Department of Environmental Sciences

Outstanding Achievements 2020

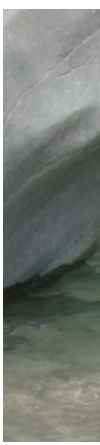
Foreword

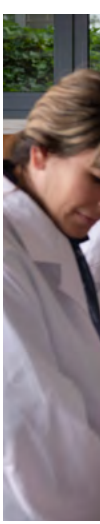
Prof. Dr. Milena Horvat
Head, Department
of Environmental Sciences

Explaining the link between natural processes and human activities and the effects that these activities have on human and ecosystem health is a challenge, one that requires a team of highly competent and interdisciplinary research staff as well as access to state-of-the-art research infrastructure and instrumentation, all of which are available here at the Department of Environmental Sciences. Altogether, it means that the Department's activities are as varied and diverse as the environment itself.

Sometimes, however, we recognise that the results we produce exceed our ability to interpret them, which forces us to either upgrade our knowledge by strengthening our cooperation with different disciplines. This effort is reflected in the coordination of and participation in many national and international projects.

During this global pandemic, our work and home life have merged and communicating and collaborating using digital resources has become part of the daily routine. Although adjusting to this new situation is challenging, we continue to explore new ways of working together, as evidenced by our remarkable achievements in 2020. We are, therefore, in this brochure, proud to share some of our successes in graphics and words in a way that makes them understandable to a broad audience.





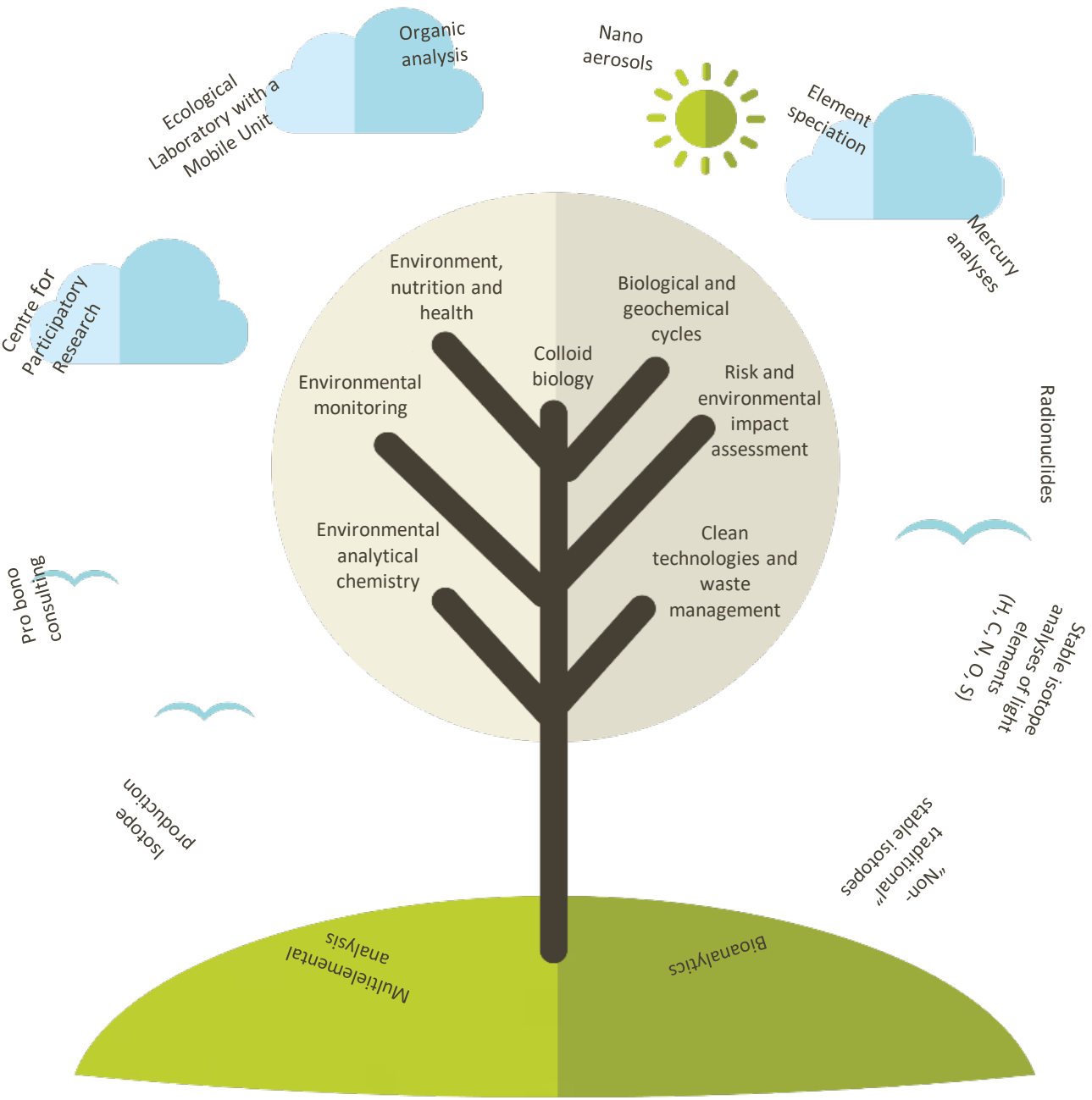
About us

The Department of Environmental Sciences (O-2) focuses on interweaving the physical, chemical, and biological processes that shape our environment. The research we perform here at the Department of Environmental Sciences is interdisciplinary and multidisciplinary and covers several areas, such as environmental analytical chemistry, biogeochemical cycles, microbial ecology, environment and health, environmental technologies, risk and environmental assessment, and environmental monitoring. We also focus on the development of technical solutions for environmental problems and environmental management.

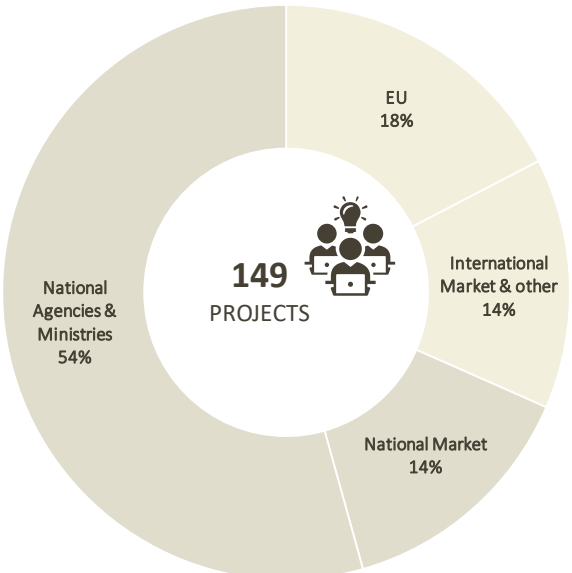
Currently, our Department hosts the "ISO-FOOD" ERA Chair for isotope techniques in food safety, quality and traceability, the infrastructure Centre of Mass Spectrometry (CMS), the Mobile Ecological Laboratory Unit (ELMU) and the Center for Participatory Research. It coordinates the H2020 Marie Skłodowska-Curie Innovative Training Network GMOSTrain, the H2020 Twinning project SurfBio, and participates in many EU, national, and international projects.

We also offer contract work for partners from industry, academia, public services and other customers and our laboratories are specialised in inorganic and organic analytical chemistry, radiochemistry and isotope ratio analysis. Besides analytical services, we also provide strategic environmental assessment, consulting and project assistance in environmental analysis, natural resource management, eco-technologies, food research and authentication, and public health.

O-2 at the glance



Highlights of 2020



The Department of Environmental Sciences has a long tradition of developing collaborative partnerships with industry. This collaboration helps deliver new products and services, which advances the Slovene economy, improves our quality of life, and brings real-world technologies and management issues into our research laboratories. Building international partnerships are recognised as a necessity for advancing technologies and solving global problems.

The Department offers a broad spectrum of research topics and excellent laboratory facilities, fosters public-private partnerships to design, propose and launch new projects, and participates in EU and international research programmes. In 2020 the Department was involved in 102 national and 47 international projects 26 were within the EU framework projects.

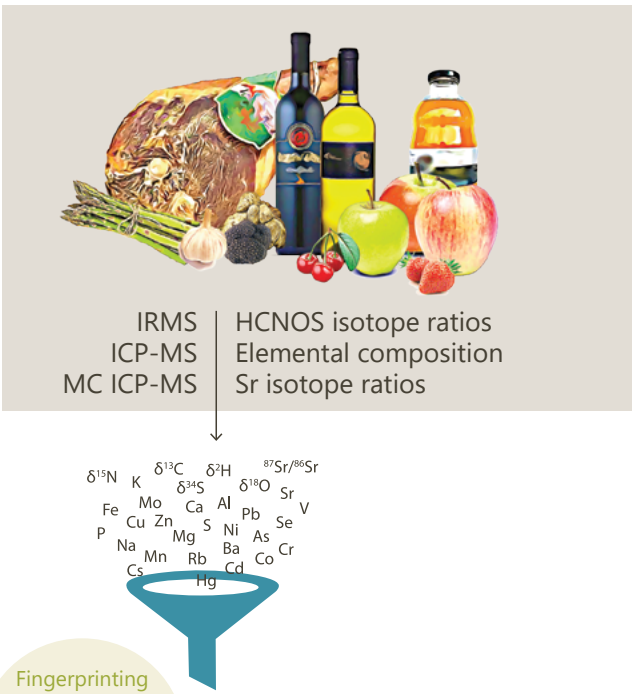
ERA-Chair ISO-FOOD

The work of the ERA-Chair ISO-FOOD includes:

- Developing standard operating procedures and optimising methods using response surface methodology (RSM) and artificial neural network (ANN).[1, 2, 3, 4]
- Preparing reference materials for stable isotope analysis of light elements of plant and animal origin.[5]
- Database creation and data visualisation.[6]
- Modeling using multivariate statistical methods such as Linear Discriminant Analysis (LDA), Orthogonal Partial Least Squares Discriminant Analysis (OPLS-DA), and Data Driven Soft Independent Modeling of Class Analogy (DD-SIMCA).[7]
- Using the data to discriminate foodstuffs based on species, cultivars, type, geographical origin and agricultural practices.[8, 9]

This approach will help develop the appropriate traceability system to protect economically important Slovenian high-quality food products.[10]

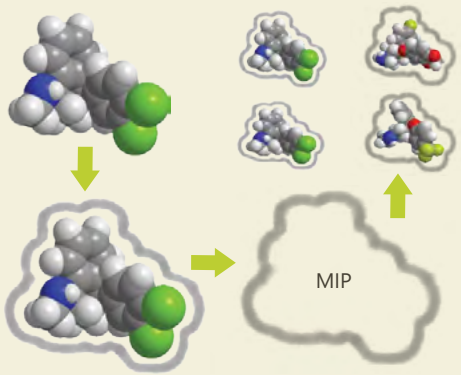
https://metinalista.si/top-objave-september-2020/



Treatment and degradation of contaminants of emerging concern

Pharmaceutical residues enter, either through direct disposal or indirectly through humans, into the sewerage system. Similarly, bisphenols migrate from consumer products into sewage and further to the wastewater treatment plant. [11]

In this novel extraction procedure, structurally related pharmaceuticals are bound to the molecularly imprinted polymer (MIP), making this technology potentially useful for wastewater treatment.[17]



We used the antidepressant pharmaceutical sertraline as the template for the synthesis of MOLECULARLY IMPRINTED POLYMERS (MIPs) [17]

During wastewater treatment, pharmaceuticals and bisphenols are either SORBED on activated sludge or BIODEGRADED. [12, 13, 14]

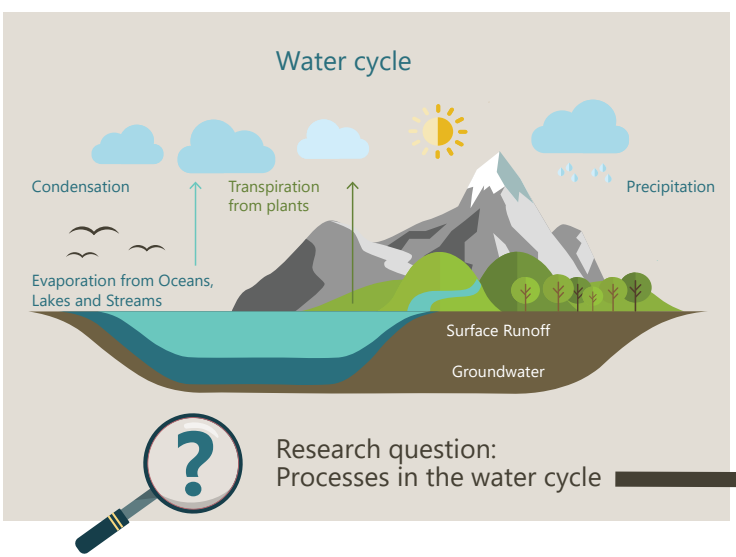
Together with biodegradation products, treated wastewater enters the aqueous environment

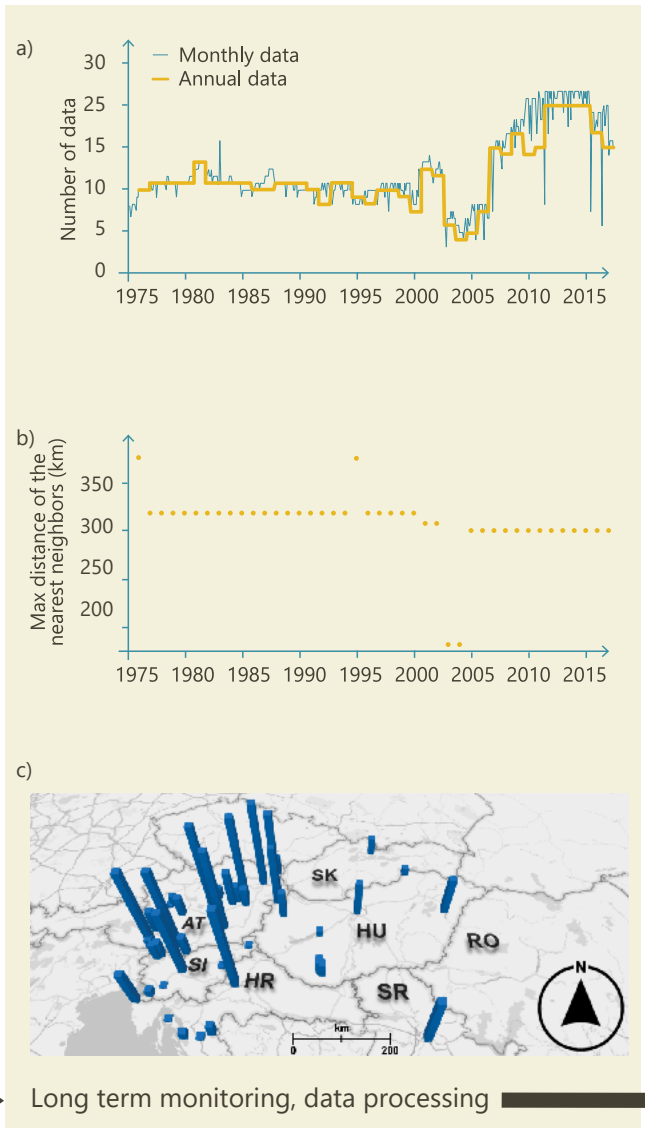
Sunlight triggers the formation of photodegradation products in surface waters. [15, 16]

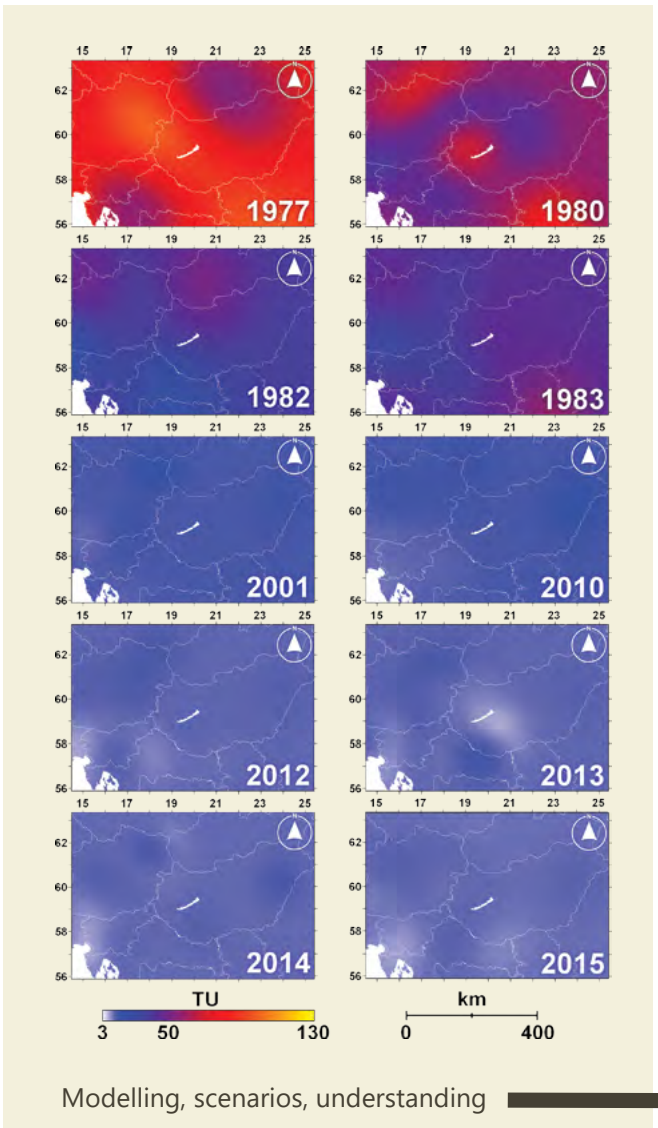
Isotopes in water management

Tritium (^3H) occurs in nature only in trace quantities. Nuclear weapons testing in the 1950s and 1960s introduced large but uneven amounts of ^3H into the atmosphere. Since then, the ^3H activity in precipitation has been decreasing at an uneven rate.

Because the ground- and surface waters are recharged by precipitation, their ^3H activities can be used as a unique tracer for determining the age and residence time of young water (< 60 years) in aquifers and understanding the mixing of ground- and surface water in springs, rivers or lakes.

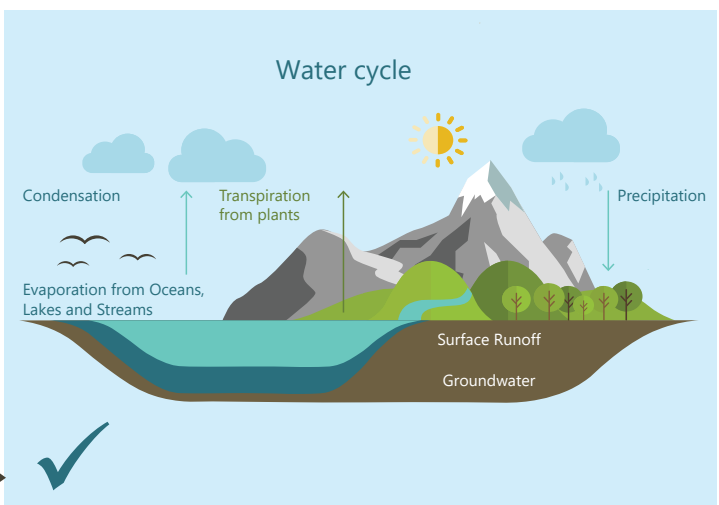






After more than 40 years of observation and international cooperation, a spatio-temporal model and time series of distribution maps of mean annual ^{3}H activity in precipitation in the Adriatic-Pannonian region covering for the years 1976 to 2017 were finally published. With these maps, much more precise data will be available for the sustainable exploitation and protection of water resources.

Figure: From local data to a regional AP3H model and better management of water resources[18]

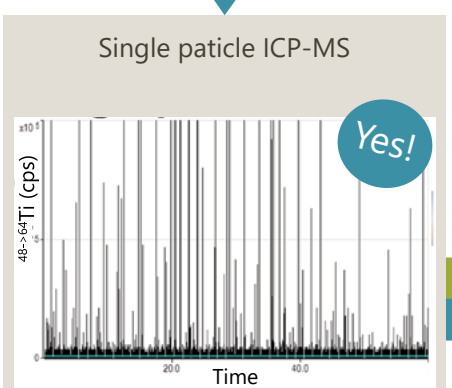


HUMAN BIOMONITORING in the context of environmental and human health interactions

Main achievements:

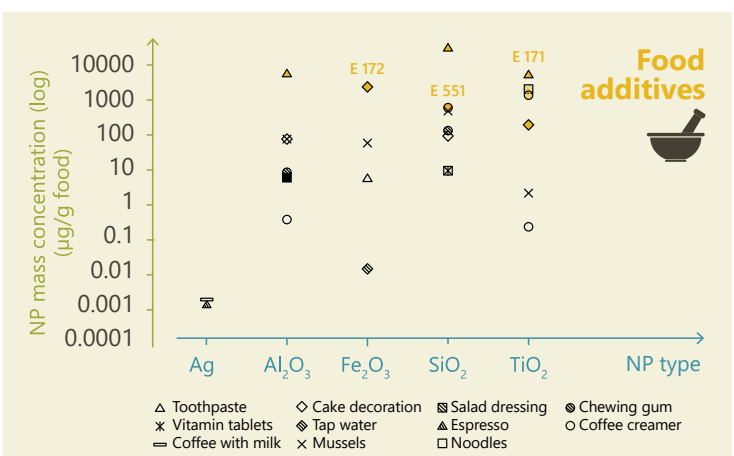
- Exposure of children and adolescents from Slovenia to bisphenols depends on fatty food consumption, while parabens are associated with the use of cosmetics (e.g., lipstick).[19]
- Connection between levels of urinary endocrine disrupting chemical biomarkers in the human population and genetic polymorphism was demonstrated for the first time.[11]
- Exposure of adolescents living in rural regions of Northeastern Slovenia to the herbicide glyphosate and AMPA is low.[20]
- The Slovenian population is widely exposed to several phthalate parent compounds from food and other products (e.g. plastic packaging, tins, personal care products, PVC) and lifestyle and habits (e.g. living space, time spent outside).[21]
- Rural populations and having a lower level of education are associated with higher phthalate concentrations.[13]
- For the first time, exposure of Slovenian mothers and their children to organophosphate and pyrethroid pesticides was assessed.[22]
- Fatty acid composition can be used as nutritional markers for seafood consumption.[23, 24]
- Selenium status observed in healthy pregnant women carrying allele ε4 could be linked to the proposed APOE ε4 beneficial effects early in life.[25]
- The exposome paradigm allows us to evaluate the impact of multiple exposures on a child's neurodevelopment.[26]

Screening of food for the presence of inorganic nanoparticles by single particle ICP-MS



Nanoparticles (NPs) can be present in food due to many potential sources, including food additives, naturally occurring NPs, contamination of food with anthropogenic NPs present in the environment or food contact materials, and NPs formed during either food preparation or production. Due to the concerns that have been raised among regulatory food authorities and consumers regarding the possible risk of NPs on human health, NP analyses of different food products are needed.

Single particle ICP-MS was applied as a screening technique for determining the presence, identity and concentration of inorganic NPs in different food samples. NPs containing iron, silicon, aluminium and titanium were most frequently quantified in the investigated food samples. The highest concentrations of NPs (in mg/g range) were associated with food containing the additives E 171 (titanium dioxide), E 172 (iron oxides) and E 551 (silicon dioxide), which are known to contain NPs.[27, 28]

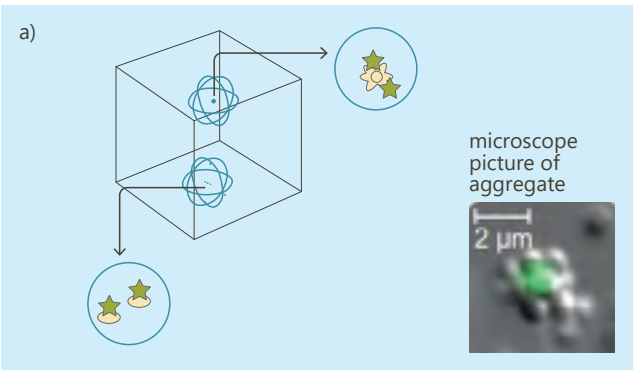


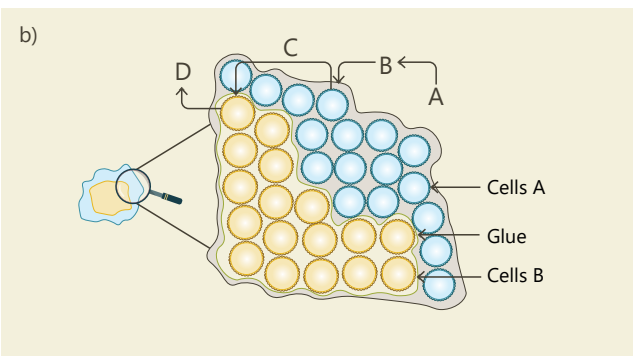
Colloidal biology creates a beneficial compromise between microbial communities and technology

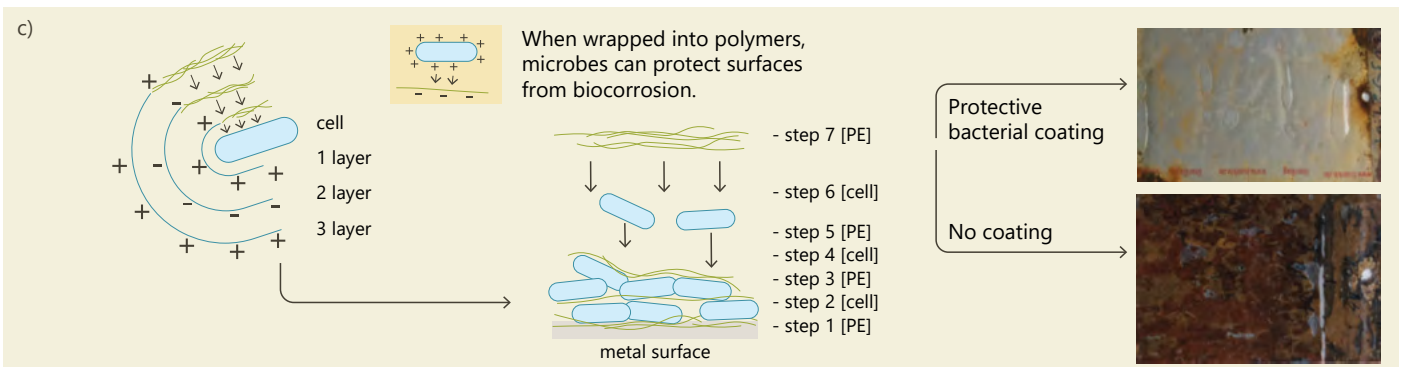
A new direction in science:
A new field of colloid biology has been established at the Jozef Stefan Institute. It is led by an interdisciplinary research group investigating the cell-surface interaction of microbes and their colloidal behaviour.
A Slovenian research institute becomes an innovative force in microbe-surface interactions (SurfBio).

a) In nature, bacterial cells are attached either to one another or the substrate surface. In our work, we show the importance of distance between two cells for metabolite exchange.[29]
b) How do we spatially arrange bacterial cells?[30]
1. We attach different bacteria to each other using special polymers as a "glue" to construct new metabolic pathways and improve bacterial cell properties.
2. By simulating natural systems, such aggregated complexes are sustainable and depend on the activity of the whole community.

c) In an alternative approach, we deposit bacterial cells on the surface of materials in the form of multi-layered artificial biofilms. Recognised by the Slovenian Research Agency, the approach is among the most visible achievements of the year in biotechnology.[31]





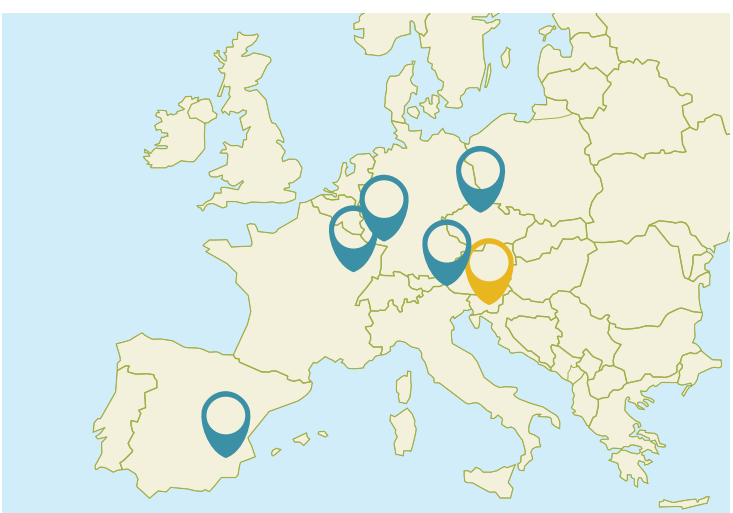


SurfBio
Innovation HUB Cration

The Laboratory for Colloidal Biology coordinates and creates an innovation hub to study microbe–surface interactions through the EU-funded SurfBio project. Using high-tech methodologies and equipment, researchers plan to support material designers, biotechnology researchers, academic institutions, industry and policy-makers with research services and assessments to optimise novel materials for various applications.

Understanding the interactions at the interface between two different materials plays a critical role in material design in scientific fields ranging from aerospace to biomedicine. Whether the material interacts with a solid, a liquid or a gas or with biological systems such as microbes or tissues, understanding and controlling surface interactions is paramount to the material's performance, safety and reliability.

surfbio.eu
SurfBio_Hub



ICARUS H2020 FINALE

In 2020 we successfully concluded a lengthy participant-oriented part of the **ICARUS H2020** project by providing each individual involved in our campaign with a personalised and detailed report of the results they collected. The task of compiling and reviewing almost 100 individual reports was completed in a short time due to our collective effort.

SENSORS & INTAKE DOSE

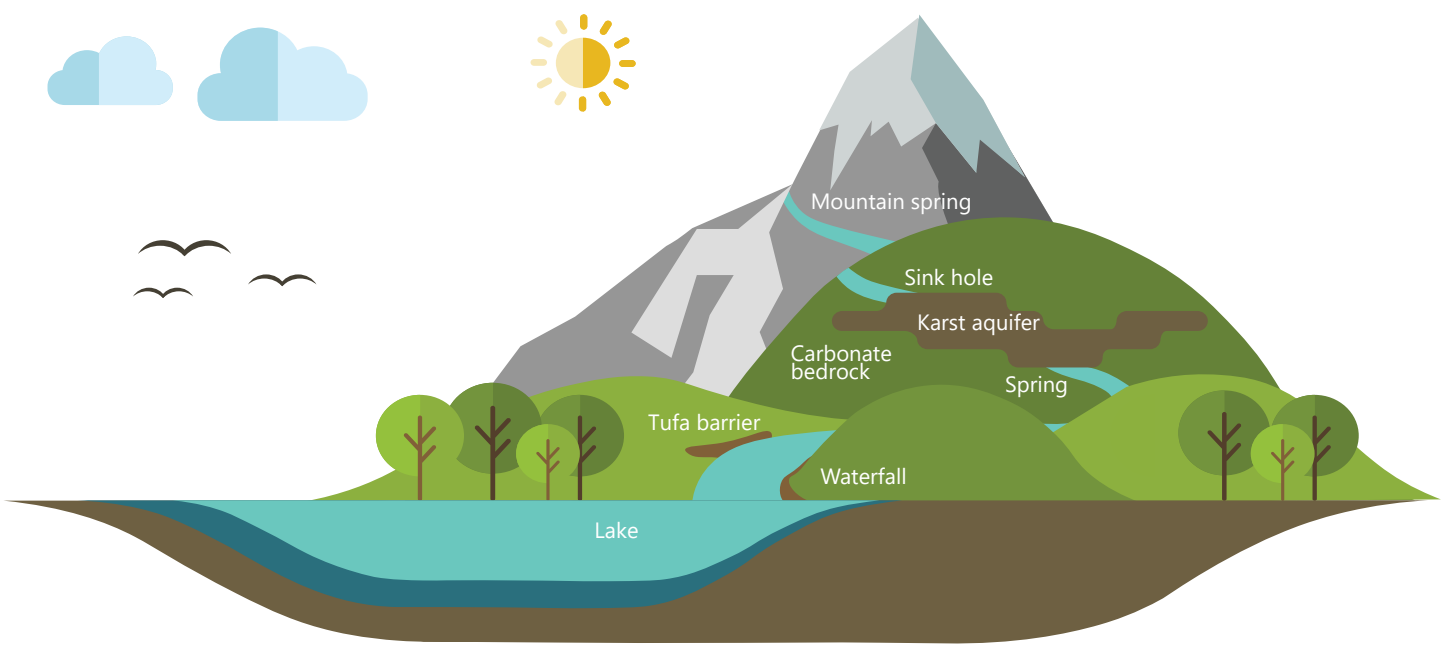
Our year started with the publication of a paper exploring the use of low-cost sensors to determine the intake dose of airborne particulate matter on an individual level, entitled: *Comparing Airborne Particulate Matter Intake Dose Assessment Models Using Low-Cost Portable Sensor Data.* An important conclusion of this research is that low-cost personal particulate matter sensors can provide accurate data for such surveys if the proper techniques are applied.

CitieS-Health Ljubljana: CITIZENS IN ACTION

A data collection campaign was launched within the **CitieS-Health H2020** project involving the citizens of Ljubljana, including elementary school pupils. To this end, a School Tech-Day Event (STDE) was organised, and lessons learned conducting in citizen science (CS) activities with pupils published in a paper entitled *Citizen Science as Part of the Primary School Curriculum: A Case Study of a Technical Day on the Topic of Noise and Health.*

Uranium as a tracer in a karst watershed

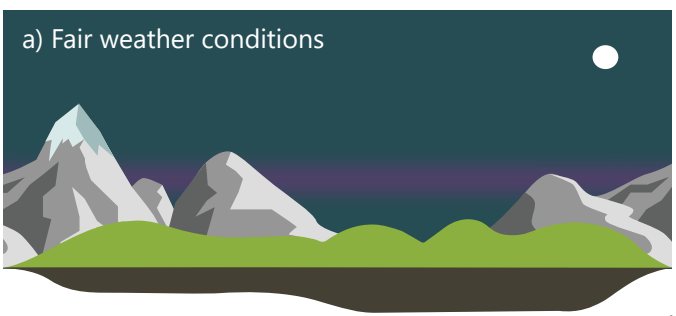
- U isotopic differences reflect the changing bedrock lithology and the mixing of waters from different sources, where fractured carbonate rocks have higher $^{234}U/^{238}U$ activity ratios while less permeable and soluble rocks have lower $^{234}U/^{238}U$ activity ratio.
- In groundwater, the $^{234}U/^{238}U$ activity ratio is changing during water-rock interactions. The $^{234}U/^{238}U$ activity ratio in crystalline aquifers is around 1 and in more soluble aquifers is up to 1.3-1.8.
- The $^{234}U/^{238}U$ activity ratio varies depending upon the mean transit time of groundwater recharging the karst stream.
- U concentration and U isotopic ratios deviate between the high- and low-water discharges. U values are lower under high flow conditions than under low flow conditions (~6%—20%) .
- Isotopically lighter U co-precipitates with carbonate in flowstone and tufa without fractionation; therefore, U isotope ratios in terrestrial carbonate formations reflect both the storage of CO_2 and the amount U bond to detrital material.[32]



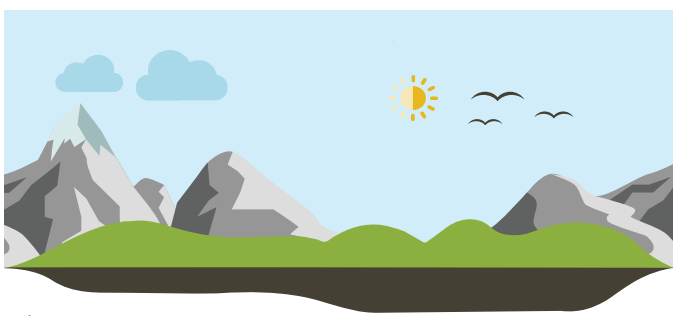
Radon-based classification of atmospheric mixing state in the Ljubljana Basin

The natural radioactive noble gas radon (^{222}Rn) has been used as a tracer to classify atmospheric mixing within the atmospheric boundary layer (ABL). Atmospheric mixing state (so-called atmospheric stability) is one of the most significant factors influencing air pollution variability within the ABL. The atmosphere is stable at night when only mechanical mixing is active and unstable during the day when convective and mechanical mixing is present.

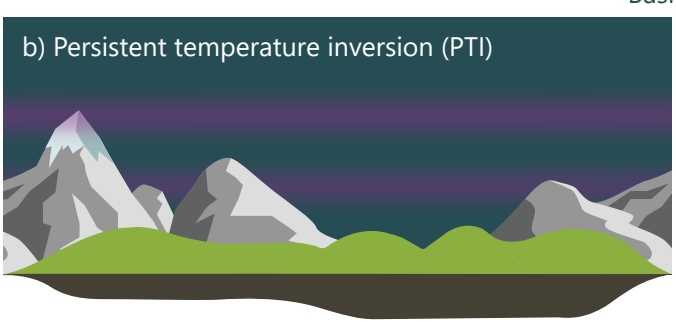
The stable nocturnal boundary layer is formed, in which pollutants emitted at or near the surface are usually trapped.



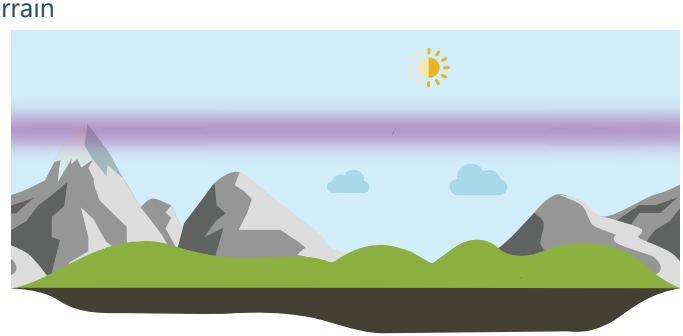
The stable nocturnal boundary layer is eroded shortly after the onset of convective mixing, and pollution events usually end abruptly.



Basin terrain



The stable nocturnal boundary layer within the synoptic inversion layer is formed.



The stable nocturnal boundary layer is eroded, the synoptic inversion layer remains present throughout the day, in which pollutants are trapped.

Radon concentration in the lower atmosphere strongly depends on meteorological conditions. Therefore observing radon concentrations can successfully replace common conventional meteorological techniques for classifying the atmospheric mixing state.

A novelly developed radon-based classification of atmospheric mixing state accounts for diurnal and synoptic timescale changes in the basin terrain and is a powerful tool for improved assessment of pollution mitigation measures and evaluating the performance of urban pollution models.[33]

Radon (Rn) and particulate matter (PM10) concentrations in radon-based mixing classes: unstable (Class #1), stable (Class #5), and PTI (Class #6) in the Ljubljana Basin over two winters ($W_{16–17}$ and $W_{17–18}$).

9 academic and 1 industrial partner in 5 countries 15 Early Stage Researchers

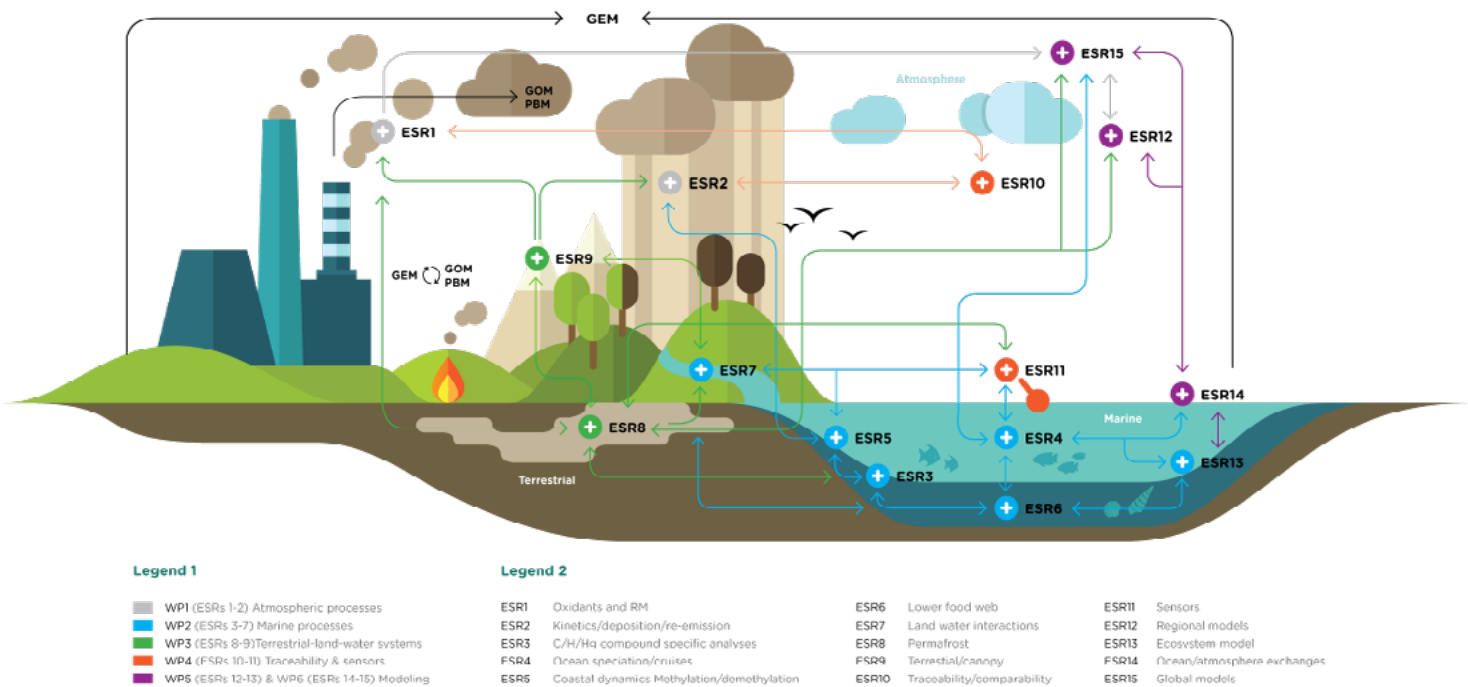
The Department of Environmental Sciences was selected to be the coordinator of an EU project within the MSCA ITN scheme entitled "Global Mercury Observing System for the Implementation of Minamata Convention" (GMOS-Train) for 2020–2024. The project includes 10 European partners and eminent research institutions, such as Harvard University and MIT, and other organisations, such as UN Environment, JRC Ispra and NGOs.

The objectives of the GMOS-TRAIN network are to:

1. Provide urgently needed training in mercury science within the context of the UNEP Minamata convention, and
2. Bridge key knowledge gaps in biogeochemical mercury cycling that currently hamper national environmental policymaking regarding mercury emissions.

The GMOS-Train aims to recruit 15 outstanding and highly motivated Early Stage Researchers to meet the project's ambitious goals.

GMOS TRAIN



DESIGNATED INSTITUTE
for the Amount of substance/Chemical trace Elements/in the organic and inorganic materials

The Department has been the holder of the national etalon for trace element content in organic and inorganic materials since 2010. In the framework of the international metrology systems, the Department is a Designated Institute (https://www.bipm.org/en/about-us/member-states/si/) and demonstrates Calibration and Measurement Capability (CMC) through Key Intercomparisons, which resulted in 15 CMCs in the BIPM Key Comparison Database (KCDB), https://www.bipm.org/kcdb/.[34]

Prestigious Awards

Award for best presentation at the conference

☆ VRZEL Janja, OGRINC Nives, LUDWIG Ralf. A modelling framework for simulating groundwater and surface water dynamics and their interactions at the 2nd Atlas Georesources International Congress, Applied Geosciences for Groundwater, Hammamet, Tunisia in March 2019.

Best Poster Award

☆ KRAJNC, Bor, NEČEMER, Marijan, CAMIN, Federica, VOGEL-MIKUŠ, Katarina, HAMZIĆ GREGORČIČ, Staša, STROJNIK, Lidija, OGRINC, Nives. Characterization of truffles (Tuber sp.) in Slovenia using stable isotope approach and elemental composition: 1st ISO-FOOD International Symposium on Isotopic and Other Techniques in Food Safety and Quality, Portorož, Slovenia, April 1-3, 2019.

☆ CHOUHAN, Raghuraj, FAJON, Vesna, ŽIVKOVIĆ, Igor, PAVLIN, Majda, BERISHA, Sabina, JERMAN, Ivan, HEATH, David, HORVAT, Milena. Development of an efficient passive sampler adsorbent for the detection of mercury in water via stratified nanostructured knitting. 1st ISO-FOOD International Symposium on Isotopic and Other Techniques in Food Safety and Quality, Portorož, Slovenia, April 1-3, 2019.

☆ STROJNIK, Lidija, HLADNIK, Jože, WEBER, Nika, KORON, Darinka, STOPAR, Matej, ZLATIĆ, Emil, KOKALJ, Doris, NAGLIČ GRIL, Mateja, GREBENC, Tine, PERINI, Matteo, PIANEZZE, Silvia, CAMIN, Federica, OGRINC, Nives. Analytical technique sniffs out aroma: 11th Jožef Stefan International Postgraduate School Students' Conference and 13th Young Researchers' Day, 15-16 May 2019, Planica, Slovenia.

☆ TKALEC, Žiga. Development of an analytical method for untargeted screening for organic contaminants in human urine (Results of the research collaboration between O-2 and Recetox (Masaryk University in Brno, Czech Republic)).

☆ Aleš Lapanje, Excellent in Science 2020

The selection of the most visible achievements of the past year – Excellent in Science 2020, carried out by members of the Scientific Research Councils of various scientific fields, includes Dr Aleš Lapanje from the Department of Environmental Sciences, JSI. In the link https://danarrs.si/, you can watch a presentation entitled "How we made a live protective coating", in which Dr Lapanje talks about his scientific achievement that was chosen as the most visible research achievement in the field of biotechnology and medicine, that can inspire a younger generation.

☆ Janja Vidmar, 2020 Jožef Stefan Golden Emblem Prize

Janja Vidmar received a Jožef Stefan Golden Emblem Prize for her PhD dissertation: *Quantification and sizing of metal-based nanoparticles in the environmental and biological samples.* Janja worked under the mentorship of prof. dr. Radmila Milačič on the development and optimisation of analytical methods for characterisation and quantification of commonly used metal nanoparticles (titanium dioxide, silver and zero-valent iron nanoparticles) in environmental and biological systems.

☆ Milena Horvat, ICMGP 2019 Kate Mahafy Life Achievement Award, Krakow, Poland

Prof. Milena Horvat, Head of Department, received the 5th Kathryn R. Mahaffey Lifetime Achievement Award in Mercury Research. The K. R. Mahaffey Lifetime Achievement Award was established in 2011 to celebrate and recognize select individuals who have made extraordinary lifetime achievements in mercury research, mentoring, and contributions to government policy and public outreach. The ceremony was held at the 14th ICMGP in Krakow, Poland, in September 2019.

☆ Nives Ogrinc, Zois 2019 Award

Prof. Nives Ogrinc received the Zois Award for Excellence for the interdisciplinary use of stable isotopes of light and heavy elements in physical chemistry, ecology, metrology, food science and archaeology. Prof. Ogrinc has focused much of her research on carbon cycling in aquatic environments and related climate change. A significant result of her work is that despite the increase in carbon dioxide concentration in the atmosphere, the Gulf of Trieste is still not susceptible to acidification processes. Through her work, she has added to the overall body of knowledge by introducing new isotopic methods that provide new knowledge about the origin and traceability of organic compounds in the environment. One of her most outstanding achievements is the use of stable isotopes in food research. Prof. Ogrinc was the first to establish a system for determining the authenticity and traceability of foodstuff in Slovenian, which helps protect producers and consumers and supports the promotion of high-quality Slovenian products. Cooperation with archaeologists has led to new insights into the development and way of living of our ancestors and represents an important contribution to Slovenian and world cultural heritage.

☆ Nives Ogrinc, 2019 Congress Ambassador

Prof. Nives Ogrinc obtained the award for the organisation of the 22nd International Symposium on Environmental Biogeochemistry (ISEB), which was held in Piran in 2015. The International Association of Environmental Biogeochemistry - ISEB has organised a symposium every two years for more than thirty years. The ISEB strives to bring together scientists from various disciplines relating to biogeochemistry in various fields, including soil science, microbial ecology and marine, lacustrine and atmospheric research. More than 100 participants from 23 countries attended the symposium. Strong international representation with six invited speakers and 52 oral and 54 poster presentations was delivered over the four days of the symposium.

Theses and Mentoring

Doctoral Dissertations

- ☆ POTOČNIK, Doris. Chemical and isotopic methods for determining authenticity and geographical origin of milk and dairy products: doctoral dissertation. Ljubljana, 2020 (mentor Nives Ogrinc; co-metor Barbara Jeršek)
- ☆ TRDIN, Ajda. Mercury speciation in prenatal exposure: doctoral dissertation. Ljubljana, 2020 (mentor Milena Horvat; co-mentor Ingrid Falnoga)
- ☆ JAGODIC HUDOBIVNIK, Marta. Trace elements in human samples and fatty acid composition of human milk in Slovenian population: doctoral dissertation. Ljubljana, 2020 (mentor Milena Horvat; co-mentor Nives Ogrinc)
- ☆ BERGANT, Matic. Development of analytical techniques for determination of Polybrominated diphenyl ethers in living organisms: doctoral dissertation. Ljubljana, 2020 (mentor Janez Ščančar; co-mentor Radmila Milačič)
- ☆ KIKAJ, Dafina. Assessing atmospheric stability in the Ljubljana Basin and Vipava Valley regions using Radon-22: doctoral dissertation. Ljubljana, 2020 (mentor Janja Vaupotič; co-mentor)

Master Thesis

- ☆ BOŽIČ, Dominik. Mass spectrometry & strontium isotope stratigraphy: 87Sr/86Sr measurements in fossils from Trnovski gozd with multi-collector inductively coupled plasma mass spectrometer: M. Sc. Thesis. Ljubljana, 2020 (mentor; co-mentor)
- ☆ PILAR, Anja Marija. Analysis of actinides in the insoluble residues after decomposition of soil and sediment samples by various decomposition techniques: M. Sc. Thesis. Ljubljana, 2020 (mentor Ljudmila Benedik; co-mentor Helena Prosen)
- ☆ ŠIŠKOVIČ, Nina. Characterisation of volatile organic compounds in truffles: M. Sc. Thesis. Ljubljana, 2020 (mentor Rajko Vidrih, co-mentor Nives Ogrinc)
- ☆ KEJŽAR, Jan. Comparison of algae dietary supplements: antioxidative potential and isotopic composition: M. Sc. Thesis. Ljubljana, 2020 (mentor Nataša Poklar Urlih; co-mentor Nives Ogrinc)
- ☆ PLEŠNIK, Helena. Determination of bacterial lignin degradation products by liquid chromatography coupled to mass spectrometry: M. Sc. Thesis. Ljubljana, 2020 (mentor Jurij Trontelj; co-mentor Tina Kosjek)

Bachelor Thesis

- ☆ GABRIČ, Maja. Chromium speciation analysis in wine and beer by high performance liquid chromatography - inductively coupled plasma mass spectrometry using enriched stable isotopes of 53 Cr(III) and 50 Cr(VI): B.Sc. Thesis, Ljubljana, 2020 (mentor Maša Islamčević Razboršek; co-mentor Janez Ščančar)

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11
SCHOLARSHIP HOLDERS in 2020/21

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100
RESEARCH ARTICLES

Publications Published in 2020

Original Article

1. Ćirić, Andrija, Krajnc, Bor, Heath, David John, Ogrinc, Nives. Response surface methodology and artificial neural network approach for the optimization of ultrasound-assisted extraction of polyphenols from garlic. Food and chemical toxicology. 2020, 135, 110976-1-110976-9. DOI: 10.1016/j.fct.2019.110976.
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