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TwiNS-I-CECs

UNIVERSITY OF NOVI SAD
FACULTY OF
TECHNOLOGY
NOVI SAD

Twinning for enhancing the scientific excellence of Faculty of Technology Novi Sad for innovative solutions to protect environmental resources from contaminants of emerging concern

Povezivanje radi unapređenja naučne izvrsnosti Tehnološkog fakulteta Novi Sad u inovativnim rešenjima zaštite resursa životne sredine **od emergentnih zagađujućih supstanci**

Novi Sad, 2025.

UNIVERZITET U NOVOM SADU
TEHNOLOŠKI
FAKULTET
NOVI SAD

TwiNSol-CECs: Horizon Europe Twinning Project for Advancing Environmental Research at the Faculty of Technology Novi Sad, Serbia

TwiNSol-CECs is a project funded by the European Commission under the Twinning Western Balkans call, as part of the Horizon Europe program - the EU's largest research and innovation funding program. The project consortium is led by the Faculty of Technology Novi Sad (FoTNS) in collaboration with two prestigious partner institutions: the Institute of Environmental Assessment and Water Research of the Spanish National Research Council (Barcelona, Spain) and NOVA University Lisbon (Lisbon, Portugal).

Primary goal of the project:

- advancing the scientific and innovative excellence of FoTNS in various aspects of research on Contaminants of Emerging Concern (CECs), by integrating the Faculty into broader European networks of excellence to contribute to national and regional scientific and economic growth and well-being, as well as harmonization of advanced research and innovation efforts within the European Research Area - key to Europe's accelerated and sustainable transition of whole Europe foreseen by European Green Deal (EGD) towards zero-pollution, toxic free environment

TwiNSol-CECs: Horizon Europe Twinning projekat za **unapređenje** istraživanja u oblasti zaštite životne sredine na Tehnološkom fakultetu Novi Sad, Srbija

TwiNSol-CECs je projekat finansiran od strane Evropske komisije u okviru poziva *Twinning Western Balkans*, kao deo programa *Horizon Europe* – najvećeg programa EU za finansiranje istraživanja i inovacija. Konzorcijum projekta predvodi Tehnološki fakultet Novi Sad (TFNS) u saradnji sa dve prestižne partnerske institucije: Institutom za dijagnostiku stanja životne sredine i analizu vode - Španskog nacionalnog saveta za istraživanja (Barselona, Španija) i NOVA Univerzitetom u Lisabonu (Lisabon, Portugalija).

Primarni cilj projekta:

- unapređenje naučne i inovacione izvrsnosti TFNS u različitim aspektima istraživanja zagađujućih supstanci koje izazivaju posebnu zabrinutost, tzv. emergentnih zagađujućih supstanci (EZS, na engleskom skraćeno CECs), integrisanjem u šire evropske mreže izvrsnosti, radi doprinosa nacionalnom i regionalnom naučnom i ekonomskom razvoju, kao i usklađivanja naprednih istraživačkih i inovacionih aktivnosti u Evropskom istraživačkom prostoru – ključnih za ubrzanu i održivu tranziciju Evrope ka okruženju bez zagađenja i toksičnih supstanci, u skladu sa Evropskim zelenim dogovorom.

SPECIFIC GOALS

- Improving the scientific visibility and attractiveness of FoTNS in the field of CECs research
- Intensifying proactive interaction between FoTNS researchers and various stakeholders for the successful implementation of scientific results
- Enhancing the excellence of FoTNS in advanced environmental protection research
- Strategic networking of FoTNS with leading research institutions in the EU
- Developing sustainable capacities in the management and administration of FoTNS research projects

SPECIFIČNI CILJEVI

- Unapređenje naučne vidljivosti i atraktivnosti TFNS u oblasti ispitivanja EZS
- Inteziviranje proaktivne interakcije istraživača TFNS sa različitim zainteresovanim akterima radi uspešne implementacije naučnih rezultata
- Podizanje nivoa izvrsnosti TFNS u oblasti naprednih istraživanja zaštite životne sredini
- Strateško umrežavanje TFNS sa vodećim istraživačkim institucije u EU
- Razvoj održivih kapaciteta menadžmenta i administracije istraživačkih projekata TFNS

Why CECs?

Hundreds of thousands of substances are used daily worldwide across various sectors, often unintentionally and/or uncontrollably entering the environment. In contrast, only a few dozen to a few hundred chemicals are monitored under standard regulatory frameworks. This discrepancy underscores the urgent need for a more comprehensive approach to chemical monitoring and environmental assessment. Unmonitored and unregulated chemicals in the environment fall into the category of Contaminants of Emerging Concern (CECs) - a term encompassing various classes of substances, including pharmaceutically active compounds, pesticides, per- and polyfluorinated alkyl substances (PFAS), UV filters, antioxidants, anticorrosive agents, microplastics, and more. Their presence in natural resources, even at trace levels, raises concerns about potential ecological and human health impacts. Current research efforts worldwide in this field are focused on the development and standardization of so-called "non-targeted" analytical methods and advanced water purification technologies, such as adsorption-based processes, membrane technologies, and oxidation techniques. The surveillance of CECs and the advancement of removal technologies play a crucial role in protecting human health and environmental resources.

These efforts align with the European Green Deal (EGD) commitment to transitioning the EU toward a zero-pollution, toxic-free environment. They also support the 2030 Agenda for Sustainable Development, contributing to the UN's Sustainable Development Goals (SDGs), particularly SDG 3 (Good Health and Well-being), SDG 6 (Clean Water and Sanitation), SDG 11 (Sustainable Cities and Communities), SDG 12 (Responsible Consumption and Production), SDG 13 (Climate Action), and SDG 14 (Life Below Water).

Zašto EZS?

Stotine hiljada supstanci koje se svakodnevno koriste širom sveta u različitim sektorima, često nenamerno i/ili nekontrolisano dospevaju u životnu sredinu. Nasuprot tome, sadržaji samo nekoliko desetina do nekoliko stotina hemikalija prate se u okviru standardnih regulatornih okvira i istraživačkih monitoring šema. Ova nesrazmera ukazuje na hitnu potrebu za sveobuhvatnijim pristupom monitoringu hemikalija i proceni stanja životne sredine. Nekontrolisane i neregulisane hemikalije u životnoj sredini spadaju u kategoriju **zagađujućih supstanci koje izazivaju posebnu zabrinutost** (EZS) - termin koji obuhvata različite klase supstanci, uključujući farmakološki aktivna jedinjenja, pesticide, per- i polifluorovane alkil supstance (PFAS), UV filtere, antioksidanse, antikorozivne agense, mikroplastiku i druge. Njihovo prisustvo u prirodnim resursima, čak i u tragovima, izaziva zabrinutost zbog mogućih ekoloških i zdravstvenih posledica. Praćenje EZS i unapređenje tehnologija za njihovo uklanjanje igraju ključnu ulogu u zaštiti zdravlja ljudi i prirodnih resursa. Aktuelni istraživački napori u svetu u ovoj oblasti baziraju se na razvoju i standardizaciji tzv. „neciljanih" analitičkih metoda i naprednih tehnologija prečišćavanja vode, poput postupaka na bazi adsorpcije, membrana, oksidacije. Ovi napori su usklađeni sa Evropskim zelenim dogovorom (EGD), koji ima za cilj prelazak EU ka okruženju bez zagađenja i toksičnih supstanci.

Takođe, doprinose Agendi 2030 za održivi razvoj, podržavajući ciljeve održivog razvoja (SDGs) Ujedinjenih nacija - posebno SDG 3 (Zdravlje i blagostanje), SDG 6 (Čista voda i sanitarni uslovi), SDG 11 (Održivi gradovi i zajednice), SDG 12 (Odgovorna potrošnja i proizvodnja), SDG 13 (Klimatska akcija) i SDG 14 (Život ispod vode).

The study on various aspects of CECs is of particular importance for Serbia and Western Balkans region because of the following reasons:

- regional water resources are relatively substantial;
- urban wastewater treatment plants generally are missing;
- only 5% of industrial wastewater undergoes the full 3-stage treatment;
- agricultural production is very important economic sector, while irrigation water is often supplied from surface water systems,
- the wide-range CECs' distribution in the regional environmental resources is largely unknown or only based on target analysis of pre-selected (generally limited) set of compounds.

Proučavanje različitih aspekata EZS od posebnog je značaja za Srbiju i region Zapadnog Balkana iz sledećih razloga:

- Regionalni vodni resursi su relativno značajni;
- Postrojenja za prečišćavanje komunalnih otpadnih voda uglavnom nedostaju;
- Samo 5% industrijskih otpadnih voda se prečišćava kroz 3 faze;
- Poljoprivredna proizvodnja je važan ekonomski sektor, a voda za navodnjavanje se često obezbeđuje iz površinskih voda;
- Rasprostranjenost EZS u regionalnim prirodnim resursima u velikoj meri nije poznata ili je bazirana na podacima ciljane analize unapred odabranog (uglavnom ograničenog) skupa jedinjenja.

TwiNSol-CECs CONSORTIUM

TwiNSol-CECs KONZORCIJUM

Coordinating institution

Koordinatorska institucija

University of Novi Sad, Faculty of Technology Novi Sad (FoTNS) is founded in 1959 and its aim is to provide academic education for fundamental and applied investigations in food, chemical, biotechnological, pharmaceutical, and material engineering. Being situated in Novi Sad, the administrative center of the Vojvodina Province, known as the main Serbian area for agriculture, food, and oil-petrochemical industries, FoTNS positioned itself as a confident partner for numerous industry players and innovations in these domains. Within the University, FoTNS is the leading autonomous entity with the highest number of published papers in international SCI journals per researcher. Numerous national, international (HORIZON/FP, IPA, TEMPUS, COST, etc), and bilateral projects have been run and/or coordinated by FoTNS.

Univerzitet u Novom Sadu, Tehnološki fakultet Novi Sad (TFNS) osnovan je 1959. godine s ciljem pružanja akademskog obrazovanja za fundamentalna i primenjena istraživanja u oblasti prehrambenog, hemijskog, biotehnološkog, farmaceutskog i inženjerstva materijala. Smešten u Novom Sadu, administrativnom centru Autonomne Pokrajine Vojvodine, poznatom po razvijenoj poljoprivredi, prehrambenoj i naftno-petrohemijskoj industriji, TFNS se pozicionirao kao pouzdan partner za brojne industrijske aktere i inovacije u ovim oblastima. Unutar Univerziteta, TFNS je vodeća autonomna jedinica sa najvećim brojem objavljenih radova u međunarodnim SCI časopisima po istraživaču. TFNS je rukovodilac i učesnik u brojnim nacionalnim, međunarodnim (HORIZON/FP, IPA, TEMPUS, COST itd.) i bilateralnim projektima.

Before TwiNSol-CECs, FoTNS proved the capacities in several preliminary monitoring studies of different trace contaminants in the environment and food, including target (UHPLC-MS/MS) analysis of compounds to contaminants of emerging concern (CECs), as well as in the application of novel and/or green approaches in contaminants removal technologies.

TwiNSol-CECs project has established a collaborative framework enabling FoTNS to enhance its research capacities on CECs within the European Research Area. By partnering with two eminent and EU research-intensive institutions renowned for their achievements in innovative solutions for sustainable development and environmental protection, the project strengthens FoTNS's scientific profile and its position at the international level.

Pre projekta TwiNSol-CECs, TFNS je potvrdio svoje kapacitete kroz preliminarna istraživanja tragova različitih zagađujućih supstanci u životnoj sredini i hrani, uključujući ciljano (UHPLC-MS/MS) određivanje sadržaja jedinjenja koja pripadaju zagađujućim supstancama od posebnog interesa (CECs), kao i primenu inovativnih i ekološki prihvatljivih metoda za uklanjanje kontaminenata.

Projekat TwiNSol-CECs uspostavio je okvir saradnje koji omogućava TFNS da unapredi svoje istraživačke kapacitete u oblasti ovih istraživanja unutar Evropskog istraživačkog prostora. Povezivanjem sa dve eminentne, istraživački intenzivne institucije iz EU, poznate po dostignućima u inovativnim rešenjima za održivi razvoj i zaštitu životne sredine, projekat jača naučni profil TFNS i njegovu poziciju na međunarodnom nivou.

Partner institutions

Spanish National Research Council (CSIC), Institute of Environmental Assessment and Water Research (IDAEA)

IDAEA, located in Barcelona, is part of CSIC - the largest public research institution in Spain, the third in Europe, and one of the most renowned institutions in the European Research Area (ERA). CSIC is an environmental science institute devoted to the study of the human footprint on the biosphere. Much of the research at IDAEA is centered on two of the great environmental challenges of our time: the cleanliness and availability of water and the quality of air, guided by the principle that scientific understanding of current threats to global ecosystems is best approached from a holistic, systems-based viewpoint. Recently awarded with the distinctive Centre of Excellence “Severo Ochoa” (2020-2023), this distinction shows the high-quality scientific leadership and global impact of the work developed at CSIC. The institute has demonstrated outstanding strengths in the study of organic pollutants, in particular emerging contaminants, the study and management of water resources, food, the study of inhalable particulate matter, toxic gases and environmental health.

TwiNSoI-CECs (CSIC) Project Manager / Menadžer projekta TwiNSoI-CECs sa CSIC: Dr. Marinella Farre, WP3 and WP4 leader / rukovodilac radnog paketa 3 i 4, https://orcid.org/0000-0001-8391-6257

NOVA University of Lisbon, NOVA School of Science and Technology (UNL)

UNL stands out in the main international rankings; it is ranked in the top 9 in Europe in the QS World University Rankings 2021 among universities founded less than 50 years ago. In 2021, UNL was the Portuguese institution whose scientific articles have the highest impact on a global scale (12.6% of all scientific output in the top 10% of the most cited publications). The NOVA School of Science and Technology has vast experience in research development and innovation due to its multidisciplinary nature and investment in fundamental and applied research in diverse areas (e.g. materials, environment, biotechnologies, IT technology, circular economy). The research activity of the School is recognized by the European Research Council (ERC); until now it has obtained 9 ERC scholarships, which attests to the School’s involvement in cutting-edge international research.

TwiNSoI-CECs (UNL) Project Manager / Menadžer projekta TwiNSoI-CECs sa UNL: Prof. Joao Crespo, WP2 and WP5 leader / rukovodilac radnog paketa 2 i 5, https://orcid.org/0000-0001-8714-3781

Partnerske institucije

Španski nacionalni istraživački savet (CSIC), Institut za procenu stanja životne sredine i istraživanje voda (IDAEA)

IDAEA sa sedištem u Barseloni, deo je CSIC, najveće javne istraživačke institucije u Španiji, treće po veličini u Evropi i jedne od najuglednijih institucija u Evropskom istraživačkom prostoru. CSIC je institut posvećen nauci o životnoj sredini i proučavanju uticaja ljudskih aktivnosti na biosferu. Istraživanja na IDAEA su usmerena na dva ključna ekološka izazova današnjice: kvalitet i dostupnost vode i kvalitet vazduha, pri čemu se koristi holistički, sistemski pristup. IDAEA je nosilac prestižne nagrade Centar izvrsnosti „Severo Ochoa” (2020-2023), što potvrđuje visok nivo naučnog liderstva i globalni uticaj istraživanja koja sprovodi. Institut se ističe istraživanjima organskih zagađujućih supstanci, posebno emergentnih polutanata, kao i u oblasti upravljanja vodnim resursima, analize hrane, čestica udisajnog aerosola, toksičnih gasova i ekološkog zdravlja.

NOVA Univerzitet iz Lisabona, NOVA Fakultet za nauku i tehnologije (UNL)

UNL zauzima visoku poziciju na međunarodnim rang-listama, s obzirom da se nalazi među 9 najboljih univerziteta u Evropi osnovanih pre manje od 50 godina (QS World University Rankings 2021). UNL je 2021. godine bio portugalska institucija sa najvećim globalnim uticajem naučnih radova (12,6% svih publikacija nalazilo se u top 10% najcitiranijih na svetu). NOVA Fakultet za nauku i i tehnologije ima bogato iskustvo u razvoju istraživanja i inovacija zahvaljujući svojoj multidisciplinarnosti i ulaganju u fundamentalna i primenjena istraživanja u različitim oblastima, uključujući materijale, životnu sredinu, biotehnologije, IT tehnologiju i cirkularnu ekonomiju. Istraživačka aktivnost ovog fakulteta priznata je i od strane Evropskog istraživačkog saveta; do sada je Fakultet osvojio 9 ERC stipendija, što potvrđuje njegovo angažovanje u međunarodnim istraživanjima na najvišem nivou.

How TwiNSol-CECs Elevates Scientific and Innovative Excellence at FoTNS in the Field of CECs Research

Analytical Upgrades

•UHPLC-HRMS was enhanced with specialized software for non-target screening, enabling Serbia's first-ever suspect screening analyses

•GC-MS was equipped with a pyrolytic unit, opening new possibilities for qualitative analysis of solid materials like biochar and microplastics extracted from water.

Strengthening Research Capacity

•Intensive trainings with with top-tier partner institutions gained FoTNS researchers the hands-on experience and new skills

•Comprehensive CECs analysis has been conducting for the first time in Serbia, including wide-scope and suspect screening analyses on Serbian water samples to better understand the presence, risks, and regulatory needs related to CECs.

•Advanced water treatments were investigated for simultaneously removal of multiple CECs from water, including membrane-based technologies, sustainable biomaterials such as lignocellulosic biomass, lignin, biochar, and hydrochar, and innovative purification techniques such as combining biochar/hydrochar with advanced oxidation and enzyme-based processes to enhance the elimination of CECs from wastewater

Promoting Knowledge Exchange and Networking

•Organization of international scientific events at FoTNS (3 workshops, 2 summer schools, and a final project conference) has positioned the Faculty as an active and accessible platform for collaboration, knowledge sharing, and idea exchange in the field of CECs research

Building International Research Bridges

•FoTNS is strengthening its scientific impact through collaborations with world-leading research institutions such as CSIC (Spain) and UNL (Portugal), by co-authoring Open Access publications and submitting joint research project proposals; contacts established during project dissemination activities with renowned research groups involved in other European projects further contribute to the Faculty's networking, its inclusion in new international consortia, and the harmonization of its research activities within the European Research Area (ERA).

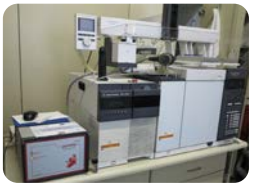
These activities confirm FoTNS as a modern and strategically important regional research center, ready to address the most current challenges related to the presence of CECs in the environment.

Kako TwiNSol-CECs **unapređuje naučnu** i inovativnu izvrsnost TFNS u oblasti istraživanja EZS

Nadogradnja **analitičkih** instrumenata

•UHPLC-HRMS je unapređen specijalizovanim softverom za „neciljano“ ispitivanje, čime je omogućeno prvo ispitivanje „pretpostavljeno prisutnih“ jedinjenja (engl. *suspect screening*) u Srbiji.

•GC-MS je opremljen pirolitičkom jedinicom, otvarajući nove mogućnosti za kvalitativnu analizu čvrstih materijala poput biouglja i mikroplastike izdvojenih iz vode.

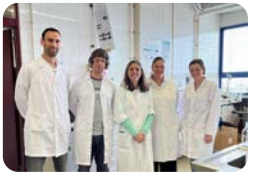


Jačanje istraživačkih kapaciteta

•Zahvaljujući intenzivnim obukama u saradnji sa vodećim partnerskim institucijama, istraživači TFNS stekli su praktična znanja i veštine u naprednim analitičkim tehnikama.

•Po prvi put u Srbiji, sprovodi se sveobuhvatna analiza EZS, uključujući široko obuhvatni i *suspect screening* uzoraka vode, sa ciljem boljeg razumevanja njihove prisutnosti, potencijalnih rizika i potreba za regulacijom.

•Istražuju se napredne metode prečišćavanja vode, uključujući membranske tehnologije, primenu biomaterijala (lignocelulozna biomasa, lignin, biougalj, hidrougalj), inovativne metode prečišćavanja – kombinacija biouglja/hidrouglja sa oksidacionim i enzimskim procesima za efikasno uklanjanje EZS iz otpadnih voda.



Podsticanje razmene znanja i umrežavanja

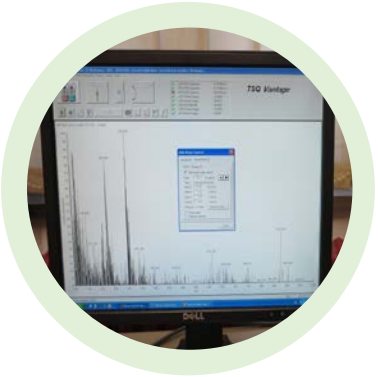
Organizacijom međunarodnih naučnih događaja na TFNS, tri radionice, dve letnje škole i međunarodne konferencije, Fakultet se pozicionirao kao dinamična i otvorena platforma za saradnju, razmenu znanja i ideja u oblasti istraživanja EZS.

Izgradnja **međunarodnih istraživačkih** mostova

TFNS jača svoj naučni uticaj kroz saradnju sa vodećim svetskim institucijama, poput CSIC (Španija) i UNL (Portugal), kroz zajedničke naučne radove otvorenog pristupa, prijave zajedničkih projekata; kontakti uspostavljeni tokom projektnih diseminacionih aktivnosti sa renomiranim istraživačkim grupama uključenim u druge evropske projekte, doprinose daljem umrežavanju Fakulteta, njegovom uključivanju u nove međunarodne konzorcijume i tako harmonizaciji istraživačkih aktivnosti u okviru Evropskog istraživačkog prostora (ERA).

Ove aktivnosti **potvrđuju** TFNS kao savremen i strateški važan regionalni **istraživački** centar, spreman da odgovori na najaktuelnije izazove vezane za prisustvo EZS u životnoj sredini.

TwiNSol-CECs RESEARCH GROUP ON TARGETED AND NON-TARGET ANALYSIS OF CECs

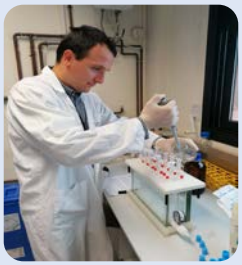


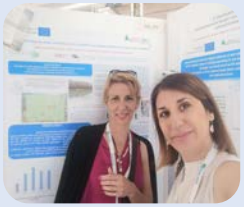
The FoTNS research group dedicated to the analysis of environmental samples based on different mass spectrometric detection of micropollutants, is included in all research sub-projects within TwiNSol-CECs, performing the wide-range target monitoring and suspect screening of CECs in samples of surface water, soil, and crops, as well as of model water treated with membrane-based processes and biomaterials.

The researchers within this group have validated and applied appropriate sample preparation methods in order to extract different classes of CECs, optimized and validated parameters of high-performance liquid chromatography coupled with tandem mass spectrometry (UHPLC-MS/MS) for targeted quantification of pre-selected wide range set of CECs, as well as parameters of UHPLC with high-resolution mass spectrometry (HRMS) for suspected screening analysis (SSA) of the CECs presence, including their transformation products, in order to track the presence of hundreds of compounds available in online and offline databases. Primarily pharmaceutically active compounds, pesticides in current use, selected industrial chemicals, and per- and polyfluoroalkyl substances (PFAS), have been analyzed. The validated analytical methods based on UHPLC-MS/MS and UHPLC-HRMS have been used for assessing the efficiency of water treatments applied in the project (membrane-based processes, advance oxidation and enzymatic processes, adsorption experiments) and for the wide-range monitoring of CECs in environmental samples.

TwiNSol-CECs partner institution, CSIC-IDAEA, transferred knowledge and practical skills to researchers in this group through training sessions on advanced instrumental analysis of CECs organized either at IDAEA under supervision of Dr. Marinella Farre or TFNS. Additionally, they have collaborated on the project research investigating the presence of CECs in surface water samples from northern Serbia.

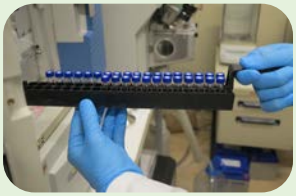
Through the project, upgrade of UHPLC-HRMS measurement was carried out with the purchase of dedicated vendor software for SSA of CECs and a computer of powerful configuration to support the efficient application of this software. Moreover, the existing gas chromatographic system with MS detection was upgraded with pyrolytic unit for qualitative analysis of solid samples, including microplastics particles found in water and biomaterials.





TwiNSol-**CECs ISTRAŽIVAČKA GRUPA ZA CILJANU** i NECILJANU ANALIZU CECs

TFNS **istraživačka** grupa **posvećena** analizi uzoraka životne sredine, zasnovanoj na **različitim** masenim spektrometrijskim tehnikama za detekciju mikropolutanta, **uključena** je u sve **istraživačke** potprojekte u okviru projekta TwiNSol-CECs. Ova grupa sprovodi ciljani široko-opsežni monitoring i tzv. *suspect screening* analizu prisustva emergentnih **zagađujućih** supstanci u uzorcima površinskih voda, zemljišta i useva, kao i u modelnim uzorcima vode tretiranim membranskim procesima i biomaterijalima.



Istraživači unutar ove grupe su validovali i primenili odgovarajuće metode pripreme uzoraka vode, zemljišta i useva radi ekstrakcije različitih klasa EZS, optimizovali i validovali parametre tečne hromatografije visokih performansi u sprezi sa tandem masenom spektrometrijom (UHPLC-MS/MS) za ciljanu kvantifikaciju unapred odabranog širokog spektra EZS, kao i parametre sistema UHPLC i masenog selektivnog detektora visoke rezolucije (HRMS) za tzv. *suspect screening* analizu (SSA) prisustva EZS i njihovih produkata transformacije. Ovim pristupom omogućeno je praćenje prisustva stotina jedinjenja dostupnih u *online* i *offline* bazama podataka. Analizirani su prvenstveno farmaceutski aktivni spojevi, pesticidi koji su trenutno u upotrebi, neke industrijske hemikalije, kao i per- i polifluoralkilne supstance (PFAS). Validirane analitičke metode zasnovane na UHPLC-MS/MS i UHPLC-HRMS primenjene su za procenu efikasnosti tretmana vode korišćenih u okviru projekta (membranski procesi, napredni oksidacioni i enzimski procesi, adsorpcioni eksperimenti), kao i za monitoring EZS u uzorcima životne sredine.

Tokom projekta, unapređena je UHPLC-HRMS analitička oprema nabavkom specijalizovanog softvera za SSA analizu, kao i računara visokih performansi za efikasnu primenu ovog softvera. Takođe, postojeći gasno-hromatografski sistem sa MS detekcijom nadograđen je pirolitičkom jedinicom za kvalitativnu analizu čvrstih uzoraka, uključujući mikroplastiku iz uzoraka vode i biomaterijale.

Partnerska institucija TwiNSol-CECs projekta - CSIC-IDAEA, učestvovala je u prenosu znanja i praktičnih veština istraživačima u ovoj grupi kroz obuke u oblasti primene napredne instrumentalne analize EZS, koje su bile organizovane u laboratorijama IDEAE pod supervizijom Dr. Marinella Farre i TFNS. Pored toga, zajedno sprovode istraživanje prisustva EZS u uzorcima površinskih voda sa područja severne Srbije.

TwiNSol-CECs RESEARCH GROUP ON MEMBRANE SEPARATION PROCESSES IN CECs REMOVAL

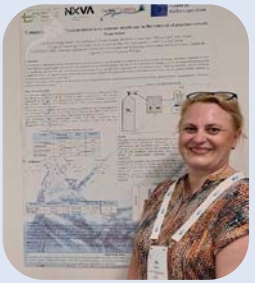
Within the TwiNSol-CECs project, this group aims to identify the best operating conditions and membranes for effective removal of CECs from various water samples by advanced membrane processes, such as nanofiltration and reverse osmosis.

Main goals of the research group within the project are to:

- Evaluate impact of operating parameters, membrane properties, and CECs properties on nanofiltration and reverse osmosis efficiency,
- Provide valuable information regarding removal mechanisms, and
- Contribute to the industrial scale application of advanced membrane processes for contaminants removal.

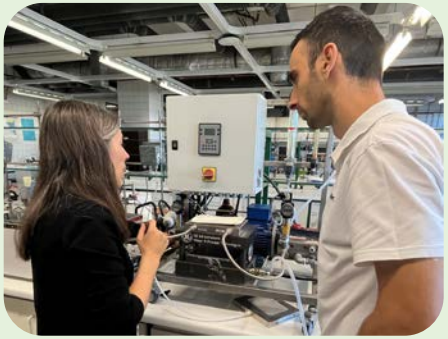
Through the TwiNSol-CECs project, this research group acquired both lab scale equipment (METcell® dead-end system) and upgraded a pilot scale equipment for membrane processes. The METcell® dead-end system enables lab-scale optimization of key parameters for effective CEC removal. It helps define optimal membrane characteristics and water properties, essential for scaling up membrane separation processes. Originally designed for micro- and ultrafiltration, the upgraded pilot-scale unit now supports high-pressure nanofiltration and reverse osmosis. With spiral wound membranes, it processes large water volumes and remains easily transportable. This unit will further support the scale-up of METcell®-based findings.

Within the TwiNSol-CECs project, the efficiency of nanofiltration and reverse osmosis for CECs removal was tested using six membranes in both dead-end and crossflow configurations, across three different pH values. Majority of tested CECs were successfully removed (removal over 90%) from water samples, with operating conditions and membrane properties playing a crucial role in the overall removal efficiency. The membrane-based experiments within the project were performed together with colleagues from NOVA University of Lisbon, supervised by Prof. Joao Crespo.



TwiNSol-**CECs ISTRAŽIVAČKA GRUPA ZA PRIMENU MEMBRANSKIH PROCESA U UKLANJANJU** EZS

U okviru TwiNSol-CECs projekta, ova **istraživačka** grupa se bavi identifikacijom najboljih operativnih uslova i membrana za efikasno uklanjanje EZS iz **različitih** uzoraka vode primenom naprednih membranskih procesa, kao što su nanofiltracija i reverzna osmoza.



Glavni ciljevi u okviru projekta su:

- Procena uticaja operativnih parametara, svojstava membrana i svojstava EZS na efikasnost nanofiltracije i reverzne osmoze,
- Dobijanje važnih informacija vezanih za mehanizme uklanjanja EZS, i
- Doprinos primeni naprednih membranskih procesa na industrijskom nivou za uklanjanje EZS.

Kroz TwiNSol-CECs projekat, nabavljena je laboratorijska oprema za membranske procese (METcell® ,,dead-end'' uređaj) i unapređen je pilot uređaj za membranske procese. METcell® uređaj omogućava laboratorijsku optimizaciju ključnih parametara za efikasno uklanjanje EZS. Definisanje optimalnih karakteristika membrana i svojstava vode je velikog značaja za primenu membranskih procesa na pilotskom i industrijskom nivou. Pilot uređaj, originalno korišćen za mikro- i ultrafiltraciju, uz unapređenje sada podržava visoke pritiske potrebne za procese nanofiltracije i reverzne osmoze. Primenom spiralno uvijenih membrana u unapređenom i lako prenosivom pilot uređaju, moguća je obrada značajnih količina vode.

U okviru TwiNSol-CECs projekta, efikasnost nanofiltracije i reverzne osmoze u uklanjanju EZS je ispitana primenom šest membrana u dva režima rada, na tri različite pH vrednosti. Većina testiranih EZS je uspešno uklonjena (uklanjanje preko 90%) iz uzoraka vode, pri čemu su operativni uslovi i svojstva membrana imali značajan uticaj na efikasnost uklanjanja. Svi eksperimenti zasnovani na primeni membrana u okviru projekta sprovedeni su u saradnji sa istraživačima sa NOVA Univerziteta u Lisabonu, pod supervizijom prof. João Crespo.

TwiNSol-CECs RESEARCH GROUP ON BIOMATERIALS APPLICATION IN CECs REMOVAL

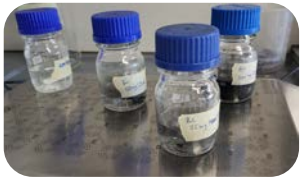
This research group focuses on the development of innovative solutions based on biomaterials, aiming at the efficient removal of CECs from wastewater. The primary goal of the research is the identification and evaluation of biosorbents from locally available sources – natural, renewable materials – in order to develop effective, economical, and environmentally friendly water treatment methods.

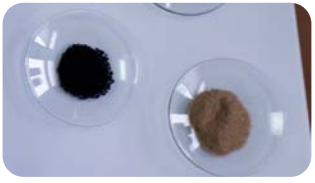
For the research within the TwiNSol-CECs project, several biosorbents with high potential for CECs removal, have been selected, considering their availability and properties.

Among them are plant-based materials, such as raspberry stems, sugar beet residues, and lignin, as well as biochar and hydrochar produced from waste biomass. Each of these materials has been studied to understand its capacity for Retaining CECs from wastewater.

One of the notable successes of this research group is the use of biochar derived from raspberry stems. This biosorbent showed remarkable efficiency in removing nearly all of studied pharmaceutically active compounds and pesticides from the effluent of a municipal wastewater treatment plant and, in some cases, outperformed powdered activated carbon.

Additionally, some of these materials have been further considered for passive sampling of CECs from water systems together with colleagues from NOVA University of Lisbon.



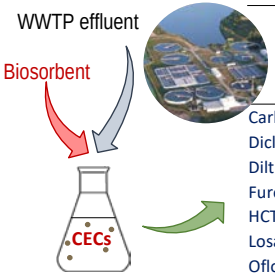


This research group continues its work on new approaches to reducing environmental pollution. Current research include the valorization of waste biomass, applying circular economy principles, in order to contribute to the protection of aquatic ecosystems and public health through the development of sustainable water and wastewater treatment methods.

TwiNSol-**CECs ISTRAŽIVAČKA GRUPA ZA PRIMENU BIOMATERIJALA U UKLANJANJU** EZS

Ova **istraživačka** grupa se bavi razvojem inovativnih rešenja zasnovanih na biomaterijalima, sa ciljem efikasnog uklanjanja EZS iz otpadnih voda. Primarni cilj istraživanja je identifikacija i evaluacija biosorbenata iz lokalno dostupnih izvora – prirodnih, obnovljivih materijala, s ciljem razvoja efikasnih, **ekonomičnih** i ekološki prihvatljivih metoda **prečišćavanja** vode.

Za istraživanja u okiru TwiNSol-CECs projekta odabrano je nekoliko biosorbenata, uzimajući u obzir njihovu dostupnost i svojstva. Među njima su materijali biljnog porekla, poput stabljika maline, ostataka šećerne repe i lignina, ali i biougalj i hidrougalj proizvedeni iz otpadne biomase. Svaki od ovih materijala je ispitan kako bi se utvrdila njegova sposobnost vezivanja EZS iz otpadnih voda.
Jedan od značajnih uspeha rada ove istraživačke grupe je biougalj dobijen iz stabljika maline.



Efikasnost nekih biosorbenata / Efficiency of some biosorbents

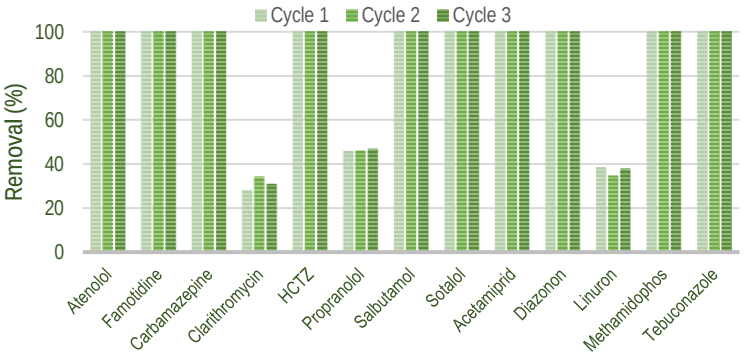
CEC	C_0	Removal from WWTP effluent(%)		
		Hydrochar (beech/oak)	Kraft lignin (thistle)	Kraft liginin (pinecone)
Carbamazepine	112.6	60.7	94.3	100
Diclofenac acid	284.1	71.8	100	100
Diltiazem	19.3	23.6	11.1	25.2
Furosemide	299.2	100	100	100
HCTZ	610.9	51.2	91.9	89.4
Losartan	122.9	21.5	100	100
Ofloxacin	64.6	100	100	100
Sotalol	182	43.3	88.6	98.4

Ovaj biosorbent je pokazao izuzetnu efikasnost u uklanjanju gotovo svih ispitivanih farmaceutski aktivnih jedinjenja i pesticida iz efluenta postrojenja za prečišćavanje otpadnih voda, a u nekim slučajevima je čak i nadmašio aktivni ugalj.

Pored toga, neki od ovih materijala su u saradnji sa kolegama sa NOVA Univerziteta u Lisabonu razmatrani za pasivno uzorkovanje EZS iz vodenih sistema.

Ova istraživačka grupa nastavlja svoj rad na novim pristupima smanjenju zagađenja životne sredine.

Trenutna istraživanja uključuju valorizaciju otpadne biomase, primenjujući principe cirkularne ekonomije, kako bi razvojem održivih metoda obrade vode i otpadnih voda doprineli zaštiti vodenih ekosistema i javnog zdravlja.



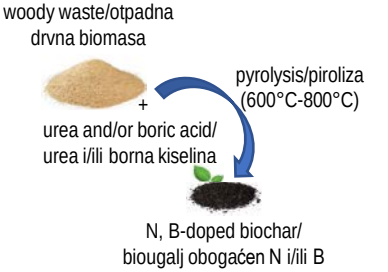
Efikasnost biouglja iz stabljike maline u trostepenoj šaržnoj adsorpciji

Raspberry biochar efficiency in three-stage batch adsorption

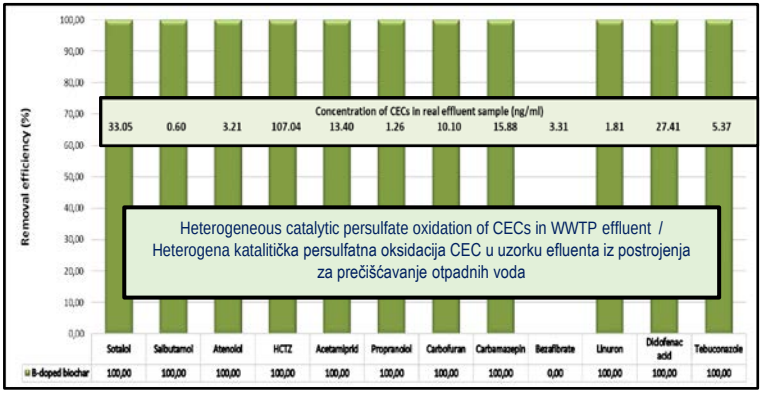
TwiNSol-CECs RESEARCH GROUP FOR THE DEVELOPMENT OF ADVANCED GREEN CATALYTIC TECHNOLOGIES FOR WASTEWATER TREATMENT

This research group focuses on developing advanced green catalytic technologies for the efficient degradation of CECs present in the wastewater. The primary goal of this research is to design, synthesize and evaluate green heterogeneous catalysts and biocatalysts from locally available sources - natural, sustainable materials.

The group developed new green synthetic routes for the production of highly efficient metal-free carbocatalysts and immobilized biocatalysts, starting from the waste biomass, which were further tested for the degradation of CECs by oxidation reaction. Through the TwiNSol-CECs project, this research group acquired mechanical stirrer (Hei-Torque core overhead stirrer), vacuum manifold set and UV-reactor for advanced oxidation processes.



Biochar-based heterogeneous metal-free green catalysts (doped and codoped with nitrogen and boron) exhibited excellent performance for the persulfate oxidation of 25 selected CECs from the water model mixture and the effluent of a municipal wastewater treatment plant. All examined catalysts showed superior catalytic activity for the degradation of pharmaceutically active compounds compared to the tested pesticides gaining very rapid and almost complete removal of CECs within the first few minutes of the reaction.



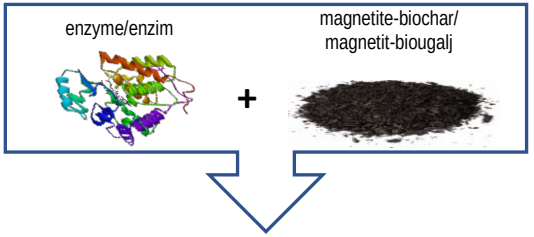
In the biocatalytic process, the immobilized peroxidase applied in the presence of hydrogen peroxide gained very high removal efficiency of the tested pesticides (43-100%) and pharmaceutically active compounds (70-100%).

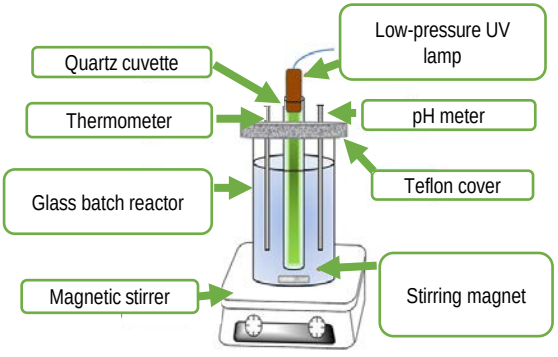
The UV/H_2O_2 advanced oxidation process proved to be more efficient for the removal of pharmaceutically active compounds (up to 83%) compared to pesticides (up to 50%).

This research provides a green and feasible approach to produce metal-free carbonaceous catalysts and biocatalysts for highly efficient degradation of various CECs with a great potential to be implemented in practice. In this way, TwiNSol-CECs project contributes to the innovative process solutions in the field of heterogeneous (bio)catalysis towards pollutant free environment.

TwiNSol-CECs **ISTRAŽIVAČKA GRUPA ZA RAZVOJ NAPREDNIH ZELENIH KATALITIČKIH TEHNOLOGIJA** ZA TRETMAN OTPADNIH VODA

Ova **istraživačka** grupa se fokusira na razvoj naprednih zelenih **katalitičkih** tehnologija za efikasnu degradaciju EZS prisutnih u otpadnim vodama. Glavni cilj ovog istraživanja je dizajn, sinteza i evaluacija zelenih heterogenih katalizatora i biokatalizatora od lokalno dostupnih izvora - prirodnih, održivih materijala.





UV-reactor for advanced oxidation processes/
UV-reaktor za unapređene oksidacione procese

Grupa je razvila nove zelene postupke za proizvodnju visoko efikasnih ugljeničnih katalizatora bez prisutnog metala i imobilizovanih biokatalizatora, počevši od otpadne biomase, koji su dalje testirani u procesu oksidativne degradacije EZS. U okviru TwiNSol-CECs projekta, ova istraživačka grupa je nabavila mehanički mešalicu (Hei-Torque core overhead stirrer), vakuumski manifold set i UV-reaktor za napredne oksidacione procese.

Heterogeni katalizatori na bazi biouglja bez prisutnog metala (dopirani i kodopirani azotom i borom) pokazali su izuzetne performanse u prosecu persulfatne oksidacije 25 odabranih EZS iz vodene model smeše, kao i efluenta iz postrojenja za prečišćavanje otpadnih voda. Svi ispitivani katalizatori su pokazali superiornu katalitičku aktivnost za degradaciju farmaceutskih aktivnih jedinjenja u poređenju sa ispitivanim pesticidima, postižući vrlo brzo i gotovo potpuno uklanjanje EZS tokom prvih nekoliko minuta reakcije. U biokatalitičkom procesu, imobilizovana peroksidaza primenjena u prisustvu vodonik-peroksida postigla je vrlo visok stepen uklanjanja ispitivanih pesticida (43-100%) i farmaceutskih aktivnih jedinjenja (70-100%). UV/H_2O_2 napredni oksidacioni proces pokazao se efikasnijim za uklanjanje farmaceutskih aktivnih jedinjenja (do 83%) u poređenju sa pesticidima (do 50%).00

Ovo istraživanje pruža zeleni pristup za proizvodnju ugljeničnih katalizatora bez prisutnog metala i biokatalizatora za visoko efikasnu degradaciju različitih EZS, sa velikim potencijalom za implementaciju u praksi. Na taj način, TwiNSol-CECs projekat doprinosi inovativnim procesnim rešenjima u oblasti heterogene (bio)katalize, a sve u cilju stvaranja životnog okruženja bez prisutnih zagađujućih supstanci.

TwiNSoI-CECs project team / TwiNSoI-CECs projektni tim

Prof. **Nataša Đurišić-Mladenović**
Main role: Project Coordinator; leader of WP1 and WP7; researcher in the group for MS analysis
Glavna uloga: Koordinator projekta; rukovodilac radnih paketa 1 i 7; istraživač u grupi za MS analizu;
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Glavna uloga: TFNS menadžer projekta za pravna, administrativna i finansijska pitanja; rukovodilac radnog paketa 6
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Glavna uloga: Surukovodilac radnog paketa 3; istraživač zadužen za katalitičke procese
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Dr. **Vesna Vasić**
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Dr. Marina **Šćiban**
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Glavna uloga: rukovodilac zadataka 2.3 i 4.3; istraživač u grupi za biomaterijale
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Glavna uloga: rukovodilac zadatka 3.3
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Main role: researcher in group for membrane-based processes
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Dušan Rakić
doktorand/PhD student
Role: researcher in group for analytical methods
Uloga: istraživač u grupi za MS analizu
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Dr. Ferenc Kiš
Main role: researcher in charge for LCA
Uloga: istraživač zadužen za *LCA*
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Dr. Mirjana Petronijević
Main role: researcher responsible for enzyme- and photooxidation-based processes
Glavna uloga: istraživač zadužen za enzimske i fotooksidacione procese
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Prof. Dragana Šoronja-**Simović**
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Glavna uloga: rukovodilac zadatka 3.4;
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Dr. Jovana Petrović
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TwiNSol-CECs timeline:

TwiNSol-CECs week in October, TFNS, Novi Sad:
- 1st Onsite Training Sample preparation and targeted analysis of main group of CECs in complex samples, 17-18 Oct 2022
- Kick-off meeting, 19 Oct 2022
- 1st TwiNSol-CECs Workshop Advance multicompound analyses and novel solutions for protection of environmental resources with contaminants of emerging concern in focus, 20-21 Oct 2022

2nd Onsite Training High-resolution mass spectrometry application in revealing the CECs presence in water, CSIC-IDAEA, Barcelona, 21-25 Nov 2022

3rd Onsite Training Transfer of knowledge and best practice for TwiNSol-CECs research and strategic activities, UNL, Lisbon, 12-16 Dec 2022

Series of UNL trainings "Membrane separation technologies in the spotlight":
- Principles of Pressure Driven Membrane Processes, online lecture, 25 Aug 2023
- Principles of Pressure Driven Membrane Processes, online lecture, 5 Sept 2023
- 5th Onsite Training Computational methods as a support for membrane based separation technologies, TFNS, Novi Sad, 26-27 Sept 2023

2022 | **2023**

1st Meeting of "Club of TwiNSol-CECs interest", TFNS, Novi Sad, 27 Apr 2023

Public tribune "Science Talks" Soare with scientists - our habits and the environment, Science Club Novi Sad, KC Svilara, Novi Sad, 09 Dec 2023

4th Onsite Training Target and suspect screening of CECs present in surface water samples, CSIC-IDAEA, Barcelona, 8-12 May 2023

1st TwiNSol-CECs Summer School Analytical Methodologies for Determination of CECs in the Environment, TFNS, Novi Sad, 02-06 June 2023

TwiNSol-CECs researchers also attendeed additional trainings such Data Management and Open Science in the Horizon Europe, Intellectual Property Rights and Patent Protection of Inventions Knowledge Valorisation in Academia, Public Speaking Skills in the Academic World Financial Issues in Horizon Europe, Thermo Scientific meeting for Compound Discoverer Users, training of TU Delft on PFAS – Persistent Micropollutants in the in Water Cycle, etc.

main events

2nd TwiNSol-CECs **Workshop** Advanced Water Treatments in Emerging Contaminants Mitigation with Cutting Edge Technologies,TFNS, Novi Sad, 06-07 June 2024

2nd TwiNSol-CECs **Summer School** Innovative Technologies for Water Treatment: Removal of micropollutants with CEC in focus, TFNS, Novi Sad, 08-12 June 2024

9th **Onsite Training** Analysis of Microplastics CSIC-IDAEA, Barcelona, 15-28 June 2025

Final Project Conference International Conference on Environmental and Sustainable Research Solutions TFNS, Novi Sad, 05-07 June 2025

3rd TwiNSol-CECs **Workshop** TFNS, Novi Sad, 05-06 June 2025

2024 | **2025**

2nd **Meeting of "Club of TwiNSol-CECs interest**, TFNS, Novi Sad, 26 Sept 2024

6th **Onsite Training** Development of pilot scale nanofiltration unit – transfer of knowledge and best practice, UNL, Lisbon 29 Sept-04 Oct 2024

8th **Onsite Training** Testing biomaterials for passive samplers development – transfer of knowledge and best practice, UNL, Lisbon, 24-29 Nov 2024

7th **Onsite Training** Development of new project proposals CSIC-IDAEA, Barcelona, 13-18 Oct 2024

3rd **Meeting of "Club of TwiNSol-CECs interest"**, TFNS, Novi Sad

Public tribunes, TFNS, Novi Sad

Istraživači uključeni u projekat TwiNSol-CECs takođe su pohađali dodatne obuke, kao što su: upravljanje podacima i otvorena nauka u okviru programa Horizont Evropa, prava intelektualne svojine i patentna zaštita izuma, valorizacija znanja u akademskom okruženju, veštine javnog nastupa u akademskom svetu, finansijski aspekti programa Horizont Evropa, sastanak Thermo Scientific za korisnike softvera Compound Discoverer, obuka Tehničkog univerziteta u Delftu o jedinjenjima PFAS – postojanim mikrozagađujućim materijama u vodenom ciklusu, i druge.

TwiNSol-CECs Strategy "BE PART OF A SOLUTION FOR THE CECs POLUTION": Road map for stepping up the excellence of FoTNS in domain of environmental research related to CECs for the period 2024 - 2028

One of the key objectives of the TwiNSol-CECs project is to establish a sustainable and strategically driven approach to further research on CECs at FoTNS. The strategy is designed to ensure continuity in the scientific and innovation development initiated during the project, with the aim of strengthening research excellence and positioning FoTNS as a recognized and respected scientific institution for the CECs research in Serbia, the Western Balkans, and the European Union.

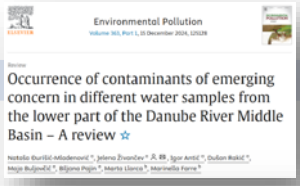
Recognizing chemical pollution of natural resources as one of the major global challenges, the framework of the strategy builds upon the already proven human and material capacities of FoTNS in the field of CEC research. Its goal is to further align these capacities with the priority research streams on CECs within ERA, contributing to the harmonization of contemporary relevant research activities in the EU. The document defines the strategic directions for further research activities on CECs at FoTNS, accompanied by an action plan and key performance indicators for its implementation, such as number of research project proposals submitted to international calls, OA manuscripts submitted to international journals for the review, number of reputable guest lecturers at FoTNS, organized international scientific events and open-access public events, etc. It has been developed based on a comprehensive SWOT analysis, the exchange of knowledge and best practices with partner institutions, and the identification of needs from various target groups, informed through consultations with representatives of public utility companies in the fields of surface water management, drinking water supply, wastewater treatment, as well as representatives of education, science, and civil society. The strategy outlines concrete measures aimed at improving the efficiency of resource use and fostering continuous international collaboration, while enhancing the visibility and relevance of TFNS as a reliable partner within the European research landscape in the domain of CEC-related environmental research.

TwiNSol-CECs strategija „BUDI DEO REŠENJA ZA EZS-**ZAGAĐENJE**": Putokaz za **unapređenje** izvrsnosti TFNS u oblasti istraživanja EZS za period 2024–2028.

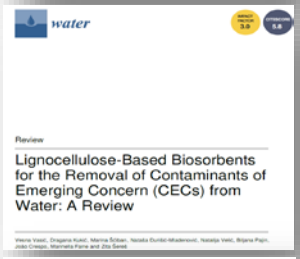
Jedan od ključnih ciljeva projekta TwiNSol-CECs jeste uspostavljanje održivog i strateški promišljenog pristupa daljim istraživanjima EZS na TFNS. Strategija je osmišljena tako da obezbedi kontinuitet naučnog i inovacionog razvoja započetog tokom projekta radi ojačavanja istraživačke izvrsnosti i dugoročnog pozicioniranja TFNS kao prepoznatljive i respektabilne naučne institucije u Srbiji, Zapadnom Balkanu i Evropskoj uniji.

Uzimajući u obzir hemijsko zagađenje prirodnih resursa kao jedan od ključnih globalnih izazova, strateški okvir projekta oslanja se na već potvrđene ljudske i materijalne kapacitete TFNS za istraživanja u oblasti EZS. Cilj je njihovo dalje usmeravanje ka prioritetnim istraživačkim tokovima u oblasti EZS u okviru ERA, doprinoseći usklađenosti savremenih istraživačkih aktivnosti u EU i rešenjima za problem stalnog prisustva i akumulacije brojnih hemikalija u životnoj sredini. Strategija predstavlja dokument u kojem su definisani strateški pravci daljih istraživačkih aktivnosti u oblasti EZS na TFNS, akcioni plan i indikatori uspeha implementacije strategije, kao što su: broj istraživačkih projektnih prijava podnetih na međunarodne konkurse, broj radova poslatih na recenziju međunarodnim časopisima sa otvorenim pristupom, broj uglednih gostujućih predavača na TFNS, organizovanih međunarodnih naučnih skupova i javnih događaja otvorenih za širu javnost, itd. Pripremljena je na osnovu izvršene SWOT analize, razmene saznanja i prakse sa kolegama iz partnerskih institucija i identifikacije potreba različitih ciljnih grupa u kontaktu sa predstavnicima javnih preduzeća u oblasti upravljanja površinskim vodama, pripreme pijaće vode, obrade otpadnih voda, prosvete, nauke, građana. Time su predviđene konkretne mere za efikasnije korišćenje postojećih resursa i kontinuirano jačanje međunarodne saradnje uz jačanje vidljivosti i značaja TFNS kao relevantnog partnera u evropskom naučnoistraživačkom prostoru u oblasti istraživanja EZS.

Project publications/Projektne publikacije


Environmental Pollution

Occurrence of contaminants of emerging concern in different water samples from the lower part of the Danube River Middle Basin – A review ☆


water

Review

Lignocellulose-Based Biosorbents for the Removal of Contaminants of Emerging Concern (CECs) from Water: A Review


Environmental Technology & Innovation

Valorization of waste biomass towards biochar production – Characterization and perspectives for sustainable applications in Serbia

Scientific/Naučne

Book of Abstracts/Knjiga izvoda - the 1st TwiNSol-CECs Workshop, 2022
Book of Abstracts/Knjiga izvoda - the 2nd TwiNSol-CECs Workshop, 2024
Book of Proceedings/Knjiga radova - the 2nd TwiNSol-CECs Workshop, 2024
Book of Abstracts /Knjiga izvoda - the International TwiNSol-CECs Conference on Environmental and Sustainable Research Solutions, 2025
2 OA review articles in international journals with impact factors/ 2 pregledna rada u međunarodnim časopisima otvorenog pristupa sa impakt faktorom :

- *Lignocellulose-based biosorbents for the removal of contaminants of emerging concern (CECs) from water: A review. Water, 2023, 15, 1853*
- *Occurrence of contaminants of emerging concern in different water samples from the lower part of the Danube River Middle Basin – a review. Environmental Pollution, 2024, 363, 125128*
- 1 OA review article in national journal/1 pregledni rad u nacionalnom časopisu otvorenog pristupa:
- *Biochar and hydrochar as adsorbents for the removal of contaminants of emerging concern from wastewater, Advanced Technologies 2023, 12 (1), 57-74*

1 Original OA research article in international journals with impact factors/1 originalni naučni rad u međunarodnom časopisu otvorenog pristupa sa impakt faktorom:

- *Valorization of waste biomass towards biochar production - Characterization and perspectives for sustainable applications in Serbia. Environmental Technology & Innovation, 2025, 37, 104043*

Still in preparation: 6 original research articles for submission to OA international journals with impact factors/Još šest originalnih naučnih radova je u fazi pripreme za podnošenje u međunarodne časopise otvorenog pristupa sa impakt faktorom.

Promotional/Promotivne


Advanced technologies 12(1) (2023) 57-74

BIOCHAR AND HYDROCHAR AS ADSORBENTS FOR THE REMOVAL OF CONTAMINANTS OF EMERGING CONCERN FROM WASTEWATER

Newsletter no.1 “The 1st year of TwiNSol-CECs”, 2023/TwiNSol-CECs bilten br.1 “The 1st year of TwiNSol-CECs”, 2023
Newsletter no 2 “After three years of TwiNSol-CECs”, 2025/TwiNSol-CECs bilten br.2 “After three years of TwiNSol-CECs”, 2025
Final project-dedicated brochure/Završna projektna brošura, 2025

A series of short retrospective views from TwiNSol-CECs researchers on topics of the project interest:
•Advances in monitoring of unregulated contaminants in the environmental resources – a perspective by TwiNSol-CECs
•TwiNSol-CECs perspective of innovative catalytic solutions towards pollutant free environment
•Microplastics - a macro problem tackled by TwiNSol-CECs
•TwiNSol-CECs project - through the eyes of engaged PhD students
•Empowering Research Management and Strengthening Institutional Capacities - A Perspective by TwiNSol-CECs
•Fighting Water Pollution: How Advanced Oxidation Processes Tackle Emerging Contaminants

Serija kratkih retrospektivnih osvrta TFNS istraživača iz projektnog tima na teme od značaja za projekat:
•Napredak u monitoringu neregulisanih zagađujućih supstanci u životnoj sredini – perspektiva projekta TwiNSol-CECs
•Iz perspektive projekta TwiNSol-CECs o inovativnim katalitičkim rešenjima za životnu sredinu bez zagađujućih supstanci
•Mikroplastika – makro problem od značaja za projekat TwiNSol-CECs
•Projekat TwiNSol-CECs očima angažovanih doktoranada
•Osnaživanje upravljanja istraživanjima i jačanje institucionalnih kapaciteta – perspektiva projekta TwiNSol-CECs
•Borba protiv zagađenja voda: kako napredni oksidacioni procesi utiču na nove zagađujuće supstance

Invited guest lecturers at the project events / Gosti predavači po pozivu na projektnim događajima

During the TwiNSol-CECs project, the FoTNS hosted prominent researchers from various fields of environmental protection, becoming a significant Western Balkan hub for the proactive exchange of scientific knowledge, experiences, and ideas for future collaboration.

TFNS je tokom trajanja projekta TwiNSol-CECs ugostio istaknute **istraživače** iz **različitih** oblasti zaštite životne sredine, **čime** je postao **značajno** mesto na Zapadnom Balkanu za proaktivnu razmenu **naučnih** saznanja, iskustava i ideja za **buduću** saradnju.

In alphabetic order/po abecednom redu

Prof. Hans Peter Arp, Norwegian University of Science and Technology, Trondheim, Norway

Prof. Biljana Basarin, University of Novi Sad, Faculty of Sciences, Novi Sad, Serbia

Prof. Vladimir Beškoski, University of Belgrade, Faculty of Chemistry, Belgrade, Serbia

Dr. Minja M. Bogunović, University of Novi Sad, Faculty of Sciences, Novi Sad, Serbia

Prof. Sandra Budžaki, University of Osijek, Faculty of Food Technology, Osijek, Croatia

Prof. Joao Crespo, NOVA University, ITQB, NOVA School of Science and Technology, Lisbon, Portugal

Dr. Marinella Farre, CSIC, Institute of Environmental Assessment and Water Research, Barcelona, Spain

Dr. Cláudia Galinha, NOVA University Lisbon, NOVA School of Science and Technology, Portugal

Prof. Đurđa Kerkez, University of Novi Sad, Faculty of Sciences, Novi Sad, Serbia

Prof. Szabolcs Kertész, University of Szeged, Faculty of Engineering, Szeged, Hungary

Prof. Dimitra Labropoulou, Aristotle University of Thessaloniki, Department of Chemistry, Thessaloniki, Greece

Prof. Snežana **Maletić**, University of Novi Sad, Faculty of Sciences, Novi Sad, Serbia

Dr. Dragana Miladinović, National Institute of Republic of Serbia: Institute of Field and Vegetable Crops, Novi Sad, Serbia

Dr. Aleksandra Mišan, University of Novi Sad, Institute of Food Technology in Novi Sad, Novi Sad, Serbia

Dr. Nicola Montemurro, CSIC, Institute of Environmental Assessment and Water Research, Barcelona, Spain

Dr. Nandor Nemestothy, University of Pannonia, Veszprém, Hungary

Dr. Sylwin Pawlowski, NOVA University, NOVA School of Science and Technology, Portugal

Dr. Vanessa Pereira, NOVA University, IBET, Lisbon, Portugal

Petar Pižurica, Wastewater treatment plant, PUC Subotica Waterworks and Sewerage, Subotica, Serbia

Prof. Olívia Salomé G. P. Soares, Faculty of Engineering of the University of Porto, Porto, Portugal

Prof. Dr. Natalija Velić, J.J. Strossmayer University of Osijek, Faculty of Food Technology, Osijek, Croatia

Dr. Gábor Veréb, University of Szeged, Faculty of Engineering, Szeged, Hungary

TwiNSol-CECs results are presented at numerous conferences, including prominent international conferences:

TwiNSol-CECs rezultati su predstavljeni na mnogim konferencijama, uključujući renomirane **međunarodn**e konferencije:

ICCE2023, Venice, Italy
SETAC Europe 34th Annual Meeting, 2024, Seville, Spain
CEMEPE 2024 & SECOTOX, Conference, Lefkada, Greece
SDEWES 2024, Rome, Italy
EUROMEMBRANE 2024, Prague, Czech Republic
CEMEPE 2025 & SECOTOX Conference, Myconos, Greece
ICCE2025, Belgrade, Serbia

... also, FoTNS researchers participated in events organized by other Horizon projects:

... **takođe**, **istraživači** TFNS **učestvovali** su na **događajima** koje su organizovali drugi Horizont projekti:

TwinSubDyn (101059546, 2022-2025), SmartWaterTwin (101060110, 2022-2025), PFAStwin (101059534, 2022-2025), ZeroPM (101036756, 2021-2026), GREENELIT (951747, 2020-2023), CROPPINO (101059784, 2022-2025)

These participations provided valuable opportunities to explore complementarities and shared research interests, paving the way for future joint endeavors.

Ova učešća pružila su dragocene prilike za istraživanje komplementarnosti i zajedničkih istraživačkih interesa, otvarajući put za buduće zajedničke poduhvate.

Project Acronym/Akronim projekta: TwiNSol-CECs
Grant Agreement no./Broj ugovora o grantu: 101059867
Funding Programme/Program finansiranja: Horizon Europe
Call/Poziv: HORIZON-WIDERA-2021-ACCESS-02
Duration/Trajanje: 01.08.2022 – 31.07.2025
Total budget/Ukupan budžet: 1,432,938.00 EUR
Independent Ethics Expert/Nezavisni etički stručnjak: Dr. Dubravka Vejnović

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Publisher/Izdavač:
University of Novi Sad, Faculty of Technology Novi Sad, Novi Sad, Serbia/
Univerzitet u Novom Sadu, Tehnološki fakultet Novi Sad, Srbija
Editor-in-charge/Odgovorni urednik:
Prof. Nataša Đurišić-Mladenović
Design/Dizajn:
Dr. Dragana Lukić
Text/Tekst:
Prof. Nataša Đurišić-Mladenović, Prof. Biljana Pajin, Dr. Nikola Maravić,
Dr. Vesna Vasić, Dr. Sanja Panić,
Dr. Igor Antić, Dr. Ivana Lončarević
No. of printed copies/Tiraž: 100

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Funded by the European Union