

## ANNUAL REPORT ON GEOTRACES ACTIVITIES IN CROATIA

May 1st, 2022 to April 30th, 2023

### *New GEOTRACES or GEOTRACES relevant scientific results*

The Croatian GEOTRACES activities were related to:

- interaction of trace metals with marine microplastics
- investigation of cobalt (II) complexes with naturally present ligands, relevant to understanding the speciation of cobalt, especially in aquatic but also in atmospheric and terrestrial environments and various organisms
- application of improved electrochemical methods (in combination with ICPMS) for determination of number of trace metals, their speciation, fractionation and interaction with organic matter and sulphur species in natural waters, including monitoring of the coastal and open waters of the Adriatic Sea;
- mercury speciation and determination by CV-AAS in natural waters, including monitoring of the coastal and open waters of the Adriatic Sea;
- study of geochemistry of redox proxies and redox transformations in seawater under a range of critical environmental conditions (Cu, V, Re, Mo and U);
- study of geochemistry of technology critical elements (Li, Nb, Sc, Ga, Y, La, Sb, Ge, Te and W) in marine sediments;
- geochemical research and biological response in different environmental systems (coastal and open sea, marine lakes, anchialine caves, submarine groundwater discharge);
- development of new methods for ex- and in-situ determination of natural and anthropogenic radionuclides (focus is on  $^{86/87}\text{Sr}$ ,  $^{89,90}\text{Sr}$  and  $^{210}\text{Pb}$ );
- development of electroanalytical method for determination and characterization of polysulfides in anoxic seawater conditions;
- study of interactions between surface water chemistry, phytoplankton, atmospheric chemistry, and climate;
- characterization of atmospheric precipitation (rain, aerosols - PM2.5) regarding presence of major cations and anions, organic matter, sulphur species and trace metals;
- measurements of activity concentration of  $^7\text{Be}$  and  $^{210}\text{Pb}$  in atmospheric precipitation (rain, aerosols - PM2.5) in order to monitor dynamics of particle transport, metrological information, origin of air mass transfer and seasonal variation of aerosol deposition;
- work on advanced technologies for water quality control/monitoring and prediction purposes.

### *New projects and/or funding*

Current projects supported by the Croatian Ministry of Science, Education and Sport and Croatian Science Foundation (CSF):

- 2018-2022: Biochemical REsponses of oligotrophic Adriatic surface ecosystems to atmospheric Deposition Inputs (BiREADI) (PI. Sanja Frka)

- 2018-2022: MARine lake (Rogoznica) as a model for EcoSystem functioning in a changing environment (PI. I. Ciglencečki-Jušić)
- 2018-2022: Geochemistry and Records of Redox Indicators in Different Environmental Conditions: Towards a better understanding of redox conditions in the past (PI: E. Bura-Nakić)
- 2020-2024, CSF project: Marine (micro)plastic litter and pollutant metals interaction: a possible pathway from marine environment to human (METALPATH) (PI Vlado Cuculić)
- 2020-2024: SNSF/CSF: Understanding copper speciation and redox transformations in seawater (PI: E. Bura-Nakić)

#### *Other projects:*

2020-2023: HAMAG-BICRO: "Application of artificial intelligence in advanced predictive technologies for online water quality control". (PI. D. Omanović)

2020-2023: INTERREG CRO-ITA: InnovaMare - "Model of innovation ecosystem in the field of underwater robotics and sensors for control and monitoring purposes with a mission focused on the sustainability of the Adriatic Sea". (PI. M. Mlakar)

2020-2022: INTERREG ADRION: "SEAVIEWS - Sector Adaptive Virtual Early Warning System for marine pollution". (AP. D. Omanović)

2020-2022: SKLEC China Open Research Fund: "Eco-environmental impacts of submarine groundwater discharge-derived nutrients, carbon and metal in oligotrophic karstic estuary of the Krka River (Adriatic Sea, Croatia)". (PI. N. Cukrov)

#### ***Other GEOTRACES activities***

- D. Omanović is a member of the GESAMP working group 45 - Climate Change and Greenhouse Gas Related Impacts on Contaminants in the Ocean.

#### ***New GEOTRACES or GEOTRACES-relevant publications (published or in press)***

- Lucija Knežević and Elvira Bura-Nakić, Investigation of thiol compounds (L-cysteine, thioacetic acid and ethanethiol) with V(V) and V(IV) using combined spectroscopy and chromatography, *Journal of Inorganic Biochemistry*, 242 (2023) 112158
- Saša Marcinek, Josep Galceran, Irena Ciglencečki and Dario Omanović, A new tool for the determination of humic substances in natural waters: Pulsed voltammetry approach, *Talanta* 259 (2023) 124547
- Niki Simonović, Iva Dominović, Marija Marguš, Antonija Matek, Zrinka Ljubešić and Irena Ciglencečki: Dynamics of organic matter in the changing environment of a stratified marine lake over two decades, *Science of The Total Environment*, 865 (2023) 161076
- Marija Marguš, Marijan Ahel, Milan Čanković, Zrinka Ljubešić, Senka Terzić, Vedranka Hodak Kobasić, Irena Ciglencečki: Phytoplankton pigment dynamics in marine lake fluctuating between stratified and holomictic euxinic conditions, *Marine Pollution Bulletin*, 191 (2023) 114931

- Krešimir Maldini, Neven Cukrov, Kristina Pikelj, Natalija Matić and Marina Mlakar, Geochemistry of metals and organic matter in water and sediments of the karst river Cetina, Croatia, *Water*, 15 (2023) 1429
- Irena Ciglencečki, Palma Orlović-Leko, Kristijan Vidović, Niki Simonović, Marija Marguš, Jelena Dautović, Sarah Mateša and Ivo Galić: The possibilities of voltammetry in the study reactivity of dissolved organic carbon (DOC) in natural waters, *Journal of Solid State Electrochemistry* (2023) 1-13.
- Vlatka Filipović Marijić, Maria Angels Subirana, Dirk Schaumlöffel, Josip Barišić, Etienne Gontier, Nesrete Krasnići, Tatjana Mijošek, Jesús S. Hernández-Orts, Tomáš Scholz and Marijana Erk: First insight in element localisation in different body parts of the acanthocephalan *Dentitruncus truttae* using TEM and NanoSIMS, *Science of the total environment*, 887 (2023) 164010
- Petra Burić, Ivana Čarapar, Dijana Pavičić-Hamer, Ines Kovači, Lara Jurković, Maja Dutour Sikiri, Darija Domazet Jurašin, Nevenka Mikac, Niko Bačić and Daniel Mark Lyons: Particle Size Modulates Silver Nanoparticle Toxicity during Embryogenesis of Urchins *Arbacia lixula* and *Paracentrotus lividus*, *International Journal of Molecular Sciences*, 24 (2023) 745
- Nevenka Mikac, Martina Furdek Turk, Dragana Petrović, Miljan Bigović, Sladjana Krivokapić: First assessment of butyltins (BuTs) contamination of the Montenegrin coast (Southeast Adriatic): Tributyltin (TBT) poses a threat to the marine ecosystem, *Marine Pollution Bulletin* 185 (2023) 114270
- Damir Kapetanović, Irena Vardić Smrzlić, Snježana Kazazić, Dario Omanović, Neven Cukrov, Ana-Marija Cindrić, Ana Rapljenović, Lorena Perić, Karla Orlić, Tatjana Mijošek, Zuzana Redžović, Ana Gavrilović, Tena Radočaj and Vlatka Filipović Marijić, A preliminary study of the cultivable microbiota on the plastic litter collected by commercial fishing trawlers in the south-eastern Adriatic Sea, with emphasis on *Vibrio*, *Marine Pollution Bulletin* 187 (2023) 114592
- Ana Vrdoljak Tomaš, Danijela Šantić, Mladen Šolić, Sanda Skejić, Andrea Milinković, Ana Cvitešić Kušan, Blaženka Gašparović, Stefanija Šestanović and Sanja Frka, How do open coastal fire episodes' impact sea surface microlayer neuston communities?, *Science of The Total Environment*, 861 (2023) 10593
- Lucija Knežević, Emanuele Zanda, Elvira Bura-Nakić, Montserrat Filella and Vladimir Sladkov, Vanadium(IV) and vanadium(V) complexation by succinic acid studied by affinity capillary electrophoresis. Simultaneous injection of two analytes in equilibrium studies, *Journal of Chromatography A*, 1695 (2023) 463941
- Abra Penezić, Xinke Wang, Sebastien Perrier, Christian George and Sanja Frka, Interfacial photochemistry of marine diatom lipids: Abiotic production of volatile organic compounds and new particle formation, *Chemosphere*, 313 (2023) 137510
- Sergio Stefanni, Luca Mirimin, David Stanković, Damianos Chatzievangelou, Lucia Bongiorno, Simone Marini, Maria Vittoria Modica, Elisabetta Manea, Federico Bonofiglio, Joaquin del Rio Fernandez, Neven Cukrov, Ana Gavrilović, Fabio C. De Leo and Jacopo Aguzzi: Framing Cutting-Edge Integrative Deep-Sea Biodiversity Monitoring via Environmental DNA and Optoacoustic Augmented Infrastructures, *Frontiers in Marine Science*, 8 (2022) 797140
- Ante Šiljeg, Ivan Marić, Fran Domazetović, Neven Cukrov, Marin Lovrić and Lovre Panda: Bathymetric Survey of the St. Anthony Channel (Croatia) Using Multibeam Echosounders

(MBES)-A New Methodological Semi-Automatic Approach of Point Cloud Post-Processing, *Journal of Marine Science and Engineering*, 10 (2022) 101

- Jinlong Wang, Mark Baskaran, Neven Cukrov and Jinzhou Du: Geochemical mobility of  $^{137}\text{Cs}$  in marine environments based on laboratory and field studies, *Chemical Geology*, 614 (2022) 121179
- Abra Penezić, Violetta Drozdowska, Tihana Novak and Blaženka Gašparović: Distribution and characterization of organic matter within the sea surface microlayer in the Gulf of Gdańsk, *Oceanologia*, 64 (2022) 631-650
- Andrea Milinković, Abra Penezić, Ana Cvitešić Kušan, Valentina Gluščić, Silva Žužul, Sanda Skejić, Danijela Šantić, Ranka Godec, Gordana Pehnec, Dario Omanović, Anja Engel and Sanja Frka, Variabilities of biochemical properties of the sea surface microlayer: Insights to the atmospheric deposition impacts, *Science of The Total Environment* 838 (2022) 156440
- Sanja Frka, Martin Šala, Helena Brodnik, Bogdan Štefane, Ana Kroflić and Irena Grgić, Seasonal variability of nitroaromatic compounds in ambient aerosols: Mass size distribution, possible sources and contribution to water-soluble brown carbon light absorption, *Chemosphere*, 299 (2022) 134381
- Marija Parać, Vlado Cuculić, Nuša Cukrov, Sunčana Geček, Marin Lovrić and Neven Cukrov, Microplastic Distribution through the Salinity Gradient in a Stratified Estuary, *Water*, 14 (2022) 3255
- Mišić Radić, T., Vukosav, P., Čačković, A. and Dulebo, A.: Insights into the morphology and surface properties of microalgae at the nanoscale by atomic force microscopy (AFM): A review, *Water*, 15 (2023) 1983
- Vukosav, P., Pašalić, L., Bakarić, D., Domazet Jurašin, D. and Mišić Radić, T.: Interaction of Silica Nanoparticles with Microalgal Extracellular Polymers, *Water*, 15 (2023) 159-159
- Mišić Radić, T., Vukosav, P., Komazec, B., Formosa-Dague, C., Domazet Jurašin, D., Peharec Štefanić, P., Čačković, A., Juraić, K. and Ivošević DeNardis, N.: Nanoplastic-induced nanostructural, nanomechanical, and antioxidant response of marine diatom *Cylindrotheca Closterium*, *Water*, 14 (2022) 2163
- Hana Fajković, Neven Cukrov, Stanislav Frančišković-Bilinski, Laura Huljek, Iva Kostanjšek, Željko Kwokal, Renata Matekalo, Kristina Pikelj and Vlado Cuculić, Correlation of metals and degraded marine (micro)plastic litter in geologically similar coastal areas with different anthropogenic characteristics, *Marine pollution bulletin*, 183 (2022), 114041
- Ivanka Lovrenčić Mikelić, Neven Cukrov, Višnja Oreščanin, Krunoslav Škaro and Delko Barišić:  $^{137}\text{Cs}$  Sediment profiles as a tracer of marine sedimentation processes in a semi-enclosed bay affected by anthropogenic releases-example of Kaštela Bay (Adriatic Sea, Croatia), *Water*, 14 (2022) 2655
- Anđela Bačinić, Petra Vukosav, Ivana Kero and Marina Mlakar, Study on the Surface Interactions of Co(II) with Phospholipids from the Marine Environment, *Journal of Marine Science and Engineering*, 10 (2022) 1261

### ***Completed GEOTRACES PhD or Master theses***

- Doctoral Thesis: Lucija Knežević, Biogeochemical cycling of vanadium(+IV and +V) in aquatic systems and sediments, University of Zagreb, May 2023.
- Doctoral Thesis: Anđela Bačinić, Electrochemical characterisation of Co(II) complexes with organic ligands from seawater, University of Zagreb, December 2022. (URL: <https://www.bib.irb.hr/1277006>)

### ***GEOTRACES presentations in international conferences***

- *5<sup>th</sup> International Symposium on Anchialine Ecosystems*, Kona, Hawaii, USA, November 2022: Anchialine caves of the Krka River estuary, Croatia; Cukrov N., Bishop R., Cuculić V., Cukrov M., Cukrov N., Geček S., Jalžić B., Klanjšček T., Kwokal Ž., Omanović D. et al.
- *ECSA 59 Using the best scientific knowledge for the sustainable management of estuaries and coastal seas*, San Sebastian, Spain, September 2022: Beached marine plastic litter as a carrier of abiotic and biotic phases in the coastal Adriatic Sea; Rapljenović A., Fajković H., Kapetanović D., Lakuš I., Pikelj K., Stančec V., Cuculić V.
- *3rd European NECTAR Conference*, Ljubljana, Slovenija, August 2022: Vanadium(IV) and vanadium(V) complexation with succinic acid by affinity capillary electrophoresis; Knežević L., Zanda E., Bura-Nakić E., Sladkov V.
- *Goldschmidt 2022*, July 2022: Dynamics of trace elements and dissolved organic matter in estuarine surface microlayer; Marcinek S., Cindrić A.M., Omanović D.
- *11<sup>th</sup> ISE Satellite Student Regional Symposium on Electrochemistry*, Zagreb, Croatia, July 2022: Modification of electroanalytical method for analysis of metal amounts from marine plastic surfaces; Rapljenović A., Cuculić V.
- *EGU General Assembly 2022*, Vienna, Austria, May 2022: Rhenium geochemistry in hypoxic and euxinic marine lakes of the Eastern Adriatic Sea; Živković I.; Knežević L., Omanović D., Jagodić Hudobivnik M., Rovanić L., Bura-Nakić E.
- *EGU General Assembly 2022*, Vienna, Austria, May 2022: Preliminary studies on V(III) determination in the form of picnolate complex using HR ICP-MS; Knežević L., Mandić J., Živković I., Omanović D., Bura-Nakić E.
- *EGU General Assembly 2022*, Vienna, Austria, May 2022: Insights to the short-term atmospheric deposition impacts on the biology and chemistry of the sea surface microlayer in the Adriatic Sea coastal region; Milinković A., Penezić A, Cvitešić Kušan A., Bakija Alempijević S., Gluščić V., Žužul S., Jakovljević I., Skejić S., Šantić D., Godec R. et al.
- *EGU General Assembly 2022*, Vienna, Austria, May 2022: Comparison of the trace metals mass fractions adsorbed on the beached plastic litter: different ubiquitous items of everyday use; Rapljenović A. and Cuculić V.
- *7<sup>th</sup> Croatian Congress of Microbiology with International Participation*, Sveti Martin na Muri, Croatia, May 2022: Diversity and antibiotic resistance of bacteria associated to marine plastic litter collected by commercial fishing trawlers in the southern Adriatic Sea, Croatia; Kapetanović D., Vardić Smrzlić I., Kazazić S., Perić L., Orlić K., Filipović Marijić V., Mijošek T., Redžović Z., Cukrov N., Cindrić A. M., Rapljenović A., Gavrilović A. and Radočaj T.

- *8<sup>th</sup> Croatian Meeting of Chemists and Chemical Engineers*, Rovinj, Croatia, March 2023: An attempt to quantitatively analyse submillimetre microplastics by DSC; Pucić I., Rapljenović A., Kwokal Ž., Cuculić V.
- *28<sup>th</sup> Croatian Meeting of Chemists and Chemical Engineers*, Rovinj, Croatia, March 2023: Trace metal adsorption on plastic pellets and fibers in the marine and estuarine environment; Viskić M., Rapljenović A., Cukrov N., Cuculić V.
- *Regional Meeting & Conference of the International Society of Electrochemistry*, Prague, Czech republic, August 2022: Complexation of membrane phospholipids with metal ions in the marine environment; Bačinić A., Matijević T., Kero I., Mlakar M.
- *8<sup>th</sup> hybrid SOLAS Open Science Conference*, Kaapstad, Južnoafrička Republika, September 2022: Variabilities of biochemical properties of the sea surface microlayer: insights to the atmospheric deposition impacts; Milinković A., Penezić A, Cvitešić Kušan A., Gluščić V., Žužul S., Skejić S., Šantić D., Godec R., Pehnc G., Omanović D. et al.
- *8<sup>th</sup> hybrid SOLAS Open Science Conference*, Kaapstad, Južnoafrička Republika, September 2022: Impacts of biomass burning versus anthropogenic aerosol deposition on the surface layers in the central Adriatic Sea: A mesocosm study; Milinković A., Penezić A, Bakija Alempijević S., Cvitešić Kušan A., Skejić S., Šantić D., Lehnert C., Striebel M., Niggemann J., Žužul S. et al.
- *11<sup>th</sup> International Aerosol Conference (IAC 2022)*, Atena, Grčka, September 2022: Variability of black carbon aerosol concentrations and sources at the Central Adriatic coastal zone: light-absorption observation and source-oriented modelling; Milinković A., Gregorić A., Džaja Grgičin V., Vidić S., Penezić A., Cvitešić Kušan A., Bakija Alempijević S., Kasper-Giebl Anne., Frka S.

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