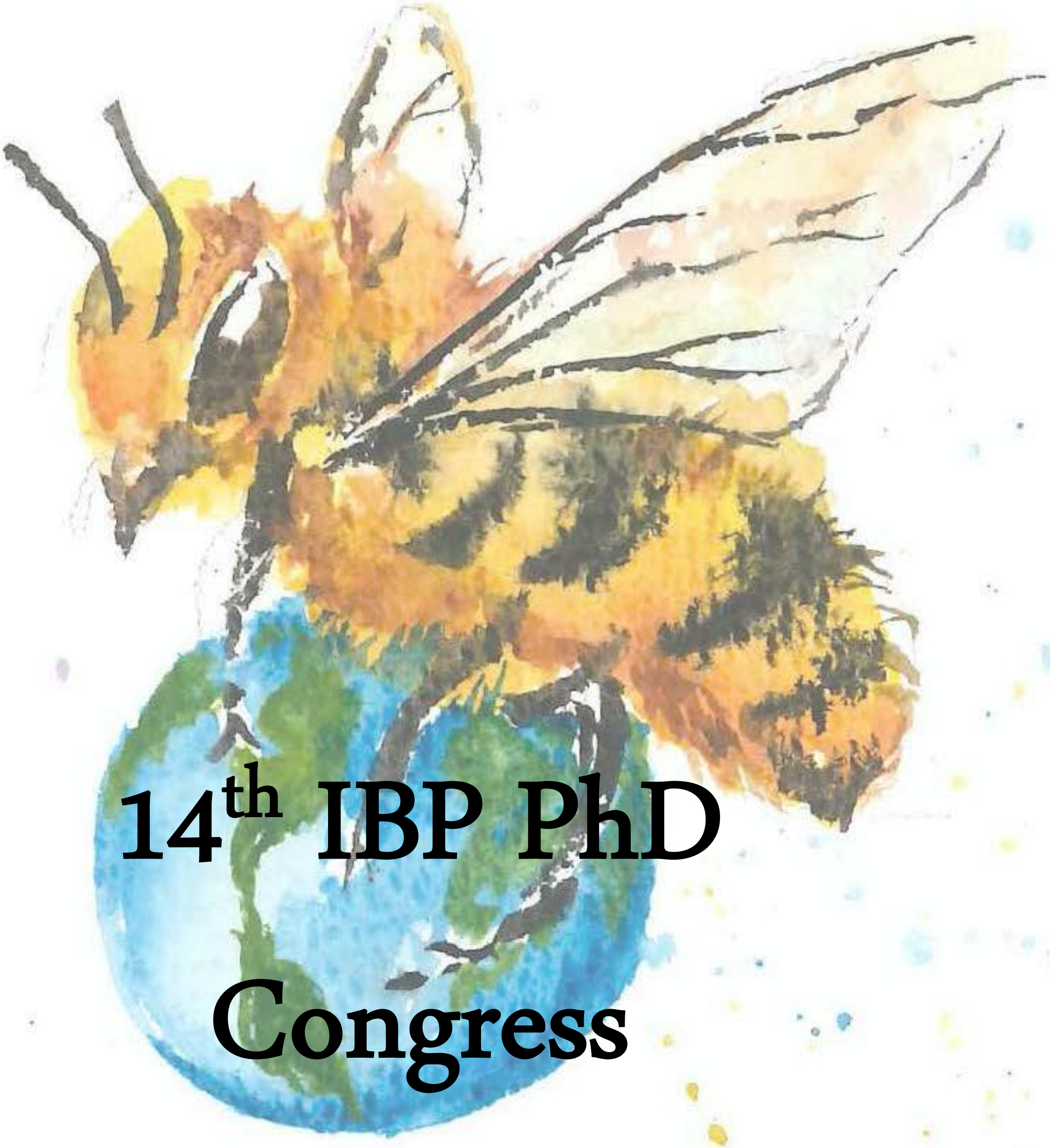
BE THE CHANGE!

12 amazing TALKS and 36 astonishing POSTERS



14th IBP PhD Congress

22 April 2022 8:30 AM – 7 PM in CAB ETH Zentrum

ETH zürich eawag aquatic research

Welcome!

We are very excited to welcome you in person again to the 14th IBP PhD Congress! This year, we present an overview of research at the institute of Biogeochemistry and Pollutant Dynamics (IBP). You will have the opportunity to explore the very diverse research disciplines and the connections between them to better understand the dynamics of our environment. We assure that today's Congress will allow you to connect scientifically and personally with new people, all while having lots of fun. Together we study the environment, and together we can *Be the Change!*

April 22, 2022
CAB Building
ETH Zentrum, Zürich

Organizing Committee

Maya Amacha
Kevin Kleemann
Tong Yang

Chairpersons

Charlotte Bopp
Rachel London

With great help from

Dr. Anouk N'Guyen van Chinh

PROGRAM

8:30 **Registration**

CAB Foyer

9:00 **Welcome by chairpersons**
Charlotte Bopp, Rachel London

Opening Speech
Prof Dr. Kris McNeill

G11

9:20 **Session 1 - The dynamics of the environment**

Joanna Houska
Non-target screening reveals the identity of carbonous and nitrogenous carbonyl- containing oxidation byproducts during ozonation of lake water and wastewater

Emanuele Fara
The role of lambda prophage in a cross-feeding bacterial community

G11

Anish Kirtane
A Matter of State: Evaluation of Methods for Sorting States of Environmental DNA

Andrew Grigg
Stability of jarosite in an acid sulfate soil from Central Thailand

10:45 **Poster session A & Coffee**

H41

12:00 **Lunch**

13:00

13:10 **Session 2- Environmental Exposure of Materials**

Barbora Pinlova
Microplastics; what happens to weathered textiles?

Mattia Cerri
Assessing biodegradation of commercial plastic mulches in Swiss soils.

Joel Rüthi
Metagenome mining of the alpine plastisphere for novel plastic degrading esterases.

G11

Hyunjoo Hong
Prospective dynamic and probabilistic material flow analysis of graphene-based materials in Europe from 2004 to 2030

14:35 **Poster session B & Coffee**

H41

15:50

16:00 **Session 3 - From land to sky**

Benedikt Lauper
Systematic Underestimation of Pesticide Burden for Invertebrates under Field Conditions: Comparing the Influence of Dietary Uptake and Aquatic Exposure Dynamics

Zoé Le Bras
Seasonal variability and production mechanisms of volatile selenium species at a coastal site in the Mediterranean Sea

Esther Breuninger
Insights into the atmospheric cycle of selenium and arsenic: Linking elemental speciation with atmospheric transport in a 5-year aerosol series

G11

Sarah Partanen

Satellite-based non-clear-sky correction factors for clear-sky incident irradiance spectra

17:25

17:30 **Awards & Dinner**

Stuz

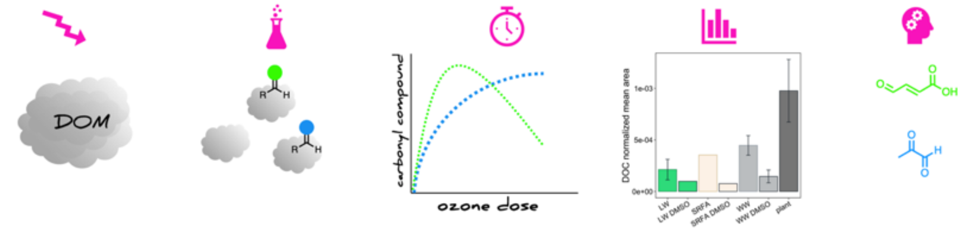
19:00 **After Party!**

Presentations

Joanna Houska
Water Resources and Drinking Water | EAWAG and EPFL

Non-target screening reveals the identity of carbonous and nitrogenous carbonyl- containing oxidation byproducts during ozonation of lake water and wastewater

The application of ozone for disinfection or abatement of micropollutants during treatment of drinking water and wastewater is accompanied by ozone reactions with matrix components such as dissolved organic matter (DOM) which leads to the formation of undesired oxidation by-products (OBPs) such as low molecular weight aldehydes and ketones. To date, the identification of unknown carbonyl compounds in complex water types remains a bottleneck in analytical chemistry. By applying a recently developed non-target workflow and combining the findings with kinetic and mechanistic information, the following three objectives were met: (1) evaluating the formation of carbonyl compounds at varying specific ozone doses across a wide range of water types revealed around 180 carbonous and nitrogenous carbonyl compounds with a significantly higher share of N-containing carbonyl compounds in wastewater compared to lakewater, (2) providing a link between carbonyl compounds and their precursors by combination with electron-donating capacity (EDC) and ozonation of model compounds proved successful and (3) identifying a set of relevant carbonyl compounds by non-target screening including mechanistic information, revealed the identity of many carbonyl compounds with confidence level 1 and 2 including a nitrogenous carbonyl compound.



1. ozonation of lake water & wastewater leads to carbonyl compounds

2. derivatization enables their measurement

3. formation trends of unknown carbonyl compounds

4. comparison among different water types

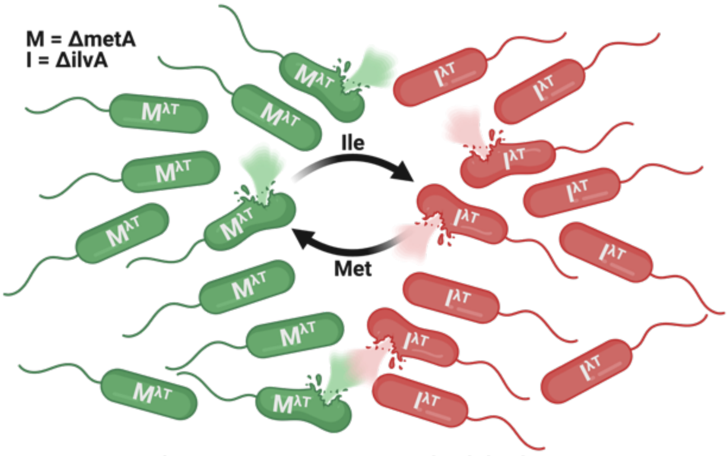
5. combining knowledge leads to the identification of carbonyl compounds

Approach to identify unknown carbonyl compounds

Emanuele Fara
Environmental Microbiology | EAWAG and ETH

The role of lambda prophage in a cross-feeding bacterial community

Microbes are present in almost every habitat on Earth and can form spatially structured communities. Often, each individual cell of a community cannot produce everything it needs but it relies on taking up metabolites produced by other organisms. Hence, microbial cells engage in metabolic interactions with surrounding cells of the same or another species. Such interactions change over time and are strongly influenced by biotic and abiotic factors like viruses and temperature. My research focuses on how bacterial viruses, or phages, influence metabolic interactions in microbial communities through induction and lysis. In fact, some phages can integrate their DNA into the host genome and become prophages. Depending on several factors, prophages can be induced and will ultimately lyse the host cell. I study the function of lambda prophage in a community composed by two amino acid auxotrophs derived from E. coli. The two strains need to exchange the two amino acids in order to grow in an environment deprived of such metabolites. The presence of a temperature-sensitive lambda prophage allows me to study the effect of prophage induction in this community, thus shining light on the role of prophages from an ecological perspective.



λT = temperature-sensitive lambda phage

THE SYSTEM: Bacterial community where one strain (M) is auxotroph for methionine (Met) and the other one (I) for isoleucine (Ile). When amino acids are not externally available, the two strains need to exchange Met and Ile in order to grow. Lysis by phage (□T) can release amino acids in the environment and benefit the establishment of interactions between the two auxotrophic strains.

Anish Kirtane
Environmental DNA | ETH

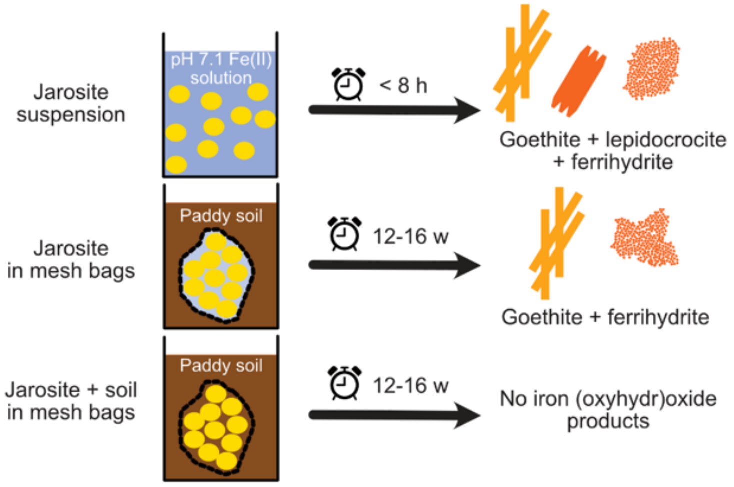
A Matter of State: Evaluation of Methods for Sorting States of Environmental DNA

Environmental DNA analysis has the potential to revolutionalize biodiversity assessment aiding in conservation and management decisions. eDNA once shed can exist in numerous states with varying behaviors including degradation rates and transport potential. In this study we consider three states of eDNA: 1) DNA enveloped in a cellular or organellar membrane, 2) dissolved extracellular DNA molecule without any interaction with other particles, and 3) extracellular DNA adsorbed to a particle surface in the environment. Capturing, isolating and analyzing a particular state of eDNA provides utility towards better interpretation of eDNA data. While methods for separating different states of DNA have been developed, they remain poorly evaluated due to the lack of state-controlled experimentation. We evaluate the methods for separating states of eDNA by using DNA from three different species to represent the three states of eDNA as state-specific controls. We use chicken DNA to represent the dissolved state, salmon DNA adsorbed to clay particles as the adsorbed state, and mouse cells grown in liquid culture for the membrane-bound state. We perform the separation in three water matrices, two environmental and one synthetic, spiked with the three eDNA states. The success of isolation and recovery of each state are evaluated.

Andrew Grigg
Soil Chemistry | ETH

Stability of jarosite in an acid sulfate soil from Central Thailand

Jarosite is an iron hydroxysulfate mineral that is prominent in acid sulfate soils, where it regulates the cycling of trace elements, iron, and acidity. In controlled laboratory experiments, Fe(II) catalyses jarosite transformation to crystalline iron (oxyhydr)oxides. However, the rates and products of jarosite transformation in complex geochemical conditions remain unclear. We compared the transformation of synthetic jarosite in a mixed-suspension system with transformation in Thai rice paddy soil. Jarosite suspended in 50mM MOPS buffer (pH 7.1) and 0.5 or 5 mM Fe(II) transformed into ferrihydrite, lepidocrocite, and goethite within eight hours. In contrast, complete transformation of jarosite to goethite, with minor ferrihydrite, occurred within twelve to sixteen weeks when jarosite was reacted with pore-water by burying jarosite-filled mesh bags in rice paddy topsoil. Transformation was not observed in subsoils, which did not become reducing following flooding. When contact between jarosite and soil was maximised by burying mesh bags containing soil with 57Fe-labelled jarosite enrichment, jarosite was no longer observed by 57Fe Mössbauer spectroscopy after sixteen weeks in topsoil. However, crystalline products such as ferrihydrite, goethite and lepidocrocite were not formed. The differing behaviour of jarosite in these experiments demonstrates the importance of the media in mineral transformation experiments.



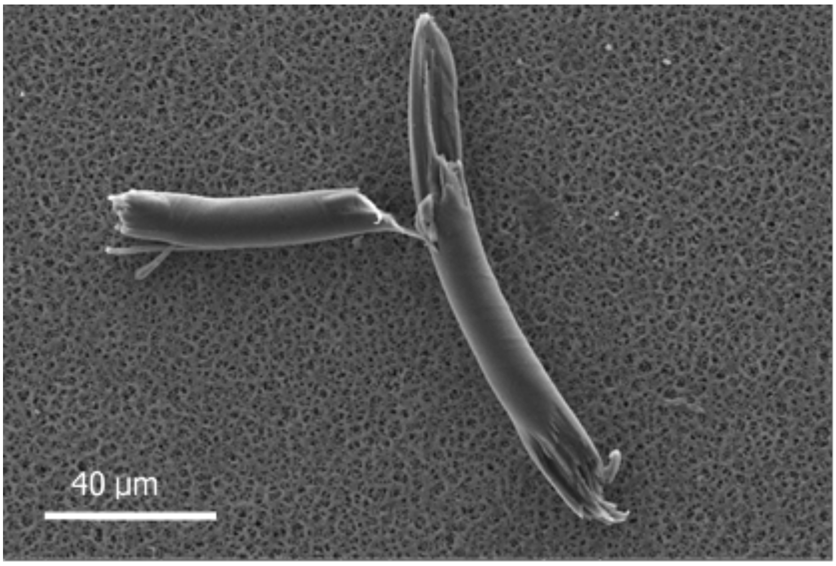
Jarosite (yellow dots, left hand side) transforms to different products depending on the reaction conditions.

Barbora Pinlova
Environmental Risk Assessment and Management│EMPA

Microplastics; what happens to weathered textiles?

We live surrounded by textiles. Many of these textiles are made of synthetic fibers, in 2021 almost 60 metric tons of polyester were produced. We already know that textiles are one of the prime sources of microplastics in the environment, often released into wastewater during laundry washing. However, what happens, when the textiles are left to weather, either as outdoor textiles, or a lost piece of clothing during hiking, or disposed at a landfill? Do they contribute to the microplastics found in the environment? We aimed to answer those questions by selecting a range of polyester textiles and exposing them to artificial weathering by UV light for 2 months.

Our findings show that the fibers in the textiles experience structural damage from the UV exposure over time, forming pits and cracks on the surface. Once an additional mechanical force is introduced, such as during washing, the cracks propagate and produce microplastics. This results in increased release of microplastic fibers, from hundreds of fibers per gram of textile at the beginning of the experiment, to hundred thousand fibers per gram of textile after 2 months of weathering. In addition, we found different forms of microplastic fibers, which have not been previously differentiated in literature.

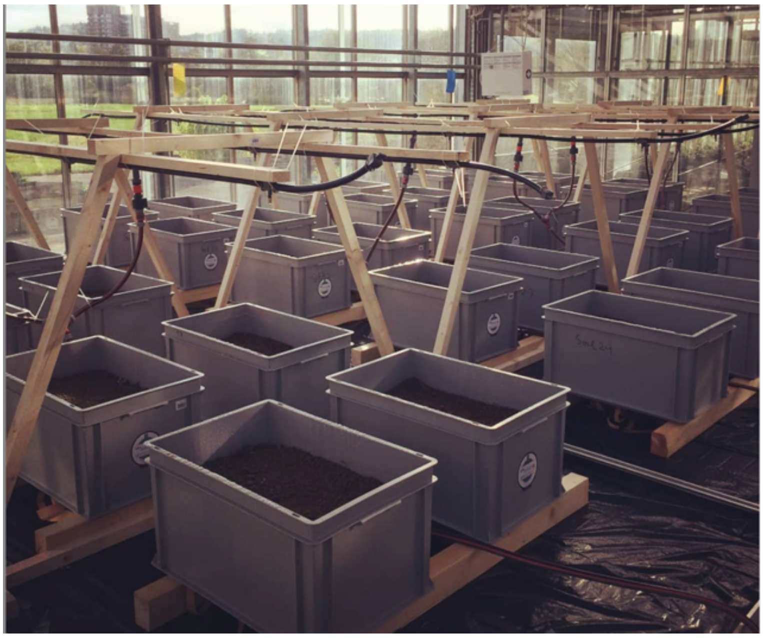


Weathered microplastic fiber splitting into two shorter pieces

Mattia Cerri
Environmental Chemistry| ETH

Assessing biodegradation of commercial plastic mulches in Swiss soils

Modern agriculture relies heavily on the use of plastic mulch films to increase crop yields while lowering use of water and herbicides. However, repeated application of films composed of non-biodegradable plastics - primarily polyethylene - leads to accumulation of plastic residues in soils, raising concerns on long-term negative effects. A possible strategy to avoid plastic pollution is to employ biodegradable mulch films designed to be degraded in situ by native soil microorganisms. While such products are already available on the market, the environmental chemistry of these films and our understanding of the factors that drive their biodegradation in soils remains poorly understood. To overcome this knowledge gap, we are performing long-term incubations of commercially available mulch films - composed of polybutylene adipate-co-terephthalate (PBAT) and poly lactic acid (PLA) - in three Swiss agricultural soils at three scales – laboratory, greenhouse mesocosm and field. In this contribution, we will discuss the experimental setup and show results of film biodegradation over the first year of the incubation, as determined by quantification of the residual polymer using Soxhlet extraction of the soil followed by quantitative 1H-NMR.

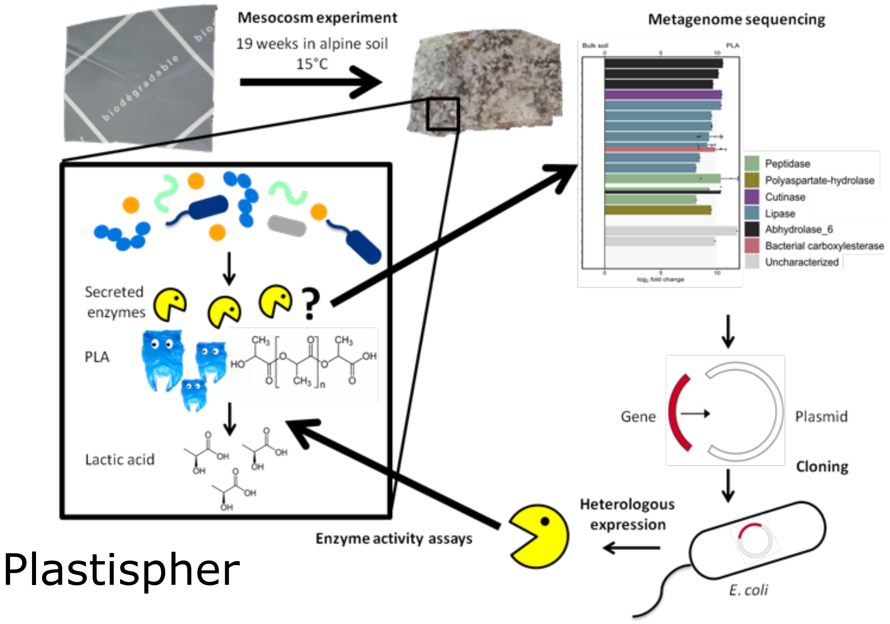


Incubation setup at the greenhouse scale

Joel Rüthi
Forest Soils and Biogeochemistry | WSL

Metagenome mining of the alpine plastisphere for novel plastic degrading esterases

Plastic pollution is a global issue affecting even the most remote ecosystems such as high alpine soils. Whereas biodegradable plastics like PLA and PBAT are easily mineralized in favorable environments like industrial compost, it has barely been studied whether cold-adapted microorganisms are able to degrade bioplastics in soils by producing plastic degrading enzymes. A major challenge in the discovery of novel enzymes is the fact that only a small fraction of microorganisms is cultivable in the laboratory. Here, we identified genes coding for potential novel plastic-degrading enzymes from plastisphere metagenomes of alpine soils. Twelve esterase and protease encoding genes, which were highly abundant in the metagenomes, were synthesized, cloned and heterologously expressed using the pMAL-p5g vector in E. coli BL21 (DE3). For five of the produced enzymes we detected esterase activity and two of these five also showed activity against the polyurethane dispersion impranil® as a proof-of-concept. These novel enzymes reveal the potential of uncultivated alpine soil microorganisms to degrade biodegradable polyesters and might represent a valuable biotechnological approach of bioplastics for a circular economy at low temperature.

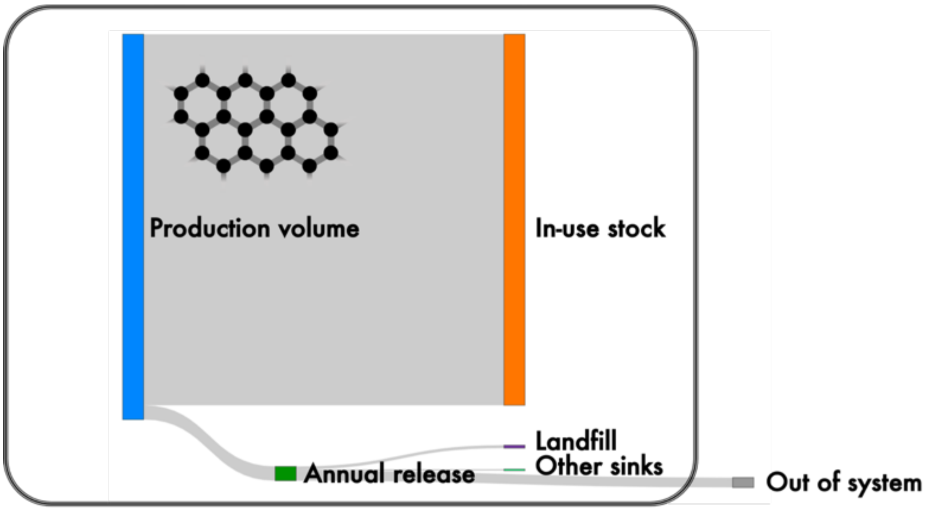


Plastisphere metagenome mining approach

Hyunjoo Hong
Environmental Risk Assessment and Management | EMPA

Prospective dynamic and probabilistic material flow analysis of graphene-based materials in Europe from 2004 to 2030

Attention to the potential environmental risks of graphene-based materials (GBM) has grown with the positive expectation of a higher demand for GBM in research and industry. We present a first study on the possible environmental exposure of GBM. The model considers production volume and use-scenarios of GBM in various consumer products, spanning the years from 2004 to 2030. The transfer coefficients of the model were estimated based on physico-chemical properties of GBM and their behavior during release and in technical compartments. Although the production volume of GBM is expected to increase strongly in the next years, the annual release of GBM shows only a slight positive trend due to the delay of some applications entering end-of-life processes where release of GBM can occur. Of all the GBM that will have been released until 2030 in Europe, more than half will be eliminated in waste incineration plants and 12 % will be exported out of the Europe. The results of the study characterize the release concentration of GBM in various environmental compartments such as surface water (1.4 ng/L) and natural and urban soil (16 ng/kg). Therefore, the results can be used for further environmental risk assessment.

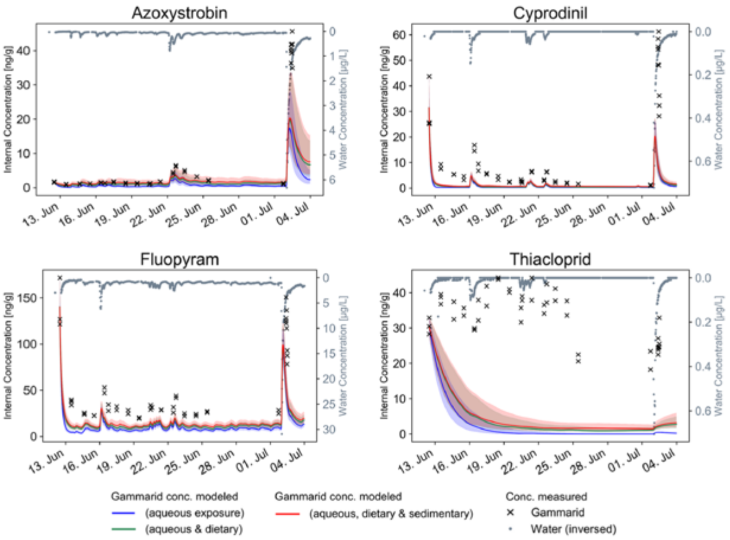


Life of graphene based material in Europe, 2030

Benedikt Lauper
Environmental Chemistry | EAWAG

Systematic Underestimation of Pesticide Burden for Invertebrates under Field Conditions: Comparing the Influence of Dietary Uptake and Aquatic Exposure Dynamics

Bioaccumulation and biotransformation of organic micropollutants in aquatic organisms have been investigated extensively for risk assessment using laboratory experiments. But for several pesticides the measured internal concentrations in gammarids in field trials exceeded the predictions based on the laboratory data, sometimes by orders of magnitude.To investigate this discrepancy, we conducted a field bioaccumulation study in a stream known to receive pollutant loadings from agriculture. Our work incorporated measurements of stream pesticide concentrations at high temporal resolution (every 20 min), as well as sediment, leaves, and caged gammarid analyses (every 2−24 h) over several weeks. The internal concentration of gammarids was subsequently modelled using a one-compartment toxicokinetic model using the measured field data as well as toxicokinetic parameters taken from accompanying lab studies and feeding rates from literature. This showed that the pesticide burden on gammarids remains underestimated by a factor of 1.9 ± 0.1 to 31 ± 3.0, with the highest underestimations occurring after rain events. Including dietary uptake from polluted detritus leaves and sediment in the model explained this underestimation only to a minor proportion. However, suspended solids analyzed during rain events had high pesticide concentrations, and uptake from them could partially explain the underestimation after rain.


Azoxystrobin
Cyprodinil
Fluopyram
Thiacloprid

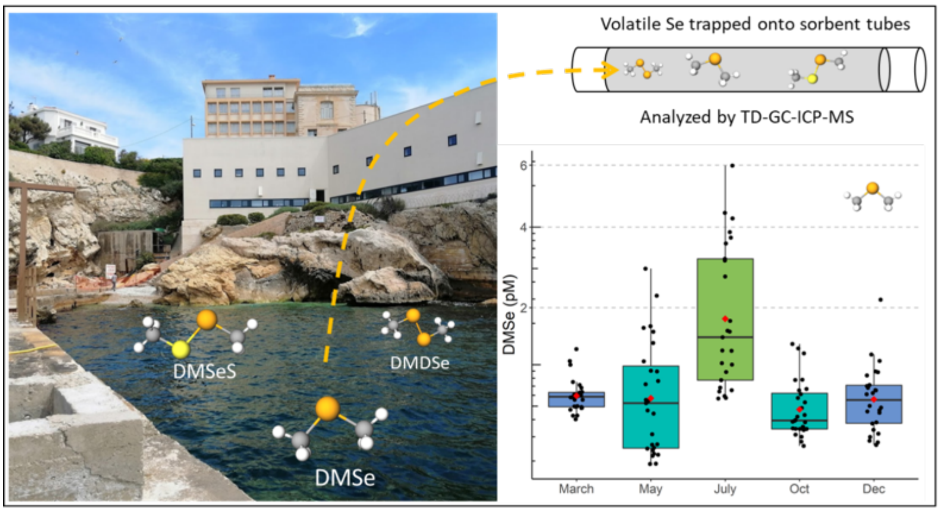
Modeled internal concentration of the pesticides azoxystrobin, cyprodinil, fluopyram and thiacloprid in gammarids when considering only aqueous uptake (blue line), aqueous and dietary uptake combined (green), and when considering uptake from sediment as well (red). The colored band represents the error range of the model (mainly 95% CIs). Their measured internal concentrations (black crosses) and the measured water concentrations (gray dots) are plotted for comparison.

Zoé Le Bras

Inorganic Environmental Geochemistry|ETH

Seasonal variability and production mechanisms of volatile selenium species at a coastal site in the Mediterranean Sea

Selenium (Se) is an essential trace element for humans and animals mainly acquired through consumption of terrestrial food products. The atmosphere is an important reservoir of Se and a source of Se to terrestrial ecosystems. Marine biogenic emissions of volatile organic Se, e.g., dimethyl selenide (DMSe), are the main source of atmospheric Se. However, the spatial distribution and temporal variability as well as the mechanisms of formation of these Se species in marine environments are poorly constrained due to a lack of efficient methods to detect these species present in trace levels (fM-pM) in seawater. We developed a new high throughput and sensitive method combining thermal desorption with gas chromatography inductively coupled plasma mass spectrometry to quantify concentrations of volatile Se species in seawater and implemented it in six two-week time periods between March 2021-2022 at the coastal station of Endoume in the Mediterranean Sea to study the daily and seasonal cycling of volatile Se species. In the same time periods, incubation experiments with natural seawater were carried out under various conditions, (dark/light, size fractions, biological inhibitors) to give insights into (a)biotic processes involved in the production of volatile Se species, for which the results will also be presented here.



Esther Breuninger
Inorganic Environmental Geochemistry | ETH and EAWAG

Insights into the atmospheric cycle of selenium and arsenic: Linking elemental speciation with atmospheric transport in a 5-year aerosol series

The atmosphere is an important reservoir of the essential metalloid selenium but also the toxic metalloid arsenic. Atmospheric deposition is a source of these elements to marine and terrestrial ecosystems, including agricultural soils, impacting environmental and human health. However, atmospheric cycling of these trace elements is still rather unknown, i.e., open questions are: i) what are seasonal inputs of anthropogenic and biogenic sources, ii) what are (bio)geochemical transformations in the atmosphere and iii) what is the fate of these elements deposited to surface environments? Knowing the chemical speciation of these elements in atmospheric samples is of key importance to answer these questions.

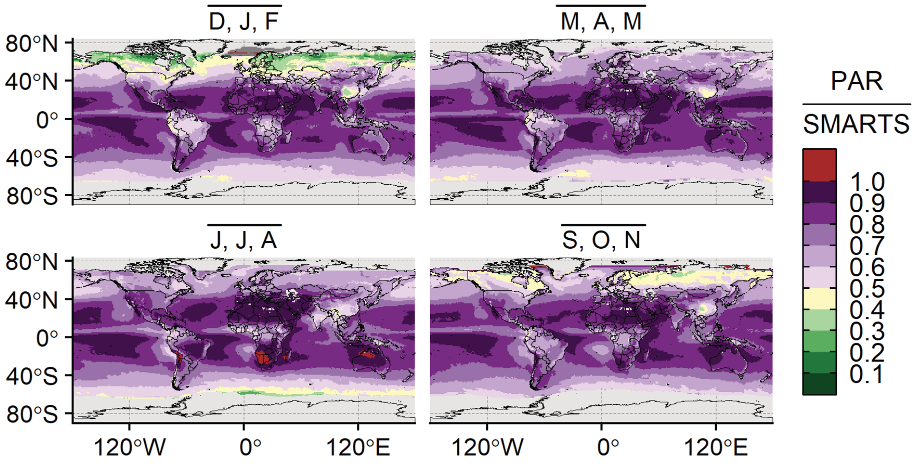
In this study, we applied new ICP-MS/MS based methods to investigate concentrations and speciation of selenium and arsenic in aerosol samples collected weekly from 2015-2020 at Pic du Midi Observatory (French Pyrenees). This high-altitude site enables the investigation of local and long-range elemental transport from both marine and continental environments. In addition to trace elements, speciation of sulfur and organic composition (using pyrolysis-GC/MS) of aerosols was studied and air parcel backward trajectories were calculated. The combination of these analyses gives new insights into the seasonal variability of atmospheric sources and cycling of selenium and arsenic.

Pic du Midi Observatory

Sarah Partanen
Environmental Chemistry | ETH

Satellite-based non-clear-sky correction factors for clear-sky incident irradiance spectra

Photochemical transformation can be an important removal process for some organic contaminants in surface waters such as lakes and rivers, as well as in oceans. An important environmental variable affecting photochemical processes in surface waters and oceans is the incoming solar irradiance, as this is the energy source required for these processes to occur. However, clear-sky incident irradiance spectra are often used when evaluating the fate of aquatic contaminants, leading to an underestimation of contaminant half-lives due to photochemical transformation. In this work incident irradiance satellite data were used to develop global scale non-clear-sky correction factors for commonly used reference irradiance spectra. Non-clear-sky conditions can decrease incident irradiance by over 90% depending on geographic location and time of year, with latitudes above 40°N being most heavily affected by season. The impact of non-clear-sky conditions on contaminant half-lives has been highlighted in a case study of triclosan in Lake Greifensee, which show a 33% increase in triclosan half-life over the course of a year. The correction factors developed in this work are available at daily, monthly, and seasonal resolutions for every point on the globe, and can be used by researchers and practitioners who need accurate estimates of incident irradiance.



Maps of non-clear-sky correction factors for clear-sky incident irradiance spectra displayed at a seasonal resolution

A01 Silvan Arn

Environmental Chemistry, ETH

Quantifying biodegradable mulch film residues in agricultural fields

Biodegradable mulch films are a promising alternative to conventional polyethylene-based mulch films, which are a known source of plastic contamination in the environment. Since these products are certified as biodegradable, they can be plowed into the soil after the crop harvesting and don't need to be recollected. This practice leads to a relatively large input of biodegradable polymers into agricultural soils. However, it is not yet fully understood if the biodegradation in all soils can keep up with these high input rates. In certain cases, there could be the possibility of a fluctuating background concentration of not yet degraded biodegradable polymer in agricultural fields.

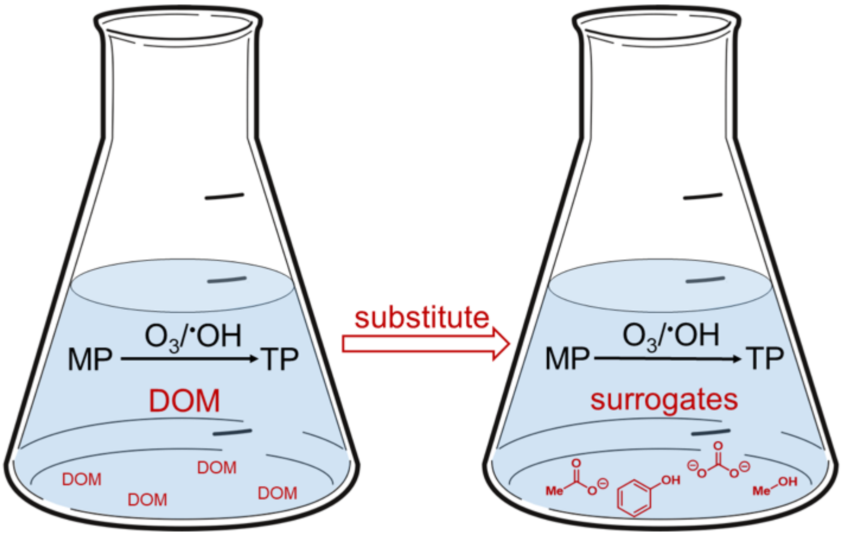
In my poster I will show how I intend to measure remaining biodegradable polymer concentrations in agricultural fields and deal with the challenges of creating a statistically appropriate sampling method.

Collection of a sample for the quantification of biodegradable mulch foil residues by Ghimire, S., Scheenstra, E., & Miles, C. (2019). Soil sampling method to assess the amount of mulch fragments in the field after tillage.

A02 Simon Rath
Aquatic Science and Technology, EAWAG

Simulation of Realistic Aqueous Ozonation Conditions: Use of Small Scavenger Molecules as Surrogate for Dissolved Organic Matter

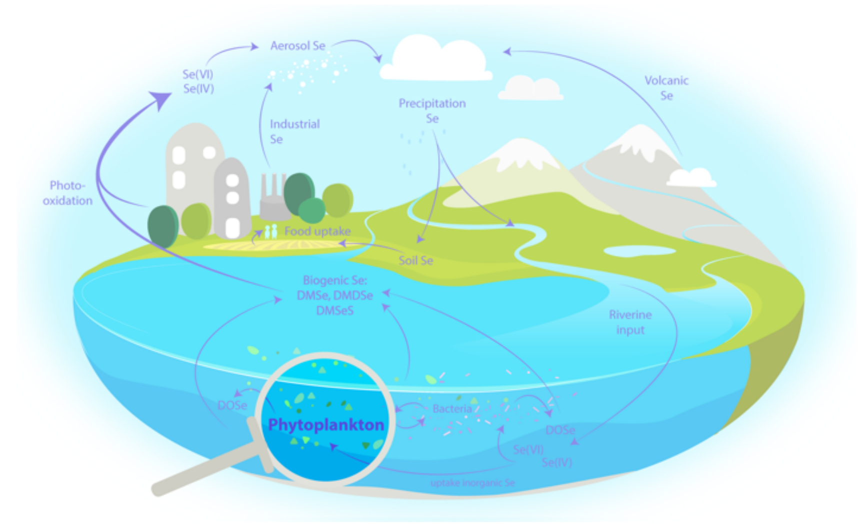
To investigate kinetics and mechanisms of micropollutant (MP) abatement during ozonation and the formation of ensuing transformation products (TP) or disinfection by-products (DBPs) both the reactions with ozone and the secondary oxidanet, hydroxyl radicals, need to be investigated. Moreover, successive reactions with both oxidants need to be accounted for. Due to the constraints of using real waters on reproducability and high end analytical instruments, for studying MP abatement, a tool is needed to accomplish realistic ozonation conditions without using dissolved organic matter (DOM). Herein, the development of a standardised system to simulate realistic ozonation conditions is reported using the concept of initiators, promoters and inhibitors to control the ozone decay. Small molecules such as acetate, methanol or phenol are used as model scavengers to act as surrogate for DOM. Using this system, realistic ozonation conditions for surface waters and wastewaters have been accomplished, regarding the initial ozone decay (IOD), the ozone exposure and the hydroxyl radical exposure. Equivalent substance abatement and product formation has been found for model MPs such as Bezafibrate compared to their abatement in real waters.



A03 Pauline Béziat
Inorganic Environmental Geochemistry, ETH

Phytoplankton in the marine selenium cycle - optimizing extraction and analytical techniques for algal intracellular Se speciation

Marine phytoplankton are hypothesized to play a key role in environmental selenium (Se) cycling. Microalgae are suspected to incorporate inorganic Se from seawater into organic metabolites that might serve as precursors for the generation of volatile Se species by either algae or marine bacteria. Most studies that investigated the algal selenometabolism have focused on freshwater algae exposed to Se concentrations orders of magnitude higher than environmental ones to enable detection of selenometabolites. These studies have employed a plethora of extraction and detection techniques which may impact metabolite stability and extraction efficiency, complicating comparisons between results. We present a thorough investigation of how different extraction techniques and growing conditions affect intracellular Se speciation in marine algae, using Symbiodinium voratum and Emiliana huxleyi as model marine phytoplankters grown in laboratory batch cultures. Se compounds in algae extracts were characterized using a combination of different liquid chromatographic separations coupled to ICP-MS/MS. Next to Se partitioning between cellular fractions, we report effects of extraction techniques on selenometabolites as well as preliminary results of first selenometabolome analyses of natural marine phytoplankton. These insights now allow us to perform process-oriented incubation experiments, tracing Se in phytoplankton-bacteria interactions which are key

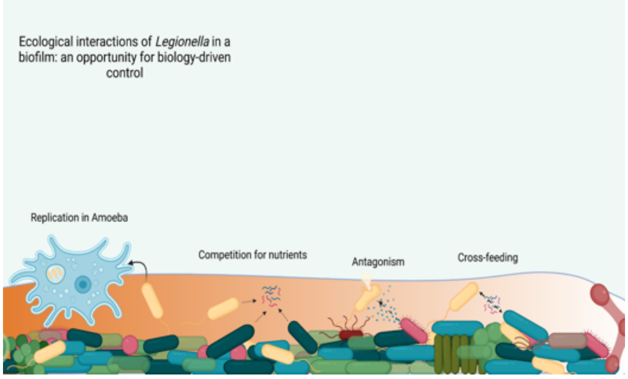


A04 Alessio Cavallaro

Environmental Microbiology, EAWAG and ETH

Probiotic control of Legionella in building plumbing systems: a two-sided approach towards identifying and characterising antagonistic bacteria

Building plumbing systems are engineered aquatic environments in which some opportunistic pathogenic bacteria proliferate in complex biofilms, interacting and finding niches within resident microbial communities. Among these, Legionella spp. are one of the most reported pathogens associated with waterborne disease in industrialized countries. The close interaction between Legionella and the drinking water microbiome suggests an opportunity to develop biological "probiotic" control strategies. Here we use a two-sided approach to identify bacteria antagonistic towards Legionella spp. as candidate probiotic organisms. In a first molecular-based approach, the community composition of 100 shower hose biofilm samples with considerably different Legionella relative abundances (0-7%) revealed associations between specific bacterial/eukaryotic genera and high (i.e. Chthonomonas; SM1A02), respectively low (i.e. Dechloromonas; Aquabacterium), Legionella spp. numbers. In the second cultivation-based approach, we isolated bacteria from different water sources and tested their ability to inhibit a range of 11 pathogenic Legionella species in agar-spot-on-lawn assays. We identified 10 antagonistic strains: two strains (Pseudomonas baetica; Spingomonas adhesiva) inhibited nine respectively seven Legionella species, while the remaining eight strains inhibited only three Legionella species each. Next, we will analyse the pure culture genomes, searching for potential biosynthetic pathways with the aim of identify and isolate the specific anti-Legionella compounds. We propose that the two-sided approach of community analysis and the study of direct competition in the laboratory could lead to the identification of diverse Legionella antagonists (or inhibitory compounds) and the eventual design of a probiotic strategy against Legionella to be further tested in more realistic conditions.



A05 Emma Chollet Ramampiandra
EAWAG

Learning ecological species responses from machine learning models

A main interest in ecology is to better understand how species respond to their environment. Species distribution modelling is a common way to address this. Traditionally, statistical models were used to infer species responses to environmental factors. Recently, there has been an increasing use of machine learning models, because they are more flexible and often better in prediction. In this study we ask, 1) how much predictive performance can we gain by allowing more complex response shapes 2) do the inferred responses differ and are they ecological meaningful? We applied seven different models to predict the probability of occurrence of freshwater macroinvertebrates based on 2689 monitoring samples. We compared their performance during calibration and prediction and visualized the inferred responses to environmental factors. While some of the more complex models predicted slightly better than standard statistical models, they were prone to overfitting. In cases of overfitting, they learned non-smooth relationships that were not meaningful from an ecological viewpoint. However, in many cases, the models inferred similar patterns, indicating that the simpler models were already sufficient to capture the ecological information in the data. We conclude that it is important to quantify overfitting when using the models to learn responses.

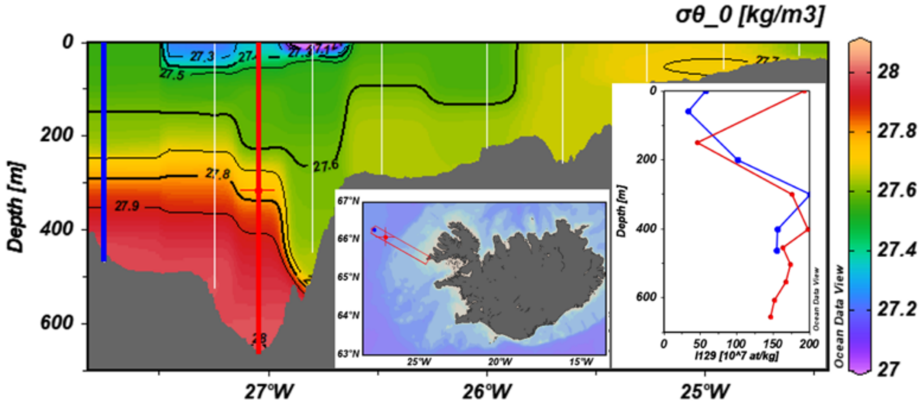
Illustration of freshwater stream macroinvertebrates in Swiss rivers

A06 Duncan Dale
Physical & Tracer Oceanography, ETH

Using anthropogenic radionuclides to trace ocean circulation around Iceland

The release of artificial radionuclides from European nuclear reprocessing plants has provided a unique opportunity to trace ocean circulation in the Arctic and subpolar North Atlantic (SPNA). In particular, the concentrations and ratios of 129I and 236U have been used to identify and trace Atlantic-derived waters transiting around the Nordic and Arctic Seas where many important transformations occur, such as the formation of deep waters of the Atlantic meridional overturning circulation (AMOC).

Iceland stands at a key nexus point of this circulation regime and specific flow pathways in the vicinity are still being identified. Here we present the results of measurements on samples taken during two cruises conducted during 2021. From this preliminary sampling, we can clearly identify water masses with distinct 129I concentrations reflective of the different pathways and mixing regimes experienced by each mass. For example, at the Denmark Strait (Figure 1) we have identified an outer branch of the East Greenland Current with high 129I concentration commensurate with previous measurements made “upstream” at Fram Strait. The source of this and other water masses will be clarified by 236U measurements which, combined with 129I, can be used to “fingerprint” and distinguish different sources from along the tracer pathway.

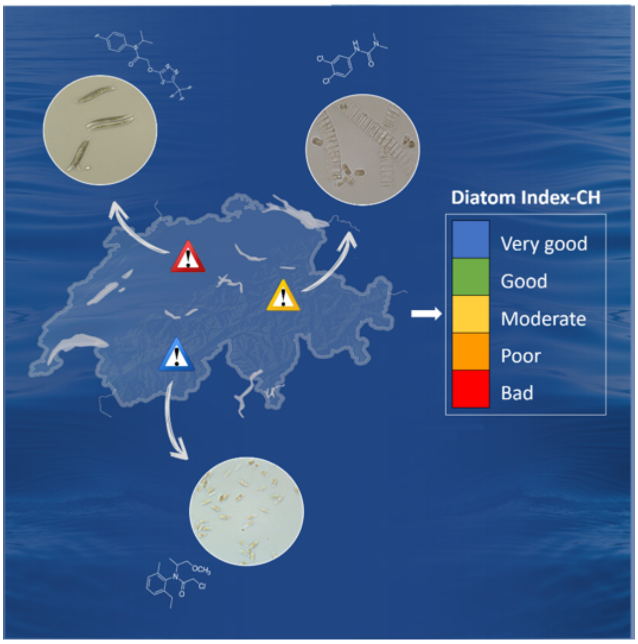


Transect of the Denmark Strait with contours and colours indicating potential density (kg/m3). Insets showing location of transect (left) and 129I concentrations (107 at/kg) at stations marked in blue and red.

A07 Sarah Descloux
Environmental Toxicology, EAWAG

Benthic diatoms as indicators for pesticide pollution in the Swiss watercourses

The protection of rivers from pollution by pesticides and micropollutants in general is currently one of the highest environmental priorities. Despite this, the majority of bioindicators used in monitoring programs do not specifically target this problem. Among the battery of such bioindicators, benthic diatoms are widely used to indicate the impact of nutrients and organic matter in rivers. Given the variable sensitivity of their species to chemical pollutants, benthic diatoms could also be excellent indicators for pesticide pollution. Therefore, the overarching aim of this project is to identify benthic diatom taxa that are specifically sensitive or tolerant to pesticide pollution. To reach this goal, the project is structured around three interconnected research axes: (1) laboratory experiments under controlled conditions that will disentangle the effects of pesticides from those of a set of environmental factors; (2) field surveys to link (and validate) the outcomes obtained in the laboratory experiments to real environmental conditions; and (3) further analyses of existing Swiss diatom databases. Ultimately, this project will serve as a base to develop a diatom index that is specific to pesticides and that can be implemented in Swiss river biomonitoring programs, along with the other indicators.

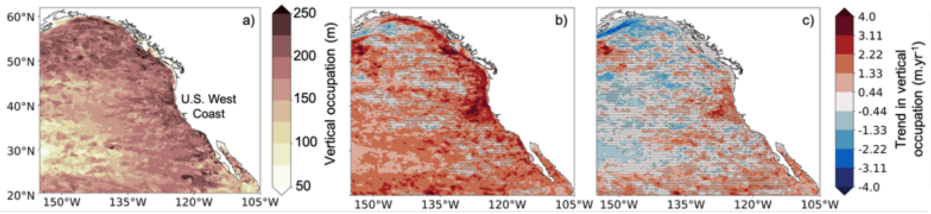


Identification of diatoms from streams with different ecological status.

A08 Flora Desmet
Environmental Physics, ETH

Anthropogenically forced increase of acidification extreme conditions in the Northeast Pacific ocean modulated by climate modes

The ocean acidifies as it takes up anthropogenic carbon from the atmosphere. While mean changes in ocean carbonate chemistry have been widely studied, little is known about the trends and interannual to decadal variability of episodic high acidity extreme events. Understanding the temporal variability of such extreme events is crucial to investigate their potential predictability. Using a regional ocean model coupled to a biogeochemical-ecosystem model (ROMS-BEC) we found that acidification extreme events increase from 1984 through 2019 in the upper 250 m of the Northeast Pacific, mostly due to rising atmospheric CO2 concentration. The increase is enhanced in the highly productive California Current System (CCS) by changes in upwelling strength. Our study further reveals that El Niño-Southern Oscillation (ENSO) and the North Pacific Gyre Oscillation (NPGO) modulate the long-term trends in acidification extreme events, especially in the southern and central parts of the CCS. La Niña (El Niño) increases (decreases) the amount of extreme conditions experienced by the region. Similarly, the positive (negative) phase of NPGO is associated with more (less) extreme conditions. These results offer potential for predicting unusual acidity stress ahead of time in some regions of the Northeast Pacific ocean, such as the CCS.

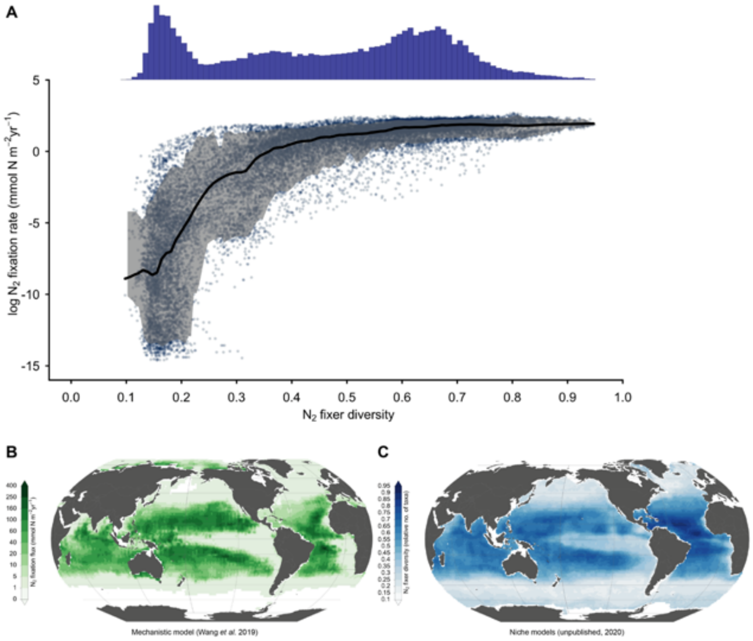


Maps of (a) the maximum vertical occupation by acidifition extreme conditions on any given day between 1984 and 2019 in the upper 250 m of the Northeast Pacific ocean and long-term trends in the yearly maximum vertical occupation for (b) a hindcast and (c) a simulation with linearly de-trended atmospheric CO2 forcing. The California Current System refered to in the abstract is located along the U.S. West Coast.

A09 Dominic Eriksson
ETH

Predicting global distribution of diazotrophs using species distribution models

Diazotrophs are prokaryotic organisms that are able to convert atmospheric nitrogen gas into bioavailable nitrogen, thereby relieving nitrogen limitation and supporting marine production. Trichodesmium has long been thought to be the main contributor to marine nitrogen fixation in the open ocean. However, several new diazotrophic taxa, such as UCYN-A, have been discovered within the last decade and little is known about their contribution to the global nitrogen cycle. Due to the sparse data available on open ocean diazotrophs, no global biodiversity assessments have yet been made to look at global diazotrophic biogeography and diversity patterns. Here we develop and use species distribution models for sparse datasets and model each diazotrophic taxon to analyse diazotroph distribution along environmental gradients, diazotroph diversity patterns and link those patterns to ecosystem functions.



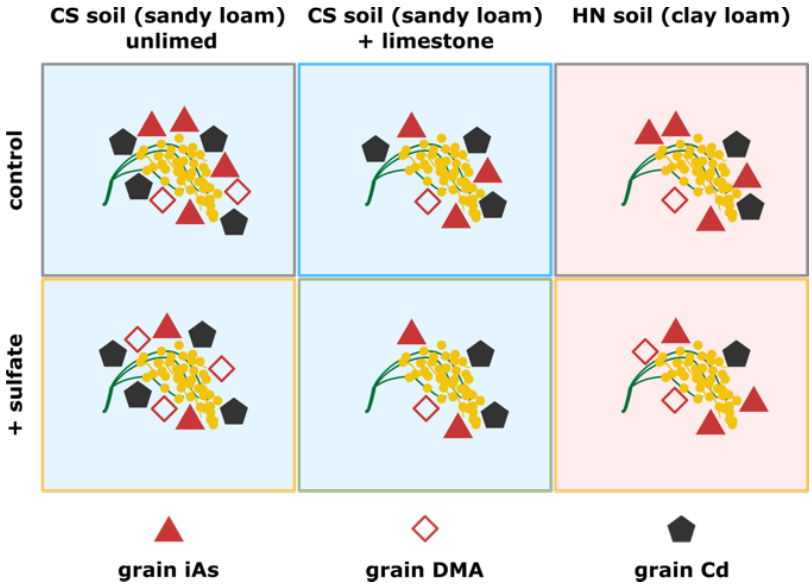
Diazotroph diversity as a function of nitrogen fixation rates. (A) Increased annual mean nitrogen fixation as a function of diazotroph diversity, (B) global estimate of nitrogen fixation rates from the mechanistic model by Wang et al. 2019, (C) relative fraction of total diazotroph diversity based on Species Distribution Models.

A10 Xu Fang

Soil Chemistry, ETH

Decreasing arsenic and cadmium in rice: Interactions of soil sulfate amendment, liming, and soil texture under intermittent flooding

Arsenic (As) and cadmium (Cd) represent two main threats to the global production of safe rice. Via a pot experiment, we studied the unknown interactions of sulfate amendment, limestone liming, and soil texture under intermittent soil flooding for simultaneously decreasing As and Cd accumulation in rice grain. We found that combined sulfate and limestone amendment resulted in the lowest grain inorganic As (iAs), dimethylarsenate (DMA), and Cd simultaneously for an acidic sandy loam soil (CS). Compared to the unlimed CS soil, sulfate amendment showed less decrease in grain iAs but a clear decrease in grain Cd for an acidic clay loam soil (HN). Differences in grain iAs among treatments cannot be explained by porewater chemistry but by root iron-plaque as a dynamic source of iAs for plant uptake. Grain Cd closely correlated with the adjusted soil extractable Cd which was derived from 0.01 M CaCl2-extractable Cd and Mn of moist soils at harvest. Our results suggest combining sulfate amendment, liming, and intermittent flooding can simultaneously decrease the accumulation of iAs, DMA, and Cd in rice grain, while extra caution should be taken for fine-textured soils during water management to ensure soil aeration but avoid water stress to plants.

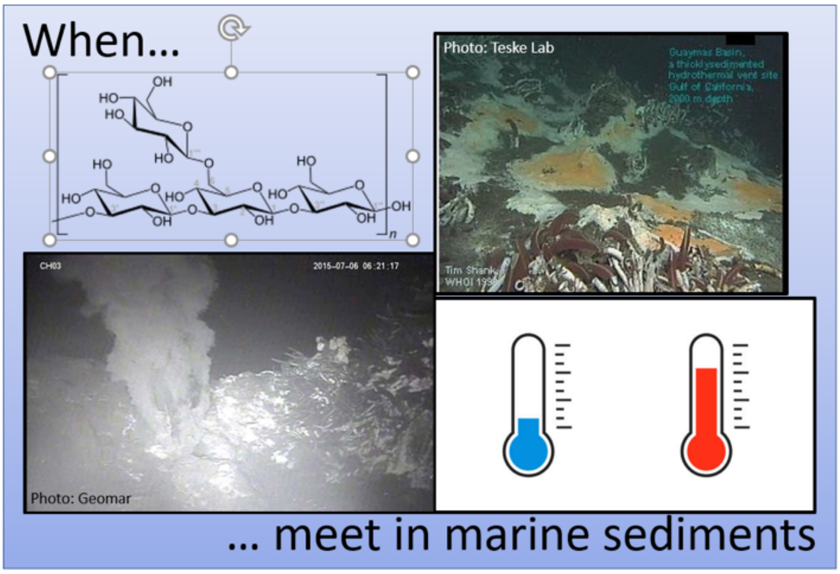


A11 Niroshan Gajendra

Environmental Microbiology, ETH

How does sediment temperature affect the long-term storage of organic carbon in marine sediments?

Aquatic sediments represent the biggest organic carbon (OC) sink on Earth and play a key role in controlling the global climate. Thus, understanding the controls of OC degradation and preservation in sediments is crucial to humankind. This study focuses on how temperature and OC chemical composition drive the long-term burial of OC in sediments across 10 sites in the Guaymas Basin (Gulf of California). These sites experience contrasting sediment temperatures and OC inputs. The latter range from photosynthesis-derived OC from overlying water, OC produced in surface sediments by chemosynthetic microbial mats, and thermogenic OC introduced from deeper layers by hydrothermal seepage. Pyrolysis-GC/MS analyses show that chemically diverse organic matter of likely photosynthetic origin dominates areas with no hydrothermal seepage, irrespective of in-situ temperature and surface sediments at a low-temperature seep site. In contrast, organic matter is chemically much less diverse at a hydrothermal seepage site with a steep in situ temperature gradient that indicates high hydrothermal fluid flow from below. This site is dominated by polyaromatic hydrocarbons, chlorophyll, and alkanes reflecting strong thermal alteration of OC, though the main origins of OM (e.g., photosynthetic, microbial, geothermal) remain unclear.

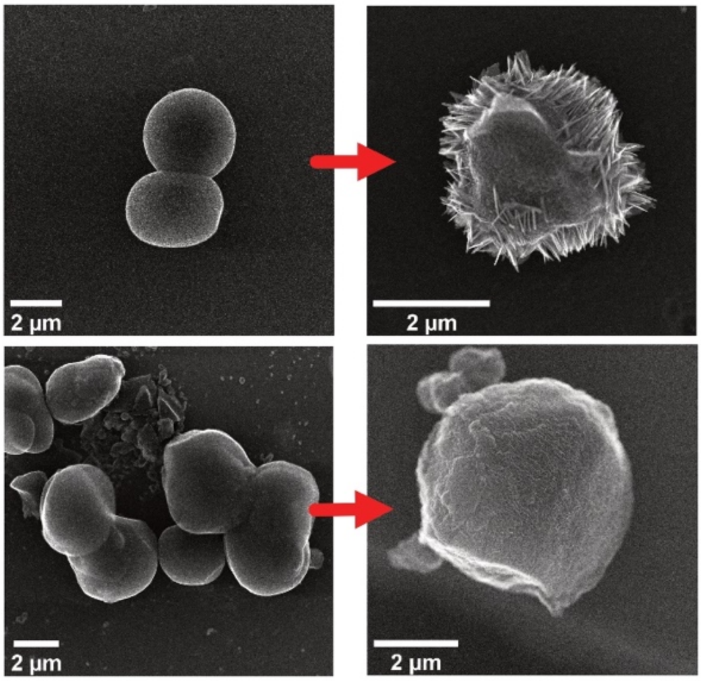


A12 Andrew Grigg

Soil Chemistry, ETH

Interactions between jarosite and the aluminium cycle

Jarosite [$KFe_3(SO_4)_2(OH)_6$] is an abundant mineral in acid sulfate soils (ASS) and acid mine drainage environments that is known to scavenge trace elements and mitigate release of acidity. Aluminium is also abundant in these environments where Al toxicity can cause significant environmental damage. Although jarosite and alunite [$KAl_3(SO_4)_2(OH)_6$] are isostructural minerals in which Al and Fe are freely interchangeable, the environmental consequence of Al substitution in jarosite has not been widely explored. We present evidence of Al substitution (~5%) in natural jarosite from a Thai ASS using Energy Dispersive X-Ray (EDX) spectroscopy. Then, to measure the effect of Al substitution on jarosite stability under conditions that mimic flooded ASS, synthetic (Al-)jarosite, containing up to 7.1% Al-for-Fe substitution, was reacted with Fe(II) (5:5 mM or 0.5:5 mM Fe(II)-to-Fe(III) mixtures) at pH 7.1 for up to 24 hours. Electron microscopy and quantitative analysis of X-ray diffractograms showed that structural Al stabilised jarosite against Fe(II)-catalysed transformation and promoted the formation of short-range-ordered minerals such as ferrihydrite and poorly-crystalline goethite instead of lepidocrocite (see figure). The study improves our understanding of the retention of Al in acid sulfate systems that contain jarosite, as well as the retention of (Al-)jarosite-associated trace elements, Fe and acidity.



Secondary electron microscope images of unreacted jarosite (top left), unreacted aluminium-substituted jarosite (bottom left), jarosite reacted with 5 mM FeII (1:1 FeII:FeIII) for 1 hour (top right) and aluminium-substituted jarosite reacted with 5 mM FeII (1:1 FeII:FeIII) for 1 hour (bottom right).

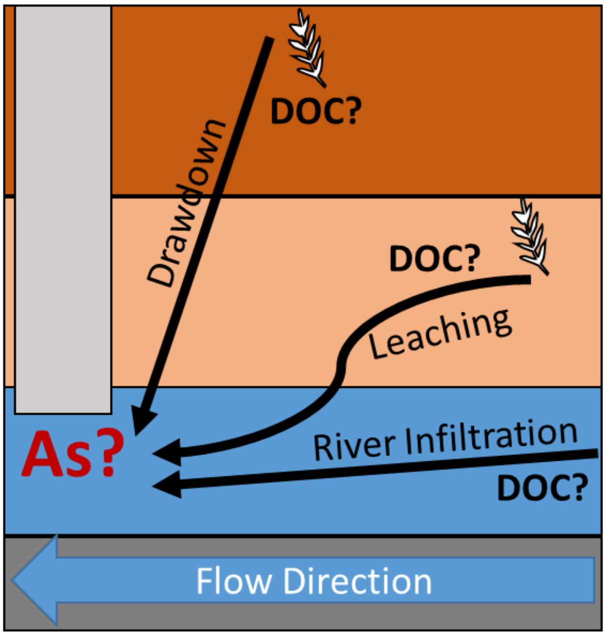
A13 David Haaf
Inorganic Environmental Geochemistry (IEG)/Eawag W+T

Understanding Hydrogeological Effects on Groundwater Arsenic Contamination in Hanoi, Vietnam

Geogenic contamination of groundwater with the toxic element arsenic (As) is a global health problem affecting over 200 million people, mainly in Southeast (SE) Asia. One of the affected areas is the Red River Delta and its capital Hanoi in Vietnam. Multiple natural and human-induced mechanisms have been proposed to explain As contamination of shallow aquifers including the main geochemical mechanisms of microbially induced reductive dissolution of iron (oxyhydro) oxides. Recent studies have shown that changes in the groundwater flow direction due to increased groundwater abstraction for domestic water supply potentially lead to As enrichment of previously uncontaminated aquifers. For example, in the village Van Phuc, located south of Hanoi, it was shown that lateral riverbank infiltration and aquitard leaching of dissolved organic carbon (DOC) induced As mobilization.

However, on a larger scale (e.g., greater Hanoi area and whole Red River delta) it is unknown where and how DOC infiltration and degradation in relation to changes in groundwater flow affect As mobilization. To investigate this question, geological, hydrological, and hydrochemical information are analyzed combined. Here it will be presented how this approach gives new insights into where and how DOC is mobilized and how this affects As concentrations on large scales.

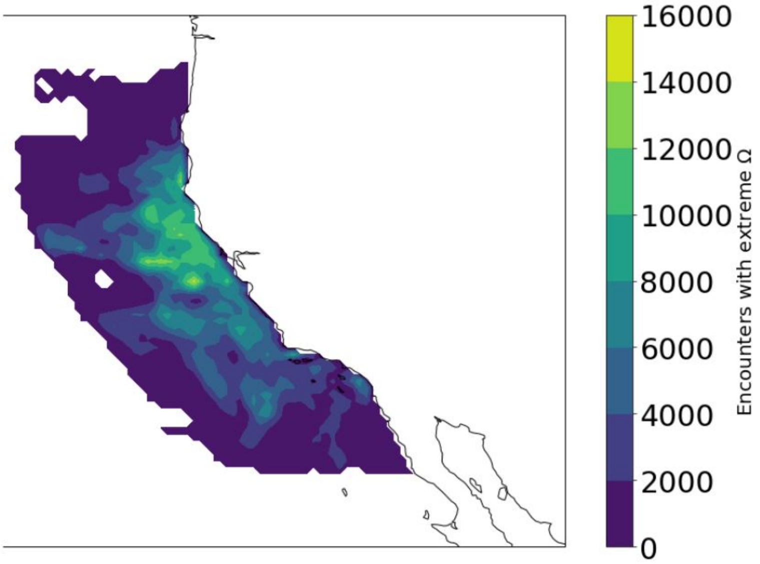
Figure: Schematic diagram of hypothesised DOC infiltration pathways of drawdown, leaching and river bank infiltration leading to As mobilization.



A14 Urs Elizondo Hofmann
Environmental Physics, ETH

Pteropod population-level responses to acidification across different time-scales in the California Current System

Climate change will increase the frequency, magnitude and duration of acidification extremes in the California Current System (CalCS). Observational evidence suggests that extremes superimposed on the long-term ocean acidification trend and seasonal variations have resulted in widespread dissolution, lack of accretion, and developmental delays in calcifying pteropods. However, a comprehensive attribution of ecosystem impacts to carbonate chemistry perturbations at different time scales is limited. Here, we quantify the effects of ocean acidification at different time-scales on the population-level across several generations of pteropods. We use an individual-based model with life stage specific responses to environmental conditions in a regional hindcast simulation (1984-2019) of the CalCS to compare the effects of long-term ocean acidification with the seasonal variation and short-lived acidification extremes. We find that the timing of extremes and life-stage composition of the pteropod community determine the life-stage specific impact relative to the long term trend and the seasonal variation. Extremes during periods of rapid growth significantly increase the mortality of the juvenile life-stages. The life-stage dependent responses to extremes suggest that life cycle dynamics need to be investigated in future impact and attribution studies to accurately characterize and quantify the effects of ocean acidification extremes.

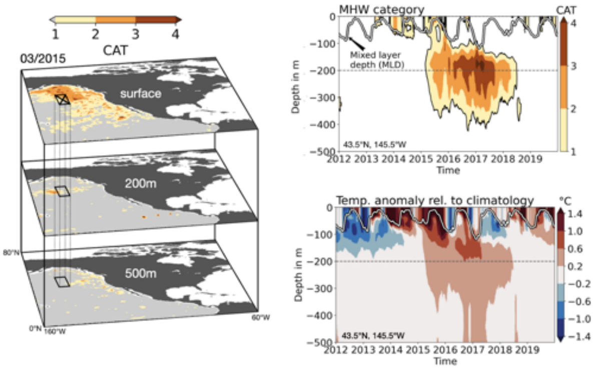


Cumulative number of encounters with extreme aragonite saturation states (Ω) throughout a simulation year in the California Current System.

A15 Eike Köhn
Environmental Physics, ETH

On the vertical structure and propagation of marine heatwaves in the Eastern Pacific

Anthropogenically driven ocean warming increases the frequency and intensity of marine heatwaves (MHWs) with potentially far-reaching consequences for marine life, such as the disruption and reorganisation of food-webs. As most research has focused on MHWs at the ocean surface, only little is known about their vertical extent and structure. This is a gap, since subsurface MHWs can also affect marine organisms. In this study, we investigate the vertical structure of Eastern Pacific (EP) MHWs in a hindcast simulation (1979-2019) performed with a regional ocean model (ROMS). We identify and track vertically propagating MHWs by connecting adjacent grid cells in the vertical and temporal dimension, in which temperature exceeds a seasonally varying 90th percentile threshold. We restrict our analysis to MHWs that surface at least once. We find that vertically propagating MHWs affect upper ocean ecosystems for substantially longer time periods than MHWs diagnosed from the surface-only perspective (55 vs. 27 days on average). We further find that ~80% of MHWs in the EP are restricted to the surface mixed layer. Clustering of MHWs reveals that 20% (12%) of MHWs move downward (upward) throughout their lifetime and another 12% show a complex multi-surfacing structure. Our results serve to better understand the drivers of MHWs and their effects on pelagic ecosystems.



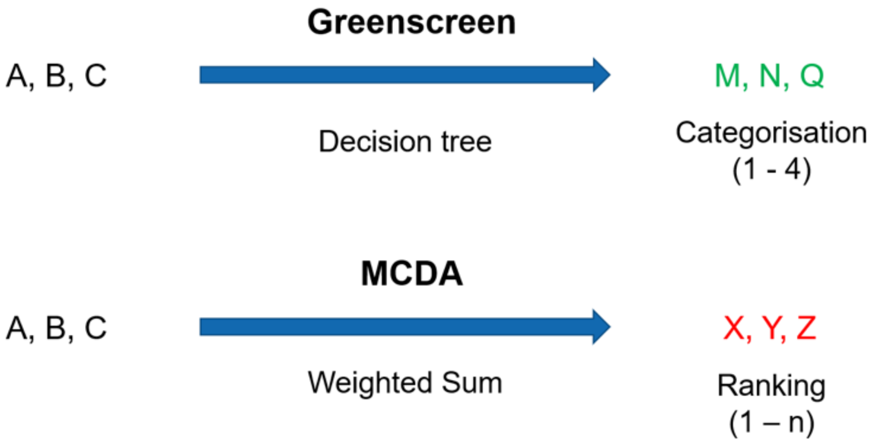
Model representation of "The Blob", i.e. the strong marine heatwave in the Northeast Pacific in 2014-2016. The left panel shows snapshots of the associated marine heatwave categories (CAT), i.e. intensity (1=moderate, 2=strong, 3=severe, 4=extreme) at three different depths in March 2015. The right panels show depth-time sections of the categories (top) and temperature anomalies relative to the climatology (bottom) at 43.5°N, 145.5°N (location indicated by column in left panel).

A16 Rachel London
Environmental Chemsitry, ETH

What is the Right Method for Assessing the Alternatives to PFAS?

Alternatives are being sought for per- and polyfluoroalkyl substances (PFAS), as evidence mounts of the extreme persistence, environmental ubiquity, and negative human health outcomes of PFAS. Proposed alternatives should be assessed to avoid regrettable substitution. Assessment of Alternatives (AoA) frameworks with decision-making methods already exist, however, are existing methods suitable for PFAS given the extreme environmental persistence of PFAS and the problematic chemicals associated with their lifecycle?

AoA frameworks were investigated by applying their decision-making methods to analyze the conclusions from the different methods for the same data set. The data set consisted of the hazard data for 256 hypothetical substances created for the purposes of investigating these methods. For the hypothetical substances with a similar hazard profile to PFAS, decision-making methods using a decision tree approach (e.g., Greenscreen) were more appropriate than decision-making tools using a weighted sum approach (e.g., Multi Criteria Decision Analysis (MCDA)). Additionally, such methods should be updated to include environmental fate hazards such as Persistence, without requiring that they are found in combination with other hazards.



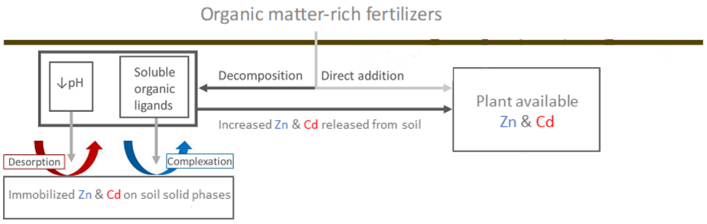
Comparison of methods - same input, different output

A17 Jill Bachelder
Plant Nutrition, Institute of Agricultural Sciences, ETH
Inorganic Environmental Geochemistry, IBP, ETH
EAWAG, W+T

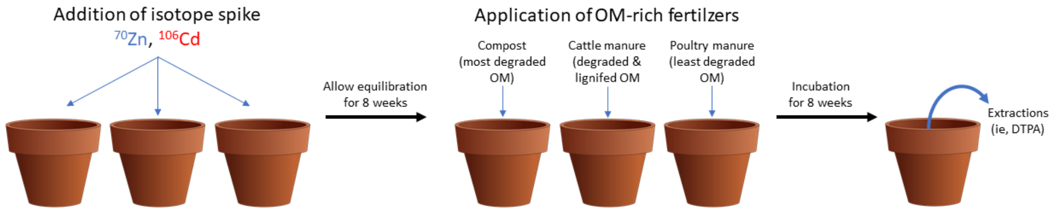
How do organic matter-rich fertilizers impact bioavailable Zn, and Cd, in an unpolluted arable Swiss soil?

Wheat grown in Zn-limiting conditions can lead to decreased nutritional value of resulting food products. Previous studies indicate organic matter (OM)-rich fertilizer application can increase the pool of available Zn. However, this may also increase bioavailable Cd, a toxic element with similar plant uptake pathways as Zn. We performed an incubation experiment aimed at improving our understanding of how OM-rich fertilizers impact the bioavailability of soil Zn/Cd. First, an unpolluted arable soil was isotopically enriched with 70Zn and 106Cd to distinguish the sources (soil vs. fertilizer) of Zn/Cd in bioavailable soil pools (ex. DTPA-extractable). The soil was mixed with three fertilizers we previously identified as having contrasting OM compositions: compost (most degraded OM), cattle manure (degraded and highly lignified OM), and poultry manure (less degraded OM). First results showed poultry and cattle manure increased the DTPA-Zn pool more than compost, while DTPA-Cd was unaffected by all fertilizer treatments. Isotope mass balances revealed increased DTPA-Zn was derived from the fertilizers, with negligible contribution of Zn derived from soil. While these results could indicate OM-rich fertilizers may increase bioavailable Zn but not Cd, we must as a next step perform a pot experiment to understand how OM-rich fertilizers impact Zn/Cd in wheat.

Concept:



Experimental setup:



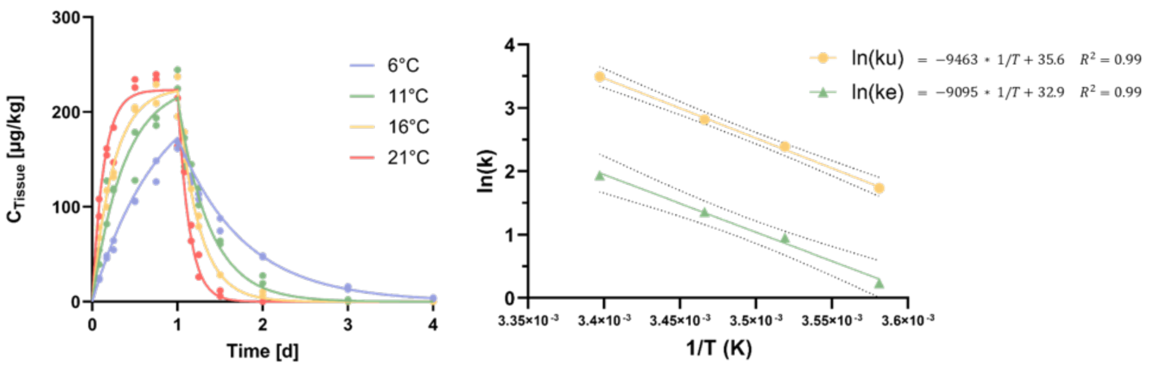
A18 Johannes Raths
EAWAG and ETH

Speed it up: Temperature drives toxicokinetic processes in aquatic invertebrates

Studies for the environmentally risk assessment of chemicals are generally conducted in standardised laboratory tests. However, environmental parameters are known to exert a strong influence on organism fitness. The ongoing climate change draws a lot of attention towards the parameter temperature. However, the exact interactions of combined stress (temperature and pollution) do remain unravelled. This study aimed to investigate the influence of temperature on toxicokinetic parameters in aquatic invertebrates. Bioconcentration experiments at four different temperatures with a mixture of compounds were carried out using the aquatic invertebrate *G. pulex*. Tissue and medium samples were taken in regular intervals and analysed by LC-HRMS/MS. From these data uptake and elimination kinetics, as well as toxicokinetic rate constants were modelled.

A positive relationship between toxicokinetic rate constants (uptake, bitransformation, elimination) and temperature was observed. However, the steady state bioconcentration factors of the tested compounds were similar between the different temperatures or even lower at higher temperatures due to biotransformation.

We demonstrated that temperature can be an important driver of toxicokinetic processes and provide data and methods for risk assessment implications. The obtained results help understanding the mechanisms of temperature on toxicokinetic rate constants and their interaction resulting in temperature dependent sensitivity changes.



Toxicokinetic models for the pharmaceutical carbamazepine at four different temperatures (left) and Arrhenius temperature relationship for uptake ku and elimination ke (right) rate constants.

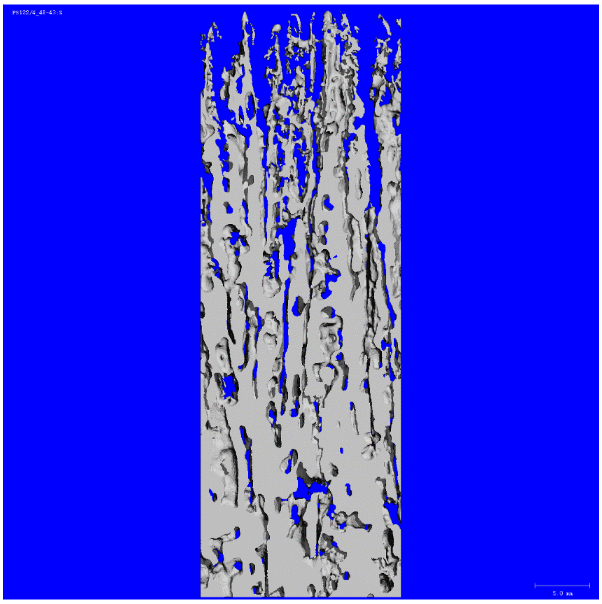
Poster Session B

B01 Amy Macfarlane

WSL Snow and Avalanche Research SLF

Evolution of micro and macro-structural changes of melting sea ice and influence on reflectance

There is a continuous decrease in the age of Arctic sea ice. By the end of summer 2021, the increased melt meant that multiyear sea ice reached its second-lowest level. As sea ice melts, the physical and optical characteristics of the surface determine the availability of light and freshwater to the upper ocean. However, the relationship between the physical and optical properties of bare, melting sea ice is still poorly constrained. We do not know the significance of the spatial and temporal changes on albedo and light transmission. This study is the first to measure the surface microstructure of bare melting sea ice. The measurements provide insight into local changes, thickness and origin of the microstructure. We observed a highly anisotropic, coarse and porous structure with a small optical diameter at the surface that increases with depth. We see no correlation between net regional radiation and SSL thickness, indicating that we need to look at local net radiation changes due to surface roughness rather than floe-scale regional radiation. We predict the surface roughness to increase with younger ice in the Arctic, resulting in greater differences in SSL thicknesses and hence more variable light transmission.

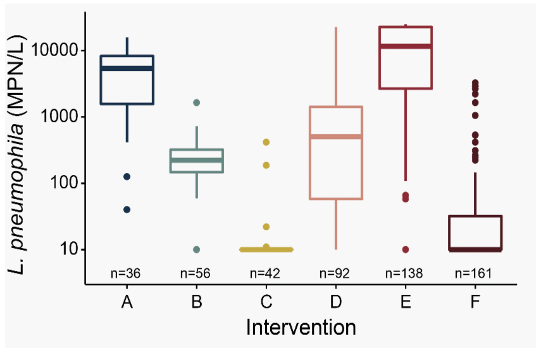


The melting sea ice surface measured using a microcomputer tomograph. The measurements showed an anisotropic, coarse and porous structure with a small optical diameter at the surface that increases with depth

B02 Céline Margot
Environmental Microbiology, EAWAG and ETH

Impact of boiler temperature on L. pneumophila in building plumbing: a long-term case study

Potable water systems are often contaminated with the opportunistic pathogenic bacteria Legionella pneumophila. Growth of the pathogen in buildings is affected by system design, water use patterns and operational settings such as water temperature. The impact of technical interventions on Legionella is often studied after detection of Legionellosis, or in buildings with at-risk occupants that prioritize rapid reduction of Legionella, limiting the number of studies that evaluate more moderate interventions. The aim of this work was to evaluate boiler operational settings that attempted to balance reduced energy demands with Legionella numbers. Samples were collected throughout a contaminated building supplied with non-chlorinated water. During 12 months, the boiler temperature and system operation were systematically changed and the impact on L. pneumophila was quantified. Our results show that a boiler temperature of 45 °C combined with one or more 70°C superheating cycle(s) was ineffective in reducing Legionella numbers. However, a constant boiler temperature of 60 °C effectively reduced pathogen numbers. These findings suggest that straightforward technical interventions on the boiler temperature can be sufficient to control *L. pneumophila*.



L.pneumophila concentrations measured during each period of intervention.

Intervention	Boiler Temperature setting	Super-heating (70 °C) and circulation (7 min per hour during 4 hours)
A (initial)	45 °C daily	1x per week, no circulation
B (3 weeks)	45 °C daily	1x/week, with intervals of circulation (7 min per hour during 4 hours)
C (3 weeks)	60 °C daily	None
D (6 weeks)	45 °C daily	1x/week, with intervals of circulation (7 min per hour during 4 hours)
E (5 months)	45 °C daily	3x/week with intervals of recirculation (7 min per hour during 6 hours)
F (4 months)	60 °C on weekdays, 45 °C on weekend	None

B03 Yuchen Meng

Ecology, visiting student, ETH

Blue carbon "hidden" in mangroves

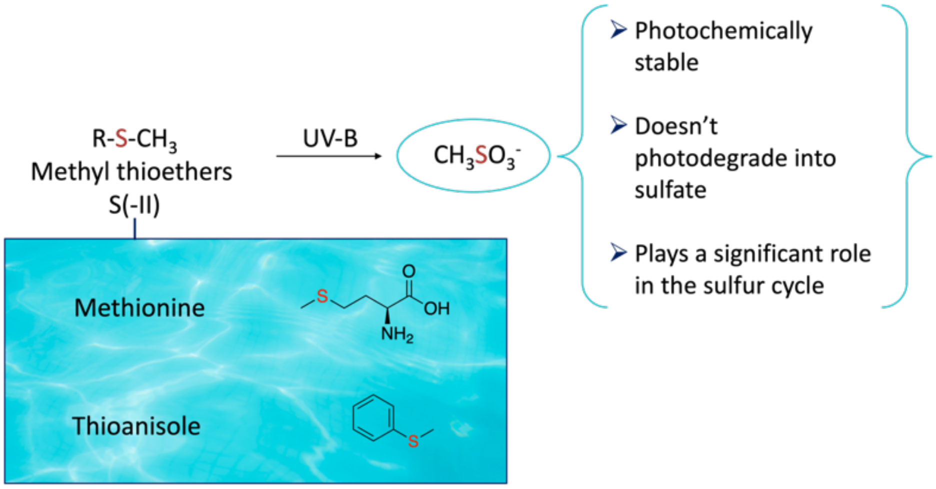
Mangrove wetlands are highly biodiverse and productive ecosystems, which provide many ecological system services. One of them is the high carbon sink (also called "blue carbon") capacity for atmospheric CO2 in mangrove forests worldwide. Although great efforts have been made to quantify mangrove carbon stocks, reliable estimation of below-ground carbon stocks remains big challenges. In this study, we aim to establish possible relationships between above- and below-ground carbon stocks for mangrove forests and trying to explain the sediment bacteria effects on microbe scale. This may provide scientific bases for estimating mangrove carbon stocks over large scale by remote sensing or other approaches.

Mangrove forests in Haikou City, Hainan Province (Cover image via VCG.)

B04 Sahar Naim
Environmental Chemistry, ETH

A comparative study of the photochemical behavior of aliphatic and aromatic methyl thioethers and their photoproduction of methane sulfonic acid

The relationship between the chemical structure of a molecule and its photochemical behavior can be used to understand the fate of this molecule and to predict the behavior of other molecules with similar structures. A molecule with a methyl sulfide functional group, referred to as methyl thioether, is expected to be a precursor to methane sulfonic acid when exposed to light. However, little is known about what photodegradation pathways different methyl thioethers might undergo. Here, we investigate the photochemical behavior of two types of model methyl thioethers; one is aliphatic (methionine) and the other is aromatic (thioanisole). The irradiation experiments showed that the photolysis pathway was mainly indirect for methionine and direct for thioanisole. The main photoproducts for both compounds were their sulfoxide forms. But methane sulfonic acid was mainly formed from the starting methyl thioethers used, not from their sulfoxide forms unless a carboxyl group was added to the aromatic ring of the thioanisole. A range of intermediates preceded the formation of methane sulfonic acid and affected its delayed kinetics. Knowing that methane sulfonic acid is an important sulfur species in the environment, this work helps to better understand the role of photochemical processes in the sulfur cycle.

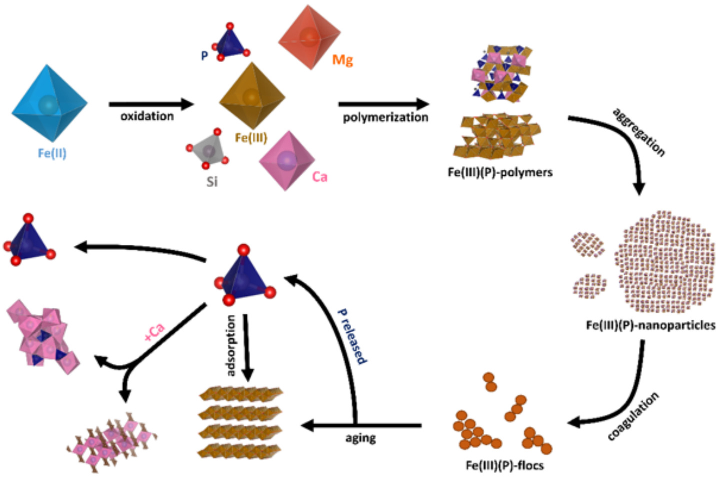


The formation of photostable methane sulfonic acid from methyl thioethers, such as methionine and thioanisole, when exposed to UV-B light

B05 Ville Nenonen
Water Resources and Drinking Water, EAWAG

Phosphate retention by Fe(III)- and Ca-precipitates formed upon oxidation of Fe(II)

Phosphorus is an essential nutrient, but excessive inputs into surface waters may lead to the eutrophication and impairment of aquatic ecosystems. The biogeochemical cycling of phosphorus is coupled to the redox cycling of Fe. The oxidation of dissolved Fe(II) in natural waters leads to the formation of Fe(III)-precipitates with a high sorption capacity for phosphate (P). Fresh Fe(III)-precipitates are metastable and can transform into more stable phases over time, which may lead to the release of initially bound P. The formation and transformation of Fe(III)-precipitates in natural waters is strongly affected by other solutes (Ca, Mg, P, Si) that interfere with Fe(III) precipitation and polymerization, and thereby also affect P binding. Furthermore, in the presence of Ca, repartitioning of P released from Fe(III)-precipitates into Ca-carbonates or –phosphates, could attenuate P release. In this project, our focus was on the interdependent effects of Ca, Mg, Si, P on these coupled processes in laboratory experiments under conditions representative for natural waters. We used a selection of spectroscopic and microscopic techniques to provide new insights into the molecular- and nanometer-scale processes that control the fate of P in environmental systems.



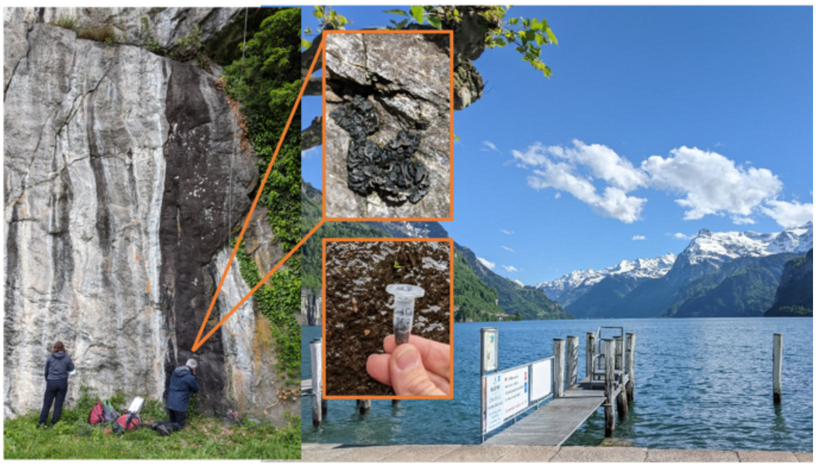
A schematic representation of Fe(III)- and Ca-precipitate dynamics with phosphate in fresh and aging suspensions.

B06 Juliana Oliveira

Biodiversity and Conservation Biology, WSL
Environmental Chemistry, EAWAG

Tintenstrich communities: occurrence, mobility and potential risk of cyanobacteria and their toxins in lichen communities

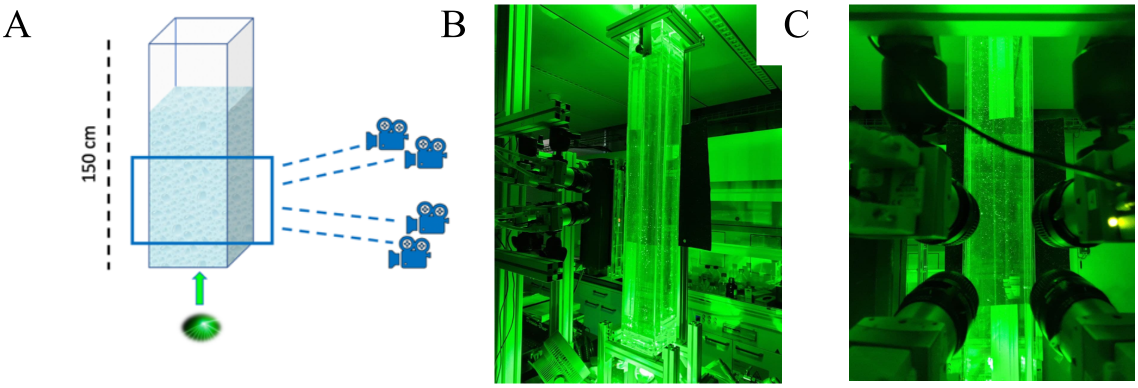
Subaerial and often dark-colored biofilms, termed Tintenstrich communities ("ink-lines", TCs) extend on rock surfaces in semi-aquatic environments. TCs are widely distributed in high mountain areas, including large parts of the Alpine region. They are predominantly composed of free-living cyanobacteria and associated with lichen-forming fungi, i.e., cyano-lichen. Cyanobacteria are known to produce diverse bioactive metabolites including toxins that could protect them from graziers. Cyanotoxins pose a major concern for environmental and public health and the World Health Organization defined limits for cyanotoxins in drinking water and recreational water quality guidelines. Despite that, many questions remain unsettled about their role at the soil-water interface including TCs. The occurrence of cyanotoxins in the Swiss Alps is currently unknown. As alpine areas are highlighted for playing a major role in the hydrologic system, the risk to local water resources of releasing of toxic TCs cyanobacterial metabolites remains undetermined. Additionally, cyanobacteria take part in important ecological relationships triggered and/or remediated by the production of chemical compounds, worthy of exploration. Therefore, this proposal aims to determine the metabolic diversity of cyano-lichen species in TCs, investigate whether these metabolites could threaten the water quality in the Swiss water catchments, and to assess cyano-lichen interactions with local herbivores.



B07 Francesco Parrella
Environmental Chemistry for Antrophogenic Materials, ETH

Influence of Microplastics and Freshwater Snow Heteroaggregation on Particle Settling Rates in Freshwater

To date, only few studies have been conducted to systematically understand the processes which drive MPs fate in freshwater ecosystems. This includes heteroaggregation with colloids or biota and how these interactions affect MPs transport. Freshwater snow (FWS), a mixture of algae and natural particles, is responsible for the mass flux of organic matter through the water column and can potentially alter the MPs deposition. Here we analysed the settling rates of particles in a plexiglass column, illuminated by a laser to track particles with a camera system. Image sequences were acquired with a tracking software to determine settling rates of the particles in three tests: MPs of various composition, size and morphology, FWS and MPs-FWS heteroaggregates. Our goal was to assess if the settling rates changed when plastic and FWS were aggregated together, compared to their settling dynamics individually. While data analysis is still ongoing, we hypothesize that MPs morphologies and extent of incorporation into FWS will be important variables in the settling dynamics. Through this work, we demonstrate the utility of our experimental setup for the analysis of settling dynamics and we provide better insights on how MPs can impact the biogeochemical cycles through altering FWS settling in freshwater.



A) Schematic of column set-up, B, C) column and cameras with laser illumination during an experimental run

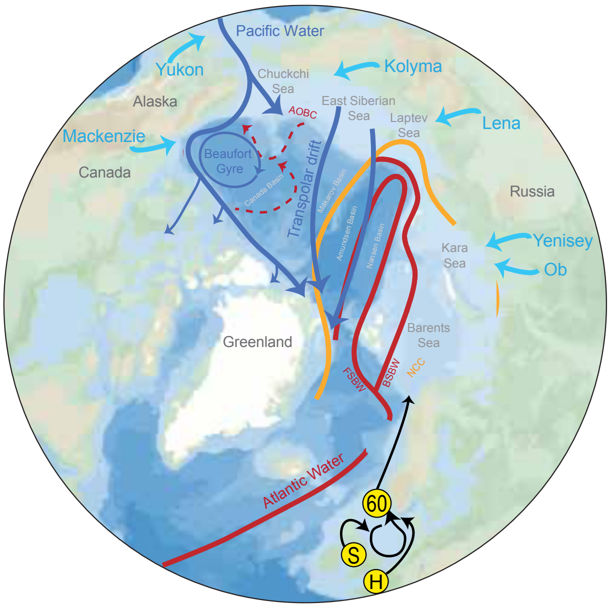
B08 Annabel Payne

TITANICA: Physical Oceanography

A multi-tracer investigation of ocean circulation and ventilation in the Canada Basin

The Arctic Ocean is particularly vulnerable to the effects of global warming – An improved understanding of the water masses and circulation regime within the Canada basin is needed, given the contribution of arctic water to the global overturning circulation which ventilates the deep oceans.

Released from European nuclear reprocessing plants, annual observations of radionuclides 236U and 129I provide an invaluable opportunity to observe temporal variations of warm Atlantic water (AW) input, deep-water ventilation, and the response of surface water circulation to the highly variable atmospheric mode of the Arctic Oscillation index. Combining our new tracers of water mass transport, ventilation, and freshwater input with established process tracing methods (εNd, εHf, δ18O) we provide a powerful tool for the oceanographic community to forecast the future ocean response to climate change. Here we present 236U and 129I data from the JOIS 2020 expedition, providing an initial overview of the water masses and flow paths within the Canada Basin. Calculations of transit time distribution models will provide estimates of tracer (water mass) ages within the mid-depth Atlantic layer of the Canada Basin.

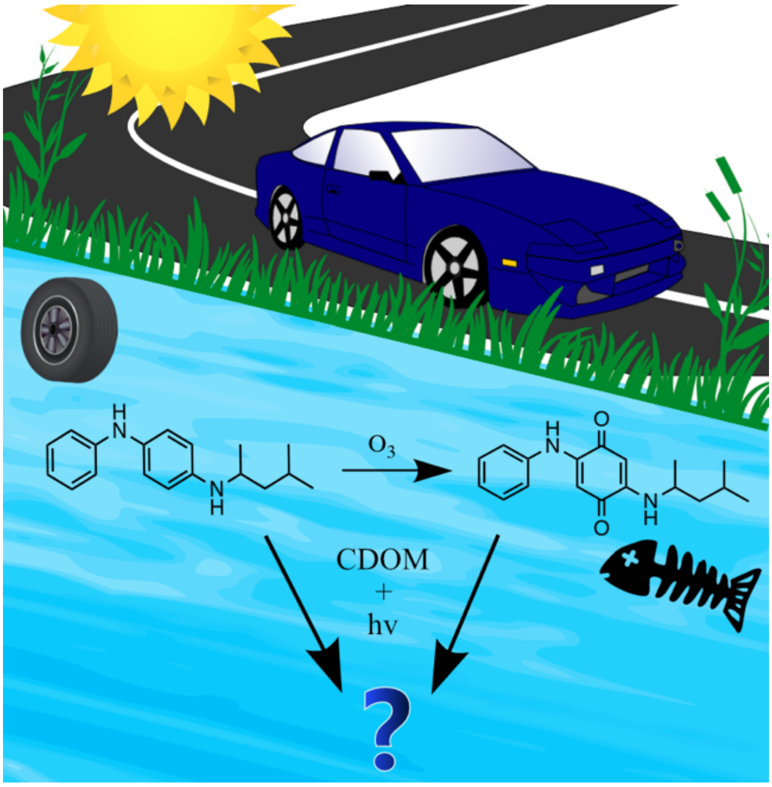


Map of the Arctic Ocean including bathymetric features and major current systems. Atlantic sourced waters are coloured red and orange, Pacific sourced waters are blue. AOBC: Arctic Ocean Boundary Current. NCC: Norwegian Coastal Current. FSBW: Fram Strait Branch Water. BSBW: Barents Sea Branch Water. Sellafield and La Hague reprocessing plants are marked S and H respectively. Surface currents in the North Sea are marked in black and the location of the 60N input function is indicated. Base map adapted from GEBCO (2012) and oceanographic features added from Wefing et al. (2021).

B09 Katie Platt
Environmental Chemistry, ETH

The Photochemical Reactivity of 6PPD and 6PPD Quinone: The Coho Salmon Killer

A ubiquitously used tire rubber antidegradant, 6PPD (N-(1,3-dimethylbutyl)-N'-phenyl-p-phenylenediamine), and it's toxic ozonation product, 6PPD quinone, have recently been gaining interest in the environmental chemistry world. A 2020 study identified 6PPD quinone as the cause of mass fish kills of Coho salmon that have been occurring in norwthwestern USA since the 1980s. The transport and reactivity of 6PPD, 6PPD quinone, and similar phenylenediamines requires study to better understand their fate in the environment. This project explores the aquatic photochemical reactivity of 6PPD and 6PPD quinone via direct photolysis, as well as indirect photolysis through excited triplet state chromophoric dissolved organic matter (3CDOM*) and other photochemically produced reactive intermediates. The relative contributions of each pathway to the degradation of the compounds is studied using both steady state photolysis and time resolved laser spectroscopy techniques. Additionally, the possibility of creating 6PPD quinone via photochemical pathways other than ozonation is explored to identify the ways in which the toxic quinone may be released to the environment.



B10 Grégoire Saboret

EAWAG

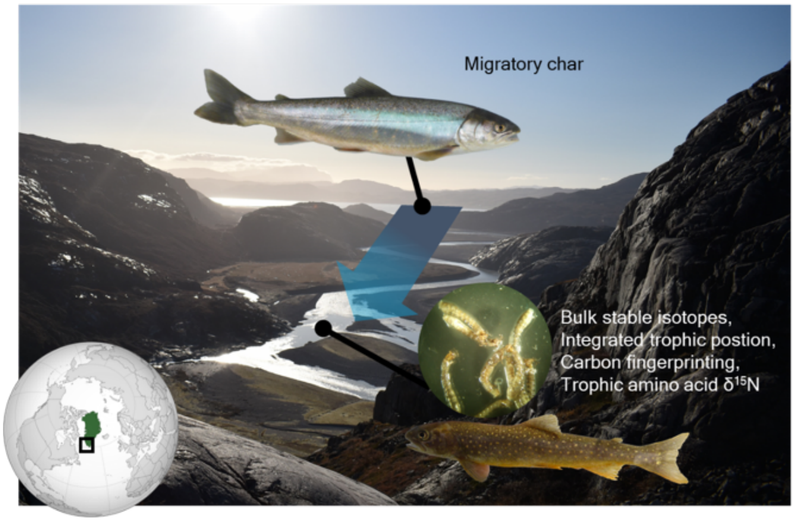
Stable isotope insights on the ecosystem effects of migratory salmonids on stream food webs.

Migratory animals act as cross-boundary subsidies, such as returning anadromous char carrying marine-derived nutrients and organic matter across the freshwater-marine ecotone. In South-Western Greenland, we studied the ecosystems effect of returning char in streams, using sites above barriers, that prevent migratory fish to pass, as controls. We used a combination of bulk and amino acid stable isotope (CSIA) to characterize ecosystem effects across trophic levels.

Stable isotopes revealed that resident fish populations were highly dependent on marine subsidies. Carbon fingerprinting showed a high within-population variability of the source of primary production, i.e. some phenotypically similar fish relied on distinct freshwater or marine primary production, likely through egg cannibalism as revealed by amino acid δ15N.

Source amino acid δ15N showed the assimilation of marine nitrogen by freshwater primary producers, with potential bottom-up effects. We further characterized changes in energy transfer efficiency using integrated trophic position of invertebrate communities (results to follow).

Our study shows how migratory animals affect energy flow in recipient ecosystems and how they provide coupling with allochthonous sources of primary production.

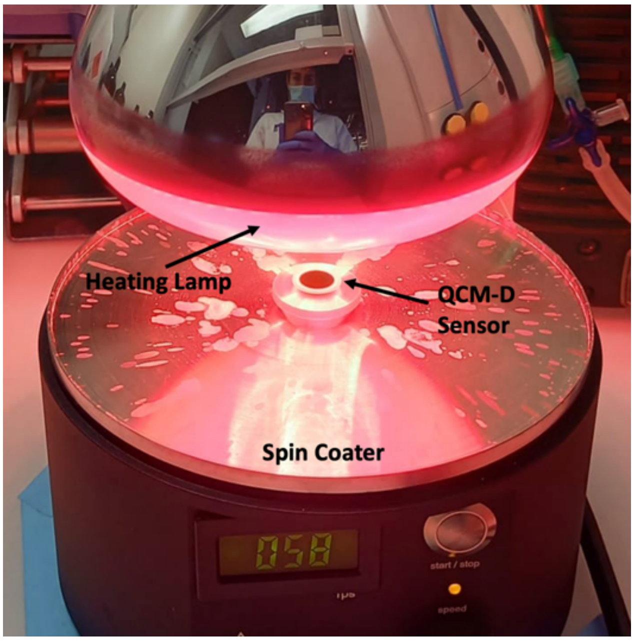


B11 Roman Schefer
Environmental Chemistry, ETH

Eco-corona Formation on Plastic: Effect of Plastic Type and Aging

Concerns about the adverse environmental impacts of nano- and microplastic are continuously increasing, yet the understanding of plastic fate in freshwater environments is still limited. Plastic chemistry, size, shape, density as well as the freshwater composition all influence plastic particle fate. Aging of plastics, either by photochemical weathering or by adsorption of (bio)macromolecules which leads to formation of an ecocorona, can further change the physicochemical properties of plastics. However, the impact(s) of photochemical weathering on the physicochemical properties of plastic, and how this impacts subsequent adsorption of (bio)marcromolecules and ecocorona formation, is often neglected. Here we conducted systematic studies on adsorption of a selection of ubiquitous (bio)macromolecules (humic & fulvic acids) to a set of the most environmentally prevalent polymer types (PE, PP, PET & PS) in their pristine and photochemically weathered forms. Using Quartz Crystal Microbalance with Dissipation (QCM-D) allowed for determination of changes in mass of (bio)marcromolecule adlayers on the plastic coated sensor surface. The plastic coating was achieved by spincoating (Fig. 1). The extent of ecocorona formation on pristine plastics was compared to plastic films which underwent photochemical weathering. This information will help to understand the rate and extent of ecocorona formation for (bio)macromolecules on different pristine and photochemically weathered plastics. Ultimately, this will allow us to produce more realistically aged materials to be used in further experiments on fate of plastics.

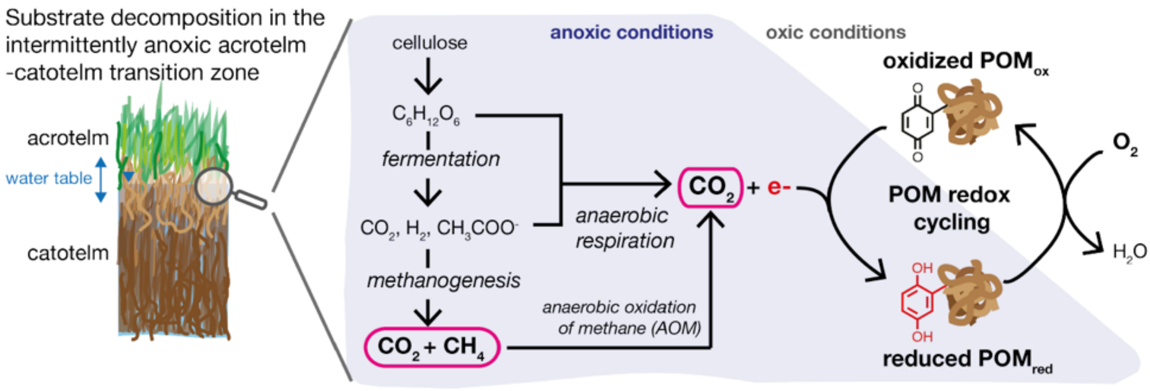
Spin coating of polypropylene on QCM-D Sensor under elevated temperature.



B12 Robert Schmitz, Nikola Obradović
Environmental Chemistry, ETH

Characterization of electron exchange with peat particulate organic matter and its impact on methane formation dynamics

Northern peatlands constitute a major global carbon pool from which CO2 and CH4 are naturally emitted. Ombrotrophic bogs within these peatlands are anoxic, water-logged soils that are deprived of inorganic terminal electron acceptors (TEAs) such as nitrate and sulphate. In the absence of TEAs, an equimolar production of CO2 and CH4 is expected to form through methanogenesis, as the final step in the microbial degradation of organic matter. However, several studies have reported elevated CO2:CH4 ratios pointing towards the presence of a previously unrecognized TEA, resulting in a shift from methanogenesis to anaerobic respiration. We hypothesize that peat particulate organic matter (POM) is acting as an alternative TEA in anaerobic respiration, suppressing methanogenesis. By combining laboratory experiments and in-field studies, we aim to link the redox properties of POM to CH4 formation dynamics in these systems. The elucidated redox properties include the number of electrons that can be transferred to and from POM, the reduction potential distribution of electron accepting moieties in POM, the reversibility of electron transfer to POM, and the potential role of DOM as an electron shuttle to POM. The studied redox properties are further linked to CO2 and CH4 formation dynamics in peat soil incubations.



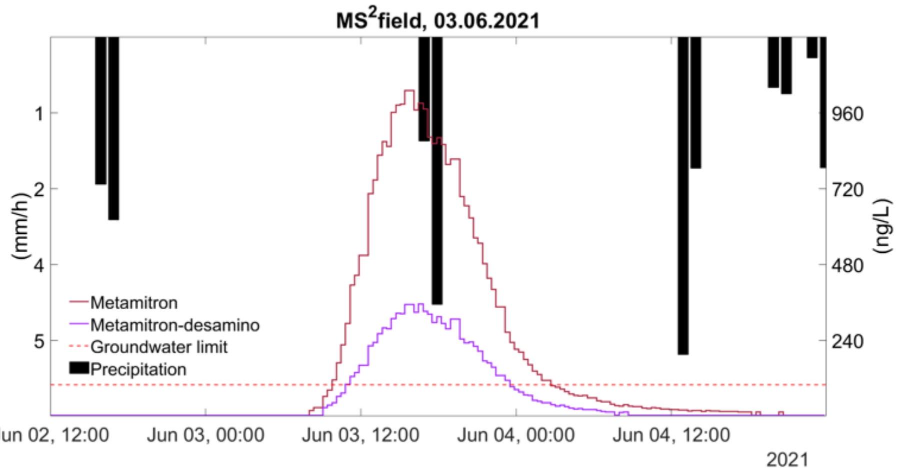
B13 Johannes Schorr
Aquatic Science and Technology, EAWAG and ETH

Temporally highly resolved in-situ monitoring of pesticide dynamics in a karst spring in the Swiss Jura

For karst aquifers, sporadic grab sampling most likely provides an incomplete picture of pollutant occurrences and variations. In contrast to unconsolidated aquifers, also substances that are relatively easy to degrade or less mobile can be detected at karst springs. Therefore, this pilot study aimed at assessing the short-term concentration variations of pesticide concentrations in karst groundwater.

A mobile orbitrap mass spectrometer platform (MS2field) that allows for analyzing pesticides and their transformation products in real-time, automatically, and in-situ every 20 minutes, was employed. Measurements were recorded over 6 weeks in May and June 2021, alongside the continuous measurement of other parameters such as electrical conductivity, turbidity, water temperature nitrate, pH, and bacterial cell count (online flow cytometry).

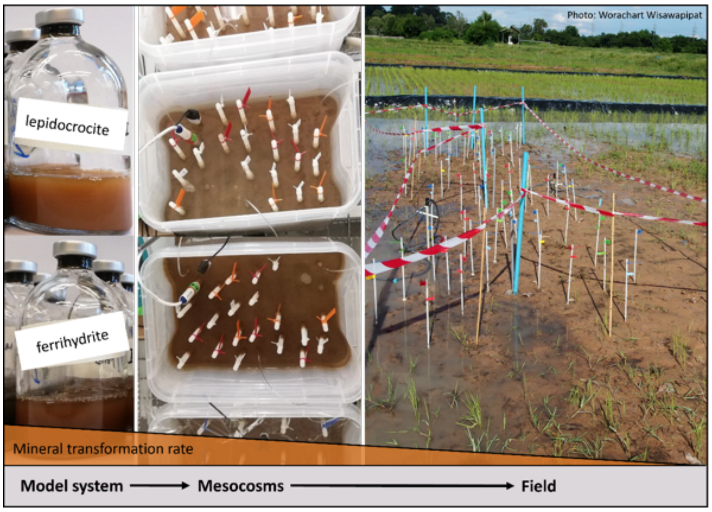
The MS2field data allowed the detection of pesticide peaks directly following recharge events. The detected peaks arrived at the spring at different points in time and thus the groundwater limit of 100 ng/L was exceeded for up to 39 hours in one particular event. Together with a detailed assessment of land-use activities, including information on the application of pesticides in the catchment, the findings provide more insight into subsurface transport processes and help to explain the occurrence of pesticides at the related spring.



B14 Katrin Schulz
Soil Chemistry, ETH

Moving from the lab to the field – Ferrihydrite and lepidocrocite mineral transformations in model systems and a rice paddy soil

Redox-driven iron (Fe) mineral transformations in soils have implications for nutrient and contaminant cycling, but have rarely been studied in-situ in soils. We hypothesized that Fe mineral transformation is impacted by the direct contact with the complex soil matrix. Therefore, we studied ferrihydrite and lepidocrocite transformations in mineral suspensions with spiked Fe(II) and in-situ in a Thai rice paddy soil. For the in-situ studies, we incubated minerals (100 mg) in mesh bags in laboratory mesocosms and in the field. At multiple time points, mineral transformation products were identified by X-ray diffraction and the total element composition was analyzed in aqueous phases of the model system and in soil pore waters. Mineral transformations in the model system were faster than in soil mesocosms, likely due to the presence of impurities in the soil porewater and diffusion limitations. However, mineral mesh bags in mesocosms seem to have acted as hot spots for Fe(II) production and mineral transformation. Under field conditions, mineral transformation was slowest, despite similar Fe(II) concentrations in mesocosm and field porewaters. The results demonstrate that Fe mineral incubation in model systems, in soil mesocosms and under field conditions lead to strongly differing mineral transformation pathways and rates. Therefore, Fe mineral interactions with the soil matrix need to be considered when assessing iron mineral transformation in rice paddy soil systems.



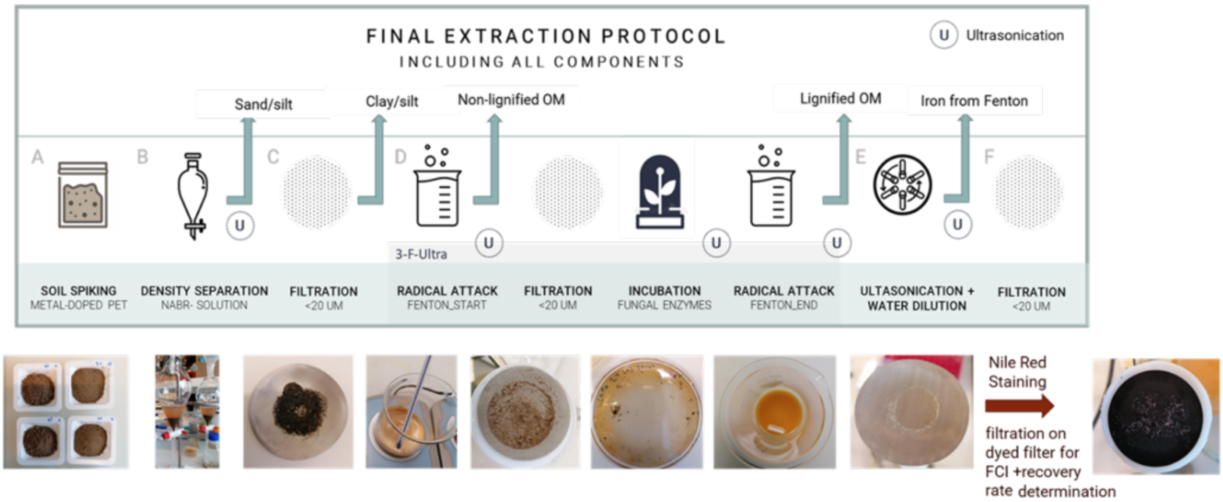
Ferrihydrite and lepidocrocite incubation in mineral suspensions (model system) and in a Thai rice paddy soil as minerals in mesh bags (mesocosm, field).

B15 Alissa Tophinke

Environmental Chemistry of Anthropogenic Materials, ETH

Systematic Development of Extraction Methods for Quantitative Microplastic Analysis in Soil using Metal-doped Plastics

The lack of harmonization in current microplastics (MPs) analysis in soil demands novel methodologies for extraction and quantification. To enable robust and accurate assessment of extraction procedures, PET-MPs (125–250 µm) with a passive inorganic tracer (Indium, 0.2% w/w) were added as spiked additions to several model soil components and standard-soils with varying composition. Due to the selectivity of the metal tracer, recovery rates of MP could be quantitatively assessed using ICP-MS. The prior systematic investigation of specific subgroups (sand, silt, clay, non-lignified and lignified biomass), allowed the adaptation of the extraction methods to the characteristics of the respective soils. Removal of recalcitrant cell wall components is one of the major hurdles in isolating MPs, requiring specific approaches to remove lignocellulosic structures. Therefore, a new biotechnological method (3-F-Ultra) was developed which mimics natural degradation processes occurring in aerobic (Fenton) and anaerobic fungi (CAZymes). Finally, a Nile Red staining protocol was developed to evaluate the suitability of the proposed workflow for non-metal-doped MP, which requires a filter with minimal background residues for chemical identification, e.g. by FTIR spectroscopy. For this, a deep learning tool was used to distinguish the number of residues in brightfield mode and MP counted in fluorescence mode.

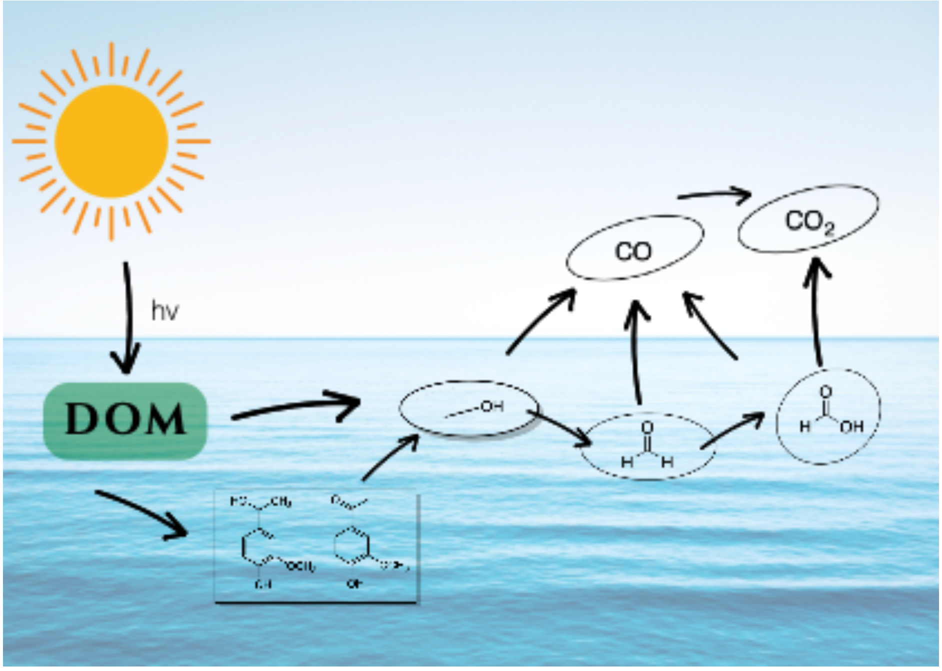


Final extraction protocol for soil including all components (sand, silt, clay, lignified OM) applied to LUFA standardsoil (photo LUFA 6S).

B16 Morgan Vallières
Environmental Chemistry, ETH

Photo-Oxidation of C1 Compounds; Formaldehyde, Formic acid and Methanol, Via Natural Water Components.

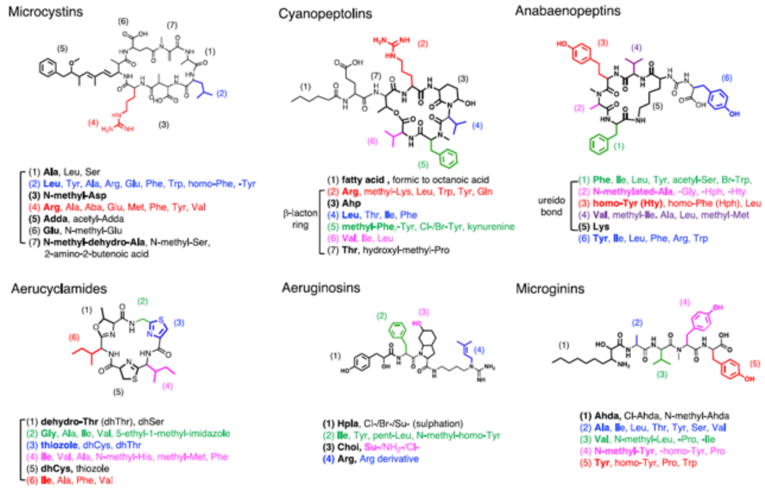
The photo-oxidation pathways and fate of low molecular weight compounds in the environment has gained importance due to the observed impact on the global carbon cycle and production of CO and CO2. Despite this the formation pathways are relatively understudied, but their importance were highlighted when studies showed CDOM to be the proxy for CO production in the oceans. Further studies showed lignin monomers with specific structural components such as methoxy groups, were good indicators of the molecules ability to form carbon monoxide, this was corroborated by studies in our group which showed methanol to be the key intermediate species produced by irradiation of lignin monomers leading to CO production. Previously work has looked at their reactivity to pure OH radical sources, but this may not be entirely representative of natural waters, which are much more chemically complex. This study focuses on the product distribution, yield, and kinetic rates of all C1 components when irradiated in the presence of Suwanee River Natural Organic Matter using C13 NMR. We observed a mixture of products upon methanol irradiation which included formaldehyde, formic acid, ethene CO and CO2, we also investigated pathways and kinetics starting with these observed products.



B17 Xuejian Wang
Eawag Uchem

Seasonal and annual profiles of cyanobacterial non-ribosomal peptides in Lake Greifensee and their stability in waters

Cyanobacterial harmful algal blooms (CyanoHABs) are increasing in frequency, magnitude, and duration globally and they pose threats to ecosystem and human health, especially when toxic non-ribsomal peptides (NRPs) are produced and released into aquatic environment. Cyanopeptolins, anabaenopeptins, aerucyclamides, aeruginosines, and microginins are cyanopeptides that can be co-produced with microcystins (MCs) in similar concentrations contributing to toxic effects. However, long-term lake observations of the co-produced NRPs on their production profiles are rare. Thus, I will first investigate an existing dataset (2019-2021) to evaluate the extracellular and intracellular concentrations and profiles of co-occurring toxins/NRPs in Lake Greifensee. I will further explore the correlations between toxin production dynamics in the lake and environmental parameters such as water temperature, pH and chlorophyll-a concentrations. During the decay phase of a CyanoHAB event, the lysed cells release all intracellular toxins in short time, which often increase adverse effects on the aquatic environment. Therefore, knowing the stability of the released NRPs is of great significance. Second, I will investigate the biodegradation potential for the released toxins/NRPs in surface waters and explore the contribution of extracellular aquatic enzymes of heterotrophic bacteria. My research is part of an interdisciplinary project where we investigate the presence of toxic cyanobacteria 'from the genes to the ecosystem'. Even when toxin-producing genes are present, it does not necessarily infer that the toxins are also produced. Third, I will investigate how toxin production dynamics compare to the prevelance of toxin producing cyanobacteria when they grow in competition with non-producing strains. Overall, I aim to improve our understanding of co-occurring and environmental stability of cyanotoxins relevant to Swiss surface waters.



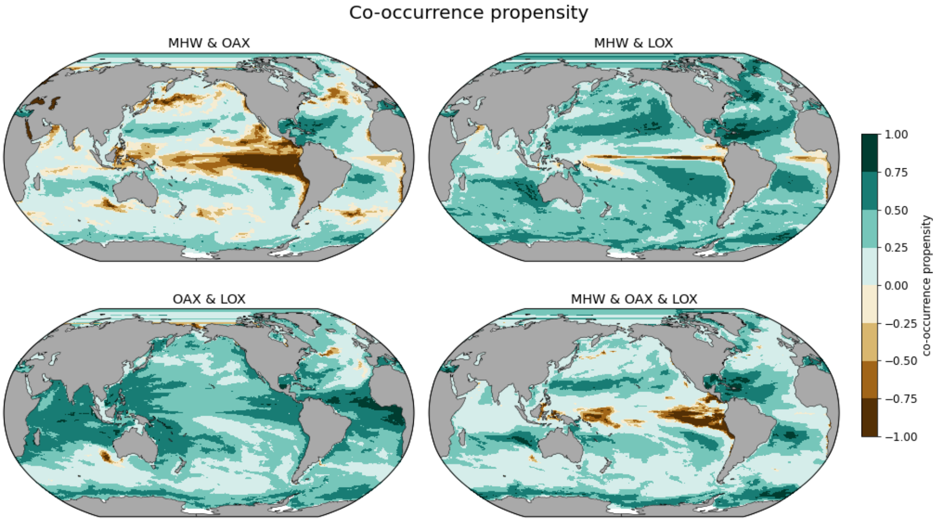
Representative structures for six cyanopeptide classes (Janssen, 2019)

B18 Meng Wong

IBP, UP

Characteristics of Recent Compound Extremes in the Global Ocean

Marine extreme events can be detrimental to organisms and ecosystems across the global ocean. Marine heatwaves (MHW), and extremes with respect to ocean acidification or low oxygen occur everywhere, superimposed on the already changing trends of temperature, pH, and oxygen. When such extremes occur spatially or temporally close together, the synergistic effects of such compound events may exacerbate the impact on marine organisms. While MHWs have been studied extensively, there has been less focus on extremes associated with ocean acidification (OAX) and low oxygen conditions (LOX), and even less on compound extremes. Our model simulations show that a large proportion of extremes in the 150m column are driven by El Niño events, leading to co-located and co-temporal compound events. The results show that the tropics and subtropics have a high propensity for compound extremes, experiencing high habitat contraction within the vertical water column. In addition, the Southern Ocean is identified as a hotspot for and triple compound events. These could be driven by anomalous stratification and upwelling during phases of the Antarctic oscillation. The results of this study provide an overview of the propensity and vertical extent of compound events, motivating the postulation of their drivers and mechanisms.



Co-occurrence propensity of marine extremes in the global ocean.