ANNUAL REPORT ON GEOTRACES ACTIVITIES IN CROATIA

May 1st, 2023 to April 30th, 2024

New GEOTRACES or GEOTRACES relevant scientific results

The Croatian GEOTRACES activities were related to:

- interaction of trace metals with marine microplastics
- study of interactions between surface water chemistry, phytoplankton, atmospheric chemistry, and climate;
- 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 $^{86/87}$Sr, ^{89,90}Sr and ^{210}Pb);
- measurements of activity concentration of ^{7}Be and ^{210}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;
- development of electroanalytical method for determination and characterization of polysulfides in anoxic seawater conditions;
- characterization of atmospheric precipitation (rain, aerosols - PM2.5) regarding presence of major cations and anions, organic matter, sulphur species and trace metals;
- 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):

- 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, CSF and Swiss National Science Foundation: Understanding copper speciation and redox transformations in seawater (PI: E. Bura-Nakić)
- 2018-2023, CSF: Biochemical REsponses of oligotrophic Adriatic surface ecosystems to atmospheric Deposition Inputs (BiREADI) (PI. Sanja Frka)

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)
- 2020-2023; INTERREG CRO-ITA: Hadriaticum Data Hub - Data management, protocols harmonization, preparations of guidelines: cross-border tools for maritime spatial planning decision-makers (HATCH). (PI. M. Krželj)
- 2021–2023; Cogito Hubert Curien project: Photochemistry of marine phytoplankton surfactant films at the air-water interface: impact to atmospheric particle formation (PI. Sanja Frka; co-lead C. George)
- 2024–2025; project funded by IRB: KP2-Establishment of a new facility to study photoinduced changes in the physico-chemical properties of atmospheric aerosols (PI. Sanja Frka)

GEOTRACES workshops and meetings organized

- International scientific symposium: XVI International Estuarine Biogeochemistry Symposium (IEBS 2023), 23-26 May 2023, Šibenik
- International scientific symposium: Interdisciplinary Approach to the Scientific Research of the Adriatic Sea (InspireAdriatic 2023); 11-12 September 2023, Ruđer Bošković Institute, Zagreb
- Advanced school on aqua ions and hydrolysis-related equilibria, COST Action CA18202 - NECTAR (Network for Equilibria and Chemical Thermodynamics Advanced Research); 29 September 2023, Ruđer Bošković Institute, Zagreb

Other GEOTRACES activities

- I. Ciglenečki (Ruđer Bošković Institute, Zagreb) is a member EMB working group on Ocean Oxygen.
- D. Omanović (Ruđer Bošković Institute, Zagreb) is a member of the GESAMP working group 45 - Climate Change and Greenhouse Gas Related Impacts on Contaminants in the Ocean.
- Members of the European Marine Board (EMB): Institute of Oceanography and Fisheries, Split (Melita Peharda Uljevic and Daria Ezgeta-Balić) and Ruđer Bošković Institute, Zagreb (Martin Andreas Pfannkuchen (vice-Chair) and Ivica Vilibić).

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

- Strmečki, S., Dešpoja, I., Penezić, A., Milinković, A., Alempijević, S. B., Kiss, G., ... Frka, S. (2024). How do certain atmospheric aerosols affect Cu-binding organic ligands in the oligotrophic coastal sea surface microlayer?. *Environmental Science: Processes & Impacts*, *26*(1), 119-135. Doi: 10.1039/D3EM00415E

- Grozdanić, O., Cindrić, A. M., Finderle, I., Omanović, D. (2024). Examining the Impact of Long-Term Industrialization on the Trace Metal Contaminants Distribution in Seawater of the Pula Bay, Croatia. *Journal of Marine Science and Engineering*, *12*(3), 440. Doi: 10.3390/jmse12030440
- Cukrov, N., Cukrov, N., Omanović, D. (2024). Early Diagenetic Processes in the Sediments of the Krka River Estuary. *Journal of marine science and engineering*, *12*(3), 466. Doi: 10.3390/jmse12030466
- Cukrov, N., Cindrić, A. M., Omanović, D., Cukrov, N. (2024). Spatial Distribution, Ecological Risk Assessment, and Source Identification of Metals in Sediments of the Krka River Estuary (Croatia). *Sustainability*, *16*(5), 1800. Doi: 10.3390/su16051800
- Vidović, K., Hočevar, S., Grgić, I., Metarapi, D., Dominović, I., Mifka, B., ... Ciglenečki, I. (2024). Do Bromine and Surface-Active Substances Influence the Coastal Atmospheric Particle Growth?. *Heliyon*. Doi: 10.1016/j.heliyon.2024.e31632
- Supić, N., Budiša, A., Ciglenečki, I., Čanković, M., Dautović, J., Djakovac, T., ... Vilibić, I. (2024). Are winter conditions impacting annual organic production in the northern Adriatic? Verifications and future projections. Progress in Oceanography, 224, 103247. Doi: 10.1016/j.pocean.2024.103247
- Mateša, S., Marguš, M., Šegota, S., Ciglenečki, I. (2024). Characterization of polysulfides (Sx2−) in seawater euxinic conditions by electroanalytical methods. *Marine Chemistry*, 104398. Doi: 10.1016/j.marchem.2024.104398
- Simonović, N., Marguš, M., Paliaga, P., Budiša, A., Ciglenečki, I. (2024). Changes in organic carbon properties during intense plankton blooms and macroaggregate formation in the coastal Adriatic Sea, Croatia (case studies in 2020-2022). *Mediterranean Marine Science*, *25*(1), 160-178. Doi: 10.12681/mms.35082
- Simonović, N., Dominović, I., Marguš, M., Matek, A., Ljubešić, Z., Ciglenečki, I. (2023). Dynamics of organic matter in the changing environment of a stratified marine lake over two decades. *Science of the total environment*, *865*, 161076. Doi: 10.1016/j.scitotenv.2022.161076
- Marguš, M., Ahel, M., Čanković, M., Ljubešić, Z., Terzić, S., Kobasić, V. H., Ciglenečki, I. (2023). Phytoplankton pigment dynamics in marine lake fluctuating between stratified and holomictic euxinic conditions. *Marine pollution bulletin*, *191*, 114931. Doi: 10.1016/j.marpolbul.2023.114931
- Mifka, B., Telišman Prtenjak, M., Kavre Piltaver, I., Mekterović, D., Kuzmić, J., Marciuš, M., Ciglenečki, I. (2023). Intense desert dust event in the northern Adriatic (March 2020); insights from the numerical model application and chemical characterization results. Earth and space science, 10(7), e2023EA002879. Doi: 10.1029/2023EA002879
- Debi, M., Wang, J., Bi, Q., Xu, R., Aftabuddin, S., Cukrov, N., Du, J. (2023). Atmospheric depositional fluxes of 210Pb in bulk precipitation at the Adriatic coast, Croatia. *Marine pollution bulletin*, *194*, 115353. Doi: 10.1016/j.marpolbul.2023.115353
- Mikelić, I. L., Oreščanin, V., Cukrov, N., Tomašić, N., Rubčić, M., & Barišić, D. (2023). Relationships between radionuclides, metals, and sediment properties in sediment of a bay exposed to anthropogenic pressure and mixed sediment sources (Kaštela Bay, Adriatic Sea, Croatia). *Marine pollution bulletin*, *197*, 115731. Doi: 10.1016/j.marpolbul.2023.115731

- Ciglenečki, I., Orlović-Leko, P., Vidović, K., Simonović, N., Marguš, M., Dautović, J., ... & Galić, I. (2023). The possibilities of voltammetry in the study reactivity of dissolved organic carbon (DOC) in natural waters. *Journal of Solid State Electrochemistry*, *27*(7), 1781-1793. Doi: 10.1007/s10008-023-05423-y
- Kapetanović, D., Smrzlić, I. V., Kazazić, S., Omanović, D., Cukrov, N., Cindrić, A. M., ... Marijić, V. F. (2023). 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 isolates and their antibiotic resistance. *Marine pollution bulletin*, *187*, 114592. Doi: 10.1016/j.marpolbul.2023.114592
- Matek, A., Mucko, M., Casotti, R., Trano, A. C., Achterberg, E. P., Mihanović, H., ... Ljubešić, Z. (2023). Phytoplankton Diversity and Co-Dependency in a Stratified Oligotrophic Ecosystem in the South Adriatic Sea. *Water*, *15*(12), 2299. Doi: 10.3390/w15122299
- Tomaš, A. V., Šantić, D., Šolić, M., Skejić, S., Milinković, A., Kušan, A. C., ...Frka, S. (2023). How do open coastal fire episodes' impact sea surface microlayer neuston communities? *Science of the total environment*, *861*, 160593. Doi: 10.1016/j.scitotenv.2022.160593
- Vrana, I., Gašparović, B., Geček, S., Godrijan, J., Novak, T., Kazazić, S. P., ...Pfannkuchen, D. M. (2023). Successful acclimation of marine diatoms Chaetoceros curvisetus/pseudocurvisetus to climate change. *Limnology and oceanography*, *68*, S158-S173. Doi: 10.1002/lno.12293
- Gašparović, B., Vrana, I., Frka, S., Marić Pfannkuchen, D., Vlašiček, I., Djakovac, T., ...Godrijan, J. (2023). Paradox of relatively more phospholipids in phytoplankton in phosphorus limited sea. Limnology and oceanography, 68(12), 2800-2813. Doi: 10.1002/lno.12464
- Gašparović, B., Lampitt, R. S., Sudasinghe, N., & Schaub, T. (2023). Molecular-level evidence of early lipid transformations throughout oceanic depths. *Geochimica et cosmochimica acta*, *343*, 49-63. Doi: 10.1016/j.gca.2022.12.021
- Gluščić, V., Žužul, S., Pehnec, G., Jakovljević, I., Smoljo, I., Godec, R., ... Frka, S. (2023). Sources, Ionic Composition and Acidic Properties of Bulk and Wet Atmospheric Deposition in the Eastern Middle Adriatic Region. *Toxics*, *11*(7), 551. Doi: 10.3390/toxics11070551
- Godrijan, J., Marić Pfannkuchen, D., Djakovac, T., Frka, S., Gašparović, B. (2023). Lipids of different phytoplankton groups differ in sensitivity to degradation: Implications for carbon export. *Global change biology*, *29*(17), 5075-5086. Doi: 10.1111/gcb.16839
- Penezić, A., Wang, X., Perrier, S., George, C., Frka, S. (2023). Interfacial photochemistry of marine diatom lipids: Abiotic production of volatile organic compounds and new particle formation. *Chemosphere*, *313*, 137510. Doi: 10.1016/j.chemosphere.2022.137510
- Marcinek, S., Galceran, J., Ciglenečki, I., Omanović, D. (2023). A new tool for the determination of humic substances in natural waters: Pulsed voltammetry approach. *Talanta*, *259*, 124547. Doi: 10.1016/j.talanta.2023.124547
- Kapetanović, D., Katouli, M., Lušić, D. V. (2024). Microbial Communities in Changing Aquatic Environments. *Microorganisms*, *12*(4), 726. 10.3390/microorganisms12040726
- Šantić, Danijela; Stojan, Iva; Matić, Frano; Trumbić, Željka; Vrdoljak Tomaš, Ana; Fredotović, Željana; Piwosz, Kasia; Lepen Pleić, Ivana; Šestanović, Stefanija; Šolić,

Mladen; Picoplankton diversity in an oligotrophic and high salinity environment in the central Adriatic Sea // Scientific reports, 13 (2023), 7617, 13. Doi:10.1038/s41598-023-34704-9

- Ćatipović, Leon; Matić, Frano; Kalinić, Hrvoje; Reconstruction Methods in Oceanographic Satellite Data Observation—A Survey // Journal of marine science and engineering, 11 (2023), 2; 11020340, 38. Doi:10.3390/jmse11020340
- Omanović, Dario; Marcinek, Saša; Santinelli, Chiara; TreatEEM—A software tool for the interpretation of fluorescence excitation-emission matrices (EEMs) of dissolved organic matter in natural waters // Water, 15 (2023), 12; 2214, 16. Doi:10.3390/w15122214
- Redžović, Z., Erk, M., Gottstein, S., Perić, M. S., Dautović, J., Fiket, Ž., ... Cindrić, M. (2023). Metal bioaccumulation in stygophilous amphipod Synurella ambulans in the hyporheic zone: The influence of environmental factors. *Science of the total environment*, *866*, 161350. Doi: 10.1016/j.scitotenv.2022.161350
- Donald Canfield, Carmen Castro, Irena Ciglenečki, Peter Croot, Karine Salin, Birgit Schneider, Pablo Serret, Caroline Slomp, Tommaso Tesi, Mustafa Yücel, *Future Science Brief N^0 10: Ocean Oxygen - The role of the Ocean in the oxygen we breathe and the threat of deoxygenation*, Sheila J. J. Heymans (Ed.), European Marine Board IVZW, Ostend Belgium, First edition, June 2023. Doi: 10.5281/zenodo.7941157
- Živković, I., Bura-Nakić, E., Knežević, L., Helz, G. R. (2023). Deposition of Mo, Re and U under contrasting redox conditions; assessment of the [Re/Mo] sw redox proxy. *Geochimica et Cosmochimica Acta*, *359*, 176-190. Doi: 10.1016/j.gca.2023.08.020
- Knežević, L., Zanda, E., Bura-Nakić, E., Filella, M., Sladkov, V. (2023). 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*, 463941. Doi: 10.1016/j.chroma.2023.463941
- Knežević, L., & Bura-Nakić, E. (2023). 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*, 112158. Doi: 10.1016/j.jinorgbio.2023.112158

Completed GEOTRACES PhD or Master theses

- Doctoral Thesis: Andrea Milinković, Biological and chemical responses of sea surface layer to atmospheric deposition, Univ. of Zagreb, 2023
- Doctoral Thesis: Niki Simonović, Dynamics and properties of organic matter in the changing environment of a marine Rogoznica Lake, Univ. of Zagreb, June 2023

GEOTRACES presentations in international conferences

- Dora Crmarić, Elvira Bura-Nakić: Copper redox speciation in the Krka River estuary // XVI International Estuarine Biogeochemistry Symposium: Book of Abstracts / Omanović, Dario, Cobelo-García, Antonio, Schäfer, Jörg (ur.). Zagreb: Institut Ruđer Bošković, 2023. str. 35
- Marcinek Saša, Cindrić Ana Marija, Omanović Dario: Trace elements and dissolved organic matter in estuarine surface microlayer - Case study in the Krka River estuary // XVI International Estuarine Biogeochemistry Symposium: Book of Abstracts / Omanović,

Dario ; Cobelo-García, Antonio ; Schäfer, Jörg (ur.). Zagreb: Institut Ruđer Bošković, 2023. str. 34

- Lucija Knežević, Nuša Cukrov, Elvira Bura-Nakić: Vanadium redox speciation in the extractable fraction of surface sediment in Krka River estuary // XVI International Estuarine Biogeochemistry Symposium: Book of Abstracts / Omanović, Dario ; Cobelo-García, Antonio ; Schäfer, Jörg (ur.). Zagreb: Institut Ruđer Bošković, 2023. str. 28
- Igor Živković, Lucija Knežević, Polona Klemenčič, Leja Rovan, Marta Jagodic Hudobivnik, Elvira Bura-Nakić: Contrasting behavior of mercury in marine sediments from two marine lakes // XVI International Estuarine Biogeochemistry Symposium: Book of Abstracts / Omanović, Dario ; Cobelo-García, Antonio ; Schäfer, Jörg (ur.). Zagreb: Institut Ruđer Bošković, 2023. str. 45
- Hollister Adrienne, Marcinek Saša, Omanović Dario, Schulte Mai-Brit, Koschinsky Andrea: Elbe, Weser and Ems rivers as sources of platinum to the southern North Sea // XVI International Estuarine Biogeochemistry Symposium: Book of Abstracts / Omanović, Dario; Cobelo-García, Antonio ; Schäfer, Jörg (ur.). Zagreb: Institut Ruđer Bošković, 2023. str. 41-42
- Ana Rapljenović, Željko Kwokal, Marko Viskić, Vlado Cuculić: Plastic debris as a medium for trace metal adsorption in the estuarine environment // XVI International Estuarine Biogeochemistry Symposium: Book of Abstracts / Omanović, Dario ; Cobelo-García, Antonio ; Schäfer, Jörg (ur.). Zagreb: Institut Ruđer Bošković, 2023. str. 16
- Nuša Cukrov, Abel Barré, Elisa Catao, Remi Chemin, Damien Sous, Jean-Francois Briand, Veronique Lenoble: Impact of biofilm on the microplastics settling velocities // XVI International Estuarine Biogeochemistry Symposium: Book of Abstracts / Omanović, Dario ; Cobelo-García, Antonio ; Schäfer, Jörg (ur.). Zagreb: Institut Ruđer Bošković, 2023. str. 14
- Jadranka Pelikan, Dijana Pavičić-Hamer, Marin Glad, Kristina Pikelj, Bojan Hamer: Assessment of marine sediments quality of Rovinj coastal area and Lim bay estuary // XVI International Estuarine Biogeochemistry Symposium: Book of Abstracts / Omanović, Dario ; Cobelo-García, Antonio ; Schäfer, Jörg (ur.). Zagreb: Institut Ruđer Bošković, 2023. str. 23-24
- 35th Topical Meeting of the International Society of Electrochemistry, Gold Coast, Australia, May 2023: Electrochemical analysis of Co(II) complex with L-glutathione under seawater conditions; Bačinić A., Mlakar M.
- Saša Marcinek, Ana Marija Cindrić and Dario Omanović: Does seasonal differences in organic matter influence copper bioavailability in Krka River estuary? // 1st International Scientific Symposium Interdisciplinary Approach to the Scientific Research of the Adriatic Sea - InspireAdriatic 2023 Book of Abstracts. Zagreb: Institut Ruđer Bošković, 2023. Str. 28
- Andrea Milinković, Abra Penezić, Ana Cvitešić Kušan, Valentina Gluščić, Silva Žužul, Sanda Skejić, Danijela Šantić, Ranka Godec, Gordana Pehnec, Dario Omanović, Sanja Frka: Variabilities of biochemical properties of the sea surface microlayer: Insights to the atmospheric deposition impacts // 1st International Scientific Symposium Interdisciplinary Approach to the Scientific Research of the Adriatic Sea - InspireAdriatic 2023 Book of Abstracts. Zagreb: Institut Ruđer Bošković, 2023. Str. 29-30
- Nuša Cukrov, Lucijan Ljubičić, Vlado Cuculić, Anamarija Frankić and Neven Cukrov: Microplastic in the Adriatic Sea, urban vs remote areas // 1st International Scientific

Symposium Interdisciplinary Approach to the Scientific Research of the Adriatic Sea - InspireAdriatic 2023 Book of Abstracts. Zagreb: Institut Ruđer Bošković, 2023. Str. 30-31

- Marija Parać, Nuša Cukrov, Neven Cukrov: Conducted research about microplastics analysis in Krka River estuary and its further prospects // 1st International Scientific Symposium Interdisciplinary Approach to the Scientific Research of the Adriatic Sea - InspireAdriatic 2023 Book of Abstracts. Zagreb: Institut Ruđer Bošković, 2023. Str. 31-32
- Ivica Vilibić: What we know after centurial thermohaline observations in the Adriatic Sea? // 1st International Scientific Symposium Interdisciplinary Approach to the Scientific Research of the Adriatic Sea - InspireAdriatic 2023 Book of Abstracts. Zagreb: Institut Ruđer Bošković, 2023. Str. 22
- Iva Tojčić, Clea Denamiel, Petra Pranić, Ivica Vilibić: Kilometer-scale coupled atmosphere-ocean climate modelling in the Adriatic region // 1st International Scientific Symposium Interdisciplinary Approach to the Scientific Research of the Adriatic Sea - InspireAdriatic 2023 Book of Abstracts. Zagreb: Institut Ruđer Bošković, 2023. Str. 23
- Neven Cukrov, Marija Parać, Nuša Cukrov, Željko Kwokal, Sandi Orlić, Dario Omanović, Branko Jalžić: Anchialine caves around Krka River estuary // 1st International Scientific Symposium Interdisciplinary Approach to the Scientific Research of the Adriatic Sea - InspireAdriatic 2023 Book of Abstracts. Zagreb: Institut Ruđer Bošković, 2023. Str. 25
- Vedran Damjanović, Valentina Gašo, Stijepo Grljević, Marko Kapelj, Iva Kostanjšek, Viktorija Milec, Marko Pervan, Anamarija Tremljan, Antonio Brcković, Tomislav Fiket: Ocean bottom seismometers – a new way of researching the seabed in Croatia // 1st International Scientific Symposium Interdisciplinary Approach to the Scientific Research of the Adriatic Sea - InspireAdriatic 2023 Book of Abstracts. Zagreb: Institut Ruđer Bošković, 2023. Str. 27
- Frka Milosavljević, Sanja; Penezić, Abra; Wang, Xinke; Perrier, Sebastian; George, Christian | Photochemistry of marine organics at the air-water interface as a source of volatile organic compounds influencing new particle formation // abstracts of keynote invited lectures and contributed papers. Beograd, Srbija: Vinča Institute of Nuclear Sciences, Serbia; Environment and Climate Research Institute NILU, Norway, 2023
- Milinković, Andrea; Penezić, Abra; Gluščić, Valentina; Žužul, Silva; Godec, Ranka; Pehnec, Gordana; Frka Milosavljević, Sanja | Atmospheric deposition of nitrogen and phosphorus to the Central Adriatic area and biogeochemical implications // International conference and 13th Croatian scientific and professional meeting “Air Protection 2023”: Book of Abstracts. Zagreb: Hrvatsko udruženje za zaštitu zraka (HUZZ), 2023.
- Žužul, Silva; Gluščić, Valentina; Bešlić, Ivan; Milinković, Andrea ; Penezić, Abra ; Frka, Sanja | The impact of anthropogenic and natural sources on particle-bound metals at the middle Adriatic // 28HSKIKI : 28th Croatian Meeting of Chemists and Chemical Engineers and 6th Symposium Vladimir Prelog : Book of Abstracts / Rogošić, Marko (ur.). Zagreb: Hrvatsko društvo kemijskih inženjera i tehnologa (HDKI), 2023.

Submitted by Saša Marcinek (smarcin@irb.hr).