, acetamiprid, thiacloprid, flate-plate photoreactor

Upravljanje vodama /
Water Management

HISTORICAL WATER SUPPLY SYSTEMS AND WATER MANAGEMENT SYSTEMS AS A BASIS FOR SPATIAL DEVELOPMENT

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During the history of water management systems (both those that prevented floods and those that provided irrigation or water supply) enabled the development of urban civilizations and were the basis for the arrangement of significant spatial units. Their history shows how much they have transformed the space in which people live, ie how much their influence has enabled human existence. In this sense, a number of examples with their importance as examples of tangible cultural heritage are equally important as examples for directing today's spatial planning, not only in the direction of protecting these historical values, but also ensuring sustainable development in using their examples. Croatian and worldwide examples of historical water supply systems and the history of water management are a significant element of the spatial context and the basis for spatial planning. This work will present examples from Croatia and the world that have changed their spatial and social environment and that still provide a significant example of possible and necessary actions, but also the dangers associated with water management and water resources in the context of space planning.

Keywords: history of water management systems, history of water supply systems, heritage protection, urban nad physical planning

IZMJENA I DOPUNA PRAVILNIKA O PRIRODNIM MINERALNIM, PRIRODNIM IZVORSKIM I STOLNIM VODAMA

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Primarna svrha zakonodavstva Europske unije o prirodnim mineralnim vodama je zaštititi zdravlje potrošača, osigurati njihovo pošteno informiranje, omogućiti slobodno kretanje prirodnih mineralnih voda i stvaranje jednakih uvjeta tržišnog natjecanja. Pravilnikom o prirodnim mineralnim, prirodnim izvorskim i stolnim vodama („Narodne novine“, broj 85/19) propisani su zahtjevi koje prirodne mineralne, prirodne izvorske i stolne vode moraju ispunjavati prilikom korištenja, obrade i stavljanja u promet. Izmjenama i dopunama navedenog Pravilnika mijenja se naziv "prirodna izvorska voda" u "izvorska voda" radi daljnjeg usklađivanja s Direktivom 2009/54/EZ o iskorištavanju i prometu prirodnih mineralnih voda. Propisani su uvjeti koje prirodna mineralna voda mora ispunjavati u pogledu prisutnosti ukupnih i pojedinačnih pesticida. Propisane su izmjene u postupku priznavanja prirodnih mineralnih i izvorskih voda u vezi s potrebnom dokumentacijom, te se uvodi mogućnost provođenja očevida tijekom provođenja postupka priznavanja. Propisano je uzorkovanje prirodnih mineralnih i izvorskih voda za provođenje laboratorijskih analiza u postupku priznavanja. Propisuje se točan popis navoda koji se mogu koristiti pri označavanju prirodnih mineralnih voda. Propisuje se način ocjenjivanja sukladnosti rezultata analiza s vrijednostima odgovarajućih propisanih parametara. Kako bi se omogućilo proizvođačima prirodnih izvorskih voda da se prilagode odredbama propisano je prijelazno razdoblje od 3 godine, od dana stupanja na snagu Pravilnika, a u slučaju galona za uređaje za vodu 5 godina unutar kojih su dužni uskladiti deklaracije.

Ključne riječi, izmjena i dopuna Pravilnika, izvorske vode, prirodne mineralne vode

AMENDMENTS TO ORDINANCE ON NATURAL MINERAL, NATURAL SPRING AND TABLE 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. The Ordinance on natural mineral, natural spring and table waters (Official Gazette 85/19) prescribes the requirements that natural mineral, natural spring and table waters must meet when using, treating and placing on the market. Amendments to the said Ordinance change the name "natural spring water" to "spring water" in order to further harmonize with Directive 2009/54/EC on the exploitation and marketing of natural mineral waters. Requirements that natural mineral water must meet regarding the presence of total and individual pesticides are prescribed. Changes in the procedure for the recognition of natural mineral and spring waters are prescribed in connection with the necessary documentation, and the possibility of conducting a site-visit during the implementation of the recognition procedure is introduced. Sampling of natural mineral and spring waters for conducting laboratory analyses for the purposes of the recognition procedure is prescribed in more detail. An exact list of statements that can be used in the labelling of natural mineral waters is prescribed. The method of assessing the conformity of the results of analyses with the values of the corresponding prescribed parameters is also prescribed. In order to enable producers of natural spring waters to adapt the provisions a transitional period of 3 years is prescribed, from the date of entry into force of the Ordinance, and in the case of gallons for water appliances 5 years and within which they are obliged to reconcile declarations.

Keywords: amendment to ordinance, spring waters, natural mineral waters

APPLICATION OF THE DAVIDSON-HILL VENTURI TURBINE TECHNOLOGY (DHV) - POTENTIAL AND INNOVATION

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Hydro energy is one of the least toxic and most powerful and under-utilized renewable energy sources in the world. New hydrokinetic turbine technologies are being developed for open flow environments as this is much less disruptive to the local ecosystem than traditional damming as the structure does not occupy the entire river and allows free flow in and around the structure. With regards to the calculations and testing, it has been shown that the Davidson-Hill Venturi Turbine Technology (DHV) is potentially the most efficient hydrokinetic turbine in the world. The idea of the turbine operational work is based on the Venturi effect in the open watercourses. The intention of the research is to present innovation and test turbines on real sites in Europe, especially in Croatia. Such will consist of the sizing of the turbines, building the prototype, comparison of the calculated and measured values, as well as the proposals for the improvements. A special accent will be on providing the foundation and an assembly with regard to the base of the river bed, bridges, or similar constructions. It should be mentioned that DHV turbines could be used to harness tidal flow in the open ocean on a mass scale.

Keywords: kinetic energy, turbine, Venturi, environment

HIDROLOGIJA KROZ ISKUSTVA S OBORINAMA

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Upravljanje vodama bazirano je na hidrološkim podatcima, među kojima su podatci o oborinama često i najvažniji. Oborina je neizostavan dio tumačenja kruženja vode u prirodi i suvremeno se redovito opaža u okviru praćenja vremenskih prilika. U radu se prvo opisuju osnove postupaka prikupljanja podataka o oborinama, odnosno korištenja raznih kišomjera. Zatim se ukazuje na neka iskustva problematične interpretacije raspoloživih podataka. Primjerima se ukazuje na vremensku i prostornu varijabilnost oborinskih događaja te se ističu neki načini prikaza obrađenih skupova podataka. Na kraju se predstavlja i primjer složenije analize hidroloških podataka kojom se omogućuje uočavanje elementa klimatskih promjena.

Ključne riječi: hidrologija, oborina, kišomjer, varijacije

HIDROLOGY THROUGH EXPERIENCES WITH RAINFALL

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Water management is based on hydrological data, among which rainfall data are often the most important. Rainfall is an indispensable part of the interpretation of water circulation in nature and is nowadays regularly observed in the context of monitoring weather conditions. The paper first describes the basics of the procedure for collecting data on rainfall, i.e. the use of various rain gauges. Then, some experiences of problematic interpretation of available data are pointed out. Examples indicate the temporal and spatial variability of rainfall events. Some ways of displaying processed data sets are highlighted. Finally, an example of a more complex analysis of hydrological data is presented, which enables the observation of the element of climate change.

Keywords: hydrology, rainfall, rain gauge, variation

UPRAVLJANJE PODZEMNIM VODAMA

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Karakteristike podzemne vode uvjetovane su različitim hidrogeološkim parametrima kao što su poroznost, specifični prinos (koeficijent skladištenja ili efektivna poroznost) i hidraulička vodljivost te interakcijom različitih društvenih aktivnosti i fizičkog okoliša. Podzemna voda je najkvalitetniji vodni resurs za potrebe korištenja voda. Potrebno je održavati hidrodinamičku ravnotežu između prirodnog i/ili umjetnog prihranjivanja i zahvata podzemnih voda. Dok je većina strategija upravljanja podzemnim vodama usmjerena na povećanje ponude, upravljanje potražnjom također je ključno za sprječavanje sniženja razine podzemnih voda i osiguravanje dostupnosti podzemne vode tijekom suše. Stalno snižavanje razine podzemne vode ukazuje na nerazumno iscrpljivanje i smanjenje akumulacije podzemnih voda. Snižavanjem razine podzemnih voda dolazi i do snižavanja tla. Na količinu i kakvoću podzemnih voda nekog područja utječu klimatski uvjeti, brzina obnavljanja, količina crpljenja, urbanizacija, poljoprivreda, namjena zemljišta i vegetacija. S obzirom na navedeno od iznimne je važnosti osigurati dovoljne količine i kakvoću podzemnih voda što se može ostvariti održivim upravljanjem. Održivo upravljanje podzemnim vodama podrazumijeva upravljanje usmjereno na osiguranje dovoljnih količina podzemnih voda dobrog stanja te višestruke dugoročne koristi bez pogoršanja uvjeta koji uzrokuju značajne ekonomske, društvene ili ekološke utjecaje. Potrebno je osigurati program praćenja stanja podzemnih voda i u skladu sa stanjem podzemnih voda primijeniti adekvatno upravljanje. Održivo upravljanje podzemnim vodama u uvjetima klimatskih promjena postalo je važan element globalne politike.

Ključne riječi: korištenje voda, održivo upravljanje, podzemne vode, poljoprivreda, urbanizacija

GROUNDWATER MANAGEMENT

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Groundwater properties are determined by various hydrogeological parameters such as porosity, specific yield (storage coefficient or effective porosity), and hydraulic conductivity, as well as by the interaction of various social activities and the physical environment. Groundwater is the highest-quality water resource for water use. It is necessary to maintain a hydrodynamic balance between natural and/or artificial recharge and groundwater extraction. While most groundwater management strategies aim to increase supply, demand management is also instrumental in preventing groundwater degradation and ensuring groundwater availability during periods of drought. A continuous decline in groundwater levels indicate an inadequate pumping and a reduction in groundwater storage. A reduction in groundwater levels also leads to soil erosion. The quantity and quality of groundwater in a given area is affected by climatic conditions, the renewal rate, the amount of pumping, urbanization, agriculture, land use, and vegetation. In light of the above, it is of utmost importance to ensure sufficient quantity and quality of groundwater, which can be achieved through sustainable management. Sustainable groundwater management is a management that seeks to ensure sufficient quantities of groundwater in good condition and with multiple long-term benefits without deteriorating the conditions that result in significant economic, social, or environmental impacts. A groundwater status monitoring program should be established and appropriate management should be implemented according to groundwater status. Sustainable groundwater management under climate change conditions has become an important element of global policy.

Keywords: agriculture, groundwaters, sustainable management, urbanization, use of water

VIZUALIZACIJA PROCJEĐIVANJA ISPOD TEMELJA BRANE

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Interesantne i neočekivane zakonitosti tečenja podzemne vode predstavljaju zagonetku inženjerima prilikom projektiranja hidrotehničkih objekata. Tečenje podzemne vode kroz tlo ispod objekta (betonske brane) ili kroz tijelo objekta (nasipi i nasute brane) naziva se procjeđivanje ili filtracija. Kako bi se upoznali s fenomenom procjeđivanja napravljen je fizikalni model gravitacijske brane sa ciljem vizualizacije procjeđivanja kroz tlo ispod brane. Model je napravljen u laboratoriju Građevinskog i arhitektonskog fakulteta u Osijeku. Simulirano je stacionarno procjeđivanje ispod brane za nekoliko različitih struktura temeljnog tla. Karakter procjeđivanja procijenjen je preko Darcyjeve jednažbe i konstruirane strujne mreže uz pomoć fluorescente otopine. Uspoređena je količina procjeđivanja kroz tlo različite strukture te je pokazan utjecaj hidrauličkog gradijenta na pojavu likvefakcije i unutarnje erozije. Analizirana je raspodjela pornih tlakova i vrijednost sile uzgona ispod temelja. Konačno, pretpostavljene su i vrednovane mjere koje inženjeri koriste prilikom suočavanja s procjeđivanjem, kako bi se utjecalo na hidraulički gradijent i spriječilo lokalnu eroziju.

Ključne riječi: podzemna voda, procjeđivanje, likvefakcija, lokalna erozija, fizikalni model

VISUALIZATION OF SEEPAGE BELOW THE DAM FOUNDATION

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Interesting and unexpected rules of groundwater flow represent a mystery to engineers when designing hydraulic structures. The flow of groundwater through the soil below a building (such as gravity dams) or through the body of a building (embankments and backfill dams) is called seepage. In order to get acquainted with the phenomenon of seepage, a physical model of the gravitational dam was made with the aim of visualizing the seepage through the soil below the dam. The model was built in the laboratory of Faculty of Civil Engineering and Architecture in Osijek. Stationary seepage below the dam was simulated for several different types of foundation soil. The seepage characteristics was estimated using the Darcy's law and a constructed flow grid using a fluorescent solution. The seepage through the different types soil was quantified and compared. The influence of the hydraulic gradient on the occurrence of liquefaction and internal erosion was shown. The distribution of pore pressures and the value of buoyancy force below the foundation were analyzed. Finally, measures used by engineers to prevent local erosion are assumed and evaluated.

Keywords: groundwater, seepage, liquefaction, local erosion, physical model

PRIPREMA VODOOPSKRBNIH SUSTAVA NA MOGUĆE OPASNOSTI – MUHA PROJEKT

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Prirodne katastrofe i katastrofe uzrokovane čovjekovom djelatnošću predstavljaju sve veću prijetnju u vodoopskrbi stanovništva pitkom vodom. Opasnosti poput suša, poplava, slučajnih onečišćenja i potresa najveći su rizici sigurne vodoopskrbe, za čiju je obranu potrebno definirati usklađene mehanizme i protokole nadležnih institucija. Iz tog razloga su u izmjenama i dopunama Zakona o vodi za ljudsku potrošnju iz 2017. godine (NN 104/17) planovi sigurnosti voda definirani kao bitan element upravljanja opasnostima i mogućim rizicima te su prema europskoj Direktivi o vodi ispravan alat za sigurnu vodoopskrbu pitkom vodom. Glavni ciljevi projekta MUHA, sufinanciranog iz programa INTERREG ADRION su izrada harmoniziranoga plana, metoda i definiranih naredbi provedbe, kao odgovarajućih mehanizama u slučaju opasnosti s ciljem poboljšanja planova sigurnosti voda. Upravo će tako, jedan od glavnih alata projekta MUHA WASSP-DSS pomoći u identificiranju i procjeni rizika mogućih opasnih događaja koji utječu na vodoopskrbni sustav. Unaprjeđenje alata biti će moguće kroz konstituirajuću mrežu UNAS, koja korisnicima pruža jednostavnu, učinkovitu i sigurnu transnacionalnu platformu za razmjenu znanja i iskustava o MUHA alatu i daje smjernice za izradu poboljšanih planova sigurnosti voda. Navedeni rezultati pomoći će u izradi dokumenta strateškog usmjeravanja za uspješniju provedbu planova sigurnosti voda. Uz navedene projektne rezultate, Hrvatski geološki institut provodi hidrogeološko istraživanje u zadarskom zaleđu na prostoru slijeva Bokanjac – Poličnik, s naglaskom na slijev krškog izvora Golubinka.

Ključne riječi: upravljanje vodama, opasnosti, vodoopskrbni sustavi, planovi sigurnosti voda, MUHA projekt

THE PREPARATION OF THE DRINKING WATER SYSTEMS FOR POSSIBLE HAZARDS – THE MUHA PROJECT

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Natural and man-induced disasters pose an increasing threat to the population's drinking water supplies. Hazards such as droughts, floods, accidental pollutions and earthquakes are the most significant risks for securing water supplies, for which is necessary to define harmonized mechanisms and protocols of responsible institutions. For this reason, the amendments to the Water Act for Human Consumption of 2017 (OG 104/17) define water safety plans as an important element in managing hazards and possible risks in the water supply systems, as well as EU Water Directive 2020/2184 which individuates water safety plans as the correct tool for water utilities to ensure safe, drinkable water. The main objectives of the MUHA project, co-financed by the INTERREG ADRION, are aimed to develop harmonized plans, methods and defined implementation orders as appropriate mechanisms in case of hazards and to improve water safety plans. One of the MUHA project's main tools WASSP-DSS will help identify and assess the risk of possible hazardous events impacting the water supply systems. The tool will be improved by the constituting UNAS network, which provides users an easy, effective and safe transnational platform for sharing knowledge and experiences on the MUHA tool and development of improved water safety plans. These results will lead to developing a document with strategic guidance for more successful implementation of water safety plans. In addition to the mentioned project results, the Croatian Geological Survey is conducting hydrogeological research in the Zadar hinterland, in the Bokanjac – Poličnik system, with an emphasis on the Golubinka coastal karst spring.

Keywords: water management, hazards, water supply systems, water safety plans, the MUHA project

Monitoring kakvoće voda /
Monitoring of Water Quality

AKTIVNOSTI NASTAVNOG ZAVODA ZA JAVNO ZDRAVSTVO OSJEČKO-BARANJSKE ŽUPANIJE U SKLOPU PROJEKTA NATURAVITA: MONITORING PODZEMNIH VODA

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Kopački rit je jedna od najvećih fluvijalno-močvarnih nizina u Europi, omeđena Dravom i Dunavom u vrhu Baranjskog trokuta. Dinamika plavljenja održava veliku raznolikost biljnog i životinjskog svijeta što predstavlja iznimnu prirodnu vrijednost Kopačkog rita. Opstanku Kopačkog rita, između ostalog, prijeti opadanje razine i onečišćenje podzemnih voda. Intenzivna poljoprivreda uzrokuje onečišćenje tla, osobito umjetnim gnojivima i pesticidima koji se zatim ispiru i dospijevaju u površinske i podzemne vode. U sklopu projekta Naturavita : monitoring stanja voda, podzemnih voda, recentne sedimentacije, staništa i faune, provodi se hidrokemijski monitoring u pet piezometarskih bušotina s ciljem određivanja kakvoće i porijekla podzemne vode, utjecaja površinskih na podzemne vode, miješanja različitih voda i vremena zadržavanja vode u podzemlju. Sukladno projektnom zadatku, Nastavni zavod za javno zdravstvo Osječko-baranjske županije provodi uzorkovanje i ispitivanje podzemnih voda na osnovne fizikalno-kemijske i kemijske pokazatelje (električna vodljivost, otopljeni kisik, pH vrijednost, osnovni anioni i kationi) te onečišćujuće tvari (nitrati, pesticidi i specifične onečišćujuće tvari). Ispitivanje se provodi tijekom dvije godine, jednom mjesečno na svih pet piezometara.

Ključne riječi: podzemna voda, Kopački rit, Naturavita, fizikalno-kemijski pokazatelji, onečišćujuće tvari

ACTIVITIES OF THE TEACHING INSTITUTE FOR PUBLIC HEALTH OF OSIJEK-BARANJA COUNTY WITHIN THE NATURAVITA PROJECT: GROUNDWATER MONITORING

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Kopački Rit is one of the largest fluvial lowlands in Europe, bordered by the river Drava and the Danube in the Baranja triangle. The flood dynamics maintains a high biological diversity, which is an exceptional natural value of Kopački Rit. The sustainability of Kopački Rit, among other things, is threatened by groundwater decline and pollution. Intensive agriculture causes soil pollution, especially by the runoff and leaching of fertilizers and pesticides which are reaching and contaminating surface water and groundwater. As a part of the "Naturavita project: monitoring of surface water, groundwater, recent sedimentation, habitats and fauna", hydrochemical monitoring is carried out in five piezometer wells in order to determine the quality and origin of groundwater, surface water impact on groundwater, mixing different waters and underground water retention capacity. In accordance with the aims of the Naturavita project, the Institute of Public Health for the Osijek – Baranja County conducts groundwater sampling and testing for basic physicochemical and chemical indicators (electrical conductivity, dissolved oxygen, pH value, basic anions and cations) and pollutants (nitrates, pesticides and specific pollutants). The testings are being conducted in the period of two years; once a month on all five piezometer wells.

Keywords: groundwater, Kopački Rit, Naturavita, physicochemical indicators, pollutants

DEVELOPMENT OF A NEW POTENTIOMETRIC SENSOR FOR SURFACTANTS

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Surfactants are organic molecules which reduce the surface tension. They have a amphiphilic structure with polar head with hydrophilic group that has affinity to water; and a nonpolar tail – a “fatty“ hydrophobic alkyl chain with 8 to 22 carbon atoms. There are four main groups of surfactants - anionic, cationic, amphoteric and nonionic. Anionic surfactants are usually used as washing agents in households and industry, while cationic surfactants are used as disinfectant, preservatives and cleaning agents. Except their positive sides, surfactant have a negative effect on the cells (they disintegrate the cell membrane), they can cause skin irritation and prevent the oxygen exchange on the air/ware phase borders endangering the aquatic life. Since surfactants are widely used, there is a need to establish reliable protocols for their quantification in commercial products (as a quality control tool) and in waters (and wastewaters). Classical methods for their detection, like two-phase titration, are not reliable, require a trained personnel and use toxic solvents. To overcome this issues, surfactants sensors are used. They are fast in response, reproducible, do not use toxic solvents and are easy to use. A new, low-cost, simple and fast potentiometric surfactant sensor based on the 2-methyl-1,3-dioctadecyl-1*H*-benzo[d]imidazol-3-ium - tetraphenylborate ionophore was fabricated, characterized and tested on model and real samples of commercial products and wastewaters containing surfactants. The proposed sensor was suitable for surfactant quantification at high and low concentrations. The results showed good agreement with the standard method.

Keywords: surfactant, potentiometric sensor, imidazole

IDENTIFIKACIJA TEŠKIH METALA U HIDROAKUMULACIJAMA JABLANICA I SALAKOVAC

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Voda iz dva hidroakumulaciona jezera izgrađenih na rijeci Neretvi, Jablanica i Salakovac je bila temom ispitivanja. Vremenom su ove hidroakumulacije postale od iznimne važnosti za ljude, na njima su izgrađena i brojna ribogojilišta u kojima se između ostalih uzgaja i kalifornijska pastrmka. Riba uzgojena u ovim jezerima može akumulirati toksične metale u visokim koncentracijama, koji u konačnici predstavljaju ozbiljan rizik. Živa (Hg), kadmijum (Cd) i olovo (Pb) privlače veliku pažnju jer su skloni akumuliranju u tkivima ribe i mogu naštetiti ljudskom zdravlju ako se unose hranom. Ova studija je imala za cilj da ispita fizičko hemijske osobine i zagađenje vode teškim metalima (Cu, Zn, Hg, Cd i Pb) u dva hidroakumulaciona jezera (Jablanica i Salakovac) na rijeci Neretvi. Uzorci vode prikupljeni su na šesnaest lokacija iz ova dva jezera u rano proljeće i ljeto. Fizičko-hemijski parametri koji su ispitani i analizirani su: okus, miris (bez), boja (bez), ukupna tvrdoća (180 i 300 mg/L $CaCO_3$), mutnoća (2,1-5,31 NTU), pH vrijednost (7,2-7,5), utrošak $KMnO_4$ (1,48 do 4,39 mg/L O_2), amonijak (1,76 - 2,83 mg/L NH_4^+), nitrati (1,97 - 2,58 mg/l NO_3-), nitriti (0,002 - 0,009 mg/L NO_2^-). Ispitivan je nivo teških metala: olovo (0,63 - 2,52 µg/L), živa (0,01 µg/L), kadmij (0,93 - 0,97 µg /L), bakar (4,30 - 6,70 µg/L) i cink (1,40 - 1,80 µg/L).

Ključne riječi: hidroakumulacije, teški metali, analiza vode, fizičko-hemijski parametri

IDENTIFICATION OF HEAVY METALS IN HYDROACCUMULATIONS JABLANICA AND SALAKOVAC

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Water from two hydro-accumulation lakes built on the Neretva River, Jablanica and Salakovac was the subject of research. Over time, these reservoirs have become extremely important for humans, and numerous fish farms have been built on them, where, among others, California trout are farmed. Fish grown in these lakes can accumulate toxic metals in high concentrations, which ultimately pose a serious risk. Mercury (Hg), cadmium (Cd) and lead (Pb) attract a lot of attention because they tend to accumulate in fish tissues and can harm human health if ingested. This study aimed to examine the physicochemical properties and pollution of water with heavy metals (Cu, Zn, Hg, Cd and Pb) in two hydro-accumulation lakes (Jablanica and Salakovac) on the Neretva River, which we did through two samplings during the quarterly water analysis. Water samples were collected at sixteen locations from lakes Jablanica and Salakovac in the early spring and summer of 2018. Physico-chemical parameters tested and analyzed were: taste, odor (no), color (no), total hardness (180 and 300 mg / L $CaCO_3$), turbidity (2.1 - 5.31 NTU), pH value 7.2 - 7.5), consumption of $KMnO_4$ (1,48 - 4,39 mg/L O_2), ammonia (1.76 - 2.83 mg / L $NH4^+$), nitrates (1.97 - 2.58 mg) / l NO_3-), nitrites (0.002 - 0.009 mg / L NO_2^-). The level of heavy metals was examined: lead (0.63 - 2.52 µg / L), mercury (0.01 µg / L), cadmium (0.93 - 0, 97 µg / L), copper (4.30 - 6.70 µg / L) and zinc (1.40 - 1.80 µg / L).

Keywords: hydroaccumulations, heavy metals, water analysis, physicochemical parameters

ŠTO MOŽEMO SAZNATI O PODZEMNIM VODAMA ANALIZOM IZOTOPNOG SASTAVA

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Hrvatska je jedna od rijetkih zemalja koja ima značajne rezerve čiste pitke vode. Na 5. je mjestu u Europi te 42. u svijetu. 68,9 % slatke vode zarobljeno je u ledenjacima, 0,3 % je u jezerima i rijekama, a 30,8 % u podzemnim vodama. Hrvatska ima dovoljne zalihe vode za svoje potrebe za nekoliko sljedećih desetljeća, a značajno vodno bogatstvo predstavljaju podzemne vode (12%) koja se u oko 85 % koristi za vodoopskrbu. Podzemne vode, nalaze se unutar šupljina i pora u tlu te u stijenama. Nastaju infiltracijom ili gravitacijskim procjeđivanjem s površine u procesu kruženja vode u prirodi koji je stalan proces i koji omogućuje život na planeti: voda iz mora i oceana isparava, u atmosferi se kondenzira i u različitim oblicima pada na tlo. Površinskim ili podzemnim tokovima opet dospijeva do mora i oceana te se proces neprestano ponavlja. Izotopi su oblici kemijskog elementa koji imaju isti broj protona, ali različit broj neutrona u jezgri i stoga različite atomske mase. Budući se voda sastoji od atoma kisika i vodika upravo analizom omjera njihovih izotopa mogu se saznati vrlo korisne informacije o tokovima podzemnih voda, geografskom porijeklu flaširanih voda, identifikaciji izvora vode, praćenju hrane ka svom mjestu proizvodnje i otkrivanje krivotvorenja (patvorina), identificiranje uvjeta rasta biljnih sustava, istraživanje povijesti klimatskih događaja i analiza ledenih jezgri te razumijevanje protoka vode podrijetlom iz oceana.

Ključne riječi: podzemne vode, izotopni sastav, geografsko porijeklo, klimatski događaji

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WHAT WE CAN LEARN ABOUT GROUNDWATER BY ANALYTICAL COMPOSITION ANALYSIS

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Croatia is one of the few countries that has significant reserves of clean drinking water and is on 5th place in Europe and 42nd in the world. 68.9% of fresh water is trapped in glaciers, 0.3% in lakes and rivers, and 30.8% in groundwater. Croatia has sufficient water supplies for its needs for the next few decades, and a significant water wealth is groundwater (12%), which in about 85% is used for water supply. Groundwater is found inside cavities and pores in the soil and in rocks. They are formed by infiltration or gravitational leachate from the surface in the process of circulating water in nature which is a constant process and which enables life on the planet: water from the sea and ocean evaporates, condenses in the atmosphere and falls to the ground in various forms. Surface or underground currents reach the sea and oceans again, and the process is constantly repeated. Isotopes are forms of a chemical element that have the same number of protons, but different numbers of neutrons in the nucleus and therefore different atomic weights. Since water consists of oxygen and hydrogen atoms, the analysis of their isotopes ratios can provide very useful information on groundwater flows, geographical origin of bottled water, identification of water sources, monitoring food to its place of production and detection of counterfeits, identifying plant growth conditions, research into the history of climate events and analysis of ice cores, and understanding the flow of water originating from the ocean.

Keywords: groundwater, isotopic composition, geographical origin, climate events

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MICROPLASTICS ASSESSMENT IN THE KRKA RIVER ESTUARY SURFACE WATER

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Microplastics (MPs), commonly defined as particles less than 5 mm, are a persistent ubiquitous anthropogenic contaminant that can be found in every environment, making it a global environmental, health and socioeconomic problem. Due to their high surface area, MPs adsorb toxic pollutants that become bioavailable to organisms upon ingestion as they are often mistaken for food leading to biomagnification. The sampling area represents the lower part of the Krka River Estuary and is under direct anthropogenic influence from city of Šibenik runoff waters, nautical and communal ports, city harbor, tourism, mariculture, and fishing. Estuaries and harbors have been recognized as hotspots and transfer pathways for MPs primarily because of the vicinity of urban environment that emits contaminants from various sources. The main focus of this research was to determine MPs size, shape, color, surface area and abundance in surface water using volume-reduced samples collected by Manta trawls. Laboratory protocol included sieving, wet peroxidation (H_2O_2), density separation (saturated NaCl solution), sonication and filtration. Filter papers were then visually inspected for MPs and stained with Nile Red (NR) fluorescent dye. Image processing and measurements were carried out with ImageJ open-source software.

Keywords: Microplastics (MPs), Krka River Estuary, surface water, Nile Red (NR), ImageJ

ADVANCED SURFACE AND GROUNDWATER SALINITY MONITORING

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Due to climate change and the global trends of sea level rise, seawater intrusion into coastal aquifers is leading to an increasing risk of soil and water salinization in coastal river deltas. Although the problem of seawater intrusion and salinization of surface and groundwater occurs in all of the Croatian coastal areas, these processes are most evident in the intensively hydromeliorated and cultivated areas of Neretva River delta which is considered one of the most vulnerable areas to climate change in Croatia. In such environments, monitoring systems are necessary for quality and timely decision making. With the project DELTASAL, an automatic advanced water monitoring system was established at two locations in the Neretva River delta. Automatic multiparameter probes for monitoring physicochemical parameters such as water temperature, water depth, pH, oxidation-reduction potential, electrical conductivity, salinity, total dissolved solids, seawater specific gravity, resistivity and dissolved oxygen were installed in drainage canals for surface and shallow piezometers for groundwater monitoring. The multiparameter probes are connected to a GPRS modem that collects and transmits data at hourly resolution. The collected data are automatically sent and stored in a newly developed database. The data were compared and validated with laboratory data from long-term monitoring of water salinity at the same locations. This paper presents the results of a one-year period (March 2021 to March 2022) of surface and groundwater quality monitoring under the established advanced monitoring system.

Keywords: water monitoring, water salinity, multiparameter probe, climate change

ECOLOGICAL SUSTAINABILITY OF KARST SPRINGS IN BOSNIA AND HERZEGOVINA

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Bosnia and Herzegovina have very specific geomorphological and hydrological features, which result in numerous and diverse karst spring habitats. These habitats are characterized by physico-chemical stability, low water temperatures with small annual fluctuations, high oxygen and carbon dioxide concentrations, and generally oligotrophic conditions, which makes them extremely valuable ecosystems in terms of biodiversity. From an economic and hydrological point of view, springs are generally perceived as sources of clean drinking water, resulting in most springs being captured for water supply, and the effects of environmental changes caused by human activity are visible in many Dinaric karst springs. Due to their isolation and fragmentation and obvious anthropogenic impact, spring habitats are considered particularly vulnerable to climate change. According to forecasts, these ecosystems will be exposed to multiple pressures caused by changes in water regime, rising water temperatures and a continuous decline in quality care. At the same time, unlike many other aquatic habitats, springs are not included in the standard assessment tools developed by the European Water Framework Directive (WFD). Although, a large number of assessment methods developed for springs have emerged since the 1990s, all existing assessment procedures apply to the mid-European region, while for the Dinaric region appropriate assessment procedures for spring habitats have not yet been developed. The aim of this paper is to show the specific biodiversity and ecological characteristics of karst springs in Bosnia and Herzegovina, their ecological status and sensitivity to the effects of anthropogenic and climate changes and the possibilities of sustainable management of these valuable resources.

Keywords: springs ecosystems, ecological status, the Water Framework Directive, climate change, sustainable management

PRIKAZ VRIJEDNOSTI NUTRIJENATA UKUPNOG FOSFORA I NITRATA KAO POKAZATELJA EKOLOŠKOG STANJA POVRŠINSKIH VODA KOPAČKOG RITA U SKLOPU PROJEKTA NATURAVITA ZA PERIOD OD SRPNJA 2020. DO LIPNJA 2021. GODINE

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Obogaćivanje površinske vode hranjivim tvarima uzrokuje intenzivan rast algi i viših oblika biljnog života što dovodi do neravnoteže u ekosustavu i narušavanja kvalitete same vode. Povećane koncentracije nutrijenata (ukupni fosfor, nitrati) dovode do brze asimilacije anorganske u organsku tvar u procesu fotosinteze, što rezultira porastom brojnosti i biomase algi (cvjetanje algi) te povećanjem ukupne produkcije i koncentracije organske tvari vodenih ekosustava. Sukladno Projektnom zadatku u sklopu projekta Naturavita izvršen je monitoring ekološkog stanja površinskih voda na 19 lokacija u razdoblju od srpnja 2020. do kraja lipnja 2021. godine u Parku prirode Kopački rit. Ocjena ekološkog stanja tijela površinske vode u odnosu na osnovne fizikalno-kemijske i kemijske elemente, definirana je prema graničnim vrijednostima 50-og percentila, a sukladno Uredbi o standardu kakvoće voda (NN 96/2019). Vrijednosti 50-og percentila za pokazatelj ukupni fosfor kretale su se od 0,02 do 0,10 mg P/l, a za nitrate od 0,11 do 1,35 mg N/l. Od 19 lokacija temeljem 50-og percentila 17 lokacija je ocjenjeno vrlo dobrim i 2 lokacije dobrim ekološkim stanjem promatrajući parametar nitrati. Promatrajući kretanje vrijednosti za ukupni fosfor 14 lokacija je u vrlo dobrom i 5 lokacija u dobrom ekološkom stanju.

Ključne riječi: Kopački rit, površinske vode, ukupni fosfor, nitrati

PRESENTATION OF TOTAL PHOSPHORUS AND NITRATE VALUES AS INDICATORS OF ECOLOGICAL CONDITION OF SURFACE WATERS IN KOPAČKI RIT WITHIN THE NATURAVITA PROJECT FOR THE PERIOD FROM JULY 2020 TO JUNE 2021

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Enrichment of surface water with nutrients causes intensive algal growth and higher plants growth, which leads to imbalances in the ecosystem and Water Quality Impairment. Increased concentrations of nutrients (total phosphorus, nitrates) lead to rapid assimilation of inorganic into organic matter in the process of photosynthesis, resulting in increased algal biomass (algal blooms) and increased total production and concentration of organic matter in aquatic ecosystems. In accordance with the aims of the Naturavita project, the ecological status of surface waters was monitored at 19 locations in the period from July 2020 to the end of June 2021 in the Kopački Rit nature park. Regarding its basic physico – chemical and chemical parameters, the assessment of the ecological status of surface water bodies is defined according to the limit values of the 50th percentile, and in accordance with the Decree on the water quality standard (OG 96/2019). The values of the 50th percentile for the total phosphorus ranged from 0.02 to 0.10 mg P/l, and for nitrates from 0.11 to 1.35 mg N/l. Out of 19 locations based on the 50th percentile, 17 locations were rated as very good and 2 locations as good ecological status according to nitrates and according to values for total phosphorus, 14 locations are in very good and 5 locations are in good ecological condition.

Keywords: Kopački Rit, surface water, total phosphorus, nitrates

DETERMINATION OF THE INFLOW AREA OF THE WELLFIELD VINOKOVŠČAK BY USING NUMERICAL METHODS

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Groundwater resources are the most important sources of drinking water for human needs, so their protection is recognized as one of the global priorities. Because wellfields are particularly vulnerable due to the impact on groundwater flow, more attention is paid to the protection of their inflow areas, which is crucial for quality water supply. For this work, the research area is determined, which includes the wider area of the Vinokovščak wellfield located northwest of the city of Varaždin in Croatia. Based on the previously developed groundwater flow model of the Varaždin aquifer, a model that covers the defined area of the Vinokovščak wellfield is developed. The inflow area of the observed wellfield in working conditions is determined based on the flow model. The results of the research show that the water protection zones of the sanitary protection are marked by applicable regulations, however, to further preserve the groundwater quality at the observed wellfield, it is recommended to additionally protect the wider catchment area. The developed groundwater flow model presents the starting point for further research to locate and quantify sources of pollution that affect the groundwater quality of the observed wellfield.

Keywords: groundwater, wellfield, protection, quality, numerical model

PROCJENA KVALITETE VODE ZA LJUDSKU POTROŠNJU POMOĆU INDEKSA KVALITETE

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Zdravstveno ispravna voda za ljudsku potrošnju presudan je čimbenik za očuvanje ljudskog zdravlja. Praćenje (monitoring) zdravstvene ispravnosti vode za ljudsku potrošnju vode u Republici Hrvatskoj (RH) provodi se sukladno zahtjevima EU Direktive o vodi za ljudsku potrošnju i nacionalnih propisa. Na godišnjoj razini uzorkuje se oko 8000 uzoraka vode čija se ocjena sukladnosti radi uspoređujući dobivene vrijednosti s propisanim maksimalno dozvoljenim koncentracijama. Kako bi se kvaliteta vode učinkovito i pojednostavljeno izrazila, koriste se indeksi kvalitete vode koji su dugi niz godina u upotrebi za ocjenu stanja voda u prirodi, dok s druge strane postoji vrlo malo indeksa kvalitete za vodu za ljudsku potrošnju (*engl. Drinking Water Quality Index, DWQI*). Indeksi kvalitete vode modificiraju i objedinjuju različite parametre koji opisuju kvalitetu vode u bezdimenzijski broj. Koraci i metode koji se koriste za razvoj indeksa kvalitete vode za ljudsku potrošnju slični su onima za vode u prirodi, a glavne razlike odnose se na izbor vrste parametra kvalitete vode, pri čemu se ovdje veći značaj daje parametrima s većim zdravstvenim značajem. Cilj ovog rada je iz rezultata monitoringa odrediti indeks kvalitete vode za ljudsku potrošnju u RH po zonama opskrbe koji se može primijeniti kao alat za razumijevanje prostorno-vremenske varijabilnosti kvalitete vode za ljudsku potrošnju, za komunikaciju sa stanovnicima te za podršku kod donošenja odluka vezanih uz upravljanje vodom za ljudsku potrošnju.

Ključne riječi: voda za ljudsku potrošnju, monitoring, indeks kvalitete vode za piće

ASSESSMENT OF WATER FOR HUMAN CONSUMPTION USING WATER QUALITY INDEKS

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Safe drinking water is a crucial factor in maintaining human health. Monitoring of water for human consumption in the Republic of Croatia is carried out in accordance with the requirements of the EU Drinking Water Directive and national regulations. About 8000 water samples are collected annually, the conformity assessment of which is done by comparing the obtained values with the prescribed maximum allowable concentrations. In order to express water quality efficiently and in a simplified way, water quality indices have been used for many years to assess the state of water in nature, whereas there are very few drinking water quality indices (DWQI). Water quality indices modify and pool together various parameters that describe water quality into a dimensionless number. The steps and methods used to develop the water quality index for drinking water are similar to those for water in nature, and the main differences relate to the choice of the type of water quality parameter, with greater importance given to parameters with greater health significance. The aim of this paper is to determine the quality index of water for human consumption in the Republic of Croatia according to water supply zones, which can be an applicable tool for understanding the spatial and temporal variability of water quality for human consumption, communication with residents, and support in decision making regarding drinking water management.

Keywords: water for human consumption, monitoring, drinking water quality index

PRISUSTVO *Salmonella* U MORU ZA KUPANJE NA UŽEM PODRUČJU GRADA RIJEKE

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Redovito praćenje kakvoće mora za kupanje uključuje ispitivanje dva rutinska pokazatelja fekalnog onečišćenja: *Escherichia coli* (EC) i crijevni enterokoki (ENT). Kategorija kakvoće vode za kupanje vode (izvrsna, dobra, zadovoljavajuća, nezadovoljavajuća) procjenjuje se temeljem koncentracije pokazarelja u ispitanom uzorku morske. Ispitivanje patogena nije dio rutinskog praćenja, uglavnom zbog složenih i dugotrajnih postupaka određivanja. *Salmonella*, pripadnik obitelji *Enterobacteriaceae*, jedan je od raširenijih patogena. Kod čovjeka može uzrokovati gastroenteritis, crijevnu groznicu i sepsu. Cilj ovog rada bio je procijeniti prisustvo *Salmonella* u moru za kupanje te utvrditi povezanost s rutinskim pokazateljima. Istraživanje je provedeno na 4 plaže (ukupno 12 lokacija) na području grada Rijeke u sezoni kupanja 2021. kao dio EUROBATH-a, istraživačkog projekta HRZZ. *Salmonella* je određivana metodom HRN EN ISO 19250. Uzorkovanje na plažama obavljano je u prijepodnevnim i poslijepodnevnim satima, što je omogućilo praćenje utjecaja sunčevog zračenja na prisustvo ove bakterije. Od ispitana 302 uzorka mora, *Sallmonella* je dokazana u 11 (3,6%), od čega je njih 7 (2,3%) prema EU Direktivi (2006/7/EC) zadovoljavalo kriterije za kupanje za EC i ENT. Sedam *Salmonella*-pozitivnih uzoraka uzeto je u prijepodnevnim satima a četiri u poslijepodnevnim. Prema dobivenim rezultatima, praćenje samo rutinskih pokazatelja, EC i ENT ne isključuje mogućnost kontakta kupača sa bakterijama roda *Salmonella*.

Ključne riječi: kakvoća mora za kupanje, *Escherichia coli*, enterokoki, patogeni, *Salmonella*

THE PRESENCE OF *Salmonella* IN THE COASTAL BATHING WATER IN THE INNER CITY AREA OF RIJEKA MUNICIPALITY

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Routine seawater quality monitoring includes testing for two indicators of faecal contamination: *Escherichia coli* (EC) and intestinal enterococci (ENT). The bathing water quality category (excellent, good, satisfactory, unsatisfactory) depends on their concentration in the tested seawater sample. Testing for pathogens is not part of routine monitoring, mainly because of the difficult and time-consuming analytical procedure. *Salmonella*, a member of the *Enterobacteriaceae* family, is one of the most common pathogens and can cause gastroenteritis, typhoid fever, and sepsis in humans. The aim of this study was to evaluate the presence of *Salmonella* in bathing waters and determine its association with EC and ENT. The study was conducted during the 2021 bathing season as part of EUROBATH, a research project of the Croatian Science Foundation, at 4 beaches (12 sites in total) near the the city of Rijeka. *Salmonella* was tested according to the method HRN EN ISO 19250. Sampling on the beaches was carried out not only in the morning, but also in the afternoon, in order to observe the influence of the sun on the occurrence of this bacterium. Of the 302 seawater samples tested, *Salmonella* was detected in 11 (3.6%), of which 7 (2.3%) met the bathing criteria for EC & ENT according to the EU Directive (2006/7 / EC). Seven *Salmonella* positive samples were collected in the morning and 4 in the afternoon. According to the results obtained, the examination of only the faecal indicators EC & ENT does not exclude the possibility of contact of bathers with bacteria of the genus *Salmonella*.

Keywords: coastal bathing water quality, *Escherichia coli*, enterococci, pathogens, *Salmonella*

Vodooskrbni sustavi i odvodnja / *Water Supply and Sewage Systems*

UTJECAJ VODNOG GUBITKA NA VRIJEDNOSTI SLOBODNOG REZIDUALNOG KLORA U VODOOPSKRBNOM SUSTAVU

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Kloriranje je standardna procedura dezinfekcije vode u vodoopskrbnim sustavima na područje Republike Hrvatske pri čemu se najčešće primjenjuje klor i njegovi derivati. Potreba za klorom u vodoopskrbnom sustavu može se izraziti kao količina klora (mg/L) koju je potrebno dodati do pojave slobodnog rezidualnog klora (SRK). SRK predstavlja količinu klora (višak) koji će zaostati u vodi nakon dezinfekcije. SRK je i dokaz uspješne dezinfekcije. Aktualna problematika vodnih gubitaka ili curenja vode u cjevovodima vodoopskrbnih sustava, postavlja pitanje utjecaja istih na stanje SRK. Povećani protoci u cjevovodima, uzrokovani povećanjem nekontroliranog curenja vode, posljedično smanjuju vrijeme zadržavanja vode u cjevovodima te samim time omogućuju svježi dotok dezinfekcijskog sredstva. Ovim istraživanjem praćeni su vodni gubitci te vrijednosti SRK. Za očekivati je da će se u područjima većih vodnih gubitaka pokazati i veće vrijednosti SRK dok se u područjima manjih vodnih gubitaka očekuju smanjenje vrijednosti SRK uslijed duljeg zadržavanja vode u mreži. S obzirom da na stanje SRK utječu i drugi čimbenici, ovim radom će se pokazati ima li mjerljivog utjecaja vodnog gubitka na stanje SRK i može li se taj utjecaj praktično primijeniti u svrhu definiranja utroška dezinfekcijskog sredstva te pod kojim kriterijima i uvjetima. Analiza će se provesti korištenjem regresijskog modela putem kojeg će se definirati koeficijent determinacije te interpretirati Chadockovom ljestvicom veze.

Ključne riječi: slobodni rezidualni klor, vodni gubitak, regresijski model

INFLUENCE OF WATER LOSS ON THE VALUE OF RESIDUAL FREE CHLORINE IN THE WATER SUPPLY SYSTEM

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Chlorination is the standard procedure for water disinfection in the water supply systems of the Republic of Croatia. The need for chlorine in a water supply system can be expressed as the amount of chlorine (mg/L) that must be added until the occurrence of residual free chlorine (RFC). RFC represents the amount of chlorine (excess) that will remain in the water after disinfection, and it is this residual amount of chlorine that proves the success of disinfection. The current issue of water losses or water leaks in the pipelines of water supply systems raises the question of their impact on the state of RFC. Increased flows in the pipelines, caused by the uncontrolled water leakage, consequently, reduce the retention time of water in the pipelines and thus allow a fresh inflow of disinfectant. This research analyses water losses and values of RFC since it has been noticed that higher water losses are in relation to higher values of RFC. Given that the state of RFC is influenced by other factors, this paper will show whether there is a measurable impact of water loss on the state of RFC and whether this impact can be applied in practice to define the dose of disinfectant.The analysis will be performed using a regression model through which the coefficient of determination will be defined and interpreted using the Chadock scale.

Keywords: residual free chlorine, water loss, regression model

Močvarna staništa / *Wetlands*

NATURE-BASED SOLUTIONS FOR INTEGRATED LOCAL WATER MANAGEMENT

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Nature-based solutions (NBS) imitate natural processes and serve to generate multi-benefit value and services to the local communities. Sustainable solutions are multi-purpose measures implemented at the site and offer communities:

- decentralized systems for wastewater and sludge treatment,
- water retention under the climate adaptation needs,
- buffer systems that protect water from runoff from agricultural land and infrastructure,
- sustainable urban drainage systems.

Presentation would share good cases and further opportunities in combining NBS for environmental pollution mitigation and prevention. They can be implemented and managed locally and are stimulated as zero emission and climate resilient technology. Main areas of intervention, where NBS are best applied are:

- Mitigating agricultural run-off by constructed ecosystems to protect nutrient release into surface waters,
- Revitalisation of standing water bodies (local ponds, lakes and water accumulations) by floating treatment islands, constructed wetlands etc,
- Stormwater retention measures that mitigate storm surpluses and enable water reuse,
- Constructed wetlands for wastewater and leachate treatment (incl. zero discharge solutions).

A presentation would include the results of a new report by Global water partnership Sanitation Task force on NBS in wastewater treatment (Slovenia and Croatia are included). It gives an overall estimation of the application of several NBS treatment technologies for rural sanitation improvement and water reuse potentials.

Keywords: nature-based solutions, wastewater treatment, SUDS, water management

Voda i zdravlje /
Water and Health

PETOGODIŠNJI TREND IZLOŽENOSTI NEKIM KONTAMINANTIMA IZ VODE ZA LJUDSKU POTROŠNJU S PODRUČJA GRADA ZAGREBA

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Na području grada Zagreba godinama se provodi opsežni monitoring vode za ljudsku potrošnju, kojim je obuhvaćeno nekoliko desetaka različitih kemijskih, bioloških i fizikalnih parametara, mjesto uzorkovanja te vremenski uvjeti tijekom uzorkovanja. S obzirom na značajan svakodnevni unos vode u naš organizam, mogućnost unosa određenih kontaminanta vodom ima svoju značajnu ulogu. To se osobito odnosi na nitrate, za koje je utvrđeno da je voda kao njihov izvor, na drugom mjestu po značajnosti. U ovom radu želimo prikazati petogodišnji trend, za razdoblje 2016. – 2020. godine, za prisutnost slijedećih kontaminanata: aluminija, kadmija, klorata i klorita, nitrata te žive u vodi koja se može konzumirati na području grada Zagreba. Rezultati ukazuju na stabilne prosječne godišnje vrijednosti praćenih kontaminanata, osim za aluminj i klorate, za koje je utvrđeno da se vrijednosti godišnjih prosjeka razlikuju i po nekoliko puta. Međutim, i u slučajevima viših vrijednosti, njihov doprinos unosu iz vode za ljudsku potrošnju ne predstavlja rizik za zdravlje konzumenata, niti značajnije doprinosi njihovom ukupnom unosu. Ipak s obzirom na pretpostavku da se radi o specifičnoj izloženosti, za koju je konzument vezan mjestom stanovanja, važno je stalno pratiti trendove, kako bi se svaka izloženost svela na najmanju moguću mjeru.

Ključne riječi: voda za ljudsku potrošnju, kontaminanti, izloženost

Ovaj rad je nastao uz pomoć Gradskog ureda za socijalnu zaštitu, zdravstvo, branitelje i osobe s invaliditetom Grada Zagreba, koji je dao suglasnost za korištenje podataka prikupljenih na temelju monitoringa vode na području Grada Zagreba

EXPOSURE TO SOME CONTAMINANTS FROM DRINKING WATER IN ZAGREB CITY AREA - A FIVE YEARS TREND

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In the Zagreb city area extensive monitoring of drinking water has been carried out for years, which includes several dozen different chemical, biological and physical parameters, the place of sampling and remarks on weather conditions. Given the significant daily water intake in our body, the possibility of ingesting certain contaminants via water has a significant role. This especially applies on nitrates, which are on the second place of importance, since it has been found that the water are their source. This paper presents a five-year trend, for the period 2016-2020, for the presence of the following contaminants: aluminum, cadmium, chlorate and chlorite, nitrate and mercury in water that can be consumed via water in the city of Zagreb. The results indicate stable average annual values of monitored contaminants, except for aluminum and chlorates, for which it was found that the values of annual averages differ several times. However, even in cases of higher values, their contribution to water intake does not pose a risk to the health of consumers, nor does it significantly contribute to their overall intake. Still, given the assumption that this is a specific exposure, to which the consumer is tied to the place of residence, it is important to constantly monitor trends, so that each exposure is kept to a minimum.

Keywords: drinking water, contaminants, exposure

This work was done with the help of the City Office for Social Protection, Health, Veterans and Persons with Disabilities of the City of Zagreb, which gave their consent for using the data collected on the basis of water monitoring in the City of Zagreb.

VODA-HRANA-ENERGIJA-ZDRAVLJE: VAŽNOST EKOLOŠKE ODRŽIVOSTI U KRUŽNOM GOSPODARSTVU

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Voda, hrana i energija neophodni su za dobrobit ljudi, smanjenje siromaštva i održivi razvoj. Potreba za pitkom vodom, energijom i hranom značajno će porasti zbog porasta broja stanovnika, urbanizacije, mobilnosti stanovništva, gospodarskog razvoja, međunarodne trgovine te kulturnih, tehnoloških i klimatskih promjena. Zbog navedenog je nužno usredotočiti se na postizanje pravičnog pristupa vodi, hrani i energiji, uz pridržavanje principa kružne ekonomije. Svjetska grupacija banaka procjenjuje da će se poljoprivredna proizvodnja morati povećati za približno 70 % do 2050. godine. Voda se koristi za poljoprivrednu proizvodnju, šumarstvo i ribarstvo, duž cijelog poljoprivredno-prehrambenog lanca opskrbe, te za proizvodnju ili transport energije u različitim oblicima. Istodobno, proizvodnja i opskrbni lanac hrane troše oko 30 % ukupne energije koja se troši na globalnoj razini. Energija je potrebna za proizvodnju, transport i distribuciju hrane te za ekstrakciju, pumpanje, podizanje, sakupljanje, transport i obradu vode. Gradovi, industrija i drugi korisnici također traže sve više vodnih, energetskih i zemljišnih resursa, a istovremeno se suočavaju s problemima degradacije okoliša, što u nekim slučajevima dovodi do oskudice resursa i lošeg utjecaja na zdravlje živog svijeta.

Ključne riječi: hrana, kružna ekonomija, poljoprivreda, zdravlje

WATER-FOOD-ENERGY-HEALTH: IMPORTANCE OF ECOLOGICAL SUSTAINABILITY IN THE CIRCULAR ECONOMY

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Water, food, and energy are essential for human well-being, poverty reduction and sustainable development. The need for drinking water, energy and food will increase significantly due to population growth, urbanization, population mobility, economic development, international trade and cultural, technological and climate change. Therefore, it is necessary to focus on achieving equitable access to water, food, and energy, while adhering to the principles of the circular economy. The World Bank Group estimates that agricultural production will need to increase by approximately 70% by 2050. Water is used for agricultural production, forestry, and fisheries, along the entire agri-food supply chain, and for the production or transport of energy in various forms. At the same time, food production and supply chain consume about 30% of the total energy consumed globally. Energy is needed for the production, transport, and distribution of food and for the extraction, pumping, lifting, collection, transport, and treatment of water. Cities, industry, and other users are also seeking more and more water, energy, and land resources, while at the same time facing environmental degradation problems, which in some cases lead to resource scarcity and adverse effects on wildlife health.

Keywords: food, circular economy, agriculture, health

Posterska priopćenja / Poster presentations

Poljoprivreda i vodni resursi / *Agriculture and Water Resources*

PROMJENA RAZINA PODZEMNIH VODA U UVJETIMA KLIMATSKIH PROMJENA

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Posljednjih godina klimatske promjene znatno utječu na globalno zatopljenje i iscrpljivanja vodnih resursa uključujući i podzemne vode. Kao posljedice klimatskih promjena u budućnosti se očekuje još češće pojave toplinskih valova i dugotrajnih sušnih razdoblja što može rezultirati spuštanjem razine podzemnih voda i mijenjanjem uvjeta njihove eksploatacija. U područjima koja se dominantno poljoprivredna to može imate velike posljedice. Kako bi se upoznali s tim problemom, kreiran je model geografskog informacijskog sustava (GIS) koji je u mogućnosti prikazati promjene u razinama podzemnih voda tijekom dužeg niza godina. Analiziran je sliv rijeke Karašice-Vučice uz pomoć 6 mjernih mjesta za razdobolje od 1988. do 2020.godine, raspoređenih na nizinskom dijelu sliva. Za analizu su korišteni srednji mjesečni podatci o razinama podzemne vode. Statističkim proračunom određeni su homogenosti nizova podataka, koeficijenti varijacije i trendovi kretanja podzemnih voda. Ova preliminarna istraživanja ukazuju da nema statistički značajnih negativnih trendova, što znači da podzemne vode ovoga sliva još uvijek nisu jače zahvaćene globalnim utjecajima klimatskih promjena.

Ključne riječi: razina podzemnih voda, klimatske promjene, suša,GIS

GROUNDWATER LEVEL CHANGE IN CLIMATE CHANGE CONDITIONS

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In the last decade climate change has significant impact on global warming and water resources depletion, including groundwater resources. In the future we can expect even more frequent heat waves and droughts of longer duration what can result with decreasing of groundwater levels and changing exploitation conditions. In the area with dominant agricultural activities it can have great consequences. In order to focus this problem, geographic information system (GIS) is created in order to present groundwater level changes over longer time period. Study area is the Karašica-Vučica rivers catchment area. In its lowland part of the catchment there are 6 observation wells with data records 33 years long (1988 - 2020). In the analysis we used mean monthly groundwater levels. Statistical calculations consist of data homogeneity tests, trend analysis and variability calculations of groundwater levels. This preliminary research shows that there are no statistically significant negative trends. It means that groundwater resources of this catchment area are still not stronger effected by global climate change processes.

Keywords: groundwater level, climate change, drought, GIS

IRRIGATION TIME – METHODS FOR MEASURING SOIL WATER CONTENT

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Properly determined irrigation time is one of the most important elements in irrigation scheduling on which depends the sustainable management of water resources, preservation and improvement of soil quality and achieving high and stable yields. There are different methods for determine the irrigation time, while the measurement of soil water content is considered to be the most reliable and accurate method. The accuracy of the measured data will depend on several factors such as: soil type, setting method (depth and position), sensor preparation and ultimately the interpretation of the sensors readings. Regardless of the fact that some sensor manufacturers state that the sensor does not need to be calibrated, experience from field has shown that the sensor data or measurements are most accurate if the sensor is calibrated for each soil (calibration curve) on which it is used before use. The aim of this manuscript is to present different indirect methods of measuring the soil water content, i.e. soil moisture sensors, and to compare it with the direct method (gravimetric method) which also serves for the calibration of soil moisture sensors, and to present the importance of the results obtained in the context of irrigation scheduling.

Keywords: soil water content, soil moisture sensors, setup, calibration

AMENDMENT OF METAL-CONTAMINATED SOIL BY BIOCHAR IMPACTS METALS RELEASE FROM THE SOIL MATRIX & CHEMICAL SPECIATION MODELLING IN PERCOLATES

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Metal contaminated soils (MCS) pose a serious constraint to food production and human and environmental health. A controlled pot experiment was conducted with the different biochar types (derived from municipal sewage sludge – SL, wood chips – WC, and horse manure - HM) and their rates (1% and 4% w/w) to examine: i) release of metals from the MCS matrix (collected near a former Pb-Zn mine and Pb smelter plant near Zerjav, Slovenia) and ii) their chemical speciation in the water leachate 175 days after the incubation period. The highest Cd (0.07 mg/L) and Zn (0.95 mg/L) concentrations in percolates, followed by the lowest pH (6.52) were found in Control treatment (MSC without biochar addition). In addition, the highest Cu (0.17 mg/L) and Pb (0.45 mg/L), but the lowest Cd (0.04 mg/L) and Zn (0.63 mg/L) concentrations, followed by the highest pH (6.72), were found in WC treatment with 4%. Chemical speciation calculations performed in Visual Minteq software using the NICA-Donnan model indicated that Cu and Pb were present in all percolates as organo-complexes with dissolved organic carbon fractions. However, within the chemical pool of Cd and Zn, their free cationic forms (Cd^{2+}, Zn^{2+}) and chloro-complexes were confirmed in addition to organo-complexes. Obtained results suggest that the amelioration of MCS with a particular biochar type could affect the transfer of metals from a contaminated matrix to waters.

Keywords: metal-contaminated soil, biochar, chemical speciation modeling, metal sorption, metal leaching

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

KAKVOĆA OTPADNE VODE AGLOMERACIJE SLAVONSKI BROD – KIŠNI I SUŠNI PERIOD

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C-Tech tehnologija (engl. *Cyclic activated sludge technology*) – ciklička tehnologija aktivnog mulja primjenjuje se na uređaju za pročišćavanje otpadnih voda Slavonski Brod (UPOV SB). UPOV SB pušten je u rad 2014. godine, projektiran je za 80.000 ES i uključuje 3. stupanj obrade – uklanjanje C, N i P. Biološko pročišćavanje otpadne vode zbiva se u četiri SBR reaktora koji obuhvaćaju tri koraka: (i) punjenje/aeracija, (ii) taloženje i (iii) dekantiranje. Svaki SBR reaktor sadrži anoksični biološki selektor i aeracijsku zonu, a omjer volumena anoksična/aerobna zona je 2/25. SBR reaktori imaju mogućnost rada u suhom i mokrom režimu rada a razlikuju se u vremenu trajanja pojedinih ciklusa/koraka ciklusa i u ukupnom vremenu trajanja ciklus. Na UPOV SB uobičajeni je suhi režim rada, ukoliko je dotok otpadne vode > 21.000m³/d rad SBR reaktora prevodi se automatski na mokri režim rada. Otpadna voda koja dospijeva na UPOV SB je znatnim udjelom mješovitog tipa kanalizacije. Onečišćenje čine organski sastojci izraženi kao KPK i BPK_5, ukupne suspendirane krutine - TSS i anorganski sastojci (N i P). Oborinska otpadna voda ima utjecaj na omjer KPK/N otpadne vode i na biološko uklanjanje nutrijenata.

Ključne riječi: C-Tech tehnologija, otpadna voda grada, oborinska otpadna voda, suhi i mokri režim rada, omjer KPK/N, uklanjanje nutrijenata

WASTEWATER QUALITY OF SLAVONSKI BROD AGGLOMERATION - RAIN AND DRY PERIOD

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C-Tech technology (Cyclic activated sludge technology) is being applied to the wastewater treatment plant in Slavonski Brod (WWTP SB). WWTP SB was put into operation in 2014 and is designed for 80,000 PE and it includes the 3rd stage of processing - removal of C, N and P. Biological wastewater treatment takes place in four SBR reactors comprising three steps: (i) filling / aeration, (ii) sedimentation and (iii) decantation. Each SBR reactor contains an anoxic biological selector and an aeration zone, and the anoxic/aerobic zone volume ratio is 2/25. SBR reactors have the ability to operate in dry and wet mode and differ in the duration of individual cycles / cycle steps and the total cycle time. Dry mode is common at UPOV SB, if the wastewater inflow is > 21,000 m³/d, the operation of the SBR reactor is automatically switched to wet mode. The wastewater that reaches UPOV SB is a significant share of the mixed type of sewage. Pollution consists of organic constituents expressed as COD and BOD_5, total suspended solids - TSS and inorganic nutrients (N and P). Rain wastewater has an impact on the COD / N ratio of wastewater, and thus on the biological removal of nutrients.

Keywords: C-Tech technology, domestic wastewater, rain wastewater, dry and wet operation mode, COD/N ratio, nutrient removal

EFFECT OF SELECTED PARAMETERS ON NICKEL REMOVAL BY CHELATING ION EXCHANGE RESINS

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Nickel is toxic and carcinogenic at low concentrations and therefore should be removed from drinking water below the recommended limit of 20 μg/l. Conventional strongly and weakly acidic ion exchange resins can be effective for nickel removal from water. However, they are usually characterized with low selectivity. In contrast, chelating ion exchange resins adsorb nickel ions via ionic and coordinating interactions and therefore have a higher selectivity than traditional resins. The aim of this study was to investigate the influence of parameters, such as initial nickel concentration (0.05-1 mg/l), contact time (0.5-24 h) and resin dose (0.05-1 g), on the nickel removal by chelating resins with an iminodiacetate functional group (Lewatit® MonoPlus TP 207, Purolite® S-930E, and READ-HM). Laboratory experiments were conducted in batch systems using a standard JAR test According to the obtained results it was observed that 6h was sufficient, in all examined cases, to reach the adsorption equilibrium. Removal efficiency was influenced by resin dose up to 0.3 g (23-99%, depending on the applied resin). On the other hand, the removal efficiency of Ni for three investigated resins ranged from 10 up to 96%, and was negatively affected by increase in initial metal concentration.

Keywords: nickel, ion exchange, chelating resins, aqueous solutions

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FLUORIDE ADSORPTION FROM WATER ON WASTE MATERIALS

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The occurrence and concentrations of fluoride in surface and groundwater depend on pH, total dissolved solids, alkalinity, hardness and geochemical composition of aquifers, but in many countries around the world elevated fluoride concentration values are the result of fluoride-contaminated wastewater discharges. Because of fluoride pollution and the health problems that it causes, the World Health Organization (WHO) has set a maximum permissible fluoride content in drinking water of 1.5 mg/L. There are different ways of removing elevated concentrations of fluoride from water, such as coagulation and precipitation, membrane processes, electrochemical treatments, ion-exchange and its modification, but the adsorption process is generally accepted as the cheapest and most effective method for removing fluoride from water. Organic waste is increasing every day, especially in developed countries, and is generated in both industries and households. One of the ways to reduce such waste is the production of adsorbents for water defluorization. Adsorbents, most often prepared as activated carbon, can be obtained from various materials such as egg shell, fruit and vegetable peel, various leaves, stems, trunk bark, grain shells, legume shells and many others. The aim of this paper is to provide an overview of the latest research on the use of adsorbents obtained from organic waste materials in order to remove elevated concentrations of fluoride from water.

Keywords: fluoride, water, adsorption, waste materials, fluoride removal

OPTIMIZATION OF LABORATORY TREATMENTS IN DRINKING WATER PRODUCTION

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Optimization of the water treatment process is a major challenge given the large number of parameters that influence water quality and the stages of the raw water treatment process. In this work, the influence of three input parameters (pre-ozonation dose, time and main ozonation dose) on five outputs (bromates, dissolved manganese, specific ultraviolet absorption, trihalomethanes and haloacetic acids) was studied. The effect of ozone in different combinations of process conditions was investigated by 17 experiments using a Box-Behnken design of experiment, reducing the complexity and financial cost of the research compared to classical research. In addition, the response surface methodology was used to obtain predictive models for all output variables and to obtain graphical representations of the prediction of bromate formation, considering the input parameters with their optimal values and to achieve desired output values.

Keywords: bromate, process optimization

BIOSORPTION OF Zn (II) IONS FROM AQUEOUS SOLUTION USING PINE CONES

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Biosorption methods can be an alternative to the common industrial method of removal of heavy metals due to being environmentally friendly and sustainable for use. In this paper, the biosorption power of pine cones for the removal of Zn (II) ions from aqueous solutions has been studied. Based on the obtained results, the sorption properties of pine cones were determined for 120 minutes, from which it can be concluded that the extent of absorption is influenced by the metal concentration and the biomass concentration. It was found that the optimum pH for Zn (II) ions removal by cone biomass was pH 6.0. At the optimal conditions metal ions biosorption was decreased as the initial metal concentration increased. In the biosorption equilibrium study, the adsorption data were described by using the Freundlich adsorption isotherm. The maximum adsorption capacity q_{max} = 7.389 mg/g was achieved at a metal concentration of 30 mg/L and a biosorbent concentration of 10 g/L.

Keywords: biosorption, zinc removal, pine cones

ADSORPTION POTENTIAL OF SELECTED BIOCHARS FOR CHLORFENVINPHOS REMOVAL

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The work investigates the adsorption mechanism of chlorfenvinphos on biochars originated from *Miscanthus giganteus* (B_MIS) and sugar beet shreds (B_S). Biochars were obtained by slow pyrolysis at 400 ºC. Specific surface areas (SSA) for B_S and B_MIS were 20.6 and 260 m^2/g, respectively. The significant difference between SSAs may be a consequence of the different chemical composition of the used feedstock. The investigation of adsorption kinetics indicates that the adsorption of chlorfenvinphos is well described by the pseudo-second order model with satisfactory correlation coefficients (R^2=0.995-0.997). Thus, it can be concluded that the main mechanism of the adsorption process is hemisorption. The adsorption capacities (q_e) obtained from the experimental data are in line with the theoretical q_e values for pseudo-second order model. Adsorption isotherms for both materials were well described by the Freundlich model. The nonlinearity of the isotherms ranged from 0.544 to 0.647. Higher adsorption affinity was observed for chlorfenvinphos on B_S. Positive correlation was found between the obtained partition coefficients (K_d) and pore diameter of the adsorbents, indicating that chlorfenvinphos is adsorbed into the pores of the biochars. Therefore, the use of biochars as adsorbents can be a promising remediation technique for contaminated water.

Keywords: biochar, chlorfenvinphos, adsorption, Freundlich model, pseudo-second order model

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REMOVAL OF NICKEL FROM WATER USING "GREEN" SYNTHESIZED NULAVALENT IRON

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The modern industry for the production and refining of nickel is facing many challenges. The most rigorous challenges are those related to the treatment of wastewater containing nickel ions in impermissible concentrations. Nickel is used in lithium-ion batteries, in the manufacture of conductors and superconductors, as surface protection of metals, in many other metallurgical processes, but also in household detergents, and in street and hospital waste. Dynamic use has brought nickel to the list of priority pollutants. Plant extracts are increasingly being used in the synthesis of nano-zero valence iron (nZVI) because they are an environmentally friendly material, as well as economically acceptable. In this paper, the removal of Ni(II) on nZVI from the synthetic aqueous matrix was investigated. A *definitive screening design* (DSD) mathematical model was used to design and optimize the experiment. In order to achieve the highest degree of Ni(II) removal, the influence of process parameters: Ni(II) concentration, nZVI dose and pH value on the efficiency of Ni(II) removal at nZVI were simultaneously examined. Process optimization has suggested Ni(II) removal efficiency of ≈ 99%. This work has several benefits, of which the number of experiments and high efficiency of Ni(II) removal is certainly minimized.

Keywords: definitive screening design, nickel, nZVI, adsorption

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PROČIŠĆAVANJE OTPADNIH VODA NISKO OPTEREĆENIM BIOLOŠKIM POSTUPKOM – UPOV SUHOPOLJE

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Otpadne vode dio su hidrološkog ciklusa stoga je, u cilju što manjeg utjecaja čovjeka prirodu, nužno ih kanalizacijskom mrežom prikupiti i odvesti na pročišćavanje te vratiti pročišćene u okoliš. Primjena određene vrste postupka pročišćavanja otpadnih voda uvjetovana je primarno sastavom otpadne vode. U ovom radu prikazano je pročišćavanje komunalne otpadne vode Općine Suhopolje gdje se mješavina komunalne i industrijske otpadne vode pročišćava nisko opterećenim biološkim procesom pročišćavanja uz prethodnu mehaničku obradu. Uređaj je koncipiran na principu recirkulacije aktivnog mulja, kojom se postiže potrebna koncentracija aerobnih bakterija u odnosu na organsko opterećenje u dolaznim otpadnim vodama, a koja se osigurava crpkama za povrat izdvojenog aktivnog mulja u središnjoj sekundarnoj taložnici. Zbog niske opterećenosti bioaeracijskih bazena, odumrle bakterije predstavljaju višak potpuno mineraliziranog sekundarnog mulja, koji se povremeno crpi u zgušnjivač sekundarnog mulja. Navedeni nisko opterećeni aerobni postupak pročišćavanja s istovremenom stabilizacijom mulja, koji se provodi na UPOVU-u Suhopolje, predviđenog je kapaciteta od 9 900 ES. Ispust pročišćene otpadne vode provodi se u obližnji odvodni kanal Međugorje (recipijent) koji je smješten neposredno uz lokaciju UPOVA-a.

Ključne riječi: otpadne vode, pročišćavanje, biološki postupak, UPOV Suhopolje

WASTEWATER TREATMENT USING LOW-LOADED BIOLOGICAL TREATMENT - WWTP SUHOPOLJE

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Wastewater is part of the hydrological cycle, so in order to minimize human impact on nature, it is necessary to collect them through the sewage network and treat them before their discharge into the environment. The application of a certain type of wastewater treatment process is primarily determined by the composition of wastewater. This paper presents the efficiency of the wastewater treatment collected in the Municipality of Suhopolje, where a mixture of municipal and industrial wastewater is treated by low-load biological treatment process with prior mechanical treatment. This WWTP is designed on the principle of the activated sludge recirculation which achieves the required concentration of aerobic bacteria in relation to the organic load in the incoming wastewater, and which is provided by pumps to return the separated activated sludge in the central secondary sedimentation tank. Due to the low load of bioaeration basins, dead bacteria represent an excess of fully mineralized secondary sludge, which is occasionally pumped into the secondary sludge thickener. The mentioned low-load aerobic treatment process with simultaneous stabilization of sludge, which is carried out at WWTP Suhopolje, has a planned capacity of 9,900 ES. Discharged wastewater is discharged into the nearby Medjugorje drainage canal (recipient), which is located next to the WWTP site.

Keywords: wastewater, treatment, biological process, WWTP Suhopolje

MOGUĆNOSTI PRIMJENE LIGNOCELULOZNIH MATERIJALA U PROCESIMA PROČIŠĆAVANJA OTPADNIH VODA

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Nitrati su toksični anioni i uzrokuju ozbiljna oštećenja u okolišu. Prirodno se nalaze u okolišu i čine dio ciklusa kruženja dušika. Koriste se kao gnojiva, rodenticidi i aditivi u hrani. Ima ih u zraku, tlu, vodi, hrani i sintetiziraju se u ljudskom tijelu. Prekomjerna količina može izazvati neželjene posljedice po zdravlje. Vrlo stabilni, topivi ioni, teško uklonjivi konvencionalnim metodama obrade voda. Kao zamijena skupim, konvencionalnim adsorbensima, istražuju se različiti otpadni lignocelulozni materijali iz poljoprivredne, prehrambene i šumarske industrije kao nekonvencionalni adsorbensi za uklanjanje nitrata iz otpadnih voda. ˝Low-cost˝ adsorbensi ne zahtijevaju obradu ili zahtijevaju neznatnu obradu, a nalaze se u prirodi u velikim količinama ili su prisutni kao nusproizvod ili otpad iz industrije dostupni su tijekom cijele godine. Piljevina, ljuska kokosa, šećerna trska, list čaja, ljuska riže, kora banane, ljuska jajeta, ljuska bundeve, ljuska suncokreta i drugi, primjeri su otpadnih materijala poljoprivredne proizvodnje koji se, nakon odgovarajuće modifikacije, koriste kao adsorbensi. Cilj ovog rada je prikazati mogućnosti uklanjanja nitrata iz otpadne vode primjenom lignocelulozni materijala kao adsorbensa.

Ključne riječi: adsorpcija, otpadne vode, nitrati, lignocelulozni materijali

POSSIBILITIES OF APPLICATION OF LIGNOCELLULOSE MATERIALS IN PURIFICATION PROCESSES WASTEWATER

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Nitrates are toxic anions and cause serious damage to the environment. They are naturally found in the environment and form part of the nitrogen cycle. They are used as fertilizers, rodenticides and food additives. They are found in air, soil, water, food and are synthesized in the human body. Excessive amounts can cause adverse health effects. Very stable, soluble ions, difficult to remove by conventional water treatment methods. As a replacement for expensive, conventional adsorbents, various waste lignocellulosic materials from the agricultural, food and forestry industries are being investigated as unconventional adsorbents to remove nitrates from wastewater. Low-cost adsorbents do not require treatment or require minor treatment and are found in nature in large quantities or are present as a by-product or industrial waste are available throughout the year. Sawdust, coconut shell, sugar cane, tea leaf, rice shell, banana peel, eggshell, pumpkin shell, sunflower shell and others are examples of agricultural waste materials which, after appropriate modification, are used as adsorbents. The aim of this paper is to present the possibilities of removing nitrate from wastewater using lignocellulose materials as an adsorbent.

Keywords: adsorption, wastewater, nitrates, lignocellulose materials

A STUDY OF DEGRADATION EFFECTS OF SULFAMETHOXAZOLE BY USING TITANIUM OXIDE NANOTUBES IN WATER

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In this study, Titanium Oxide Nanotubes (TNT) prepared by using titanium folio for photocatalytic applications. TNT's were prepared by using electrochemical anodization. Photocatalytic experiments were carried out by using a stripe led irradiation and investigated with the UV-spectrophotometer. Because of its common usage, Sulfamethoxazole (SMX) was chosen as a micropollutant for photocatalytical experiments. It is aimed to compare the effect of TNT and without photocatalyst sample by using this process for degradation of SMX in water. TNT's was performed 41.64% degradation while without photocatalyst sample showed 4,01% degradation.

Keywords: degradation, Titanium Oxide Nanotubes, Sulfamethoxazole, LED

DEGRADATION OF BISPHENOL A BY USING TIO_2 NANOTUBES

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The target of this research is to investigate degradation of Bisphenol A (BPA) in water by using titanium oxide nanotubes (TNT). TNT's were successfully produced by using Titanium foil (TC4 Grade). The experiments were performed by using control sample and BPA solution with TNT. The samples were kept in dark atmosphere to provide adsorption-desorption equilibrium. Photocatalytic degradation performance tests were carried out with 300 W Osram Ultra-Vitalux E27 (%4.53 UVA, %1 UVB, %94.47 Vis) light source. 10 mg/L BPA solution was used as a micropollutant. Four photocatalyst was placed in the flask in order to provide photocatalytic degradation under UV-LED reactor. In addition, without photocatalyst sample was placed in UV-LED reactor. 265 nm was used for calculation of degradation efficiency of BPA. Absorbance measurements were investigated by using Schimadzu UV-Vis Spectrometer. It is observed that the best BPA degradation was reached with 10 mg/L sample as 50,73% while the lowest BPA degradation was 6,91% with control sample. As a result of, TNT's observed more degradation of BPA in water in comparison with the control sample.

Keywords: ultraviole, titanium nanotubes, Bisphenol A, degradation

GRAPHENE OXIDE: A PROMISING ADSORBENT FOR COPPER REMOVAL FROM WATER

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Industrial wastewaters often contain high concentrations of heavy metals which must be removed before discharge to the environment. Adsorption processes are seen as highly promising solutions to this problem, with much recent work focusing on developing cheap and effective adsorbents. In this work, we investigate the removal of copper from a synthetic matrix using graphene oxide (GO) prepared by modified Hummer's method. The synthesized GO was characterized by FTIR spectroscopy and SEM/EDS and preliminary batch adsorption experiments were carried out. Characterization of the GO confirmed the presence of additional oxygen-containing functional groups as well a porous structure. In the adsorption experiments, an initial Cu concentration of 1 mg/l was investigated. Treating 30 ml of this solution with 5 mg of GO adsorbent resulted in almost 92% Cu removal, a loading of 4.43 mg Cu/g GO. This demonstrates the high potential of GO as an adsorbent for the removal of Cu from the aqueous media. Future research will focus on the removal of other heavy metals, their adsorption mechanisms on GO and the influences of other aquatic constituents that can be found in real water matrices.

Keywords: graphene oxide, copper, water treatment, adsorption

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POSSIBILITIES OF ENVIRONMENTAL ORGANIC POLLUTANTS' DEGRADATION BY SOLAR PHOTOCATALYSIS

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In the frame of on-going EU regulations and amendments to the Water Framework Directive, a full consideration is given to the monitoring and removing of the micropollutants from the aquatic environment. Whereas traditional wastewater treatment plants (WWTPs) are not sufficient in removal of micropollutants, an emerging best available technique - solar photocatalysis is considered as an environmentally and economically feasible upgrading approach. Therefore, a semi-pilot scale flat-plate cascade reactor (FPCR) was developed to study the applicability of photocatalytic degradation of common organic pollutants over titanium dioxide (TiO_2) and nanocomposite of titanium dioxide and carbon nanotubes (TiO_2/CNT) thin-films supported on glass fibers. The FPCR represents the more realistic outdoor system, that can be easily scaled-up and installed at the outlet of WWTPs or in the critical part of a recipient. In this work, photocatalytic degradation of 1H-benzotriazole, imidacloprid, carbamazepine, 17β-estradiol and ibuprofen under simulated sunlight with appropriate UVB and UVA irradiation levels were presented. The experimental results were obtained by using LC/Q-TOF/MS technique. To estimate the pollutant degradation independent on the reactor size and capacity, predictive comprehensive model was applied. The "intrinsic" photocatalytic reaction constants for targeted pollutants, independent of irradiance levels, reactor geometry and hydrodynamics were presented.

Keywords: solar photocatalysis, micropollutants, flat-plate cascade reactor, titanium dioxide, carbon nanotubes

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STABILITY AND DURABILITY OF POWDERED NATURAL COAGULANT (*PHASEOLUS VULGARIS*) – A STEP TOWARDS PRODUCT COMMERCIALISATION

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This work evaluates the stability and durability of powdered bio-based coagulant produced from the been seeds (*Phaseolus vulgaris*) by freeze drying process which showed great turbidity removal efficiencies (between 50.6 and 80.2 %). The other parameters were also examined such as hygroscopicity, water solubility index, dry matter content and moisture content. Previously, dry matter contents of crude extracts were determined, and significantly higher dry matter content (around 46 g/L) in comparison to extracts obtained by distilled water as an extraction agent (around 18 g/L). All types of powdered coagulants showed great stability within several months of storage in controlled and non-controlled conditions. Dry matter content remained high (over 92 g/100 g of sample) indicating low moisture content of dried samples with negligible fluctuations over investigated time (< 2%). Likewise, dry matter content, and water solubility index were higher for extracts prepared with the salt solution as an extraction agent (between 88.02 and 92.67 %) compared to extracts obtained with distilled water (between 62.64 and 78.12 %). Mentioned results also insignificantly varied during the tested period. In terms of hygroscopicity, powdered coagulants achieved maximal saturation after 8 days in an artificially highly moisturized environment, reaching a hygroscopicity value between 7.6 and 8.5 g of water per 100 g of sample. In general, natural coagulants showed promising results in terms of their stability and durability. Furthermore, the type of storage and storage time did not significantly affect powdered coagulants' properties.

Keywords: natural coagulant, lyophilisation, wastewater treatment, commercially valuable products

UKLANJANJE ONEČIŠĆUJUĆIH TVARI IZ VODE BIOSORPCIJOM POMOĆU MIKROBNE BIOMASE

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Prisutnost različitih organskih i anorganskih onečišćujućih tvari u vodi predstavlja jedan od značajnih okolišnih problema današnjice, zbog njihova negativnog utjecaja na floru i faunu vodenih ekosustava. Posredno, uključivanjem u prehrambeni lanac, mogu imati negativan utjecaj i na zdravlje čovjeka. Razvoj novih i unaprjeđenje postojećih metoda za uklanjanje onečišćujućih tvari iz vode predmetom su mnogih istraživanja. Adsorpcija je jedna od metoda koja se intenzivno istražuje i često koristi zbog brojnih prednosti u odnosu na druge metode, poput visoke učinkovitosti, jednostavne provedbe i mogućnosti uklanjanja velikog broja kemijski različitih onečišćujućih tvari. Biosorpcija je podvrsta adsorpcije koja uključuje primjenu materijala biološkog podrijetla, poput žive ili inaktivne mikrobne biomase te lignocelulozni materijala kao adsorbensa, odnosno biosorbensa. Uklanjanje onečišćujućih tvari iz vode korištenjem žive mikrobne biomase osim biosorpcije može uključivati i druge mehanizme poput biorazgradnje i bioakumulacije (nakupljanja tvari unutar mikrobne stanice), pri čemu se najčešće upotrebljava biomasa bakterija, gljiva i mikroalgi. Cilj rada je dati pregled primjene mikrobne biomase navedenih skupina mikroorganizama u obradi otpadnih voda, za uklanjanje različitih onečišćujućih tvari.

Ključne riječi: onečišćujuće tvari, otpadne vode, biosorpcija, mikrobna biomasa

BIOSORPTIVE REMOVAL OF POLLUTANTS FROM WATER USING MICROBIAL BIOMASS

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The presence of various organic and inorganic pollutants in water is one of the major environmental problems of our time due to their negative effects on the flora and fauna of aquatic ecosystems. Indirectly, by entering the food chain, they can also have negative effects on human health. The development of new and the improvement of existing methods for the removal of pollutants from water are the subject of much research. Adsorption is one of the methods that has been intensively researched and widely used due to numerous advantages over other methods, such as high efficiency, ease of implementation, and ability to remove a wide range of chemically diverse pollutants. Biosorption is a subtype of adsorption in which materials of biological origin, such as living or inactive microbial biomass or lignocellulosic materials, are used as adsorbents (i.e., biosorbents). Removal of pollutants from water using live microbial biomass may also involve mechanisms other than biosorption, such as biodegradation and bioaccumulation (accumulation of substances within the microbial cell), with biomass from bacteria, fungi, and microalgae being the most commonly used. The objective of this work is to provide an overview of the application of microbial biomass from these groups of microorganisms in wastewater treatment for the removal of various pollutants.

Keywords: pollutants, wastewater, biosorption, microbial biomass

COMPOST LEACHATE PRETREATMENT USING FILTER PRESS

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The purpose of research was to filter the compost leachate to the extent that it would be suitable for further purification by the reverse osmosis process. The filtration was performed using a filter press. Before filtration also coagulation process was conducted The coagulant we used was the Kemiclar PAC and the flocculant was Magnafloc. Filtration fabrics were chosen. Filtration tests were performed in order to choose proper fabric for filtration of compost leachate. The compost leachate was taken at Kogal Composting Plant, Slovenia. There were huge differences between several compost leachate samples taken at the Plant, therefore it was difficult to determine optimum coagulant dosage. We found that out of all the fabrics we had available, only one was appropriate. It was made of polypropylene (marked as CM388). With other filter cloth the pressure during the filtration increased above 6 bar, which was specified as the highest allowed pressure for device used. The filtration was carried out with several differently treated samples of compost leachate. Chemical and physical parameters, such as turbidity, electrical conductivity, drying residue, ash residue, particle size and zeta potential, were determined. The best results regarding the quality of compost leachate were obtained by treating two different samples of compost leachate, when we managed to reduce turbidity by as much as 89,2 % and 89,8 %, respectively. The particle size distribution analyses showed that most of colloids and suspended solids were removed after the treatment. Chemical and physical parameters did not change much after the treatment. The hypothesis was confirmed that multi-stage treatment would be required to properly treat compost leachate.

Keywords: filter press, filter cloth, compost leachate,coagulation

NON-STATIONARY PARAMETER SENSITIVITY ANALYSIS OF A MODIFIED ACTIVATED SLUDGE MODEL No. 3

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The aim of this study was to perform global parametric sensitivity analysis of the modified Activated Sludge Model No. 3 (mASM3) using Fourier Amplitude Sensitivity Test (FAST). The analysed ASM3 model (Iacopozzi et al., 2007) is a modification of the existing Activated Sludge Model No. 3. Enhancement of the basic ASM3 model involves splitting the nitrification and denitrification process in a two-step process and describing denitrification of both, nitrate and nitrite. In the nitrification process, ammonium and dissolved oxygen act as limiting factors. This model includes 14 mass balances, 16 reaction rates and 40 stoichiometric and kinetic parameters. The FAST method ensures sensitivity to a large and simultaneous change of the complete set of the model parameters. The principle of this method includes transformation of multidimensional space of model parameters to one-dimension space of a single parameter. Since reduction of nitrate and nitrite to dinitrogen involves complex enzymatic transformations, the application of FAST will ensure non-stationary parametric sensitivities of the most important model variables; nitrite (S_{NO2}) and nitrate (S_{NO3}). Results of the FAST analysis have application in identification and optimization of key parameters in enzymatic regulation to improve the model.

Keywords: wastewater treatment, Fourier Amplitude Sensitivity Test (FAST), activated sludge model (ASM3)

ADSORPTION OF DICLOFENAC ONTO ACTIVATED CARBON

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Recently, the presence of pharmaceutical contaminants in water bodies and their potential negative impact on the ecosystem gained much attention. The usage of pharmaceutical compounds by consumers follows an increasing trend, and their incomplete removal during wastewater treatment results in contamination of water surfaces. The methods used to remove DCF from water, among others, include adsorption. Therefore, the adsorption of diclofenac on modified activated carbon produced from hazelnut shells and modified and unmodified Cullar (a commercial product) from water solutions in batch processes was investigated. The adsorbent material was characterised by FTIR and the zeta-potential was measured, as well as the pH_{pzc} was determined. The effect of pH on the adsorption capacity was evaluated in the range of 2-10 and the adsorption mechanism was described by isothermal and kinetic studies. According to obtained data, the maximum adsorption uptake of 48.7 mg/g was achieved with modified Cullar. The isotherm data were in good agreement with both, Freundlich and Langmuir isotherm models. In order to describe adsorption mechanisms, kinetic models were also calculated. Adsorption kinetics followed the pseudo-second-order model closely. Activated carbon from hazelnut shells proved to be an effective adsorbent for diclofenac removal.

Keywords: diclofenac, adsorption, activated carbon, drinking water, wastewater

ANN MODELING OF BIOSORPTION OF Fe(II) IONS FROM AQUEOUS SOLUTION BY RICE HUSKS

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In modern society, the issues of wastewater treatment and water resources management are becoming increasingly actual. Metals are important minerals for many living organisms, but it has been shown that large amounts of heavy metals such as iron can seriously damage the environment as well as human health. On the other hand, agricultural-based processing industries produce a huge amount of agro-industrial by-products every year, such as rice husks. In this investigation, an ANN model of Fe(II) ions' biosorption from an aqueous solution using natural biosorbent-rice husks was developed. The influence of investigated working parameters, time, and pH, on the adsorption capacity of Fe(II) ions by rice husks was studied, during the experimental work: biosorbent mass of 5 g, initial adsorbate concentration of 300 μg/L, room temperature ≈25 °C, and continuous agitation of 400 rpm. The biosorption was performed for the contact time of 10-300 min and pH value of 4-8. Choosing from several available types, a feed-forward back-propagation artificial neural network (ANN) with an optimal structure of 2-10-1 along with the Levenberg-Marquardt training algorithm was applied to obtain the appropriate model for this process. The utilized ANN model generated matrices of output data with a high correlation coefficient R=0.9914.

Keywords: biosorption, Fe(II) ions, rice husks, ANN modeling

A TECHNOLOGY PROJECT ON THE TREATMENT OF WASTEWATER FROM FROM A TIRE VULCANIZATION PLANT

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Technological rubber hose production processes generate wastewaters that contain various polluting components. A smaller amount of waste condensate is created in the rubber hose vulcanization using steam, whereas a larger amount of wastewater comes from rubber hose washing after vulcanization. The mixed wastewaters from the vulcanization and washing processes are mechanically and chemically polluted. They contain large amounts of polluting components, such as COD, BOD, and TSS. The quality of the treated wastewater must satisfy the standard requirements for discharging it into the sewer system. This paper presents the technology designed for a plant to treat wastewater from the production process of rubber hoses. The main process steps are coarse filtration, cooling, homogenization of the mixed wastewater, neutralization, biological treatment, disinfection of the treated wastewater, and sludge drying. After the treatment in the designed plant, the quality of the wastewater meets the legally prescribed standards. Sludge is handed over to a hazardous waste management operator as dangerous waste.

Keywords: technology project, rubber, vulcanization, wastewater treatment, biological reactor

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MIKROBIOLOŠKA ANALIZA MULJA

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Proizvodnja otpadnog mulja iz uređaja za pročišćavanje otpadnih voda u Republici Hrvatskoj u 2020. godini iznosila je 629,37 tona suhe tvari mulja (MINGOR, 2021). Mulj iz otpadnih voda je vrijedan resurs koji sadrži oko 70 % organske tvari čija se nutritivna i energetska vrijednost može iskoristiti u razne svrhe kao npr. u poljoprivredi. Prema EU direktivama 86/278/EEC za mulj, 91/271/EEC za otpadne vode i hrvatskoj legislativi mulj se mora obraditi prije upotrebe kako bi se mogao koristiti kao poboljšivač tla u poljoprivredi. Pravilnikom o nusproizvodima i ukidanju statusa otpada (NN 117/14) propisani su parametri ispitivanja, metode i dopuštene količine mikroorganizama u uzorku mulja koji se može koristiti kao poboljšivač tla. U radu je prikazan postupak određivanja *E. coli* i *Salmonella spp* u mulju prema akreditiranim metodama HRI CEN/TR 15214-2:2008 i HRI CEN/TR 15215-3:2008. Priprema za mikrobiološku analizu uključuje određivanje postotka (%) suhe tvari i pH uzorka. Brojanje *E. coli* se temelji na metodi ispitivanja otpadnih voda prema normi HRN EN ISO 9308-3. Iz pripremljene tekuće suspenzije se provodi ispitivanje pomoću mikrotitarskih ploča, izražavajući rezultat kao najvjerojatniji broj mikroorganizama po gramu suhe tvari. Metoda za određivanje *Salmonella* je kvalitativna, rezultat se izražava kao izolirana ili nije izolirana u 25 grama suhe tvari.

Ključne riječi: mulj, mikrobiološka analiza, *E.coli*, *Salmonella spp*, poboljšivač tla

MICROBIOLOGICAL ANALYSIS OF SLUDGE

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The production of waste sludge from wastewater treatment plants in the Republic of Croatia in 2020 amounted to 629.37 tons of sludge dry matter (MINGOR, 2021). Sludge from wastewater is a valuable resource that contains about 70% of organic matter whose nutritional and energy value can be used for various purposes such as agriculture. According to EU directives 86/278 / EEC for sludge, 91/271 / EEC for wastewater and Croatian legislation, sludge must be treated before use in order to be utilized as a soil improver in agriculture. The Ordinance on by-products and the abolition of waste status (NN 117/14) prescribes test parameters, methods and permitted quantities of microorganisms in a sample of sludge that can be used as a soil improver. This paper presents the procedure for determination of *E. coli* and *Salmonella spp* in sludge according to accredited methods HRI CEN/TR 15214-2:2008 and HRI CEN/TR 15215-3:2008. Preparation for microbiological analysis involves determining the percentage (%) of dry matter and pH of the sample. *E. coli* counting is based on the method of wastewater testing according to the standard HRN EN ISO 9308-3. From the prepared liquid suspension, the analysis is performed using microtiter plates, expressing the result as the most probable number of microorganisms per gram of dry matter. The method for the determination of *Salmonella* is qualitative, with the result expressed as isolated or not isolated in 25 grams of dry matter.

Keywords: sludge, microbiological analysis, *E.coli*, *Salmonella spp*, soil improver

PROČIŠĆAVANJE OTPADNE VODE KOKSNE INDUSTRIJE KOMBINACIJOM BIOLOŠKIH, KEMIJSKIH I FIZIKALNIH POSTUPAKA

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Koksna industrija smatra se velikim onečišćivačem okoliša. Ispušta velike količine otpadne vode kompleksnog sastava, koja sadrži visoke koncentracije organskih tvari, suspendiranih čestica, amonijaka, fenola, cijanida, tiocijanata te je kao takva toksična i štetna za okoliš. Kako bi se takva otpadna voda ispustila u prirodu, a u skladu sa Zakonom, potrebno ju je obraditi kombinacijom različitih postupaka, zbog kompleksnosti sastava. U ovom istraživanju, otpadna voda koksne industrije, nakon pročišćavanju u dvostupanjskom biološkom postrojenju, podvrgnuta je različitim procesima (koagulacija s flokulacijom, oksidacija, napredna oksidacija, ozon). Najbolji rezultati dobiveni su tretiranjem otpadne vode postupkom koagulacije trovalentnim željezom (100 mg Fe^{3+}/L), nakon čega slijedi oksidacija slobodnim klorom (10 mg Cl_2/L). Nakon navedene obrade, koncentracije fenola, cijanida, tiocijanata, amonijaka i KPK vrijednost iznosile su: 0,38 mg/L, 0,23 mg/L, 0,11 mg/L, 2,58 mg/L, odnosno 123 mg O_2/L.

Ključne riječi: otpadna voda, koksna industrija, koagulacija, oksidacija

COKE INDUSTRY WASTEWATER TREATMENT BY COMBINATION OF BIOLOGICAL, CHEMICAL AND PHYSICAL PROCESSES

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Coke industry is considered a major polluter of the environment. It discharges large amount of wastewater of complex composition which contains high concentrations of organic matter, suspended particles, ammonia, phenol, cyanide and thiocyanate and as such is toxic and harmful. In order for such wastewater to be discharged into natural water bodies, in accordance with the Law, it is necessary to treat it with a combination of different procedures, due to its complexicity. In this study, coking wastewater was subjected to various processes (coagulation with flocculation, oxidation, advanced oxidation, ozone), after two-stage biological treatment. The best results were obtained by treating the wastewater through coagulation process (100 mg Fe^{3+}/L), followed by oxidation with free chlorine (10 mg Cl_2/L). Concentrations of phenol, cyanide, thiocyanate, ammonia and COD value were respectively: 0.38 mg/L, 0.23 mg/L, 0.11 mg/L, 2.58 mg/L and 123 mg O_2/L.

Keywords: wastewater, coke industry, coagulation, oxidation

PROJEKT IZGRADNJE INTEGRIRANOG SUSTAVA ODVODNJE AGLOMERACIJA ZADAR – PETRČANE DOGRADNJA UPOV-a CENTAR

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Projekt poboljšanja vodno-komunalne infrastrukture aglomeracije Zadar-Petrčane pokrenut je u svrhu usklađivanja s Direktivama EU (98/83/EZ i 91/271/EEZ) koje se odnose na odvodnju i pročišćavanje komunalnih otpadnih voda te kakvoću mora za kupanje. Projektom se želi postići razvoj sustava prikupljanja i obrade otpadnih voda s ciljem doprinosa poboljšanja stanja mora i voda te povećanja priključenosti stanovništva na sustave javne odvodnje i pročišćavanja. Cilj ovog projekta je smanjenje ispuštanja djelomično pročišćenih i nepročišćenih otpadnih voda u priobalno područje Jadranskog mora i zaštita vodnih resursa. Izgradnjom sustava odvodnje će se omogućiti izvedba novih 5570 priključaka kućanstva i adekvatno pročišćavanje otpadnih voda za dodatnih 12 500 ES. U sklopu projekta nadogradit će se uređaj za pročišćavanje otpadnih voda Centar u Zadru.

Ključne riječi: vodno-komunalna infrastruktura, odvodnja i pročišćavanje

PROJECT OF CONSTRUCTION OF INTEGRATED DRAINAGE SYSTEM AGGROMERATION ZADAR – PETRČANE
UPGRADE OF WWTP CENTAR

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The project to improve the water and communal infrastructure of the Zadar-Petrčane agglomeration was launched to comply with EU Directives (98/83 / EC and 91/271 / EEC) relating to the drainage and treatment of municipal wastewater and bathing sea quality. The project aims to develop a system of wastewater collection and treatment with the aim of contributing to the improvement of the state of the sea and water and increasing the connection of the population to public sewerage and treatment systems. The aim of this project is to reduce the discharge of partially treated and untreated wastewater into the Adriatic coastal area and to protect water resources. The construction of the drainage system will enable the construction of 5570 new household connections and adequate wastewater treatment for an additional 12,500 ES. As part of the project, the Center wastewater treatment plant in Zadar will be upgraded.

Keywords: water utility infrastructure, drainage and treatment

APPLICATION OF LINEAR REGRESSION MODELS FOR WASTEWATER TREATMENT PROCESS CONTROL

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Mechanical and biological wastewater treatment processes are very dynamic and complex, so the application of mathematical models for description and process control is of particular importance. In this paper, the process of biological treatment of municipal wastewater in Beli Manastir, Croatia is analyzed. Measurements of the physical, chemical and biological parameters of the process are performed daily to gain insight into the efficiency of the process. Based on the monitoring data set, multivariate linear regression (MLR) models and piecewise linear regression (PLR) models were developed with a different number of variables. The objective of the models is to predict the output values of chemical oxygen demand (COD) and biological oxygen demand (BOD_5) as the main indicators of organic load in municipal wastewater. The models were evaluated and compared based on the value of the regression coefficients, which indicated satisfactory accuracy for all developed models and exceeded R^2 =0.89.

Keywords: wastewater treatment process, biological treatment, activated sludge, linear regression models

UKLANJANJE TEŠKIH METALA KEMIJSKI AKTIVIRANIM PIROFILITOM I BENTONITOM

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Postoji niz studija o sposobnosti pirofilita i bentonita da uklone onečišćenje iz otpadnih voda. Pirofilit je filosilikatni mineral hemijske formule $Al_2Si_4O_{10}(OH)_2$, prikladan za korištenje kao filter zbog velikog kapaciteta adsorpcije teških metala, dok je bentonit upijajuća prirodna glina koja može varirati od koagulanta do filtera. Ovi materijali su jeftini i pokazali su se učinkovitima u uklanjanju toksina, teških metala, kao što su željezo (Fe), krom (Cr), mangan (Mn), bakar (Cu), nikl (Ni), olovo (Pb) i cink (Zn). Dokazano je da bentonit vrlo dobro djeluje na uklanjanje organskih zagađivača iz vode, posebno u kombinaciji s anorganskim koagulansima. Također, ispitana je i sposobnost pirofilita kao adsorbensa i njegov učinak na huminsku kiselinu, bojila, organske onečišćujuće tvari, onečišćujuće tvari poput cijanida, fluorida, otrovnih i teških metala u otpadnim vodama. Da bi se poboljšala svojstva i povećao kapacitet adsorpcije pirofilita i bentonita potrebno je izvršiti njihovu aktivaciju. U ovom radu za potrebe aktivacije pirofilita i bentonita korištene su tri kiseline: limunska, sumporna i borna kiselina. Nakon aktivacije, ova dva minerala su korištena kao adsorbens u svrhu uklanjanja teških metala: željeza (Fe), mangana (Mn) i kroma (Cr). Zaključno, ovi materijali i metode s kojima se mogu primijeniti su budućnost upravljanja otpadnim vodama i s više istraživanja na tu temu, pokazat će se vrlo učinkovitim.

Ključne riječi: pirofilit, bentonit, hemijska aktivacija, kapacitet adsorpcije, teški metali

REMOVAL OF HEAVY METALS BY CHEMICALLY ACTIVE PYROPHYLLITE AND BENTONITE

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There is a number of studies on the ability of pyrophyllite and bentonite to remove pollution from wastewater. Pyrophyllite is a phyllosilicate, with the chemical formula $Al_2Si_4O_{10}(OH)_2$, that adsorbs heavy metals very effectively, making it useful as a filter. While, bentonite is an absorbent natural clay which can range from coagulant to filter aid. These materials are inexpensive and prove to be effective in removing toxins, heavy metals, such as Iron (Fe), Chromium (Cr), Manganese (Mn), Copper (Cu), Nickel (Ni), Lead (Pb) and Zinc (Zn). Bentonite has been shown to work very well in removing of organic pollutants from water, especially paired with inorganic coagulants. Pyrophyllite is researched for its ability as an adsorbent, alsoo for for it's effeeffet on humic acid, dyes, organic pollutants, pollutants such as cyanide, fluoride, toxic and heavy metals in wastewater. For the best results of absorption, with using pyrophyllite and bentonite we needed to activate them. In our research, we have used three types of acids: citric acid, sulfuric acid and boric acid. After being activated, these two minerals have been used as an absorbent for removing heavy metals: Iron (Fe), Manganese (Mn) i Chromium (Cr). In conclusion, these materials and methods they can be applied with are the future of wastewater management and with more research on the topic, will be proven very effective.

Keywords: pyrophillite, bentonite chemical activation, adsorption capacity, heavy metals

Upravljanje vodama /
Water Management

BIOAVAILABILITY AND ACCESSIBILITY ASSESSMENT OF POLYCHLORINATED BIPHENYL IN THE DANUBE RIVER SEDIMENT: MULTI–RATIO EQUILIBRIUM PASSIVE SAMPLING APPLICATION

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In order to assess bioavailability and accessibility the freely dissolved concentration (C_W) and the accessible/releasable concentrations (C_{AS}) was measured for lipophilic organic contaminants such as polychlorinated biphenyl (PCBs) in Danube River sediments (Serbia). Ex-sity equilibrium passive sampling methodology was applied to define different relationships between sediment and sorption polymer. PCBs were easily quantifiable in the pgL^{-1} range (PCB 118), and PCB's C_W in depleted samples were often estimated below 0.1 pgL^{-1}, confirming the sensitivity of sediment equilibrium passive sampling. For PCB 118, the total concentration in the sediment was three times larger than C_{AS}, indicating that in the sediment at site Begeč 70% of the PCB 118 is strongly sorbed and inaccessible in terms of bioavailability. This essentially means that after 30% of PCB 118 release by the sediment, C_W would become negligible and the risk for uptake by organisms has been diminished. By contrast, PCB153 was fully accessible for release to the water phase at all sampling locations. The highly significant linear isotherms for PCB obtained by multi–ratio equilibrium passive sampling confirmed the partition driven nature of their exchange between water and sediment for the investigated sediments.

Keywords: pore water, sediment, organic pollutants, Danube

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UDIO OKSIDA U PEPELU DOBIVENOM TERMIČKOM OBRADOM MULJA S UPOV-a I NJEGOV UTJECAJ NA KVALITETU OPEKE

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Direktiva Europske Unije (EU) promiče ekološki održivije gospodarenje otpadom po načelima kružnog gospodarstva. U skladu s tim, mulj s uređaja za pročišćavanje otpadnih voda (UPOV) se u razvijenim zemljama EU sve češće materijalno i energetski oporabljuje primjenom viših stupnjeva termičke obrade (spaljivanje, piroliza, uplinjavanje). Termička obrada mulja ne zbrinjava mulj s UPOV-a u potpunosti jer pritom nastaje pepeo koji se naknadno mora zbrinuti, tj. oporabiti ili odložiti. Visok udio oksida u pepelu, a posebice visok udio silicijeva oksida čini ga prikladnom sirovinom u proizvodnji građevinskih materijala (npr. opeka, beton), čime u konačnici materijalna oporaba omogućuje učinkovito zbrinjavanje mulja s uređaja za pročišćavanje otpadnih voda. U ovom radu obrađen je mulj s dva uređaja: UPOV Zagreb i UPOV Karlovac. Uzorci muljeva su osušeni i termički obrađeni u laboratorijskim uvjetima pri temperaturi od 800 °C. Oksidni sastav dobivenog pepela određen je metodom atomske apsorpcijske spektroskopije te je uspoređen s kemijskim sastavom prirodne sirovine gline. Rezultati kemijskog sastava pepela prikazuju visoke udjele SiO_2, osobito u pepelu s UPOV-a Zagreb u iznosu od 52,57 mas. % te nešto manji udio u pepelu s UPOV-a Karlovac u iznosu od 42,78 mas. %. Udio Fe_2O_3 također je bio veći u pepelu s UPOV-a Zagreb i iznosio je 7,78 mas. %, a u s UPOV-a Karlovac 5,06 mas. %. Udio MgO također je bio veći u pepelu s UPOV-a Zagreb (4,43 mas. %) u odnosu na UPOV Karlovac (2,89 mas. %). No, udjeli Al_2O_3 i CaO su bili veći u pepelu s UPOV-a Karlovac u odnosu na UPOV Zagreb. Rezultati istraživanja i ispitivanja mehaničkih svojstava proizvedene opeke pokazuju da opeke izrađene od 5 % pepela s UPOV-a Zagreb imaju za oko 8 % veću tlačnu čvrstoću u odnosu na opeke izrađene od 5 % pepela s UPOV-a Karlovac.

Ključne riječi: mulj s UPOV-a, termička obrada, pepeo, oksidi, opeka

OXIDE CONTENT IN SEWAGE SLUDGE ASH AND ITS IMPACT ON BRICK QUALITY

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The EU Directive promotes environmentally sustainable waste management. Accordingly, material and energy recovery of sewage sludge from wastewater treatment plants (WWTPs) has become a ffavored management route in developed EU countries by applying higher stages of thermal treatment (incineration, pyrolysis, gasification). Thermal treatment of sludge does not completely dispose of sludge from WWTPs because it produces sewage sludge ash which must be subsequently recovered or disposed of. The high content of oxides in the SSA makes it a suitable raw material in the production of construction materials (eg brick, concrete, mortars), by which material recovery of SSA allows efficient disposal of sewage sludge. In this study, sewage sludge from WWTP Zagreb and WWTP Karlovac were dried and thermally treated at a temperature of 800 °C. The oxide composition of the generated SSA was determined by atomic absorption spectroscopy and compared with the chemical composition of natural clay raw materials. The results showed a high proportion of SiO_2, especially in the ash from WWTP Zagreb in the amount of 52.57 wt. % and a slightly smaller share in the SSA from WWTP Karlovac in the amount of 42.78 wt. %. The share of Fe_2O_3 was also higher in the SSA from WWTP Zagreb and amounted to 7.78 wt. %, and in the WWTP Karlovac 5.06 wt. %. The share of MgO was also higher in the SSA from WWTP Zagreb (4.43% by weight) compared to WWTP Karlovac (2.89% by weight). However, the shares of Al_2O_3 and CaO were higher in the SSA from WWTP Karlovac compared to WWTP Zagreb. The testing of mechanical properties shows that bricks made of 5% SSA (as a replacement for clay) from WWTP Zagreb have about 8% higher compressive strength compared to bricks made of 5% SSA from WWTP Karlovac.

Keywords: sewage sludge, thermal treatment, ash, SSA, oxides, brick

SLANI IZVORI KONTINENTALNOG DIJELA HRVATSKE

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Iako Hrvatska nema fosilnih ležišta soli koja bi omogućila otvaranje rudnika soli poput rudnika u Salzburgu ili Tuzli, u Hrvatskoj postoji veći broj mineraliziranih izvora iz kojih izviru slane, sumporovite ili željezovite vode. Slane vode uočene su na nekoliko lokacija - Slanje pokraj Ludbrega, Slani potok i Slanovec na Medvednici, Slana voda i Slanec na JI Bilogori, Slani Dol u Samoborskom gorju te Velika i Mala Solina, sjeverno od Gline. Slan je izvor Seget kod Gvozda, izvori pokraj Brubna i Vratnik u Baniji te neke vode u dubokim bušotinama. Za razliku od slanih izvora i zaslanjenih vodonosnika u obalnom dijelu Hrvatske, čije se porijeklo može povezati sa intruzijama morske vode u krške vodonosnike, porijeklo slanih izvora kontinentalnog područja nije dovoljno istraženo te se pretpostavlja da su vezani uz ležišta ugljikovodika, ugljena ili da su anorganskog porijekla. Cilj rada je dati pregled slanih izvora kontinentalnog dijela Hrvatske te ukazati na mogućnosti eksploatacije i potencijalne probleme za okoliš.

Ključne riječi: slani izvori, slana voda, Hrvatska

SALT SPRINGS IN CONTINENTAL PART OF CROATIA

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Although Croatia does not have fossil salt deposits that would enable the opening of salt mines like in Sazburg, Austria or Tuzla, Bosnia and Herzegovina, there are several mineralized springs in Croatia from which salt, sulfur or iron waters spring. Salt waters were recorded at several locations - Slanje near Ludbreg, Slani potok and Slanovec on Medvednica, Slana voda and Slanec on SE Bilogora, Slani Dol in Samoborski gorje, Velika and Mala Solina near Glina, Seget spring near Gvozd, springs near Brubno and Vratnik in Banija, and some waters in deep wells. Unlike saline springs and aquifers in the coastal part of Croatia, whose origin can be linked to seawater intrusions into karst aquifers, the origin of the continental saline springs has not been sufficiently investigated and is assumed to be related to hydrocarbon, coal or inorganic deposits. The aim of paper is to give an overview of the salt springs in the continental Croatia and to show the possibilities of exploitation and potential environmental problems.

Keywords: salt springs, salt water, Croatia

LEGAL ASPECTS: GROUNDWATER PROTECTION IN HYDROELECTRIC POWER PLANT CONSTRUCTION

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To ensure low carbon in the field of energy sector, hydroelectric power plants are one of the main renewable sources, which prove success in sector. While hydropower plants are considered renewable energy sources in most cases, it must be noted that they also come with a certain level of interference in the environment, which are permanent. A river basin, on which hydroelectric power plant is built, entails many connected ecosystems, which includes not only aquatic habitats, but also other ones connected to the river and ones that may influence the river's characteristics. When hydropower plants are built, the underground water level changes, it can rise or fall, or new pathways can be found. In the case of a hydroelectric power plant, the environment of the river is thus affected, which could have an impact on groundwater, and there could also be impacts in the neighboring country. The paper will present the legal instruments governing transboundary waters, with a focus on groundwater, and will review the case law where the harmful effects of hydroelectric power plant construction on groundwater have been invoked.

Keywords: hydroelectric power plants, transboundary waters, groundwater, legal aspects

Monitoring kakvoće voda /
Monitoring of Water Quality

ANALIZA KLORITA, KLORATA I BROMATA IONSKOM KROMATOGRAFIJOM

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Dezinfekcija sustava javne vodoopskrbe sprječava razvoj bolesti koje se prenose vodom. Najpoznatija dezinfekcijska sredstva koja se primjenjuju u vodoopskrbi su klor, klorov dioksid, natrijev hipoklorit, a u rijetkim slučajevima i ozon. Unatoč brojnim prednostima, dezinfekcijska sredstava imaju i niz nedostataka zbog nastajanja nepoželjnih sporednih produkata pri njihovoj uporabi. Nepoželjni regulirani sporedni produkti dezinfekcije su trihalometani, halooctene kiseline, kloriti, klorati i bromati. U ovom radu opisat će se postupak validacije metode za određivanje klorita, klorata i bromata u vodi ionskom kromatografijom prema standardiziranim metodama HRN EN 10304-4:2001 i HRN EN ISO 15061:2001. Validacija metode je uključivala utvrđivanje selektivnosti metode, iskorištenje, preciznost, linearnost, granicu detekcije i kvantifikacije. Prikazani su rezultati analize uzoraka vode iz javnog vodoopskrbnog sustava grada Zagreba za period 2020-2021.godine. Ukupno je analizirano 236 uzoraka vode. Dobiveni rezultati ocijenjeni su s obzirom na postavljene zahtjeve Pravilnika (NN 125/17, 39/20) i svi su bili ispod propisane maksimalne dopuštene koncentracije.

Ključne riječi: kloriti, klorati, bromati, ionska kromatografija

DETERMINATION OF CHLORITE, CHLORATE AND BROMATE BY ION CHROMATOGRAPHY

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Disinfection of public water supplies prevents development of waterborne diseases. The most commonly used disinfectants in water treatment are chlorine, chlorine dioxide, sodium hypochlorite and in rare case ozone. Despite the many advantages, disinfectants have a number of disadvantages such as formation of undesired by-products during their use. Regulated undesired by-products of disinfection are trihalomethanes, haloacetic acids, chlorites, chlorates and bromates. This paper gives validation results for determination of chlorite, chlorate and bromate in water by ion chromatography according to standardized methods HRN EN ISO 10304-4: 2001 and HRN EN ISO 15061: 2001. Method validation included method selectivity, recovery, precision, linearity and limit of detection and quantification. The results of water samples analysis from public water supply system in city of Zagreb were presented for the period 2020. -2021. In total, 236 water samples were analyzed. The obtained results were evaluated regarding to a set of requirements within Regulation (NN 125/17, 39/20) and all of them were below maximum level.

Keywords: chlorite, chlorate, bromate, ion chromatography

APPLICATION OF NNEAR INFRARED SPECTROSCOPY FOR DISTINCTION OF DRINKING WATER QUALITY BASED ON DIFFERENT TREATMENTS

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Near infrared spectroscopy (NIRs) is gaining momentum as an analytical tool because of its ability of fast, on-line, non-destructive sample scanning and analysis. According to literature data, it is extensively used in food, chemical, textile and pharmaceutical industry, as well as in biotechnology. The aim of this study was to explore the potential of the use of NIRs for determination of drinking water quality. The analyzed samples were taken from the Butoniga Lake (Istria, Croatia) and have been undergone different treatments: pre-treatment, flocculation and main ozonation. During the pre-treatment phase, the samples were treated with different ozone concentrations (0.2, 1.1 and 2 mg/L), and during the main ozonation phase they were treated with 0.1, 0.3 and 0.5 mg/L ozone for varying duration (5, 15.5 and 30 min). The samples were scanned using the NIR-128L-1.7-USB/6.25/50 µm (Control Development, South Bend, Indiana, USA) spectrophotometer and the data was analyzed by use of principle component analysis in the Statistica v.14 software (Tibco software, Palo Alto, USA). As a result it certainly stands out that, NIR spectroscopy coupled with multivariate data analysis, was able to differentiate the water samples based on the type of treatment with high accuracy (pre-treatment, flocculation and main ozonation). Furthermore, when only the main ozonation stage was analyzed, the distinction between the dose of ozone and the duration of ozone treatment was also successful deriving from the recorded NIR spectra. These results confirm the possibility of NIRs usage in water quality analysis, which enables fast on-line analysis with no need of complicated time and resource consuming chemical analyses.

Keywords: NIR spectroscopy, multivariate analysis, drinking water, ozonation, flocculation

LEVELS OF PESTICIDE RESIDUES IN SURFACE WATER

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A rapid, simple and sensitive LC-MS/MS (liquid chromatography coupled with tandem mass spectrometry) method was established and validated for the simultaneous quantification of 58 pesticide residues in surface water using carbofuran-D3, isoproturon-D6 and atrazine-D5 as internal standards. The analysis included 120 samples (samples from 40 sites, sampled in spring, summer and autumn from the Danube-Tisa-Danube irrigation canal, during 2021). The obtained results indicated the detection of 39 pesticides with the concentrations within the established maximum allowable concentrations (MACs). Namely, the observed pesticide residue levels in the surface waters correlate with the current pesticide applications and application rates. According to the Directive (EU) 2015/495 guidelines, the so-called "Watch list" in surface waters is necessary to control insecticides from the group of neonicotinoids. The neonicotinoids are a relatively young group of insecticides which includes: imidacloprid, thiamethoxam, acetamiprid, thiacloprid and clothianidin. Our research also dealt with their residues which are often detected but usually below the MACs. It should be accentuated that the pesticides banned for the use in agriculture a long time ago were also detected (atrazine and metabolites, lindane...), which indicates their presence in soil, rainwater and watercourses throughout the year for many years after the application.

Keywords: pesticide residues, water, LC-MS/MS

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FIZIKALNO-KEMIJSKE KARAKTERISTIKE POJEDINIH IZVORIŠTA PODZEMNIH VODA RURALNIH PODRUČJA TUZLANSKOG KANTONA

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U radu su istražene fizikalno-kemijske karakteristike uzoraka podzemnih voda uzorkovanih na šest odabranih lokacija u ruralnim područjima Tuzlanskog kantona. U cilju procjene kvalitete navedenih uzoraka s aspekta vode za piće korištene su standardne analitičke metode u skladu s važećom zakonskom regulativom u Bosni i Hercegovini za pitku vodu te su ispitani sljedeći fizikalno-kemijski parametri: boja, miris, okus, pH, mutnoća i ukupne suspendirane tvari, elektroprovodljivost, fosfati, nitriti i nitrati.amonijak, ukupni fosfor, p- i m-alkalitet, kloridi, sulfati, kalcij i magnezij. Dobiveni rezultati su uspoređeni sa zahtjevima nacionalnog standarda kvalitete vode za piće i međunarodnog standarda Svjetske zdravstvene organizacije. Provedenim ispitivanjima je utvrđeno da ispitane uzorke podzemnih voda ruralnih područja Tuzlanskog kantona karakterizira visoka kvaliteta u pogledu fizikalno-kemijskih karakteristika, s obzirom da su uzorci uzorkovani na prirodnim izvorištima koja nisu bila podvrgnuta postupcima predtretmana.

Ključne riječi: voda za piće, podzemna voda, fizikalno-kemijske karakteristike voda, ruralna područja

PHYSICO-CHEMICAL CHARACTERISTICS OF SELECTED GROUNDWATER SOURCES OF RURAL AREAS OF TUZLA CANTON

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The paper investigates the physico-chemical characteristics of samples of natural mineral and natural spring waters, taken from six selected locations in rural areas of Tuzla Canton. In order to assess the quality of samples from the aspect of drinking water, standard analytical methods were used for analysis, in accordance with the current legislation in Bosnia and Herzegovina for drinking water. The examined physico-chemical parameters included: color, odor, taste, pH, turbidity and total suspended solids, electrical conductivity, phosphates, nitrites and nitrates, ammonia nitrogen, total phosphorus, p- and m-alkalinity, chlorides, sulfates, calcium and magnesium. The obtained results were compared with the requirements of the national standard of drinking water quality and the international standard of the World Health Organization. Based on the conducted research, it was generally concluded that the tested samples of natural mineral and natural spring waters of rural areas show a high level of quality in terms of physico-chemical characteristics, taking into account that these are waters of natural springs that have not undergone any pretreatment.

Keywords: drinking water, groundwater, physico-chemical quality of water, natural water of rural areas

POTENCIJALNA PRIMJENA AKTIVIRANOG MOF-5 U RAZGRADNJI ORGANSKIH ZAGAĐIVAČA IZ OTPADNIH VODA

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Metaloorganske mreže (MOF) porozni su materijali s velikom sposobnosti adsorpcije. Upotrebom različitih liganada i kationa te promjenom uvjeta sinteze MOF-a moguće je dobiti široki spektar poroznih spojeva s različitim veličinama pora. Brojne prednosti nad zeolitima sličnim poroznim materijalima potaknule su istraživanja u svrhu uklanjanja polutanata pomoću MOF-a. Među najviše korištenim metodama sinteze MOF-a ističe se mehanokemijska sinteza, zbog uštede energije i smanjene upotrebe otapala. MOF se može koristiti kao senzor za polutante te za njihovu adsorpciju i degradaciju. MOF učinkovito adsorbira organske boje, pesticide i slične polutante iz vode ukoliko veličina pora odgovara veličini molekula polutanata i ukoliko postoje interakcije između te dvije molekule. U ovome istraživanju provedena je optimizacija mehanokemijske sinteze MOF-5 koji se sastoji od klastera Zn_4O i 1,4-benzendikarboksilata kao povezivača. Sinteza je provedena pri različitim uvjetima s obzirom na brzinu i vrijeme. Dobiveni su spojevi okarakterizirani infracrvenom spektroskopijom (FTIR) te uspoređeni sa spojem sintetiziranim klasičnom metodom gdje je korišten *N,N*-dimetilformamid (DMF) kao otapalo. Spoj MOF-5 dobiven klasičnom sintezom okarakteriziran je također rentgenskom difrakcijom na prahu (PXRD) te termogravimetrijskom analizom (TGA). Glavni problem koji se javlja prilikom sinteze MOF-5 je uklanjanje molekula DMF-a iz pora te aktivacija dobivene mreže. Kako mehanokemijska metoda ne zahtijeva uporabu otapala, molekule otapala nisu zaostale u porama zbog čega su dobivene metaloorganske mreže aktivirane i pogodne za adsorpciju zagađivača, te njihovu razgradnju.

Ključne riječi: metaloorganske mreže, mehanokemijska sinteza, polutanti

POTENTIAL APPLICATION OF ACTIVATED MOF-5 IN DECOMPOSITION OF ORGANIC POLLUTANTS FROM WASTEWATER

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Metal-organic frameworks (MOFs) are porous materials that exhibit large adsorption ability. By using different ligands and metal cations and by varying synthesis parameters, it is possible to obtain a large spectrum of porous materials with different pore sizes. Numerous advantages of MOFs compared to zeolites have encouraged the development of a research area that deals with the removal of pollutants. Among widely used synthesis methods, mechanochemical synthesis stands out due to energy saving and reduced usage of solvents. MOFs can be used as sensors for pollutants and their adsorption and degradation. MOF molecules adsorb organic dyes, pesticides, and similar pollutants effectively if the pore size corresponds to the size of the pollutant molecule and if there are existing interactions between these two molecules. In this research mechanochemical synthesis optimization of MOF-5 compound that consists of Zn_4O clusters and 1,4-benzenedicarboxylate as linker was conducted. Synthesis was carried out under different conditions in terms of synthesis rate and time. Obtained compounds were characterized by infrared spectroscopy (FTIR) and compared to MOF-5 compound obtained by the classical synthesis method where *N,N*-dimethylformamide (DMF) was used as a solvent. MOF-5 compound obtained by classical synthesis method was also further characterized by powder X-ray diffraction (XRD) and thermogravimetric analysis. The main problem in classical synthesis is the removal of solvent molecules from the pores of MOF-5 and activation of the obtained framework. Since mechanochemical synthesis does not require solvent, there are no solvent molecules in the pores of MOFs which makes them activated and suitable for adsorption and degradation of pollutants.

Keywords: metal-organic frameworks, mechanochemical synthesis, pollutants

Knjiga sažetaka / *Book of abstracts*
Posterska priopćenja / *Poster presentations*

MONITORING VODA U TERMOENERGETSKOM POSTROJENJU HEP PROIZVODNJA, POGON EL-TO ZAGREB

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Klimatske promjene i nedostatak vode uvelike utječu na samu kvalitetu voda , stoga se u termoenergetskom postrojenju HEP Proizvodnje pogona EL-TO Zagreb primjenjuje kontinuirani monitoring voda koji je propisan Okolišnom dozvolom za postrojenje HEP Proizvodnja, Pogon EL-TO Zagreb od 18. svibnja 2021 godine. U Republici Hrvatskoj kvaliteta otpadnih voda propisna je Zakonom o vodama (NN 66/19) i Pravilnikom o graničnimvrijednostima emisija otpadnih voda (NN 43/14, 27/15, 03/16, 26/20). Redovite analize kemijskog sastava otpadnih voda iz termoenergetskih postrojenja omogućuju kontiniurano praćenje njihovih vrijednosti u efluentu te utvrđivanje usklađenosti s propisanim zakonskim normama kojima reguliraju maksimalno dopuštene koncentracije pojedinih kemijskih tvari u otpadnim vodama. Uz navedeno, redovite kemijske analize otpadne vode iz termoenergetskih postrojenja omogućuju i procjenu rizika i štetnih utjecaja kojeg navedena vrsta otpadnih voda može uzrokovati pri ispuštanju u okoliš. U ovom radu biti će prikazane vrijednosti kemijskih pokazatelja s naglaskom na koncentracije teških metala otpadni voda termoenergetskog postrojenja HEP Proizvodnja pogon EL-TO Zagreb.

Ključne riječi: voda, granične vrijednosti, otpadne voda

WATER QUALITY MONITORING IN THE HEP PRODUCTION THERMAL POWER PLANT, EL-TO ZAGREB PLANT

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Climate changes and water deficiencies can greatly affect water quality, so the thermal power plant HEP Proizvodnja EL-TO Zagreb has continuous water monitoring prescribed by the Environmental permit for HEP Proizvodnja EL-TO Zagreb from the May 18th 2021. Wastewater quality in the Republic of Croatia is prescribed by the Water act (NN 66/19) and the Regulation on limit values for wastewater emissions (NN 43/14, 27/15, 03/16, 26/20). Regular analysis of chemical composition of wastewater from thermal power plant enable continuous monitoring of their values in the effluent and it's compliance with prescribed legal norms which regulate maximal permissible concentrations of certain chemical substances in wastewater. In addition to aforementioned, regular chemical analysis of wastewater from thermal power plant also enable the assessments of risks and harmful effects of these types of wastewater if they would be released in the environment. This paper will present the values of chemical indicators with an emphasis on the values of heavy metals in wastewater from thermal power plant HEP Proizvodnja EL-TO Zagreb.

Keywords: water, maximal permissible concentrations, wastewater

QUANTIFICATION OF THE IMPACT OF NITRATES ON UNDERGROUND WATER QUALITY BY USING RAPS METHOD-EXAMPLE OF THE WELL FIELD BARTOLOVEC NEAR VARAŽDIN IN CROATIA

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Nitrates have their presence in underground water in natural form or from anthropogenic sources. Anthropogenic impact includes human activities in form of the fertilizers and pesticides, which have a negative impact on human health. The main problem with nitrates is their presence in underground water, when this water is used as drinking water for settlements and cities. The main goal of all research connected with the mentioned problem is to find, determine, and quantify potential sources of the nitrates, and after this to connect natural and anthropogenic factors which contribute to the rising the nitrate amount in the underground water. Such a task means lots of fieldwork and laboratory measurements. There is a plan to show methodology for contributing to solving issues of nitrate in groundwater for the case study of the well field Bartolovec, which is the primary underground drinking water source for Varaždin County and the city of Varaždin in Croatia. In the first step, the time series of the nitrates will be shown and statistically analyzed on a yearly and monthly basis. The second step is to provide further statistical analysis on a higher level by the application of the Rescaled Adjusted Partial Sums (RAPS).

Keywords: well field, nitrates, RAPS, water quality, underground water

ASSESSMENT OF METALS AND METALLOIDS IN STREAMS AND TISSUES OF WILD BOAR IN PAPUK NATURE PARK AREA

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Cadmium and lead are the most common toxic pollutants in the liver and kidneys of wild boar. In order to assess the heavy metal and metalloid burden on Papuk Nature Park area the concentrations of As, B, Cd, Cr, Cu, Hg, Ni, Pb, Sb and U in wild boar muscle, liver, and kidney samples were analyzed at five sampling locations. This area is chosen due to the low influence of industry, and the absence of agricultural activities and traffic. The results of ICP-MS analysis showed that wild boar tissues accumulated the highest Cd and Pb concentrations, with Cd and Pb occurring in higher concentrations in the kidney ($Cd_{max.}$=7.5 mg kg^{-1}), liver ($Cd_{max.}$ =12.2 mg kg^{-1}) and in muscle tissue ($Pb_{max.}$=9.1 mg kg^{-1}). In order to investigate the possible cause of high metal concentrations in wild boar tissues, the 20 samples of water were collected from five streams. Slightly elevated concentrations were found in one sample from the northern part of Papuk (11.2 µg L^{-1}). The cadmium concentrations in all investigated water samples were low and ranged from 0.09 to 0.7 µg L^{-1}. The concentration of other elements covered by the EU directive (As, B, Cr, Cu, Hg, Ni, Sb and U) were also below permitted values. From the results of this study, it can be concluded that the streams and rivers of the Papuk Nature Park are not influenced by anthropogenic factors.

Keywords: water, heavy metal and mettaloids, Papuk , wild boar, Croatia

BENTOSKI MAKROBESKRALJEŠNJACI: KOME TREBA NAJVIŠE KISIKA?

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Provedeno istraživanje ima za cilj utvrditi ovisnost bioloških metrika (broj svojta pojedinih skupina iz uzoraka bentoskih makrobeskralješnjaka) s režimom kisika (koncentracija otopljenog kisika u vodi i zasićenost kisikom). Podaci su dobiveni iz sustava nacionalnog praćenja kakvoće površinskih voda kroz razdoblje od tri godine (2015 – 2017) pri čemu je obrađeno 114 uzoraka sa 108 mjernih postaja. Svi uzorci bentoskih makrobeskralješnjaka prikupljeni su prema AQEM protokolu uzorkovanja. Koncentracija i zasićenje kisikom mjereno je prema standardnim analitičkim metodama za procjenu kakvoće površinskih voda (ISO norme), u godini kad je prikupljen uzorak bentoskih makrobeskralješnjaka. Broj svojti obalčara, tulara, vodencvjetova i virnjaka bili su umjereno pozitivno korelirani s koncentracijom kisika (Spearmanovi koeficijenti korelacije iznosili su 0,494, 0,459, 0,283 i 0,257, respektivno, i svi su bili značajni na razini $p<0,01$), kao i dvokrilci (Spearmanov koeficijent korelacije iznosio je 0,195, značajan na razini $p<0,05$). Broj svojti obalčara i tulara bili su nešto manje pozitivno korelirani sa zasićenošću kisikom (Spearmanovi koeficijenti korelacije iznosili su 0,310 i 0,256, respektivno, i oba su bila značajna na razini $p<0,01$). Slabija negativna korelacija je nađena za broj svojta sljedećih skupina: muljari, vretenca, raci, puževi, pijavice, školjkaši. Indiferentne skupine (broj njihovih svojta) prema mjerenim pokazateljima režima kisika bile su: maločetinaši, raznokrilci i kornjaši

Ključne riječi: režim kisika, bentoski makrobeskralješnjaci, vodencvjetovi, obalčari, tulari

BENTHIC MACROINVERTEBRATES: WHO NEEDS MOST OXYGEN?

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The aim of this research was to determine the dependence of biological metrics (the number of recorded taxa of certain groups from samples of benthic macroinvertebrates) with the oxygen regime (concentration of dissolved oxygen in water and oxygen saturation). Data were obtained from the national surface water quality monitoring system over a period of 3 years (2015-2017), including 114 samples from 108 sampling sites. All benthic macroinvertebrate samples were collected according to the AQEM sampling protocol. Concentration of dissolved oxygen and oxygen saturation were measured according to standard analytical methods for assessing surface water quality (ISO standards), in the year when a sample of benthic macroinvertebrates was collected. The number of taxa of Plecoptera (stonefies), Trichoptera (caddisflies), Ephemeroptera (mayflies) and Turbellaria (planarians) were moderately positively correlated with oxygen concentration (Spearman correlation coefficients were 0.494, 0.459, 0.283 and 0.257, respectively, and were significant at the level of $p < 0.01$), and Diptera (flies) (Spearman correlation coefficient was 0.195, and was significant at the level of $p<0,05$). The number of taxa of Plecoptera and Trichoptera were slightly less positively correlated with oxygen saturation (Spearman's correlation coefficients were 0.310 and 0.256, respectively, and both were significant at the level of $p < 0.01$). A weaker negative correlation was found for the groups: Megaloptera (alderflies), Odonata (dragonflies), Crustacea (crabs), Gastropoda (snails), Hirudinea (leaches) and Bivalvia (shellfish), while no correlation was found for the groups: Oligochaeta (earthworms), Heteroptera (true bugs) and Coleoptera (beetels).

Keywords: oxygen regime, macrozoobenthos, mayflies, stoneflies, caddisflies

Knjiga sažetaka / *Book of abstracts*
Posterska priopćenja / *Poster presentations*

MONITORING VODE ZA LJUDSKU POTROŠNJU IZ DISTRIBUCIJSKE MREŽE U POŽEŠKO-SLAVONSKOJ ŽUPANIJI

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Voda za ljudsku potrošnju mora zadovoljavati parametre za provjeru sukladnosti vode za ljudsku potrošnju propisane Pravilnikom o parametrima sukladnosti, metodama analize, monitoringu i planovima sigurnosti vode te načinu vođenja registra pravnih osoba koje obavljaju djelatnost javne vodoopskrbe (NN 125/17, 39/20) i Zakona o vodi za ljudsku potrošnju (NN 56/13, 64/15, 104/17, 115/18, 16/20). Plan monitoringa za 2021. godinu obuhvaćao je monitoring vode za ljudsku potrošnju iz javnih vodovoda u Požeško - slavonskoj županiji, raspoređenih u 6 zona opskrbe (Požega, Veličanka - Stražemanka, Kutjevačka Rika, Radaškovac- Sovski dol - Paka, Pleternički Brđani - Djedina Rijeka i Šumetlica), te iz lokalnih vodovoda kojih u Županiji ima također 6 (Kraguj, Doljanovci, Bešinci, Podgorje, Gradište i Poljanska). U okviru monitoringa parametara skupine A za javnu vodoopskrbu (Prilog II spomenutog Pravilnika, Tablica 1), ispitani su obvezni parametri za 72 uzorka iz javne vodoopskrbe, i 12 uzoraka iz lokalne vodoopskrbe. U okviru monitoringa parametara skupine B iz javnih vodovoda ispitano je 15 uzoraka, dok je iz lokalnih vodovoda ispitano 12 uzoraka. Cilj rada je ukazati na javno zdravstveni problem lokalnih vodovoda koji su pod nadležnosti lokalne samouprave, te zdravstveno neispravni. To je posljedica distribucije vode bez adekvatne obrade i dezinfekcije, što rezultira mikrobiološki neispravnom vodom.

Ključne riječi: monitoring, javna vodoopskrba, lokalna vodoopskrba

MONITORING OF WATER FOR HUMAN CONSUMPTION FROM THE DISTRIBUTION NETWORK IN POZEGA-SLAVONIA COUNTY

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Water for human consumption must meet the parameters for checking the compliance of water for human consumption prescribed by the Ordinance on compliance parameters, methods of analysis, monitoring and water safety plans and the manner of keeping the register of legal entities that perform the activity of public water supply (OG 125/17, 39/20) and the Water Act for human consumption (OG 56/13, 64/15, 104/17, 115/18, 16/20). Monitoring plan for 2021 included monitoring of water for human consumption from public water supply systems in Požega -Slavonia County, distributed in 6 supply zones (Požega, Veličanka - Stražemanka, Kutjevačka Rika, Radaskovac - Sovski dol - Paka, Pleternički Brđani - Djedina Rijeka and Šumetlica), and from local waterworks, of which there are also 6 in the County (Kraguj, Doljanovci, Bešinci, Podgorje, Gradište and Poljanska). Within the monitoring of group A parameters for public water supply (Annex II of the mentioned Ordinance, Table 1), mandatory parameters were examined for 72 samples from public water supply, and 12 samples from local water supply monitoring of group B parameters from public waterworks, 15 samples were tested, while from local waterworks tested 12 samples.The aim of the paper is to point out the public health problem local water supply systems that are under the jurisdiction of local self-government and unhealthy. This is due to the distribution of water without adequate treatment and disinfection, resulting in microbiologically defective water.

Keywords: monitoring, public water supply, local water supply

ZDENCI-IZVORI ŽIVOTA

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Cilj je ovog rada je prikazati kemijsku i mikrobiološku (bakterije i gljivice) kvalitetu vode iz tri slučajno odabrana zdenaca: Vignjević-Donji Grad, Galić-Nemetin i Mirkovac na području Osječko-baranjske županije, čime bi se dobilo i uvid stanje podzemnih voda koje navodnjavaju istraživane zdence. Za provedbu istraživanja odabrane su brze metode rada. Kemijska analiza vode, kvantitativno određivanje Cl^-,NH_4^+, NO_3^- i NO_2^- iona, te određivanje pH vode provedeno je pomoću Merckovog terenskog laboratorija. Mikrobiološka analiza (bakteriološka i mikološka) provedena je primjenom tri vrste fleksibilnih nosača (contact- slide ili dip slide), kod kojih su s jedne strane podloge za ukupan rast bakterija a s druge strane su selektivne podloge za dokazivanje: bakterija iz por. *Enterobacteriaceae* (VRBG agar), koliformnih bakterija (VRBL agar), te plijesni i kvasaca (Rose Bengal agar). Kultivacija uzoraka vode na mikrobiološkim podlogama obavljena je na 22 °C tijekom dva dana, prije brojanja jedinica za formiranje kolonija (CFU). Rezultati provedenog istraživanja ukazuju da su ukupni broj bakterija, broj bakterije fekalnog onečišćenja i plijesni bili veći od službeno preporučenih/dopuštenih, te stoga voda iz ispitivanih zdenaca nije pogodna za piće. Kemijskom analizom vode dobiveni su zadovoljavajući rezultati, voda iz ispitivanih zdenaca je kemijski prihvatljiva za piće.

Ključne riječi: zdenci, voda, brze metode, kemijska, mikrobiološka, očuvanje okoliša, ioni, bakterije, kvasci, plijesni, agar, fleksibilni nosači Merckov terenski laboratorij

WELLS – SOURCES OF LIFE

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Aim of this research is to reveal chemical and microbiological traits (bacteria and mycota) of water from three randomly selected wells from Osijek-Baranya county (family Vignjević from Donji grad of Osijek, family Galić from Nemetin and a well from Mirkovac, owner unknown). Merck's mobile laboratory was used to determine pH, Cl^-, NH_4^+, NO_3^- and NO_2^- ions in samples of water. Microorganisms present in water samples were cultivated on three various flexible carriers (contact-slide or dip-slide) with two sides: one side with substrate for total growth of bacteria, the other with selective substrates for *Enterobacteriaceae* (VRBG agar), coliform bacteria (VRBL agar), and for molds and yeasts (Rose Bengal agar). Cultivation of water samples on microbiological media was performed at 22 °C for two days, before counting colony forming units (CFU). The results of the research indicate that the total number of bacteria, the number of fecal bacteria and molds was higher than officially recommended / allowed CFU, and therefore the water from the tested wells is not suitable for drinking. Satisfactory results were obtained after chemical analysis of water - water from the tested wells is chemically acceptable for drinking.

Keywords: water well, chemical quality, microbiological quality, drinking water, groundwater

INTERREG DANUBE HAZZARD M3C - MONITORING VODA DUNAVSKOG SLIVA

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Fakultet kemijskog inženjerstva i tehnologije Sveučilišta u Zagrebu sudjeluje na projektu *Danube Hazard m3c* u sklopu *Interreg* programa pod nazivom *Danube Transnational Program*. Voditelj projekta je *Technische Universität Wien, Institute for Water Quality and Resource Management*. Projekt je sufinanciran od strane Europske unije, a ukupna vrijednost projekta iznosi 2.475.349,98 EUR. Trajanje projekta je 01.07.2020.-31.12.2022. Glavni cilj projekta je uspostaviti koherentan i sveobuhvatan pregled stanja voda Dunavskog sliva. Mjerenje, modeliranje i upravljanje prikupljenim podacima temelji su uz pomoć kojih će se poboljšati znanje i razumijevanje vodnog statusa Dunavskog sliva. Uz prikupljanje dostupnih podataka u pojedinoj regiji, na određenim lokacijama se postavljaju i mjerne postaje. U konačnici, svim vodenim tijelima unutar sliva bit će dodijeljen ekološki i kemijski status te će se formirati baza podataka.

Ključne riječi: Interreg, Danube Transnational Program, monitoring voda, Dunavski sliv

INTERREG DANUBE HAZZARD M3C - MONITORING OF WATER IN DANUBE BASIN

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Faculty of Chemical Engineering and Technology of the University of Zagreb participates in Interreg project Danube Hazard m3c project as a part of Danube Transnational Programme. Project leader is Technische Universität Wien, Institute for Water Quality and Resource Management. The project is funded by the European Union and participating countries. The total budget is 2,597,483.94 Euro. Project duration is 01.07.2020.-31.12.2022. The main project goal is to establish coherent and comprehensive overview of the water status in Danube basin. Measurement, modeling and management are three elements of water governance the project is based on. The project aims to achieve a durable and effective transnational control as well as to improve knowledge and understanding of the water status in Danube basin. Available data are collected in each region and measuring stations are set up at certain locations. All water bodies within the basin will be granted ecological and chemical status and a database will be formed.

Keywords: Interreg, Danube Transnational Program, water monitoring, Danube basin

PARAMETRIC STATISTICAL ANALYSIS OF MICROBIOLOGICAL WATER QUALITY INDICATORS

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Many countries including Croatia regularly monitor the microbiological quality of recreational and bathing waters to protect public health. Recreational exposure to polluted water increases the risk of waterborne diseases such as respiratory illness, skin rashes, fever, ear and eye infection. Water quality represents the presence of individual indicators of a particular substance or energy. To test the quality of bathing water, data must be collected through a continuous process of surface water monitoring. One of the most important indicators are microbiological indicators such as a number of colonies of *Escherichia coli* and intestinal enterococci. Testing of bathing water quality was conducted at two lakes in the city of Zagreb (Lake Bundek and Lake Jarun) in period of three years at 19 locations. The aim of this study was to examine the dependence of the number of microbiological indicators (*E. coli* and intestinal enterococci) on sampling points as well as the influence of the season of the year, using the ANOVA statistical method. Results show that there was no significant statistical difference between microbiological parameters observed on different sampling points. This research identified that regular monitoring of microbiological indicators is necessary, especially at locations used by people for recreation or other purpose in order to prevent possible infections.

Keywords: ANOVA, *Escherichia coli*, intestinal enterococci, microbiological indicators, water quality

WATER QUALITY OF THE DRAINAGE CANAL "SVRŽNICA"

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Svržnica is a small lowland drainage canal that flows into the river Bić. To raise public interest in adequately managing water resources, the monitoring of biological, physical, and chemical elements of water quality was carried out, from spring to winter, at four sites of the canal: S1 - a pre-discharged site characterized by the high representation of macrophytes; S2 - immediately after the discharge of municipal wastewaters characterized by the complete absence of macrophytes; S3 - the oak forest site with ruderal plants and poorly represented macrophytes; S4 - at the mouth of the canal into the Bić river, with large macrophyte cover. The water quality was mainly moderate based on physical and chemical elements, with high phosphorus and organic nitrogen load throughout the year of sampling, except on the S1 site. The highest representation of algae was established in late spring at all locations. At the same time, their presence was negligible in other seasons. Indicators of faecal contamination were determined in water samples at S2 and S3, and the microbiological load was more significant in the winter. Screening phytotoxicity tests with *Lemna minor* were conducted using undiluted water samples. Chlorosis, colony structure breakup, and buoyancy loss were noted in all water samples, and the most significant phytotoxicity effect in waters from the S1 site was due to deficient nutrients.

Keywords: surface waters, microbiological load, nutrients, macrophytes, phytotoxicity

DIVERSITY OF EPIPHYTIC MICROPHYTES IN COMMON CARP PONDS

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Microphytes are of great ecological importance and make up the majority of primary producers in aquatic environments. In ponds, their communities can be affected by fertilisation and supplemental feeding, a common management practise in fish farming that reduces pond water. The aim of the study was to investigate the epiphytic microphytes of common reed (*Phragmites australis*) in late autumn in four common carp (*Cyprinus carpio* Linnaeus, 1758) ponds in Donji Miholjac and Grudnjak. At each site, one pond with young-of-the-year and one pond with adult common carps were investigated. The ponds differed in physical and chemical parameters – water depth (0.80 - 2.45 m), dissolved oxygen concentration (3.75 - 12.88 mg/L), ammonium (0.11 - 0.89 mg/L), phosphates (0.15 - 0.78 mg/L), and chlorophyll-a concentration (7.81 to 53.09 µg/L). Water temperature was in accordance with seasonal conditions and similar in all ponds (8.7 - 9.0 °C). Epiphytic communities were diverse (> 100 taxa) and included most taxa from the Bacillariophyceae and Chlorophyta groups in all ponds. Further studies should focus on changes in epiphytic community composition and abundance as a function of season and supplemental feeding applied.

Keywords: cyanobacteria, algae, *Phragmites australis, Cyprinus carpio*

Vodooskrbni sustavi i odvodnja / *Water Supply and Sewage Systems*

UTJECAJ OTOPLJENIH MINERALNIH TVARI NA FIZIKALNO-KEMIJSKA SVOJSTVA PODZEMNIH VODA ZAGREBAČKE ŽUPANIJE

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Izvorišta vode vodoopskrbnih sustava Zagrebačke županije su većim dijelom podzemne vode na području aluvijalne doline rijeke Save (Šibice, Strmec, Velika Gorica), a manjim dijelom koriste se kaptaže na gorskim vodonosnicima (Slapnica i Lipovec na vodoopskrbnom sustavu Samobor, te izvorišta vodoopskrbnog sustava Jastrebarsko i Klinča Sela). Kemijske značajke podzemnih voda ovise o otopljenim plinovima, ionskom sastavu, mikroelementima i prisutnosti organskih tvari. Proučavajući rezultate analiza sirove vode u različitim zonama vodoopskrbe na području Zagrebačke županije uočene su razlike u dominantnim anionima (kloridi i sulfati) kao i različite vrijednosti elektrovodljivosti odnosno različite koncentracije spojeva dušika. Također, u nekim zonama vodoopskrbe detektirane su i značajne koncentracije željeza i mangana. Najveću elektrovodljivost u Zagrebačkoj županiji ima voda u ZO Velika Gorica, dok voda u ZO Pisarovina ima najmanju. Specifičnost geografskog područja i njegovog utjecaja na sastav vode Zagrebačke županije vidi se i pri velikoj razlici vrijednosti elektrovodljivosti na području gradova Sveta Nedelja (≈700 µS/cm) i Samobor (≈450 µS/cm). Koncentracija aniona u podzemnim vodama na području Zagrebačke županije ide od jako niske do jako visoke. Veća koncentracija klorida nalazi se u priobalnim vodonosnicima (ZO Velika Gorica i Strmec). Najveću koncentraciju sulfata i nitrata ima područje grada Sveta Nedelja odnosno Velika Gorica. Također, vrlo značajnu razliku u kemijskom sastavu vode vidimo u prisutnosti NH_4^+ iona na području gradova Vrbovca (ZO Blanje) i Pisarovine, dok je u ostatku županije koncentracija NH_4^+ ispod granice kvantifikacije. Voda iz javne vodoopskrbe na području Zagrebačke županije uglavnom je vrlo dobra.

Ključne riječi: podzemne vode, anioni, metali, elektrovodljivost, amonij

EFFECT OF DISSOLVED MINERALS ON PHYSICOCHEMICAL PROPERTIES OF GROUNDWATER IN ZAGREB COUNTY

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The water sources of the Zagreb County water supply systems are mostly groundwater in the alluvial valley of the Sava river (Šibice, Strmec, Velika Gorica). To a lesser extent, the catchments on mountain aquifers are used (Slapnica and Lipovec, on the Samobor water supply system, and the Jastrebarsko and Klinča Sela). The chemical characteristics of groundwater depend on dissolved gases, ionic composition, trace elements, and the presence of organic matter. Studying the results in different water supply zones in Zagreb County, differences in the dominant anions (chlorides and sulfates) as well as different values of electrical conductivity and different concentrations of nitrogen compounds were observed. Also, significant concentrations of iron and manganese were detected in some water supply zones. The water in Velika Gorica zone has the highest electrical conductivity in Zagreb County, while the water in Pisarovina zone has the lowest. The specificity of the geographical area and its impact on the water composition of Zagreb County can be seen in the difference in the value of electrical conductivity in the nearby cities of Sveta Nedelja (≈700 µS / cm) and Samobor (≈450 µS / cm). The concentration of anions in groundwater in the Zagreb County ranges from very low to very high. Higher concentrations of chloride are found in coastal aquifers (ZO Velika Gorica and Strmec). The area of Sveta Nedelja and Velika Gorica has the highest concentration of sulfates and nitrates. Also, we see a very significant difference in the chemical composition of water in the presence of $NH4^+$ ions in the cities of Vrbovec (ZO Blanje) and Pisarovina, while in the rest of the county the concentration of $NH4^+$ is below the limit of quantification. Water from the public water supply in tagreb County is generally very good.

Keywords: groundwater, anions, metals, electrical conductivity, ammonium

CONTRIBUTION TO INCREASING EFFICIENCY IN THE WATER UTILITY SECTOR - CASE STUDY KOSOVO

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Due to the growing consumption of both energy and water and the growing demands for optimizing the operation of water supply systems, the need to reduce and control water losses and reduce them to the lowest possible levels is becoming more pronounced. The problem of commercial efficiency is present all over the world, especially in countries with a lower level of development. This is also the case with Kosovo, which as a small country with a lower level of development, has serious problems in terms of commercial efficiency. Increasing the efficiency of water supply is associated with the application of best available practices to reduce water losses and improve the level of collection. The average values of water losses in Kosovo range from 49-64 % of the produced (abstracted) water. In addition to high shares of water losses, low collection rates by water utilities are also present in Kosovo and usually range between 67 and 83 %. Improvement is possible through profiling the consumption of large consumers, installing and calibrating high-precision flow and pressure meters, remote and automatic meter reading, pressure management, finding illegal connections, selling overdue debts, and finally replacing worn-out parts of pipe network with new modern pipe materials, etc.

Keywords: commercial efficiency, water losses, pressure management, flow meters, Kosovo water utilities

Močvarna staništa / *Wetlands*

Knjiga sažetaka / *Book of abstracts*
Posterska priopćenja / *Poster presentations*

STANJE ISTRAŽENOSTI VRETENACA (ODONATA) U OSJEČKO-BARANJSKOJ ŽUPANIJI, S POSEBNIM OSVRTOM NA NATURA 2000 VRSTE

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Osječko-baranjska županija se nalazi na krajnjem sjeveroistočnom dijelu Hrvatske i površinom od oko 4155 km^2 prostire se preko nekoliko riječnih slivova (Dunava, Drave, Karašice i Vuke). Vretenca su organizmi koji povezuju vodene i kopnene sustave i značajni su indikatori stanja u okolišu. Na istraživanom području je zabilježeno više od dvije trećine vrsta (66,66 %) vretenaca u odnosu na ukupan broj vrsta u fauni Hrvatske. Analize podataka ukazale su na značajan broj nalaza, ali i nejednoliku vremensku raspodjelu podataka o vretencima na istraživanom području. Većina neistraženog dijela pripada području Slavonskog gorja (Dilj, Krndija) te rubnim dijelovima Vukovarskog ravnjaka na koje buduća istraživanja trebaju biti prvenstveno usmjerena. Glavni je cilj ove cjelovite analize bio pružiti uvid u objavljene, kao i autorski neobjavljene podatke o vretencima Osječko-baranjske županije što predstavlja prvi takav popis vrsta vretenaca na tom području. Rezultati preliminarnih analiza su također pokazali iznimno mali broj nalaza za tri Natura 2000 vrste: *Cordulegaster heros*, *Leucorrhinia pectoralis* i *Ophiogomphus cecilia*. Planirana buduća istraživanja očekivano bi mogla pokazati veći broj lokaliteta za ove tri vrste, kao i otkrića drugih značajnih Natura 2000 vrsta (npr. *Coenagrion ornatum*, *Leucorrhinia caudalis*, *Gomphus flavipes*). Prikazana sinteza će doprinijeti ukupnom poznavanju faune vretenaca Republike Hrvatske pružajući nove nalaze, a time i popunjavanje praznine u općem znanju o stanju faune vretenaca Osječko-baranjske županije.

Ključne riječi: vretenca, indikatori onečišćenja, biološka raznolikost

STATUS OF RESEARCH ON DRAGONFLIES (ODONATA) IN OSIJEK-BARANJA COUNTY, WITH SPECIAL REFERENCE TO NATURA 2000 SPECIES

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Osijek-Baranja County is located in the extreme northeastern part of Croatia and covers an area of about 4155 km2 over several river basins (Danube, Drava, Karašica and Vuka). Dragonflies are organisms that connect aquatic and terrestrial systems and are important indicators of environmental conditions. More than two thirds of dragonfly species (66.66%) were recorded in the study area in relation to the total number of species in the Croatian fauna. Analyzes of the data indicated a significant number of findings, but also an uneven temporal distribution of data on dragonflies in the study area. Most of the unexplored part belongs to the area of the Slavonian Mountains (Dilj, Krndija) and the peripheral parts of the Vukovar plain, to which future research should be primarily focused. The main goal of this comprehensive analysis was to provide insight into published and unpublished data on dragonflies of Osijek-Baranja County, which is the first such list of dragonfly species in the area. The results of preliminary analyzes also showed an extremely small number of findings for three Natura 2000 species: *Cordulegaster heros*, *Leucorrhinia pectoralis* and *Ophiogomphus cecilia*. Planned future research could, as expected, show a larger number of sites for these three species, as well as discoveries of other significant Natura 2000 species (e.g. *Coenagrion ornatum*, *Leucorrhinia caudalis*, *Gomphus flavipes*). The presented synthesis will contribute to the overall knowledge of the dragonfly fauna of the Republic of Croatia by providing new findings, and thus filling the gap in general knowledge about the state of dragonfly fauna of Osijek-Baranja County.

Keywords: dragonflies, pollution indicators, biodiversity

LIFE WILDISLAND – WILD ISLAND HABITAT CORRIDOR

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In the frame of the EU LIFE Programme, the Danube Wild Island Habitat Corridor – LIFE WILDisland project started on 1st of September 2021 and it will last for 72 months. In total, 15 partners from the 8 Danube countries are participating in the project. The main objective of the project is to contribute to the strategic biodiversity objective within the EU Biodiversity Strategy 2030. The specific goal of the project is to maintain, or improve, the favorable conservation status of the target species and habitats of the Danube islands. The target NATURA 2000 habitat type, is a 91E0* flood forest with black alder and white ash (Alno-Pandion, Alnion incanae, Salicion albae). The Danube Islands represent native and autochthonous river and wetland ecosystems of specific flora and fauna. They are the result of the hydrological processes of the Danube and are an indicator of the naturalness of the river. The protection activities include the development of an international regional Ramsar initiative as a form of development of the protection of wetlands and river habitats of the Danube. The DANUBEPARKS association will coordinate and host secretariat of the RRI WILDisland.

Quotations: DANUBEPARKS - Network of Protected Areas - LIFE WILDisland - Danube Wild Island Habitat Corridor (2021-2027), accessed on 22.4.2022

Keywords: Danube, DANUBEPARKS, Wild islands, LIFE

UTJECAJ ODVODNJE NA HIDROLOŠKE PRILIKE U TRESETIŠTU ŽDRALOVAC U LIVANJSKOM POLJU

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Močvarni uslovi u barskom tresetištu Ždralovac u Livanjskom polju uzrokovani su priticajem mineralizovane podzemne vode iz vrela i estavela i njenim zadržavanjem u plitkim depresijama Veliki i Mali Ždralovac. To je pogodovalo razvoju hidrofilne vegetacije šaši i trske od čijih ostataka je i formiran treset. Ljudi su oduvijek isušivali tresetišta za iskopavanje treseta i poljoprivredu što je dovelo do snižavanja nivoa vode. Osnovni cilj ovog istraživanja je analiziranje uticaja odvodnje na hemizam i fluktuaciju nivoa podzemne vode u tresetištu, kao i na vodni bilans Histosola u nedreniranom dijelu tresetišta. Analizom klime evidentiran je trend porasta prosječne godišnje temperature za 1,2 °C na području MS Livno u periodu 1961-2014, dok su padavine nepromijenjene. Kiselost vode je u pH rangu 7,0-8,4 što tresetište svrstava u ekološki tip ekstremno bogato barsko tresetište. Fluktuacije nivoa vode praćene u pijezometrima su pokazale suho dno u ljeto 2011. i u ljeto 2012. godine u trajanju od 45 dana. Poređenje sa hidrološkim podacima prije odvodnje, pokazuje da je u nedreniranom tresetištu nivo podzemnih voda snižen (prosječni ljetni nivo podzemne vode 57-66 cm od površine) a trajanje poplava je smanjeno za tri mjeseca. Analiza vodnog bilansa u Histosolu pokazuje da su viškovi vode evidentni u vlažnom periodu od X-IV mjeseca i iznose 590 mm. Manjak vode je izražen u VII (17 mm) i VIII mjesecu (45 mm).

Ključne riječi: tresetište, odvodnja, nivo podzemne vode, Histosol

INFLUENCE OF DRAINAGE ON HYDROLOGICAL CONDITIONS IN THE ŽDRALOVAC PEATLAND IN LIVANJSKO POLJE

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Wetland conditions in the peatland Ždralovac in Livanjsko polje are caused by the inflow of mineralized groundwater from springs and estavels and its retention in the shallow depressions of Veliki and Mali Ždralovac. This affected the development of hydrophilic vegetation of sedges and reeds, from the remains of which peat was formed. People have always drained peatlands for peat excavation and agriculture which has led to lowering water table levels. The main goal of this research is to analyze the impact of drainage on the chemistry and fluctuations of water table levels in the peatland, as well as on the water balance of Histosol in the undrained part of the peatland. Climate analysis recorded a trend of increasing average annual temperature by 1.2 °C in the area of MS Livno in the period 1961-2014, while precipitation remained unchanged. The acidity of the water is in the pH range of 7.0-8.4, which classifies the peatland as an ecological type of extremely rich fen type peatland. Fluctuations in water levels monitored in piezometers showed a dry bottom in the summer of 2011 and in the summer of 2012 for 45 days. A comparison with hydrological data before drainage shows that the level of water table in the non-drained peatland was reduced (average summer groundwater level 57-66 cm from the surface) and the duration of floods was reduced by three months. Analysis of the water balance in Histosol shows that surplus water is evident in the wet period of X-IV months and amounts to 590 mm. Water deficit was expressed in VII (17 mm) and VIII month (45 mm).

Keywords: peatland, drainage, groundwater level, Histosol

Voda i zdravlje /
Water and Health

SYNTHESIS OF NEW IMIDAZOLIUM AND BENZIMIDAZOLIUM LONG ALKYL-CHAIN IONIC LIQUIDS WITH POTENTIAL ANTIBIOFOULING ACTIVITY

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Development of environmental-friendly antibiofouling compounds is desirable due to concerns on biocides use. Imidazolium and benzimidazolium long alkyl-chain ionic liquids are a class of heterocyclic organic compounds with a wide range of biological activities. A series of imidazolium and benzimidazolium ionic liquids containing long alkyl and polyalkyl chains and different anionic part were prepared in the form of quaternary salts. Using one-step procedure, salts with an alkyl *N*-substituents and Br counter anions were prepared in good yields. The procedure is convenient, mild and generally gives rise to exclusive N-alkylation. In second step bromide anion were substituted with large inorganic anions. Their chemical and spectral properties were briefly discussed. The proposed potential antibiofouling activity will be tested in near future.

Keywords: antibactericides, biofouling, *N*-alkylation, nitrogen heterocycles, quaternary salts

ORGANIC CHEMISTRY IN WATER

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It is an exceptional challenge to perform organic reactions in water. In the last decade, scientific research in the field of water as a green solvent has continued to grow exponentially. Apart from being cheap, water is harmless to the environment and sometimes gives completely unexpected reactivity in reactions. There is a wide range of organic reactions that can take place in water: from common oxido-reduction reactions, reactions involving carbocations and carboanions, pericyclic reactions, transition metal reactions and others. Organic reactions in an aqueous medium are used in the chemistry of carbohydrates and in the chemical modification of biomolecules. More recently, water has been used as a medium in microwave synthesis. It has been proven that water as a solvent, due to its hydrophobic effect, increases the reaction rates and selectivity of the reaction even when the reactants are are sparingly soluble or insoluble in this medium. This review gives an insight into the importance of this field since organic reactions in water as a solvent take place according to the principles of green chemistry. It is interesting to note that unexpected new reactivities of organic reactions were discovered in water. The development of concrete applications of water as a solvent in organic chemistry has great potential for the future development of this area.

Keywords: organic chemistry, reaction in water, enviroment friendly reactions, green chemistry

THE IMPORTANCE OF WATER INTAKE IN EVERYDAY LIFE

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Water is the most important component of human body although without energy value. Its content is variable according to age, gender and body constitution. Adults body composition content of water is generally about 50 – 60 %, and in some cases even 85%. About 65% of water is intracellurar and the rest of it is extracellular. Water is necessary in a great number of metabolic reactions. Daily water intake is very important and there are recommendations for it through the lifespan available from various recognized institutions. The majority of daily water intake is generated from intake of various liquids (80%) and 20% from solid food. Small amount of water (150 ml) is generated as a result of hydrogen oxidation from food. There are also various conesquences of poor water intake.

Keywords: water in human body, daily water intake recommendations, water in metabolism, food water sources, poor water intake

CONTAMINANTS IN DRINKING WATER AND THEIR HEALTH IMPACTS

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Adequate supply of safe drinking water is one of the main prerequisites for a healthy life, but water-borne diseases remain the leading cause of death in many parts of the world, especially in children, and are also a significant economic constraint in many economic lives. The basis on which drinking water safety is assessed are national standards or international guidelines. The most important of these are the World Health Organization (WHO) Guidelines for Drinking Water Quality. Drinking water quality and possible associated health risks vary around the world, and some regions show, for example, high levels of arsenic, fluoride or drinking water pollution by pathogens, while elsewhere they are very low and hassle-free. Marked variations also occur at the local country level due to, for example, agricultural and industrial activities. Lack of coordination, outdated or inadequate policies and regulations, and limited resources for water infrastructure, labor development, and retention create challenges. These problems significantly affect the health of the entire nation and put some communities in a higher position to achieve optimal potential. Vulnerable populations, such as children, the elderly, and low-income populations, carry a greater burden of water-related health problems.

Keywords: water, contamination, heavy metals, bacteria, parasites, viruses, pollutants, health, disease

DATA ANALYSIS FROM EXPERIMENT DESIGN TO ARTIFICIAL NEURAL NETWORKS – APPLICATION IN WATER TREATMENT AND QUALITY CONTROL

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Over the last 20 years, many scientists have had certain theories about the number of experiments and the amount of data needed to successfully test and analyse a certain processes. Design of experiments is a branch of applied statistics which can provide an answer to that question. The importance of a well-designed experiment is significant because the data obtained in that way can be successfully analysed by different statistical methods, optimized or further used in development of artificial neural networks (ANNs) which can help in process monitoring and prediction. The primary aim of this paper was to test the applicability of experiment design on processes which involve different water treatments (flocculation, ozonation). The secondary aim was to determine whether the data obtained from designed experiments can further be used in ANN training, testing and validation. Examples shown in this paper confirm the benefits of experiment design and confirm that ANNs can be successfully used for water treatment process monitoring and control, as well as for prediction of specific responses (targets) defined in the treatment process with high accuracy (the achieved values of R2 for train, test and validation were higher than 0.9 in all presented cases).

Keywords: water treatment, quality control, ANN, experiment design

TVRDA VODA - ZDRAVSTVENI ILI ESTETSKI PROBLEM?

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Crpilište Vinogradi je najveće crpilište na području Republike Hrvatske koje zahvaća pjeskovite aluvijalne vodonosne naslage. Predstavlja izvorište vode za vodoopskrbu grada Osijeka od 25. srpnja 1984. godine, kada je započelo crpljenje vode s navedenog crpilišta. Crpilište ima 18 zdenaca s pojedinačnom crpnom količinom vode od oko 40 l/s. U sklopu vodoopskrbnog sustava Osijek je i vodozahvat Pampas na rijeci Dravi kao rezervno ili dopunsko izvorište, kapaciteta 350 l/s, koje se aktivira u slučaju intervencija na primarnom crpilištu Vinogradi ili u slučaju potrebe za dopunjavanjem razlike između ukupne potrošnje vodoopskrbnog sustava grada Osijeka i zahvaćene količine vode s crpilišta Vinogradi. Tvrdoća vode je parametar kvalitete vode čija je vrijednost u najvećem dijelu ovisi o koncentraciji otopljenih soli magnezija i kalcija prisutnih u vodi. Navedene minerali nužni su za ljudsko zdravlje, stoga visoka tvrdoća ne predstavlja zdravstvenu ugrozu, No, potrošači često negoduju ukoliko voda ima visoku tvrdoću jer visoke koncentracije kalcija i magnezija mogu uzrokovati kvar na kućanskim uređajima (perilice, mlaznice, kuhala, sanitarije). Voda iz vodoopskrbnog sustava grada Osijeka ima tvrdoću od 16 do 20 njemačkih stupnjeva, čime se ubraja u tvrde vode. U ovom radu prikazani su rezultati određivanja tvrdoće osječke vode te utjecaj miješanja podzemne i površinske vode na tvrdoću vode za ljudsku potrošnju. Obrađeni podaci su prikupljeni tijekom rada vodocrpilišta Vinogradi i vodozahvata Pampas u Osijeku.

Ključne riječi: tvrdoća vode, Osijek, voda za ljudsku potrošnju

HARD WATER - HEALTH OR AESTHETIC PROBLEM?

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The Vinogradi is the largest water well field in the Republic of Croatia, composed of sandy alluvial aquifer deposits. It represents the source of water for the water supply system of the Osijek town since July 25, 1984, when water was pumped from the aforementioned pumping station. The water well field has 18 wells with an individual pumping amount of water of about 40 l/s. The town of Osijek also has a possibility of surface water usage by Pampas water pump station which can catch water from the Drava River. This presents a reserve source of water with a capacity of 350 l/s. The pumping station Pampas is usually activated when the water well field Vinogradi is out of usage or in the case when the total consumption of the water increases. Water hardness is a parameter of water quality whose value mostly depends on the magnesium and calcium concentration in the water. The mentioned minerals are necessary for human health, therefore high hardness does not represent a health hazard. However, consumers often complain if the water has high hardness because high concentrations of calcium and magnesium can cause malfunctions in household appliances (washing machines, nozzles, cookers, sanitary ware). Water from the water supply system of the city of Osijek has a hardness of 16 to 20 German degrees, which is considered hard water. This paper presents the results of determining the hardness of Osijek water and the influence of the mixing of underground and surface water on the hardness of water for human consumption. The processed data were collected during the operation of both water pumping stations Vinogradi and Pampas.

Keywords: water hardness, Osijek, water for human consumption

Studentski rad /
Student work

(1. mjesto – Natječaj za najbolji studentski rad na temu Svjetskog dana voda 2022.)

(1st place – Competition for the best student paper on the theme of World Water Day 2022)

Knjiga sažetaka / *Book of abstracts*
Studentski rad / *Student work*

SUVREMENE TEHNOLOGIJE I TRENDOVI U KORIŠTENJU I ZBRINJAVANJU OTPADNOG MULJA S UREĐAJA ZA PROČIŠĆAVANJE OTPADNIH VODA

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U današnje vrijeme, kada je potražnja za vodom u stalnom porastu, nužno je razmatrati pročišćavanje otpadnih voda kao novi nekonvencionalni izvor. Razlog povećanoj potražnje je rast stanovništva koji mijenja postojeće obrasce potrošnje. Prema nekim istraživanjima, očekuje se da će globalna potražnja za vodom nastaviti rasti stopom od oko 1 % godišnje do 2050. godine. Uspoređujući s današnjom potrošnjom, do 2050. godine će doći do povećanja potrošnje vode od 20-30 %. Otpadni mulj je nusproizvod pročišćavanja otpadnih voda. Sastav mulja je složen i čini ga mješavina anorganskih i organskih tvari raspršenih u vodi. U mulju se mogu nalaziti i patogeni mikroorganizmi, virusi, paraziti te drugi toksični elementi i spojevi. Prije nego što se mulj vrati u prirodu potrebno ga je obraditi u skladu s ekološkim i zakonskim regulativama. U ovom radu opisane su suvremene tehnologije i trendovi zbrinjavanja otpadnog mulja nastalog tijekom procesa pročišćavanja otpadne vode. Detaljno su opisana fizikalna, kemijska i mikrobiološka svojstva otpadnog mulja te ključni postupci u obradi i zbrinjavanju Opisano je stanje i načini zbrinjavanja otpadnog mulja u Republici Hrvatskoj te najučinkovitiji primjeri zbrinjavanja otpadnog mulja u pojedinim državama u svijetu.

Ključne riječi: otpadni mulj, pročišćavanje otpadnih voda, obrada i zbrinjavanje mulja

mentor: prof. dr. sc. Mirna Habuda-Stanić

MODERN TECHNOLOGIES AND TRENDS IN THE USE AND MANAGING OF WASTE SLUDGE FROM WASTEWATER TREATMENT PLANT

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Currently, where water demands are in stable increase, it is necessary to consider wastewater treatment as a new source of unconventional resources. Population growth cause the increased demand water and changing consumption patterns. According to some research, global water demand is expected to continue growing with a rate of around 1% per year until 2050. Comparing today's energy consumption, by 2050 there will be an increase in water consumption of 20-30 %. Waste sludge is formed as a by-product of wastewater treatment. The sludge has a complex composition. It is a mixture of inorganic and organic substances which are dispersed in the water. The sludge may also contain viruses, pathogenic microorganisms, parasites and other toxic compounds and elements. Before the sludge returns to nature, it must be treated in accordance with environmental and legal regulations. This paper describes modern technologies and trends in disposal of waste sludge generated during the wastewater treatment process. The physical, chemical and microbiological characteristics of waste sludge are explained in detail, as well as basic procedures in treatment sludge disposal. The currently situation and methods of sludge disposal in Croatia are also described in this paper, as well as the most efficient examples of waste sludge disposal in some world countries.

Keywords: sludge, waste water treatment, sludge managing and disposal

supervisor: Mirna Habuda-Stanić, Full Prof.

Sponzorirana predavanja / *Sponsored lectures*

FOTOKATALITIČKO PROČIŠĆAVANJE ZRAKA

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Fotokatalitičko pročišćavanje zraka je sigurno i ekonomično rješenje za sva područja gdje je potrebno pročistiti zrak. Princip rada se temelji na stvaranju ozona iz kisika u zraku pod djelovanjem UV svjetla. Tako nastali ozon oksidira organske spojeve u zraku, npr. mast, u isto vrijeme uništavaju se bakterije, spore i virusi. Uređaji za fotokatalitičko pročišćavanje zraka mogu se koristiti za pročišćavanje vrućeg zraka zasićenog masnoćama i postojanim mirisom nastalog nakon friteza, linija za prženje i sustava za pušenje, postrojenjima za upravljanje otpadom, uređajima za pročišćavanje otpadnih voda, bazenima za fermentaciju i općenito u industrijskim pogonima. Uređaj za fotokatalitičko pročišćavanje zraka se sastoji od komore sa UV-C lampama, dijela za reakciju, katalizatora (opcija), ventilatora te elektroupravljačkog ormara. Fotokatalitičko pročišćavanje zraka iznimno dobro uklanja organska onečišćenja no ne i amonijak te je stoga potrebno uklanjanje amonijaka prije fotokatalitičkog pročišćavanja – to se odvija skruberom za amonijak: zrak ulazi na dnu skrubera, a voda i kemikalije se protustrujno raspršuju, zbog određene visine skubera stvara se kontaktno vrijeme u kojem se amonijak, kiseline i toksični plinovi otapaju u vodi koja se skuplja na dnu skrubera. Navedena tehnologija ima učinkovitost pročišćavanja zraka do 99,9 %, te zbog modularnog tipa nema ograničenja u smislu količine otpadnog zraka.

Ključne riječi: zrak, fotokatalitičko pročišćavanje, UV svjetlo, ozon, skruber

PHOTOCATALYTIC AIR PURIFICATION

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Photocatalytic air purification is a safe and economical solution for all areas where air purification is required. The principle of operation is based on the formation of ozone from oxygen in the air under the action of UV light. Formed ozone oxidizes organic compounds in the air, e.g., fats, while destroying bacteria, spores and viruses. Photocatalytic air purification devices can be used to purify hot air saturated with grease and persistent odour after fryers, frying lines and smoking systems, waste management facilities, wastewater treatment plants, fermentation basins and in general in industrial plants. The device for photocatalytic air purification consists of a chamber with UV-C lamps, a reaction part, a catalyst (optional), a fan and an electrical control cabinet. Photocatalytic air purification removes organic pollutants very well, but not ammonia, so it is necessary to remove ammonia before photocatalytic purification - this is done with an ammonia scrubber: air enters the bottom of the scrubber, and water and chemicals are sprayed counter currently. Due to the certain height of the scrubber, a contact time is created in which ammonia, acids and toxic gases are dissolve in the water that is collected at the bottom of the scrubber. This technology has an air purification efficiency of up to 99.9%, and due to the modular type, there are no restrictions in terms of the amount of waste air.

Keywords: air, photocatalytic purification, UV light, ozone, scrubber

SUVREMENE I EKOLOŠKE TEHNOLOGIJE DEZINFEKCIJE PITKE VODE - PROIZVODNJA I AUTOMATSKO DOZIRANJE NATRIJ HIPOKLORITA NA MJESTO POTROŠNJE

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HLOROGEN je postrojenje za elektrolitičku proizvodnju klora u obliku otopine natrijevog hipoklorita (NaOCl) na mjestu njegove potrošnje, i to na potpuno siguran način. Sustav je dizajniran tako da omogući potpuno sigurno kloriranje vode, jer se tijekom rada ne stvara plinoviti klor. Proizvodnja otopine natrijevog hipoklorita je jednostavna jer zahtijeva samo sol, omekšanu vodu i struju, pa su operativni troškovi višestruko niži u usporedbi s korištenjem plinovitog klora ili komercijalnog natrijevog hipoklorita. Sustav je automatiziran, zahtijeva minimalno održavanje i jednostavan je za korištenje. Vijek trajanja je 25 godina. Dezinfekcija natrijevim hipokloritom na licu mjesta optimalno je i raširenо rješenje na velikim sustavima kao zamjena za plin klor. Proizvodnja natrijevog hipoklorita na licu mjesta eliminira rizik od transporta i skladištenja klora kao dezinficijensa. Proizvodnja klora na licu mjesta u obliku razrijeđene otopine natrijevog hipoklorita elektrolizom otopine natrijevog klorida, tj. sol. Za proizvodnju otopine natrijevog hipoklorita na licu mjesta treba osigurati otopinu natrijevog klorida, pristupačnu tvar čiji transport i skladištenje nije problem.
Prednosti:
• Jednostavno doziranje, • Sigurno skladištenje, • Učinkovito kao klor, • Daje ostatke dezinficijensa • Može se proizvoditi noću, kada je struja jeftinija • Zbog niske koncentracije aktivne komponente (1%) nisu potrebne posebne mjere zaštite
Postrojenja za dezinfekciju pitke vode koja se nalaze u dijelovima grada s gustom naseljenošću, a u slučaju veće nesreće bio bi ugrožen veliki broj stanovnika i degradiran okoliš.

Ključne riječi: dezinfekcija, voda za ljudsku potrošnju, elektrolitička proizvodnja klora

MODERN AND ECOLOGICAL TECHNOLOGIES OF DRINKING WATER DISINFECTION - PRODUCTION AND AUTOMATIC DOSING OF SODIUM HYPOCHLORITE AT THE SITE OF CONSUMPTION

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HLOROGEN is a plant for the electrolytic production of chlorine in the form of a solution of sodium hypochlorite (NaOCl) at the place of its consumption, and in a completely safe way. The system is designed to enable completely safe chlorination of water, because no chlorine gas is formed during operation. The production of sodium hypochlorite solution is simple because it requires only salt, softened water and electricity, so the operating costs are many times lower compared to the use of chlorine gas or commercial sodium hypochlorite. The system is automated, requires minimal maintenance and is easy to use. The service life is 25 years. Disinfection with on-site sodium hypochlorite is an optimal and widespread solution on large systems as a substitute for chlorine gas. On-site production of sodium hypochlorite eliminates the risk of transporting and storing chlorine as a disinfectant. On-site production produces chlorine in the form of dilute sodium hypochlorite solution by electrolysis of sodium chloride solution, ie salt. Sodium chloride solution, an accessible substance whose transport and storage is not a problem, should be provided on site for the production of sodium hypochlorite solution.
Advantages:
• Easy dosing, • Secure storage, • Effective as chlorine, • Gives residual disinfectant
• Can be produced at night, when electricity is cheap • Due to the low concentration of the active component (1%) no special protection measures are required
Drinking water disinfection plants are located in densely populated parts of the city, and in the event of a major accident, a large number of residents would be endangered and environmental degradation would occur.

Keywords: disinfection, water for human consumption, electrolytic production of chlorine

NEW APPROACH IN MONITORING WATER QUALITY: EDNA DETECTION

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During last few decades several directives were published with the aim of preventing further water quality deterioration and restoring good water status both for freshwaters and seawaters. The ecological status of the water body is calculated based on the biological quality elements (BQE), physico-chemical and hydromorphological quality elements. Evaluation of BQE implies monitoring the presence and the abundance of phytoplankton, phytobenthos, macrozoobenthos, macrophytes and fishes. Traditional monitoring methods, while well-defined and validated, are time-consuming, expensive, and limited by the lack of taxonomical experts. Progress in the area of environmental DNA (eDNA) research, focused on the detection of DNA present in the environment, enables rapid and efficient way of identifying organisms present in the water. There are two approaches: single-species detection using qPCR or ddPCR and multi-species detection using DNA metabarcoding. eDNA methods can be used to detect invasive species and pathogens, detect rare and endemic species, and estimate biodiversity. Company Labena d.o.o. in collaboration with the Institute Ruđer Bošković is working on developing tests for analysis of water quality based on the eDNA. As a part of the project funded by European structural and investment funds Labena d.o.o. established modern laboratory in Zagreb focused on the research and provision of services in the area of environmental DNA.

Keywords: environmental DNA, water quality, metabarcoding, eDNA laboratory

MIHOLJAČKI VODOVOD D.O.O. – PRIMJER RACIONALNOG GOSPODARENJA ENERGIJOM

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Miholjački vodovod d.o.o. distributer je vode za ljudsku potrošnju za 20 naselja u 3 jedinice lokalne samouprave: Grad Donji Miholjac, Općina Magadenovac i Općina Viljevo. Kvalitetu vode u Donjem Miholjcu osigurava tehnologija 21. stoljeća. U procesu pripreme vode za piće primjenjuju se procesi katalitičke filtracije, procesi najnaprednije membranske tehnologije ultrafiltracije te procesi adsorpcije na koloni s aktivnim ugljenom. Navedenom kombinacijom postupaka proizvodi se voda besprijekorne kemijske i mikrobiološke kakvoće te voda koja odgovara zakonskoj regulative. Izgradnja uređaja za pročišćavanje otpadnih voda, kapaciteta 8000 ES, dovršena je 2014. godine pri čemu je ostvareno usklađianje rada uređaja s Direktivom o pročišćavanju komunalnih otpadnih voda te visoka učinkovitost trećeg stupnja pročišćavanja otpadne vode. Racionalno gospodarenje energijom temelj je održivog razvoja i najveći izazov 21. stoljeća. Miholjački vodovod d.o.o. je vlasnik certifikata ISO 50001 od 2017. godine čime je i neovisno potvrđeno racionalno upravljanje energijom. Prva sunčana elektrana ukupne vršne snage 100 kW montirana je na lokaciji vodocprilišta i započela je s radom u ožujku 2020. Druga sunčana elektrana ukupne vršne snage 50 kW montirana je na lokaciji uređaja za pročišćavanje otpadnih voda i započela je s radom u kolovozu 2021. godine. Korištenje električne energije iz sunčanih elektrana bitan je iskorak u smanjenju poslovnih troškova Miholjačkog vodovoda d.o.o. ali i smanjenju emisije ugljičnog dioksida. U 2021. godini od ukupno potrošene električne energije 30 % osigurala je snaga Sunca. Strategija daljnjeg razvoja Miholjačkog vodovoda d.o.o. i nadalje će biti usmjerena na kontinuirano unapređenje proizvoda i usluga jer je to obveza prema korisnicima.

Ključne riječi: prerada vode, vodoopskrba, obnovljivi izvori energije

MIHOLJAČKI VODOVOD D.O.O. – AN EXAMPLE OF RATIONAL ENERGY MANAGEMENT

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Miholjački vodovod d.o.o. is a drinking water supplier for 20 settlements in 3 local self-government units: Town of Donji Miholjac, Municipality of Magadenovac and Municipality of Viljevo. Water quality in Donji Miholjec is ensured by 21st-century technology. Drinking water is obtained by the process treatment combined with catalytic filtration processes, processes of the most advanced ultrafiltration membrane technology, and adsorption processes on a column with activated carbon which ensures that the chemical and microbiological quality of drinking water follows regulations. In July 2014, Miholjački vodovod d.o.o. completed the construction of the wastewater treatment plant, with a capacity of 8,000 ES. By completing its construction, we complied with the Municipal Wastewater Treatment Directive and today the device has the efficiency of the third stage of treatment. Rational energy management is the basis of sustainable development and the biggest challenge of the 21st century. Miholjački vodovod has been the owner of the ISO 50001 certificate since 2017, and with this we have proven that we know how to manage energy. The first solar power plant with a total peak power of 100 kW was installed at the location of the water treatment plant and was put into operation in March 2020. The second solar power plant with a total peak power of 50 kW was installed at the location of the wastewater treatment plant and was put into operation in August 2021. The use of electricity from solar power plants is an important step forward in reducing the business costs of Miholjačko vodovodok, but also in reducing carbon dioxide emissions. In 2021, 30% of the total electricity consumed was provided by the power of the Sun. We will continue to persist in the continuous improvement of products and services because it is an obligation to our users that never ends.

Keywords: water treatment, water supply, renewable energy

LCMS-8060NX - NEW CAPABILITIES OF MASS SPECTROMETRY

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Perfluorooctane sulfonic acid (PFOS) and perfluorooctanoic acid (PFOA) are organofluorine compounds which are chemically stable, and there are concerns about health hazards due to their persistence in the body. For this reason, the production of these substances is restricted internationally by the Stockholm Convention. For water supply, the sum of the amounts of these two components, PFOS and PFOA, was set to 0.00005 mg/L (50 ng/L) as the target value (provisional) for the Complementary Items to Set the Targets for Water Quality Management. With solid-phase extraction as a pretreatment process, this article introduces the analysis results obtained by directly injecting tap water without concentration, using the LCMS8060NX liquid chromatograph mass spectrometer. The LCMS-8060NX is the crowning achievement of Shimadzu's triple quadrupole MS range, inheriting its excellent speed and world-class sensitivity while displaying improvements in robustness and ease-ofuse. Taking into account recent advancements in workflow and increasing demand for cost reductions, key customer needs for LC/MS systems are expanding from sensitivity to robustness, operability and efficiency. This instrument improves efficiency of the overall analysis workflow from analysis preparations to data processing, meeting customer needs through increased productivity.

Keywords: perfluorooctane sulfonic acid (PFOS), perfluorooctanoic acid (PFOA), tap water, LCMS-8060NX, liquid chromatograph mass spectrometer

PROČIŠĆAVANJE TEHNOLOŠKIH OTPADNIH VODA NA PRIMJERU REALIZIRANOG UPOV-A U KONTEJNERSKOJ IZVEDBI

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Tvrtka „BP GROUP d.o.o.“ , lider u pročišćavanju tehnološke otpadne vode i zraka, izrađuje UPOV-e i u kontejnerskoj izvedbi. Tehnološka, strojarska i elektro oprema smješta se u čelične kontejnere. Neke od prednosti ovakve izvedbe uređaja za pročišćavanje su jednostavna i brza montaža te puštanje uređaja u rad na lokaciji, kao i nadogradnja te mogućnost premještanja uređaja s jedne lokacije na drugu. U svrhu pročišćavanja tehnoloških otpadnih voda koriste se fizikalno-kemijski procesi. DAF (eng. Dissolved Air Flotation) je fizikalno-kemijski proces koji koristi tehnologiju otopljenog zraka pod tlakom. Uređaj radi kontinuirano, kapaciteta do 15 m3/h. Fizikalno-kemijski reaktor (FKR) odabire se kada je potrebno pročistiti manju količinu otpadne vode. Uređaj radi šaržno, kapaciteta do 20 m3/dan. U procesima se koriste kemikalije, i to najčešće: koagulant, kemikalije za korekciju pH i flokulant. Primjenom DAF tehnologije pročišćavanja, nastale flokule mulja izdvajaju se na površini vode u uređaju, dok se primjenom FKR-a nastale flokule mulja talože na dno reaktora. UPOV-i izrađeni za „VEMO TRADE d.o.o.“, „EKO PAPIR d.o.o.“ i „POLJOPRIVREDNO DOBRO BUTMIR d.o.o.” samo su tri od mnogobrojnih realiziranih postrojenja za obradu tehnološke otpadne vode u kontejnerskoj izvedbi.

Ključne riječi: tretman otpadnih tehnoloških voda, DAF, fizikalno-kemijski reaktor, kontejnerski sustav

TREATMENT OF TECHNOLOGICAL WASTEWATER ON THE EXAMPLE OF REALIZED WWTP IN CONTAINER DESIGN

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The company "BP GROUP d.o.o.", a leader in the treatment of technological wastewater and air purification, manufactures WWTPs, freestanding and in container design. Technological, mechanical and electrical equipment is placed in steel containers. Some of the advantages of this type of treatment device are simple and fast installation and commissioning of the device on site, as well as upgrading and the possibility of moving the device from one location to another. Physico-chemical processes are used for the purpose of technological wastewater treatment. DAF (Dissolved Air Flotation) is a physico-chemical process that uses dissolved compressed air technology. The device works continuously, capacity up to 15 m3/h. The physico-chemical reactor (FKR) is selected when a small amount of wastewater needs to be treated. The device works in batch, capacity up to 20 m3/day. Chemicals that are most often used in the processes: coagulant, chemicals for pH correction and flocculant. Using DAF treatment technology, the resulting sludge flocs are separated on the surface of the water in the device, while using FKR, the resulting sludge flocs are deposited on the bottom of the reactor. WWTPs made for "VEMO TRADE d.o.o.", "EKO PAPIR d.o.o." and "POLJOPRIVREDNO DOBRO BUTMIR d.o.o." are only three of the many realized technological wastewater treatment plants are in container design.

Keywords: wastewater treatment plant, DAF, physico-chemical reactor, container system

PLASSON U HRVATSKOJ

Zdravko Špoljarić

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Kao službeni zastupnik od 2007. godine za Hrvatsku, Bosnu i Hercergovinu te od 2021. godine i za Crnu Goru, Plasson nudi spojne elemente za kontrole vodovoda, plinovoda i kanalizacije. Plasson svojom vrhunskom kvalitetom i širokim asortimanom zadovoljava sve tehničke kriterije i projektne zadatke garantirajući pri tom sa tvorničkom garancijom u trajanju od 50 godina. Na području Republike Hrvatske, Plasson je najviše prisutan kod javnih poduzeća vodoopskrbe, projekata aglomeracija kao sustavno rješenje pri izgradnji i održavanju vodovodne infrastrukture.

Spojni elementi Plassona dijele se na:
- elektrofuzijske spojnice
- mehaničke spojnice
- push-Fit spojnice

Ugradnjom Plasson spojnica trajno se osigurava kontrola komunalnih infrastrukturnih mreža Vodoopskrbe korištenjem spojnica iz serije push-Fit brzo i trajno rješavaju gubitke vode u mreži osiguravajući pri tome da kvalitetna voda s izvorišta dodje do Vašeg kućanstva. Svojom vrhunskom kvalitetom i visokim standardima proizvodnje, s ponosom možemo reći kako se u 15 godina nije reklamirala niti jedna spojnica, ventil ili bio koji drugi spojni element.

Ključne riječi: Plasson, vodoopskrbni sustavi, održavanje vodoopskrbnog sustava

PLASSON IN CROATIA

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We are the official representative since 2007 for the countries: Croatia, Bosnia an Herzegovina and since 2021. for Montenegro, Plasson offers connecting elements for water, gas and sewage controls. With its top quality and wide range of products, Plasson meets all technical criteria and project tasks, giving a 50-year factory warranty. In the Republic of Croatia, Plasson is most present in public water supply companies, agglomeration projects as a systematic solution in construction and maintenance plumbing infrastructure.

Plasson fittings are divided into:
- electrofusion couplings
- mechanical couplings
- pushFit couplings

The installation of Plasson couplings permanently ensures the control of utility infrastructure networks. Water supply companies using pushFit series couplings is solves quickly and permanently water losses in the network while ensuring that quality water from the source reaches your household unchanged. With our top quality and high standards of production, we are proud to declare that in 15 years not a single coupling, valve or similar has been reported as malfunctioned.

Keywords: Plasson, water supply systems, maintenance plumbing infrastructure

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SUVREMENE I EKOLOŠKE TEHNOLOGIJE DEZINFEKCIJE PITKE VODE - PROIZVODNJA I AUTOMATSKO DOZIRANJE NATRIJ HIPOKLORITA NA MJESTO POTROŠNJE

HLOROGEN je postrojenje za elektrolitičku proizvodnju klora u obliku otopine natrijevog hipoklorita (NaOCl) na mjestu njegove potrošnje, i to na potpuno siguran način.

Sustav je dizajniran tako da omogući potpuno sigurno kloriranje vode, jer se tijekom rada ne stvara plinoviti klor. Proizvodnja otopine natrijevog hipoklorita je jednostavna jer zahtijeva samo sol, omekšanu vodu i struju, pa su operativni troškovi višestruko niži u usporedbi s korištenjem plinovitog klora ili komercijalnog natrijevog hipoklorita.

Sustav je automatiziran, zahtijeva minimalno održavanje i jednostavan je za korištenje. Vijek trajanja je 25 godina.

Dezinfekcija natrijevim hipokloritom na licu mjesta optimalno je i raširenо rješenje na velikim sustavima kao zamjena za plin klor.

Proizvodnja natrijevog hipoklorita na licu mjesta eliminira rizik od transporta i skladištenja klora kao dezinficijensa. Proizvodnja klora na licu mjesta u obliku razrijeđene otopine natrijevog hipoklorita elektrolizom otopine natrijevog klorida, tj. sol.

Za proizvodnju otopine natrijevog hipoklorita na licu mjesta treba osigurati otopinu natrijevog klorida, pristupačnu tvar čiji transport i skladištenje nije problem.

Prednosti:

- Jednostavno doziranje,
- Sigurno skladištenje,
- Učinkovito kao klor,
- Daje ostatke dezinficijensa
- Može se proizvoditi noću, kada je struja jeftinija
- Zbog niske koncentracije aktivne komponente (1%) nisu potrebne posebne mjere zaštite

Postrojenja za dezinfekciju pitke vode koja se nalaze u dijelovima grada s gustom naseljenošću, a u slučaju veće nesreće bio bi ugrožen veliki broj stanovnika i degradiran okoliš.


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2 : 1
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Voda Kristal se puni unutar ekološki zaštićene zone izvorišta, daleko od urbanizacije i industrijalizacije. Direktno sa izvora voda prelazi na automatsku proizvodnu liniju u kojoj je učešće čovjeka i mogućnost greške svedeno na najmanju mjeru zahvaljujući dosljednom sprovođenju sistema upravljanja kvalitetom i sigurnošću proizvoda u skladu sa zahtjevima standarda ISO 9001 i HACCP. U ovom procesu se ne primjenjuje bilo kakav tretman koji bi izmijenio prirodni sastav vode, a garancija toga je osnivač i idejni tvorac fabrike vode Kristal, prof. dr. Sabit Begić.

VODA KRISTAL 0.5 L - idealno rješenje za održavanje vitalnosti tokom cijelog dana, u svakoj prilici i za sve uzraste
VODA KRISTAL 2 L - donosi istinski doživljaj prirode, bilo kada i bilo gdje
VODA KRISTAL 5 L - namijenjena za potrebe domaćinstva; karakterističan dizajn boce omogućava držanje proizvoda na polici frižidera
VODA KRISTAL 15 L - namijenjena za aparate za istakanje vruće ili hladne vode, kod kuće ili na poslu
VODA KRISTAL 18.9 L - namijenjena poslovnim korisnicima dostave vode Kristal; jedna boca daje još više osvježenja i traje duže

VODA KRISTAL