

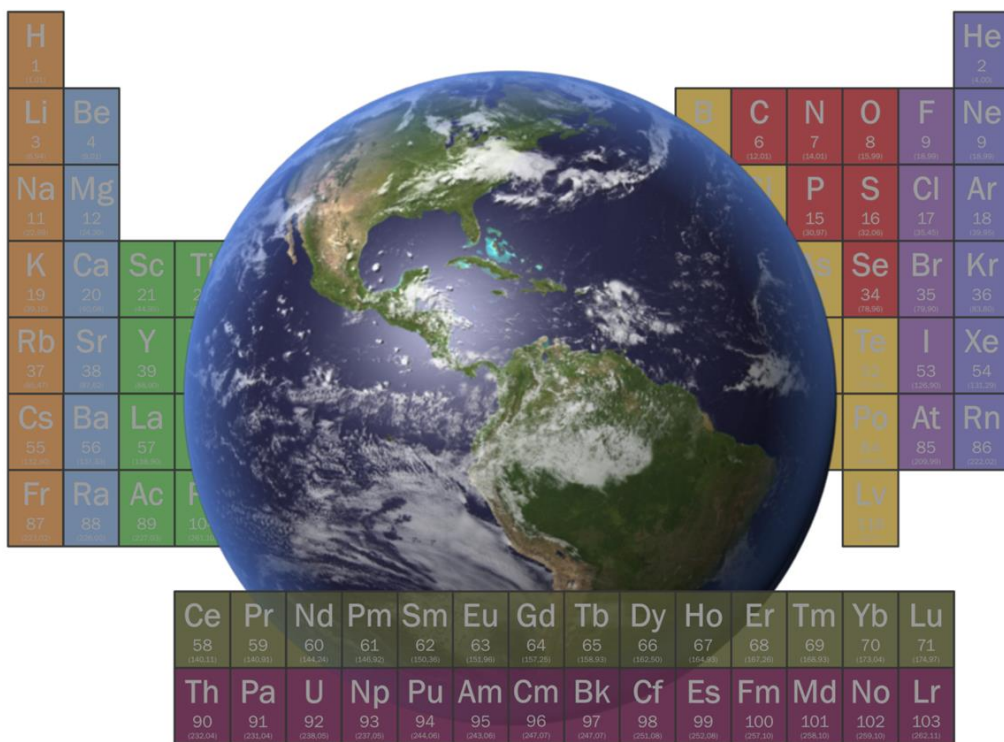
# Norwegian Environmental Chemistry Symposium - NECS



## NECS 2023

### The Norwegian Environmental Chemistry Symposium 2023

January 30 – February 1  
Vestlia Resort  
Geilo, Norway



With support from



The Research Council  
of Norway

## **Welcome Letter**

Dear colleagues,

It is with great pleasure that the members of the Organising Committee welcome you to the Norwegian Environmental Chemistry Symposium (NECS-2023) at Geilo.

This symposium builds upon a long-lasting national tradition of Norwegian environmental chemistry conferences dating back to the annual Norwegian environmental chemistry winter meetings (1998 – 2013). In this tradition, NECS 2023 will provide an inspiring platform for interdisciplinary knowledge transfer and scientific discussions among Norwegian and international specialists. The NECS symposium is organized under the auspices of Norwegian Chemical Society's Division for Analytical Chemistry (NKS-FAK) as an independent organization.

Living in a world full of distractions and technical overload, we need inspiring places to refresh our minds and bodies. In tradition with previous winter conferences, we have allocated time for recreational activities during an extended lunch break. We hope that the outdoor facilities of the area also will attract you and complement the scientific endeavour, and we hope you all will have an exciting and memorable conference and stay.

On behalf of the Organising Committee

Yngvar Thomassen  
Symposium Chair

## **Organising Committee**

### **Yngvar Thomassen**

National Institute of Occupational Health, Oslo  
Professor emeritus, Norwegian University of Life Sciences, Ås,

### **Oddvar Røyset**

Norwegian Chemical Society  
Røyset AS, Oslo

### **Georg Becher**

Professor emeritus, University of Oslo

### **Roland Kallenborn**

Norwegian University of Life Sciences, Ås

### **Rolf D. Vogt**

Norwegian Institute for Water Research, Oslo

### **Elin Gjengedal**

Norwegian University of Life Sciences, Ås

### **Lindis Skipperud**

Norwegian University of Life Sciences, Ås

### **Balazs Berlinger**

University of Veterinary Medicine Budapest, Hungary

## **General Information**

### ***Conference Desk***

The registration desk is located in the foyer of Vestlia Resort venue. It will operate as follows:

Sunday	January 29	15:00 – 20:00
Monday	January 30	07:30 – 20:00

Participants are requested to register as soon as possible upon arrival.

### ***Conference Venue***

All oral and poster sessions will be held in the conference area of Vestlia Resort.

Tel: +47 32 08 72 00      E-mail: mail@vestlia.no

Homepage: <https://vestlia.no/en>

## ***Meals***

Participants staying at Vestlia Resort are served breakfast, lunch, and dinner (from Sunday evening 19:00) (all included in their accommodation package).

## **Social Programme**

**Monday, January 29, 19:10 - 20:00: Informal get-together**

All delegates and accompanying persons are invited.

## **Scientific Programme**

### **Oral presentations**

Invited lectures and submitted oral contributions will be 30 and 20 minutes in length, respectively (including discussion).

### **Posters**

The posters should be mounted from Sunday afternoon in the poster area located in the lecture room. Materials for poster mounting are available either from the conference desk or in the poster mounting area.

### **Language**

The official language of the conference is English.

## **Liability**

The Organising Committee declines any responsibility whatsoever for injuries or damages to persons or their property during the conference.

## **Sponsors and exhibitors**

The conference is sponsored by the Research Council of Norway



The following companies have registered for display and demonstration:

 **HOLGER HARTMANN**



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 **Teknolab as**

**Correspondence after the symposium**

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## Scientific Programme:

**Monday, January 30, 2023**

**Time Abstract**

08:30-  
08:45 **Welcome/Opening remarks**  
Yngvar Thomassen, Conference Chair

### **Session I: Climate Change and Aqueous Environments**

Session Chair: Lindis Skipperud

- 08:45-  
09:15 O-1 **What is ocean acidification? From theory through quantification to monitoring.**  
Siv K. Lauvset, NORCE Norwegian Research Centre, Bjerknes Centre for Climate Research, Bergen.
- 09:15-  
09:45 O-2 **Expected and unexpected changes in lake chemistry during three decades of cleaner air and climate.**  
Heleen de Wit, Norwegian Institute for Water Research, Center of Biogeochemistry in the Anthropocene, Department of Geosciences, University of Oslo.
- 09:45-  
10:05 O-3 **Sources and pathways of halogenated natural products in northern Baltic estuaries.**  
Terry Bidleman<sup>1</sup>, Kathleen Agosta<sup>1</sup>, Agneta Andersson<sup>2,3</sup>, Sonia Brugel<sup>2</sup>, Lars Ericson<sup>2</sup>, Katarina Hansson<sup>4</sup>, Olle Nygren<sup>5</sup>, Mats Tysklind<sup>1</sup>  
<sup>1</sup>Department of Chemistry, Umeå University (UmU), Umeå, <sup>2</sup>Department of Ecology & Environmental Science, UmU, <sup>3</sup>Umeå Marine Science Centre, UmU, Hörnefors  
<sup>4</sup>IVL, Swedish Environmental Research Institute, Gothenburg, <sup>5</sup>Dean's Office, Faculty of Medicine, UmU.
- 10:05-  
10:35 O-4 **Climate change and impact on critical contaminants in seafood-Ongoing projects and future research needs.**  
Monica Sanden, Stig Valdersnes, Amund Måge, Aasim Ali, Tanja Kögel, Sylvia Frantzen, Stepan Boitsov, Bente Nilsen, Annette Bernhard and Sonnich Meier.  
Institute of Marine Research, Bergen.
- 10:35-  
11:05 **Coffee break, exhibition and poster viewing**
- 11:05-  
11:25 O-5 **Carbon emissions of boreal lakes in 2100.**  
Camille Crapart and Tom Andersen.  
Department of Chemistry and Centre for Biogeochemistry in the Anthropocene, University of Oslo.

- 11:25-11:45 O-6 **Distinguishing between anthropogenic and natural dissolved organic matter by means of spectroscopic indices.**  
Rolf D. Vogt<sup>1</sup>, Cathrine Brecke Gundersen<sup>1</sup> and Øyvind Kaste<sup>1</sup>, Petr Porcal<sup>2</sup> and Josef Hejzlar<sup>2</sup>, <sup>3</sup>Ståle L. Haaland, <sup>4</sup>Bjørnar Eikebrokk and <sup>5</sup>Geir I. Orderud,  
<sup>1</sup>Norwegian Institute for Water Research, Oslo, <sup>2</sup>Biology Centre CAS, Institute of Hydrobiology, České Budějovice, Czech Republic, <sup>3</sup>Norwegian University of Life Sciences, Ås, <sup>4</sup>Drikkevannskonsult, Trondheim, <sup>5</sup>Oslo Metropolitan University, Oslo.
- 11:45-12:05 O-7 **Presence and removal of toxic metals and organic pollutants from tunnel wash water.**  
Hanne Vistnes, Nadine A. Sossalla and Thomas Meyn.  
Department of Civil and Environmental Engineering, Norwegian University of Science and Technology, Trondheim.
- 12:10-13:00 **Vendor presentations**  
Each vendor has been allotted 5 minutes for presentation of their products and services:
- |                                      |                    |
|--------------------------------------|--------------------|
| Teknolab AS                          | Bjarne Fredheim    |
| Softwarepoint - A LabVantage Company | Sirpa Myllyperkiö  |
| Thermo Fisher Scientific             | Maria Sande        |
| Holger Hartmann                      | Laila Kvalheim     |
| Nerlien Meszansky AS                 | Emil Frøberg       |
| Lab Norway                           | Amanda Aslaksen    |
| Matriks                              | Thor Licthenthaler |
- 13:00 **Lunch**

## Session II: Environmental Pollution - Measurements and Assessment

Session Chair: Roland Kallenborn

- 16:30-17:00 O-8 **Approaches for tackling the planetary boundary for chemical pollution.**  
Ian T. Cousins, Department of Environmental Science, Stockholm University, Stockholm.
- 17:00-17:30 O-9 **How advances in the measurement of mercury are transforming our understanding of recovery from this global threat**  
Kevin Bishop, Mats B. Nilsson, Wei Zhu, Haijun Peng, Jacob Smeds, Chuxian Li, and Stefan Osterwalder, Swedish University of Agricultural Sciences (SLU), Sweden, University of Bern, Switzerland, and ETH Zürich, Switzerland.
- 17:30-18:00 **Coffee break, exhibition and poster viewing**
- 18:00-18:30 O-10 **Ten years of CERAD: Lessons learnt and future prospects.**  
Deborah Oughton, Centre for Environmental Radioactivity (CERAD), Norwegian University of Life Sciences, Ås.
- 18:30-18:50 O-11 **MetroPOEM: Metrology for the harmonisation of measurements of environmental pollutants in Europe.**  
Simon Jerome<sup>1</sup>, Lindis Skipperud<sup>1</sup>, Betül Ari<sup>2</sup>, Dirk Arnold<sup>3</sup>, Süleyman Can<sup>2</sup>, Valérie Lourenço<sup>4</sup>, Ben Russell<sup>5</sup>, Tea Zuliani<sup>6</sup>,

<sup>1</sup> NMBU, MINA, Environmental Chemistry Section, Ås, <sup>2</sup> TÜBİTAK, Ankara, Turkey, <sup>3</sup> PTB Braunschweig, Germany, <sup>4</sup> Université Paris-Saclay, CEA List, LNE-LNHB, Palaiseau, France, <sup>5</sup> NPL, Teddington, UK, <sup>6</sup> JSI, Ljubljana.

- 18:50-19:10 O-12 **Risk assessment and distribution of PFAS in a biological phosphorus recovery sludge used for agriculture.**  
Rizza Ardiyanti<sup>a</sup>, Ronita Chowdhury<sup>a</sup>, Alexandros G. Asimakopoulos<sup>a</sup>, Kamal Azrague<sup>b</sup>, Blanca Magdalena Gonzales-Silva<sup>a</sup>, Stein W. Østerhus<sup>a</sup>, Cynthia Hallé<sup>a</sup>  
<sup>a</sup>Norwegian University of Science and Technology (NTNU), Trondheim, <sup>b</sup> SINTEF Community, Infrastructure Department, Water and Environment Group, Oslo.
- 19:10 **Informal get-together**
- 20:00 **Dinner**

## Tuesday, January 31, 2023

Time Abstract

### Session III: Green Chemistry and Regulations

Session Chair: Oddvar Røyset

- 08:00-08:30 O-13 **Norwegian Ministry of Climate and Environment (KLD) 50 years: Important developments of Norwegian law.**  
Hans Christian Bugge, professor emeritus, Institute of Public Law, University of Oslo
- 08:30-09:00 O-14 **Circular economy in Norwegian industry.**  
Gunnar Grini, Federation of Norwegian Industries, Oslo.
- 09:00-09:30 O-15 **Enzymatic depolymerization of natural and synthetic polymers.**  
Gustav Vaaje-Kolstad, Norwegian University of Life Sciences, Ås.
- 09:30-09:50 O-16 **Hydrogen fuel cell technology for greener chemistry.**  
Younes Abghoui, Science Institute of the University of Iceland, Reykjavík.
- 09:50-10:10 O-17 **Enzyme encapsulated in different supports as a green biocatalyst for pharmaceuticals.**  
Ani Vardanyan and Gulaim Seisenbaeva, Department of Molecular Sciences, Swedish University of Agricultural Sciences, Uppsala.
- 10:10-10:30 O-18 **Functional silica-based sorbents for combined wastewater treatment in removal of poly- and/or perfluorinated compounds.**  
Oksana Dudarko and Gulaim Seisenbaeva, Department of Molecular Sciences, Swedish University of Agricultural Sciences, Uppsala.
- 10:30-10:50 **Coffee break, exhibition and poster viewing**



## Session IV: The Nordic and Arctic Environments

Session Chair: Rolf D. Vogt

- 10:50- 11:20 O-19 **Microplastic in the Arctic.**  
Geir Wing Gabrielsen, The Norwegian Polar Institute, Tromsø.
- 11:20- 11:50 O-20 **Exposures and health of Arctic populations.**  
Arja Rautio, Khaled Abass, Saranya Palaniswamy, Ulla Timlin and Anastasia Emelyanova, University of Oulu, Finland.
- 11:50- 12:20 O-21 **Whole blood concentrations of selected essential and non-essential elements among rural residents of Nenetsia, Russia.**  
Dag G. Ellingsen and Yngvar Thomassen, National Institute of Occupational Health, Oslo.
- 12:20- 12:40 O-22 **Chemicals of emerging Arctic concern as indicators of anthropogenic footprint in a changing Arctic.**  
Roland Kallenborn, Norwegian University of Life Sciences, Ås.
- 12:40- 13:00 O-23 **Levels and seasonal variations of per- and polyfluoralkyl substances (PFAS) in surface snow in Svalbard.**  
William F. Hartz<sup>a,b</sup>, Maria K. Björnsdotter<sup>c,d</sup>, Leo W. Y. Yeung<sup>d</sup>, Jack D. Humby<sup>e</sup>, Ingrid Ericson Jogsten<sup>d</sup>, Anna Kärrman<sup>d</sup>, Roland Kallenborn<sup>a,f</sup>  
<sup>a</sup>University Centre in Svalbard <sup>b</sup>Department of Earth Sciences, University of Oxford, UK. <sup>c</sup>Institute of Environmental Assessment and Water Research (IDAEA-CSIC), Barcelona, Spain. <sup>d</sup>Man-Technology-Environment Research Centre, Örebro University, Sweden. <sup>e</sup>British Antarctic Survey, Cambridge, UK. <sup>f</sup>Faculty of Chemistry, Biotechnology and Food Sciences, Norwegian University of Life Sciences, Norway.
- 13:00 **Lunch**

## Session V: Airborne Pollution

Session Chair: Roland Kallenborn

- 16:30- 17:00 O-24 **Changes in the atmospheric chemical composition and impacts on climate, health, and ecosystems.**  
Wenche Aas, Sabine Eckhardt, Cathrine Lund-Myhre, Stephen Platt, Sverre Solberg, Tove Svendby, Kjetil Tørseth, Karl Espen Yttri, NILU - Norwegian Institute for Air Research, Kjeller.
- 17:00- 17:30 O-25 **Tire and road wear particles in the environment - current knowledge and future needs.**  
Elisabeth Rødland, Norwegian Institute for Water Research, Oslo.
- 17:30- 18:00 **Coffee break, exhibition and poster viewing**
- 18:00- 18:30 O-26 **Deposition of tire wear particles near a motorway in Germany.**  
Stephan Weinbruch, Linyue Zou, Jeannette Matthies, Konrad Kandler, and Martin Ebert, Institute of Applied Geosciences, Technical University Darmstadt, Germany

- 18:30-18:50 O-27 **Emission of VOCs from wood building materials and impact on indoor air quality.**  
Ingrid Bakke, Norwegian University of Life Sciences, Ås.
- 18:50-19:10 O-28 **Do thermochemical processes emit toxins into the air?**  
Aysan Safavi, Christiaan Richter, and Runar Unnthorsson, School of Engineering and Natural Sciences, University of Iceland, Reykjavik.
- 19:30 **Dinner**

## Wednesday, February 1, 2023

### Session VII: Human Health and Environmental Pollutants

Session Chair: Georg Becher

#### Time Abstract

- 08:00-08:30 O-29 **Environmental DNA analysis (eDNA) – Principles and applications.**  
Alexander Eiler, Department of Biosciences, Centre for Biogeochemistry in the Anthropocene, Section for Aquatic Biology and Toxicology, University of Oslo.
- 08:30-08:50 O-30 **Risk-driving PFAS cocktail in Swedish human blood.**  
Josefin A Engelhardt, Merle Plassmann, Jana M Weiss, Department of Environmental Science, Stockholm University.
- 08:50-09:10 O-31 **Interventions to reduce cadmium exposure in low- and middle -income countries during pregnancy and childhood: A systematic review.**  
Kam Sripada<sup>1</sup> and Adrian Madsen Lager<sup>2</sup>,  
<sup>1</sup>Centre for Digital Life Norway, Norwegian University of Science and Technology, Trondheim.  
<sup>2</sup>Department of Chemical Engineering, Norwegian University of Science and Technology, Trondheim.
- 09:10-09:30 **Coffee break, exhibition and poster viewing**
- 09:30-10:00 O-32 **Future drinking water levels of nitrosamines and nitramines near a CO<sub>2</sub> capture plant (FuNitr).**  
Cathrine Brecke Gundersen<sup>1</sup>, Magnus Norling<sup>1</sup>, François Clayer<sup>1</sup>, Aina C. Wennberg<sup>1</sup>, Armin Wisthaler<sup>2</sup>, Massimo Cassiani<sup>3</sup>, Peter Dörsch<sup>4</sup>, Audun Drageset<sup>5</sup>, Marius Tednes<sup>6</sup>, Jacob Nygaard Knudsen<sup>7</sup>,  
<sup>1</sup> Norwegian Institute for Water Research, Oslo, <sup>2</sup> University of Oslo, <sup>3</sup> Norwegian Institute for Air Research, Kjeller, <sup>4</sup> Norwegian University of Lifesciences, Ås, <sup>5</sup> Technology Centre Mongstad (TCM), Mongstad, <sup>6</sup> Hafslund Oslo Celsio, Oslo, <sup>7</sup> Aker Carbon Capture, Lysaker, Norway.
- 10:00-10:20 O-33 **Acrylamide intake in a Norwegian group from food estimated via haemoglobin adducts and probabilistic modelling of self-registered diet data.**  
Efstathios Vryonidis<sup>1\*</sup>, Margareta Törnqvist<sup>1</sup>, Trine Husøy<sup>2</sup>,  
<sup>1</sup> Department of Environmental Science, Stockholm University,  
<sup>2</sup> Department for Food Safety, Division of Climate and Environment Health, Norwegian Institute of Public Health, Oslo.

- 10:20-10:40 O-34 **DDT in blue mussels from fruit growing areas in Western Norwegian fjords 2021.**  
Amund Maage and Sylvia Frantzen, Institute of Marine Research, Bergen.
- 10:40-11:00 **Closing remarks and farewell**
- 12:00 **Lunch**

## Poster Presentations

### Abstr.

- P-1 **Determination of volatile emissions from coated indoor wood surfaces.**  
Indre Tarvydaite, Norwegian University of Life Sciences, Ås.
- P-2 **Determination of clinker in thoracic dust at workplaces in cement production by positive matrix factorization.**  
Stephan Weinbruch<sup>1,2</sup>, Mark Scerri<sup>3</sup>, Wijnand Eduard<sup>1</sup>, Yngvar Thomassen<sup>1</sup>, Karl-Christian Nordby<sup>1</sup>, Balázs Berlinger<sup>1</sup>, Kari Dahl<sup>1</sup>, Grete Friisk<sup>1</sup>, Natalya Romanova<sup>1</sup>, and Hilde Notø<sup>1</sup>.  
<sup>1</sup>National Institute of Occupational Health, Oslo, <sup>2</sup>Institute of Applied Geosciences, Technical University Darmstadt, Germany, <sup>3</sup>Environmental Management & Planning Division, Institute of Earth Systems, University of Malta, Msida.
- P-3 **Nontarget workflow for novel compound identification with ion mobility-high resolution mass spectrometry: Examples and ideas.**  
Carey E Donald<sup>1</sup>, Marc HG Berntssen<sup>1</sup>, Charlotte L Nakken<sup>1,2</sup>, Ikram Belghit<sup>1</sup>, Kai K Lie<sup>1</sup>, Sonnich Meier<sup>1</sup>, Alberto Celma<sup>3</sup> and Lubertus Bijlsma<sup>4</sup>.  
<sup>1</sup>Marine Toxicology, Institute of Marine Research, Bergen, <sup>2</sup>Department of Chemistry, University of Bergen, <sup>3</sup>Department of Aquatic Sciences and Assessment, Swedish University of Agricultural Sciences, Uppsala, <sup>4</sup>Environmental and Public Health Analytical Chemistry, University Jaume I (UJI), Spain.
- P-4 **Development of a high throughput method for screening of readily biodegradable chemicals.**  
Aina Charlotte Wennberg<sup>1</sup>, Merete Grung<sup>1</sup> and Adam Lillicrap<sup>1</sup>  
<sup>1</sup>Norwegian Institute for Water Research, Oslo.
- P-5 **Tailoring a bio-based adsorbent for separation of late transition and rare earth element.**  
Troy C. Breijaert, Vadim K. Kessler and Gulaim A. Seisenbaeva,  
Department of Molecular Science, Biocentrum, Swedish University of Agricultural Sciences, Uppsala.
- P-6 **Svalbard ice core reveals levels and distribution profiles of per- and polyfluoroalkyl substances (PFAS) in the high Arctic.**  
William F. Hartz<sup>a,b</sup>, Maria K. Björnsdotter<sup>c,d</sup>, Leo W. Y. Yeung<sup>d</sup>, Andrew Hodson<sup>a</sup>, Elizabeth Thomas<sup>e</sup>, Jack D. Humby<sup>e</sup>, Chris Day<sup>b</sup>, Ingrid Ericson Jogsten<sup>d</sup>, Anna Kärrman<sup>d</sup>, Roland Kallenborn<sup>a,f</sup>.  
<sup>a</sup>University Centre in Svalbard, Longyearbyen, Svalbard, Norway. <sup>b</sup>Department of Earth Sciences, University of Oxford, UK. <sup>c</sup>Institute of Environmental Assessment and Water Research, Barcelona, Spain. <sup>d</sup>Man-Technology-Environment Research Centre, Örebro University, Sweden. <sup>e</sup>British Antarctic Survey, Cambridge, UK. <sup>f</sup>Faculty of Chemistry, Biotechnology and Food Sciences, Norwegian University of Life Sciences, Norway.

- P-7 **Sources and air-water exchange of halomethoxybenzenes in the Swedish Subarctic.**  
Terry Bidleman<sup>1</sup>, Kathleen Agosta<sup>1</sup>, Mats Tysklind<sup>1</sup>, Emma R. Shipley<sup>2</sup>, Penny Vlahos<sup>2</sup>.  
<sup>1</sup>Department of Chemistry, Umeå University, <sup>2</sup>Department of Marine Sciences, University of Connecticut Avery Point, Groton, CT, USA.
- P-8 **Halogenated natural products in commercial and wild macroalgae.**  
Terry Bidleman<sup>1</sup>, Anders Tysklind<sup>2</sup>, Mats Tysklind<sup>1</sup>  
<sup>1</sup>Department of Chemistry, Umeå University, <sup>2</sup>Kosterhavet National Park, Länsstyrelsen I Västra Götaland, Sydoster, Sweden.
- P-9 **Validation of a LC-MS/MS method for the quantification of phenanthrene metabolites in haddock embryo.**  
Mathias Brevik<sup>1</sup>, Charlotte L. Nakken<sup>1</sup>, Sonnich Meier<sup>2</sup>, Carey Donald<sup>2</sup>,  
<sup>1</sup>Department of Chemistry, University of Bergen, <sup>2</sup>Marine Toxicology, Institute of Marine Research, Bergen.
- P-10 **Methane and trace gas emissions from closed landfills investigated by cavity ring-down spectroscopy and proton transfer reaction-mass spectrometry from a mobile laboratory.**  
Silje Solevåg and Armin Wisthaler, Department of Chemistry, University of Oslo.
- P-11 **Reduction mechanism of Chromium (VI) in high acidic nitro-phosphate solutions.**  
Deniz Avsar, Niels Højmark Andersen, Dag Øistein Eriksen and Jon Petter Omtvedt,  
Department of Chemistry, University of Oslo, Oslo, Norway
- P-12 **Mercury in organism exposed to mercury pollution from U-864.**  
Sylvia Frantzen, Amund Måge, Monica Sanden, Institute of Marine Research, Bergen.
- P-13 **DOM and turbidity regarding *in situ* measurements of compensation depths versus Secchi depths in lakes.**  
Ståle Haaland<sup>1, 2\*</sup>, Haga, J. and Wien, Ø.<sup>3</sup>  
<sup>1</sup> Norwegian Institute of Bioeconomy Research, P.O. Box 115, NO-1431 Ås, Norway  
<sup>2</sup> Norwegian University of Life Sciences, NMBU, Norway  
<sup>3</sup> Sweco, P.O. Box 80 Skøyen, NO-0212 Oslo, Norway

## Oral Abstracts

**(O-1)**

### **WHAT IS OCEAN ACIDIFICATION? FROM THEORY THROUGH QUANTIFICATION TO MONITORING.**

Siv K Lauvset,

NORCE Norwegian Research Centre, Bjerknes Centre for Climate Research, Jahnebakken 5, 5007 Bergen, Norway, siv.lauvset@norceresearch.no

Ocean acidification is the term used to describe changes in ocean carbonate chemistry resulting from the ocean removing carbon dioxide (CO<sub>2</sub>) from the atmosphere. All estimates indicate that the ocean has taken away approximately 30% of human emissions of CO<sub>2</sub> to the atmosphere from the pre-industrial (1750) until today. This has resulted in increased partial pressure of CO<sub>2</sub> in the surface ocean as well as reduced pH and carbonate ion (CO<sub>3</sub><sup>2-</sup>) content. In this presentation I will go through the chemical background for why ocean acidification happens, as well as describe the methods we use to quantify the changes. The presentation will focus primarily on results from the northern North Atlantic Ocean, but there will also be a global view. Finally, I'll cover how ocean acidification is being monitored, and why international collaboration is key to understanding and quantifying these changes.

(O-2)

**EXPECTED AND UNEXPECTED CHANGES IN LAKE CHEMISTRY DURING THREE DECADES OF CLEANER AIR AND CLIMATE CHANGE**

Heleen de Wit, Norwegian Institute for Water Research, Økernveien 94, 0579 Oslo, Norway; Center of Biogeochemistry in the Anthropocene, Department of Geosciences, University of Oslo, P.O. Box 1066, 0371 Oslo, Norway. heleen.de.wit@niva.no

Long-term changes in lake water chemistry (major anions and cations, DOM, nutrients, Fe and SiO<sub>2</sub>) in Norway across wide regional contrasts in atmospheric pollution, temperature, hydrology and vegetation are presented from i) a repeated national, representative lake survey sampled in 1995 and 2019 (ThousandLakes), and ii) an annual lake survey from acid-sensitive regions (78 lakes, TrendLakes). Both surveys show strong recovery from air pollution-induced acidification, demonstrated by lower SO<sub>4</sub> and labile Al and higher pH, alkalinity and ANC. Also, light- and nutrient-limitation is more prevalent, indicated by higher DOM, lower NO<sub>3</sub>, higher CN ratios of DOM and lower NO<sub>3</sub> to totP ratios. Declines in lake NO<sub>3</sub> occurred independent of level and change in N deposition, suggesting increased catchment N retention, possibly driven by increased nutrient demand from climate- and land use-induced vegetation growth. Declines in Ca primarily occurred in base-cation poor regions in the south, whereas more base-cation rich regions showed increases in Ca despite declines in strong anions. We suggest that higher Ca is driven by increased alkalinity from higher soil CO<sub>2</sub> related to higher terrestrial productivity.

We found widespread increases in SiO<sub>2</sub>, correlated with changes in DOM. Both are more soluble under reduced atmospheric deposition. We conclude that air pollution continues to be a dominant driver of long-term trends in lake chemistry, but climate-induced change in terrestrial processes is likely to have an increasing impact on future lake acidity, nutrient and light status, that may cascade along the aquatic continuum from rivers to coast.

(O-3)

**SOURCES AND PATHWAYS OF HALOGENATED NATURAL PRODUCTS IN NORTHERN BALTIC ESTUARIES**

Terry Bidleman<sup>1</sup> terry.bidleman@umu.se, Kathleen Agosta<sup>1</sup>, Agneta Andersson<sup>2,3</sup>, Sonia Brugel<sup>2</sup>, Lars Ericson<sup>2</sup>, Katarina Hansson<sup>4</sup>, Olle Nygren<sup>5</sup>, Mats Tysklind<sup>1</sup>

<sup>1</sup>Department of Chemistry, Umeå University (UmU), SE-901 87 Umeå, Sweden. <sup>2</sup>Department of Ecology & Environmental Science, UmU, SE-901 87 Umeå, Sweden.

<sup>3</sup>Umeå Marine Science Centre, UmU, SE-905 71 Hörnefors, Sweden.

<sup>4</sup>IVL, Swedish Environmental Research Institute, SE-411 33 Gothenburg, Sweden.

<sup>5</sup>Dean's Office, Faculty of Medicine, UmU, SE-901 87 Umeå, Sweden.

Thousands of halogenated natural products (HNPs) are generated in the ocean and on land. Here we compare representative HNPs which differ in having marine or terrestrial sources and describe their pathways to northern Baltic estuaries. The compounds are 2,4-dibromoanisole (DiBA) and 2,4,6-tribromoanisole, which are O-methylation products of bromophenols synthesized by marine bacteria, phytoplankton and macroalgae, and drosophilin A methyl ether (1,2,4,5-tetrachloro-3,6-dimethoxybenzene, DAME), a secondary metabolite of terrestrial fungi.

We examined several ecosystem compartments to determine sources and exchange processes for BAs and DAME: air<sup>1</sup>, precipitation, rivers, forest fungi and litter<sup>1</sup>, and water from northern Baltic estuaries and offshore. BAs were higher in estuaries than offshore and were negatively or not correlated with chlorophyll-a, suggesting contribution by heterotrophic bacteria as well as known production by phytoplankton and macroalgae. DAME showed negative or no correlation with BAs and does not appear to be produced in the estuaries. Fungi and forest litter containing fungal mycelia are suggested as sources of DAME to the atmosphere and terrestrial runoff. The overall picture of HMB transport and exchange can be summed up by “What goes around, comes around” (Figure 1). HMBs volatilize from sea and land, disperse through the atmosphere, and return via precipitation and rivers. Production and biogeochemical cycles of HNPs are influenced by climate change and we suggest BAs and DAME for following land-sea-air exchange processes.

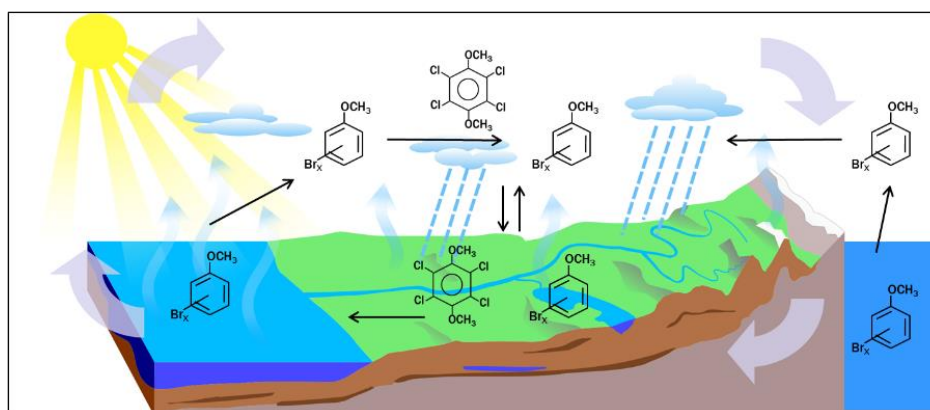


Figure 1. Transport and exchange processes for BAs and DAME. BAs: Volatilization from the Atlantic Ocean and Baltic Sea, transport across Norway and Sweden, deposition by precipitation and return to the sea via rivers. DAME: Volatilization, deposition and runoff from the terrestrial environment and discharge to the sea.

<sup>1</sup>Bidleman, T.F., Andersson, A., Brorström-Lundén, E., Brugel, S., Ericson, L., Hansson, K., Tysklind, M. 2023. Halomethoxybenzenes in air of the Nordic region. *Environ. Sci. Ecotechnol.* 13, 100209.

**(O-4)**

**CLIMATE CHANGE AND IMPACT ON CRITICAL CONTAMINANTS IN SEAFOOD  
– ONGOING PROJECTS AND FUTURE REASERCH NEEDS**

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More food from the ocean has been suggested as one of the solutions to both combat the climate changes threatening our global food systems and alleviate micronutrient deficiency. At the same time climate changes can affect seafood safety. Global warming impacts the biogeochemical and physical settings of the ocean, and thereby contaminant fate and transport dynamics in ways that are not yet well understood. Over the last decades, we built one of the most unique biological databases on contaminants in Northeast Atlantic seafood species. The database is filling knowledge gaps related to geographical and seasonal variation of various contaminants in fish species across different trophic levels, but not yet in the context of a rapidly changing climate. The role of the ocean in a food and nutrition security context is becoming increasingly important and with increasing temperatures, seafood from the Arctic may have an even more important role in the future. Despite this, the understanding of how climate change is impacting the transport and fate of critical contaminants in dynamic food webs and seafood, is unknown.

I will present results from our ongoing seafood and environmental monitoring programs on contaminants and highlight the importance of such data and time series in the understanding of climate changes in the marine ecosystem. The programs enable us to give research-based advice on seafood safety and environmental condition. A prerequisite for the quality of the monitoring is to have validated analysis methods fit for purpose. In addition to our established and often accredited methods on legacy contaminants, I will provide an overview of current analytical methods under development. These methods which target contaminants of emerging concern, such as per- and polyfluoroalkyl substances (PFAS), microplastics and nanoparticles in the marine ecosystem, are running in our laboratories, but are under iterative development to improve selectivity and sensitivity. Finally, the presentation will focus on our simulation approaches and explore the flow of legacy contaminants including emerging contaminants in food web structures and impacts from climate driven changes.



(O-5)

## CARBON EMISSIONS OF BOREAL LAKES IN 2100

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In the last decades, the colour of freshwater in boreal and arctic lakes has drastically darkened because of the increasing concentration of dissolved organic matter (DOM). This widespread phenomenon, known as browning, has been explained mainly by the decrease of acidification, due to reduced deposition of sulphur, which in turn leads to higher solubility of DOM. Hence, imports of DOM from catchment to soils have increased. However, other intertwined processes affect the concentration of DOM in freshwater. In boreal lakes, in-situ production of DOM is rarely significant, and allochthonous DOM is usually dominating. Catchments processes are therefore key predictors of DOM concentration in water. Land-use changes with increased forestry, as well as climatic changes, contribute to accumulation of soil organic matter on the catchment and to its export to freshwater.

Once in the lake, DOM faces several fates. It can be photomineralized, it can sediment, or it can be respired by heterotrophic microorganisms. The extent of these processes determines the evasive flux of greenhouse gases towards the atmosphere. Most boreal lakes are supersaturated with CO<sub>2</sub> and emit carbon dioxide toward the atmosphere. The extent of this evasion is estimated to be between 80 and 180 TgC/year<sup>1</sup>. The in-situ respiration of organic matter is suggested to be a main driver of this efflux, even though inorganic carbon may also be imported from the catchment. Therefore, total organic carbon (TOC) concentration is a key factor to predict CO<sub>2</sub> emissions in boreal lakes.

In a former project, we predicted TOC concentration in Fennoscandia based on the Northern Lakes Survey results (1995). We assessed the contribution of catchment characteristic factors to the total organic carbon concentration (TOC) in lakes. Using a spatial model, we forecasted TOC concentration in lakes under two climatic scenarios, in 2050 and 2100. We demonstrated that NDVI, a biomass proxy, and runoff were the main drivers of TOC concentration, as well as the proportion of peatland and the deposition of nitrogen at the catchment level.

Subsequently, we plan to estimate the efflux of CO<sub>2</sub> from lakes in Norway, Sweden and Finland. CO<sub>2</sub> concentration is usually determined from pH and alkalinity values, but this method is unreliable in boreal lakes with low alkalinity and high organic matter concentration<sup>2</sup>. Therefore, we will use direct CO<sub>2</sub> measurements conducted in 2019 in 73 boreal lakes to develop a finer estimation of the fugacity of CO<sub>2</sub>. The model will then be used to calculate the fugacity of CO<sub>2</sub> in the lakes included in the 1995 survey, and in turn the evasive flux into the atmosphere. Finally, using the forecast for TOC concentrations in 2050 and 2100, we will estimate the CO<sub>2</sub> emissions from boreal lakes in the coming century.

<sup>1</sup> Hastie A, Lauerwald R, Weyhenmeyer G, Sobek S, Verpoorter C, Regnier P. CO<sub>2</sub> evasion from boreal lakes: Revised estimate, drivers of spatial variability, and future projections. *Glob Chang Biol* 2018; 24(2):711–28. Available from: <https://onlinelibrary.wiley.com/doi/full/10.1111/gcb.13902>

<sup>2</sup> Liu S, Butman DE, Raymond PA. Evaluating CO<sub>2</sub> calculation error from organic alkalinity and pH measurement error in low ionic strength freshwaters. *Limnol Oceanogr Methods* 2020; 18(10):606–22. Available from: <https://onlinelibrary.wiley.com/doi/full/10.1002/lom3.10388>

**(O-6)**

**DISTINGUISHING BETWEEN ANTHROPOGENIC AND NATURAL DISSOLVED ORGANIC MATTER BY MEANS OF SPECTROSCOPIC INDICES**

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Water resource managers rely partly on monitoring data of water chemistry to assess deviations from the natural state of environment. Based on these data it is difficult to distinguish between dissolved organic matter (DOM) from anthropogenic point sources and the natural DOM from diffuse catchment sources. This challenge is augmented by the large spatial and temporal variation, as well as increasing levels, of natural DOM. Abatement actions on point sources of DOM are manageable, while dealing with the effects of increased loading from diffuse sources, due to changes in e.g., climate and land-use, are mainly out of scope. Most environmental monitoring programs measure water colour (i.e., Platinum number) or absorbency in the UV (@254nm) and visible (@410nm) range, and/or the concentration of organic carbon (i.e., TOC or DOC). Some programs also include biological and/or chemical oxygen demand (i.e., BOD and COD). Although all are good proxies for DOM, none are distinctive between anthropogenic and natural DOM. The relative quality of DOM, using the normalized ratio of absorbency to the amount of organic matter, or the ratio of BOD to COD, are instead proposed as possible indexes that may be indicative of the DOM source. Anthropogenic DOM is conceived to be relatively less aromatic and of lower molecular weight, and thus more biodegradable, than the allochthonous DOM derived from partial decomposed litterfall and soil humic matter.  $sUVA$  and  $sVISA$  are the ratios of UV and visible light absorption (i.e., proportional to Colour) relative to the amount of organic carbon. Low values reflect less aromatic and lower molecular weight DOM, and thus likely indicative of anthropogenic DOM. The ratio of BOD to COD denotes the fraction of biodegradable DOM, which is higher in organic matter stemming from anthropogenic sources.

This study assesses monitoring data from pristine sites in Norway (Vannmiljø database) and of more anthropogenic influenced water courses in the Czech Republic (DWARF project). Together, they represent a unique opportunity to unravel hidden secrets buried in the quality of DOM. Common sources of anthropogenic DOM are runoff from agriculture, and raw or treated wastewater discharge from households, as well as fish farms in the Czech Republic. These sources of DOM pollution are also enriched in the macro nutrients N and P. The study reveals that DOM in samples with elevated levels of nutrients (e.g.,  $> 500 \mu\text{g N-NO}_3^- \text{L}^{-1}$  and  $> 50 \mu\text{g P-PO}_4^{3-} \text{L}^{-1}$ ), indicative of anthropogenic pollution, have low  $sVISA$  values (i.e.,  $< 0.003$ ). Still, low  $sVISA$  values are also found in samples with lower levels of nutrients. Likewise, samples with ratios of BOD to COD above 0.5 have  $sVISA$  values  $< 0.003$ , while samples with  $\text{BOD/COD} < 0.5$  all have  $sVISA > 0.003$ . In the Czech data we find a similar negative correlation between  $sUVA$  and the BOD/COD ratio. This implies that low  $sVISA$  values may be used as an indicator, allowing water resource managers to distinguish between DOM of anthropogenic or natural origin, thereby contributing to the nature–society discussion and environmental management; ultimately also feeding into the discussion on the Anthropocene.

**(O-7)**

**PRESENCE AND REMOVAL OF TOXIC METALS AND ORGANIC POLLUTANTS FROM TUNNEL WASH WATER**

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Road tunnels are constructions built under fjords or through mountains to allow traffic to move faster and safer from one place to another. For visibility and traffic safety, tunnels are cleaned regularly. After the wash, the tunnel wash water (TWW) remains as a highly polluted matrix, containing substances, such as trace elements (e.g., Cu, Zn, and Ni), polycyclic aromatic hydrocarbons (PAH), per- and polyfluorinated alkylated substances (PFAS), benzothiazoles (BTH), benzotriazoles (BTR), and their derivatives. Therefore, TWW needs to be treated before released into the municipal sewage system or to natural water bodies.

For two years, tunnel wash water quality was investigated, and different treatment steps were tested at the Bjørnegård Tunnel in Sandvika, located in the Greater Oslo Region. The tunnel has two tubes with a length of approximately 2.3 km and is located in an urban area. The annual average daily traffic (AADT) count is about approximately 17.000 vehicles per day in each tube. A sedimentation basin serves as a preliminary treatment step for the TWW for 35 days. In this project the sedimented water was further treated with three different treatment steps: a system with two consecutive bag filters (5 and 1  $\mu\text{m}$  mask openings), a ceramic membrane system with a pore size of 0.1  $\mu\text{m}$ , and an adsorption column (220 cm high, 95 cm in diameter) filled with granulated activated carbon (GAC).

Grab samples of fresh and sedimented TWW, as well as before and after each secondary treatment step, were collected and analysed by ICP-MS and LC-MS/MS to detect the presence and investigate the removal efficiencies of metals and organic pollutants. Preliminary results show that compounds from all pollutant classes are present in the TWW, where many compounds are found in significantly higher concentrations than reported in the literature. While some compounds mainly accumulate in the particulate phase, others are remaining in the dissolved phase. A high removal efficiency was observed for particle-bound pollutants by sedimentation, while dissolved pollutants were only removed by additional treatment of adsorption to GAC.

The results support the hypothesis that tunnel wash water contains a multitude of pollutants and chemicals, that are not in the focus of today's regulation, even though they may be harmful for the environment. Furthermore, current regulation neglects the fact that only a small fraction of compounds is actually analysed, and mixture effects and transformation products are not included in the evaluation. This study provides insight into the complex matrix that TWW represents and will help to understand the environmental impact of tunnel wash water discharge. Furthermore, they will assist road agencies in making decisions regarding the implementation of TWW treatment systems in new and existing road tunnels.

**(O-8)**

## **APPROACHES FOR TACKLING THE PLANETARY BOUNDARY FOR CHEMICAL POLLUTION**

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In the planetary boundary concept developed at Stockholm University, the boundaries for “a safe operating space for humanity with respect to the functioning of the Earth System” are defined. Chemical pollution was one of the original nine anthropogenic impacts for which planetary boundaries were established. In a later publication, the chemical pollution boundary was renamed as the “novel entities” (NEs) boundary, where NEs are defined as “new substances, new forms of existing substances and modified life forms”, including “chemicals and other new types of engineered materials or organisms not previously known to the Earth system as well as naturally occurring elements (for example, heavy metals) mobilized by anthropogenic activities”. Several groups of scientists have attempted to quantify and/or define the planetary boundary for NEs and these various approaches will be reviewed in this presentation. Quantifying the planetary boundary for NEs has failed to date, and may indeed be an insurmountable problem, because (1) there are critical data gaps for a large proportion of existing NEs, (2) NEs of various types and mixtures of NEs are continuously being generated and released to the environment, and (3) there are multiple possible effects (not only toxic effects) that individual NEs or groups/mixtures of NEs can cause.

It was recently argued, in a well-publicized paper in *Environmental Science and Technology*, that per- and polyfluoroalkyl substances (PFAS) define a new planetary boundary for NEs. It was further hypothesized that if health advisories and other guidelines designed to protect human health have been widely (even globally) exceeded due to the global environmental spread of PFAS, then there is a real danger of global health effects occurring. Humans would therefore no longer be living within a safe operating space and the planetary boundary for PFAS would have been exceeded.

The hypothesis was tested in the paper by comparing the levels of four selected perfluoroalkyl acids (PFAAs) in various global environmental media with recently proposed guideline levels. It was concluded that the widespread atmospheric deposition of PFAAs has led to surface environmental media of the planet being ubiquitously contaminated, and that various health advisories set for PFAAs are often exceeded as a result. In the presentation, the temporal trends in health advisories will be presented showing that, as a result of a better understanding of the toxicities and risks of PFAAs, some health advisories are many millions of times lower than they were 20 years ago. These health advisories are in some cases impossible to achieve in the foreseeable future because they are below ambient environmental levels. Because these advisories are widely exceeded, it is concluded that the global spread of PFAS has led to the planetary boundary being exceeded.

Temporal trends of the levels of the 4 PFAAs studied (and their precursors) in the atmosphere, and other environmental media, are inconclusive, but there does not appear to be a consistent downward trend, despite their phaseout in many countries. Reasons for this lack of a downward trend in environmental media, compared to strong downward trend in human serum, will be presented and discussed. Research conducted in my group has shown that PFAAs are highly enriched on sea spray aerosols (SSA) and reemitted to the atmosphere, and this process may partly explain the lack of decline in atmospheric PFAS levels. The re-emission of PFAAs from the oceans on SSA and the subsequent deposition back to land will lead to the long-term cycling in the hydrosphere, inhibiting the decrease in environmental levels. The poor reversibility of environmental exposure to PFAS, and their associated effects, is a strong motivation to rapidly restrict the uses and emissions of PFAS, as well as other highly persistent substances.

(O-9)

**HOW ADVANCES IN THE MEASUREMENT OF MERCURY ARE TRANSFORMING OUR UNDERSTANDING OF RECOVERY FROM THIS GLOBAL THREAT**

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Since humans began utilizing mercury (Hg) four thousand years ago, pollution has increased atmospheric Hg seven-fold.<sup>1</sup> Elevated concentrations of this potent neurotoxin are now found even in the deepest oceans and the most remote Arctic soils. Mercury (Hg) contamination is the single largest cause of waters in the EU failing to live up to the goals of the Water Framework Directive. A major source of this aquatic Hg is coming from peatlands where atmospheric deposition has accumulated the legacy of past pollution. Despite the fact that peatlands have been a sink for atmospheric Hg, independent lines of research indicate that some boreal peatlands and forest soils are now returning Hg to the atmosphere. This raises fundamental questions about what controls the fate of pollution legacy Hg in peatlands. While a number of chemical pathways, biological processes and environmental conditions of relevance for Hg exchange between the soil and atmosphere have been identified, it has yet to be determined how they interact in the dynamic environment of peatlands to control that exchange. This study will demonstrate how recent methodological advances are unraveling this mystery. Important steps in micrometeorological methods for quantify Hg exchange between the land and atmosphere is a starting point. Community-level expression profiling that reveal how microbial metabolisms influence the transformation of Hg are a second area of progress, and natural abundance of Hg isotopes are another important source of information. The combination of these techniques on a 1000-year chronosequence of mires created by isostatic uplift along the northern coast of Sweden provides a unique opportunity to examine the interplay between chemical, biological and environmental processes that control Hg remobilization after deposition.

Despite uniform climate and atmospheric Hg concentrations across the 15 km extent of the chronosequence, the stock of Hg differs by a factor of 2, correlating with mire age. From this, we have hypothesized that the Hg accumulated in the peat during earlier periods of higher atmospheric Hg concentrations was no longer in balance with the contemporary atmosphere with lower Hg levels, leading to net Hg evasion. This presentation will report on the puzzle pieces that have fallen into place, and the challenges that remain to complete the picture. We conclude with a reflection on how these advances in the understanding of terrestrial Hg cycling bear on the work of the Minamata convention in regard to both the global Hg cycle, and bioaccumulation of Hg derived from the terrestrial Hg cycle.

**(O-10)**

**TEN YEARS OF CERAD: LESSONS LEARNT AND FUTURE PROSPECTS**

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The Centre for Environmental Radioactivity (CERAD) was established at NMBU in 2013 to provide long term research to improve impact and risk assessments associated with environmental radioactivity. CERAD is supported for ten years by the Norwegian Research Council under its Center of Excellence scheme and covers a broad scientific research programme based on the interdisciplinary efforts of the five CERAD partners: NMBU, DSA, NIVS, NIPH and MET, and with support from an international scientific advisory committee. CERAD's fundamental research into a series of nuclear or radiological sources, as well as transfer in ecosystems and biological responses provides new insights into the environmental impacts of ionizing radiation, also in combination with other environmental stressors. In particular, the centre has developed tools and methods to address key uncertainties in risk assessment. In addition to research in the natural science, CERAD covers also societal aspects of radiation risk. A more accurate assessment of the risks from environmental radioactivity will greatly assist their management and mitigation. As stated by the international evaluation committee: *"CERAD is a global Centre of Excellence and a flagship for Norwegian science with an agenda that is also highly relevant for society."*

The presentation will look back to elucidate why and how CERAD was established, focusing on key research areas and lessons learnt from CERAD research and education as well as emerging challenges and new areas of research. These include decommissioning of the two Norwegian research reactors, which requires a range of scientific skills, from waste characterisation and nuclear forensics, to impact assessment and stakeholder engagement, as well as expansion of emergency preparedness to include nuclear events such as detonation of nuclear bombs close to or in Norway.

(O-11)

## **MetroPOEM: METROLOGY FOR THE HARMONISATION OF MEASUREMENTS OF ENVIRONMENTAL POLLUTANTS IN EUROPE**

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The European Green Deal's ambition for zero pollution requires the development of highly sensitive techniques to detect ultra-low amounts of pollutants and to determine their isotope ratios for source term identification. Mass spectrometry is a key method for non-radioactive polluting elements determination and is of increasing importance for long-lived radionuclides. The MetroPOEM project aims to bridge the gap between decay counting and atom counting methods and will establish new tools for tracing pollutants. Understanding of the advantages, limitations, measurement uncertainties and detection limits achievable by different mass spectrometer designs will be significantly improved using newly developed reference materials, SI-traceable measurement procedures and interlaboratory comparison exercises. This will deliver an immediate impact for tracking pollution sources by commonly available mass spectrometers.

The scientific work of this project falls into four main areas:

WP1: Establish and compare the selectivity and detection limits of different mass spectrometers by establishing the capabilities of different mass spectrometry designs using radionuclide standard solutions. The focus will be on relative instrument performance with respect to current measurement challenges around detection limits.

WP2: Advancing stable and long-lived radiogenic isotope ratio measurements of environmental pollutants through the development of new and improved generic methods for stable and long-lived radioactive isotope ratio measurements by mass spectrometry with uncertainties that allow resolving natural mass dependent isotope fractionation.

WP3: Development of two reference materials, one liquid and one solid, containing radioactive pollutants (<sup>237</sup>Np, <sup>234,235,236,238</sup>U, <sup>239,240</sup>Pu, <sup>241</sup>Am and possibly <sup>226</sup>Ra and <sup>90</sup>Sr) addressing end users and stakeholders needs.

WP4: Development of SI traceable certified reference material for inorganic environmental pollutants which will be designed according to the needs of the end users performing environmental analysis and monitoring. The production and certification of the material will be carried out in accordance with the requirements of the EN ISO 17034 standard.

NMBU, Environmental Chemistry Section, ECS, will contribute to WP1 and WP3, particularly for measurements of long lived and otherwise difficult to measure radionuclides. Additionally, we will manage the dissemination of the scientific outputs of the project via the scientific literature and other publication routes as well as using through standards committees concerned with the determination of environmental pollutants.

This project started in October 2022, running for three years, and this presentation will outline the aims and objectives of the project.

The project (21GRD09 MetroPOEM) has received funding from the European Partnership on Metrology, co-financed by the European Union's Horizon Europe Research and Innovation Programme and from by the Participating States.

(O-12)

**RISKS ASSESSMENT AND DISTRIBUTION OF PFAS IN A BIOLOGICAL PHOSPHORUS RECOVERY SLUDGE USED FOR AGRICULTURE**

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Phosphorus as a nonrenewable resource with limited availability and economic significance within the European Union, can be recovered via Enhanced Biological Phosphorus Removal (EBPR). Phosphorous recovery from municipal wastewater is extensively promoted in the current proposal for the Urban Wastewater Treatment Directive<sup>1</sup>. As persistent, toxic and bioaccumulative chemicals, per- and polyfluoroalkyl substances (PFAS) can cause serious problems for the environment and human health. Wastewater is a known conduit of PFAS from industrial and domestic sources to the environment<sup>2</sup>. In Norway, PFAS are observed in municipal wastewater at a concentration between 8 and 47 ng/L<sup>3</sup>. PFAS are recalcitrant to biodegradation, and their decrease in a biological treatment plant can be attributed to their adsorption onto activated sludge<sup>4</sup>. In an EBPR process, microorganisms are exposed to alternating anaerobic and aerobic conditions. The applied feast and famine strategy under these conditions forces the development of extracellular polymeric substances by the microorganisms<sup>5</sup> which can influence the sorption and interaction behaviour towards PFAS. For this reason, EBPR sludge holds a unique property that might affect PFAS distribution in wastewater treatment plants. The goal of this study is to investigate the partitioning of PFAS (i.e., perfluorooctanesulfonic acid (PFOS), perfluorooctanoic acid (PFOA), perfluorooctanesulfonamide (PFOSA), and perfluorotetradecanoic acid (PFTDA)) in wastewater and sludge during EBPR process in a bench-scale experiment design to reproduce a biological treatment plant in Norway. In wastewater influent, PFOA and PFOS were spiked at a concentration of 100 ng/L, while PFOSA and PFTDA were spiked at 300 ng/L. PFAS concentrations in liquid and sludge samples were analysed using solid phase extraction (Phenomenex Strata-X RP® 200 mg/6 mL) followed by LC-MS/MS (Acquity UPLC® I-Class system) coupled with a Xevo TQ-S triple quadrupole mass spectrometer. Table 1 shows results from bench-scale experiments and demonstrates the distribution of PFAS between the treated wastewater and sludge. Quantitative chemical risk assessments will be conducted using PFAS concentrations in digested sludge. Results will be presented and discussed with regard to human and environmental risks in a scenario where digested sludge is used as a soil fertiliser.

**Table 1** PFAS partitioning coefficients and their concentrations in wastewater, sludge, and digested sludge

PFAS category	PFAS compound	C <sub>effluent</sub> (ng/L)	C <sub>sludge</sub> (ng/kg)	logK <sub>D</sub> (L/kg)	C <sub>digested sludge</sub> * (ng/kg)
Perfluorocarboxylic Acids	PFOA (C8)	28.9 ± 3.2	12864 ± 3609	2.6 ± 0.2	52661 ± 14774
	PFTDA (C13)	4.6 ± 2.8	14331 ± 3704	3.7 ± 0.2	28403 ± 7340
Perfluorosulfonic acids	PFOS (C8)	11.2 ± 3.5	15185 ± 3664	3.1 ± 0.2	30095 ± 7262
Perfluoroalkane sulfonamides	PFOSA (C8)	detected**	5562 ± 1876	4.4 ± 0.5	11023 ± 3718

\*predicted concentration after digester<sup>6</sup>; \*\* below limit of quantification of 2 ng/L

References: 1) COM (2022) 541 final. Proposal for Urban Wastewater Treatment Directive (recast), <https://environment.ec.europa.eu/>; 2) Moodie et al., 2021. [doi.org/10.1016/j.chemosphere.2020.129143](https://doi.org/10.1016/j.chemosphere.2020.129143); 3) Screening new PFAS compounds 2018. <https://www.miljodirektoratet.no/>; 4) Yan et al., 2021. [doi.org/10.1016/j.jhazmat.2020.123381](https://doi.org/10.1016/j.jhazmat.2020.123381); 5) Klein et al., 2022. [doi.org/10.1007/s00253-022-11759-8](https://doi.org/10.1007/s00253-022-11759-8); 6) Yu et al., 2009. [doi.org/10.1016/j.watres.2009.03.009](https://doi.org/10.1016/j.watres.2009.03.009)



**(O-13)**

**NORWEGIAN MINISTRY OF CLIMATE AND ENVIRONMENT (KLD) 50 YEARS:  
IMPORTANT DEVELOPMENTS OF NORWEGIAN ENVIRONMENTAL LAW**

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This presentation will describe the main lines of the development of Norwegian environmental law since the start of the Ministry of Climate and Environment in 1972. It will focus on the legal development in the fields of pollution control, control of chemicals, and waste regulation, but legislation related to spatial planning and nature conservation will also be touched upon.

In 1972 the legislation related to environmental problems was simple, but not ineffective. In the field of air and water pollution, it formed the basis for important programs during the 1970s for reducing emissions in the most polluting branches of Norwegian industry, as well as for comprehensive cleaning-up programs for important lakes and fjords. During the 1970s also important regional cooperation was developed in the pollution field, i.a. with regard to transboundary air pollution.

New, comprehensive and integrated legislation was adopted in the early 1980s. Simultaneously, international and European environmental law developed rapidly. Important legal principles were laid down, and a number of regional and international treaties were adopted which influence Norwegian law. With the 1992 EEA-agreement Norway became closely linked to the important development in this field in the EU. This has marked the development of Norway environmental law since then. The same with a number of global treaties, such as the 1992 UN Framework Convention on Climate change and the related international instruments.

Over the last 30 years environmental law has expanded exponentially into a complex web of international, regional (EU) and national regimes, principles and rules, on control of chemicals and pollution, waste disposal, climate change, etc. The paper will present and discuss this development and its consequences in broad terms.

**(O-14)**

## **CIRCULAR ECONOMY IN NORWEGIAN INDUSTRIES**

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The European Commission is rapidly producing initiatives to promote a more circular economy. The EU initiatives influence Norwegian policies, through the EEA-agreement. The Federation of Norwegian Industries organize a wide range of industries, such as process industries, oil and gas contractors, mining, recycling, textiles, maritime industries, etc. We believe that circular economy is key for sustainable growth, while at the same time strengthening the competitiveness for the industry. Many industry sectors og companies have set ambitions goals for reducing their emissions and environmental footprints. As an example, the Norwegian process industry has committed to a goal of becoming climate neutral by 2045.

A circular economy is an important part of this path. Some measures are best developed in Europe while other measures must be implemented nationally. However, it is crucial that Norwegian authorities and industries are active and participate in the discussions at EU level.

Achieving a circular economy requires mobilisation of industry. Therefore, policy making must be inclusive, fair and just. Tripartite cooperation is key to secure involvement from both industry and unions. One Norwegian success story is the use of voluntary agreements between competent authorities and industry. This have proven to be a powerful measure to reach environmental goals in a cost-efficient way. Such agreements between Norwegian authorities and industry have resulted in substantial reductions in NO<sub>x</sub> - and SO<sub>x</sub> emissions. Voluntary agreements may also be designed to implement provisions in the Single use plastics directive and to foster transition to a circular economy in other sectors, such as the textile industry.

Furthermore, product policies must reward products with limited environmental footprints and provide incentives to manufacture products at locations where the environmental impact is the lowest. Product policies is also key driver for increasing the demand for recycled materials. Future product regulations or standards will include requirements for product properties such as recyclability, reusability, and content of recycled materials. Where appropriate and realistic, requirements to minimum content of recycled materials could also be considered.

Public procurement is an effective measure to increase the demand for environmentally friendly products and services. It is crucial that public authorities lead by example. Circular economy is rarely prioritised in procurement today. The Norwegian Government has recently proposed changes in the national public procurement regulations, which entails that public authorises will be obliged to put more weight on environmental impacts in procurements.

New climate friendly and circular technologies will be developed by European industry. However, there is a need for increased efforts in supporting industry-oriented research and innovation in the field of circular economy. Financial support offered to “first of a kind” investments in circular solutions must reflect additional socio-economic costs and corporate risks.

**(O-15)**

**ENZYMATIC DEPOLYMERIZATION OF NATURAL AND SYNTHETIC POLYMERS**

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Two of most abundant biomolecules on earth are the structural polysaccharides cellulose and chitin. Both carbohydrates provide physical and chemical resistance to the macromolecular constructions they are part of, the plant cell wall for cellulose and insect and crustacean exoskeletons for chitin. As a consequence of their function, these polysaccharides are also recalcitrant, insoluble in water, partially crystalline and highly resistant to chemical degradation. Nonetheless, nature has evolved enzymatic systems that efficiently depolymerize these polysaccharides with the dominant motive being nutrient acquisition for the organism employing the enzymes. The enzyme activities involved are primarily glycoside hydrolases and lytic polysaccharide monoxygenases (LPMOs). The latter activity was discovered by the presenter and his colleagues in 2010 (1) and operate by cleaving glycosidic bonds by a copper-dependent oxidative reaction mechanism. The activity of the LPMOs is directed at the surface of the crystalline polysaccharides and promote depolymerization of the carbohydrate chains by the glycoside hydrolases.

Another group of (partly) crystalline, recalcitrant and water-insoluble polymers is plastic, xenobiotic synthetic polymers produced mainly from fossil feedstocks. Plastic represents a bitter-sweet problem for society. On one hand it causes major pollution problems, but on the other hand modern society cannot live without it. As chemical recirculation of plastic is not feasible for many plastic products, other recirculation approaches are needed. Drawing on our expertise in depolymerization of recalcitrant polysaccharides, we intent to develop methods for enzymatic depolymerization and recirculation of plastics.

In the present lecture, I will present the status of efficient depolymerization of cellulose and chitin with a focus on the LPMOs and couple this to our current efforts in identifying, characterizing and developing new enzyme technology for recycling of plastics.

**(O-16)**

## **HYDROGEN FUEL CELL TECHNOLOGY FOR GREENER SOCIETY**

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Rapid increase in world's food and energy demand due to global development and population surge led to increase in fossil fuel consumption. The heavy dependence on fossil fuels has not only caused their rapid depletion but also attributed to detrimental environmental issues and emergence of global warming. Hence to preserve human societies and our planet but enable sustaining long-term development, there is an urgency to develop renewable and clean alternatives for production of high-value-added chemicals and green strategies for energy storage and energy carrier purposes. Coupling renewable sources of energy (such as wind, hydro, geothermal, and solar power) with electrochemical technologies, if done efficiently, could tackle the non-dispatchable nature of renewables by providing storage in chemical bonds.

Electrochemical water splitting to produce hydrogen (and oxygen) has been considered to be a clean, efficient, and sustainable strategy to replace fossil fuels. This made hydrogen evolution reaction (HER) an attractive fundamental and practical approach, as it has a fundamental role to play in the production of hydrogen electrochemically in a clean and renewable manner. HER is the cathodic half-reaction of water splitting and akin to other evolution reactions, it needs an overpotential to adsorb protons on a surface of a catalyst for the possibility of protons recombination and H<sub>2</sub> evolution. The smaller that overpotential, the better and more promising the catalyst will be. In order to achieve optimum efficiency for HER, activity, stability, and abundance of the catalyst material are of important factors to consider. To realize industrialscale H<sub>2</sub> production, substantial challenges on both the fundamental (i.e., catalyst activity and selectivity) and system levels (i.e., mass transport, conversion rate, and energy efficiency) need to be addressed.

Here the focus is on the fundamental side where Pt electrode is the best-known cathode material for H<sub>2</sub> evolution, but Pt is very scarce and expensive and thus other catalyst material needs to be explored which are cheap and abundant and at the same time offer activities close to what Pt has. To address this challenge, state-of-the-art Density Functional Theory (DFT) calculations have been used on modelling new class of electrode materials for HER. The H coverage as a function of the applied potential was calculated, and activation energies of H<sub>2</sub> formation at varying conditions were as obtained and compared with that of Pt.

(O-17)

## ENZYME ENCAPSULATED ON DIFFERENT SUPPORTS AS A GREEN BIOCATALYST FOR PHARMACEUTICALS DEGRADATION

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During the past few decades, economic expansion and global urbanization lead to the commercial use and discharge of thousands of new synthetic chemicals including pharmaceuticals. Different pharmaceutical residues are found in water bodies in Sweden and around the world. Studies showed that the main source of these pollutants are wastewater treatment plants, since they are not normally designed to remove pharmaceutical residues and other organic pollutants that are difficult to break. Biocatalytic degradation with the use of enzymes has gained great attention in the last years due to its advantages of high efficiency and environmental friendliness. The major drawbacks, such as low stability and non-reusability have been addressed in different studies and potential strategies were suggested to overcome these limitations. As such, immobilization on different supports provides the possibility of enzyme reuse and prolonged stability in different operational conditions. Previously, a successful immobilization and subsequent removal of different pharmaceuticals, such as acetaminophen and diclofenac in presence of Cd(II) was performed in our group [1] using laccase crosslinking on Fe<sub>3</sub>O<sub>4</sub>/SiO<sub>2</sub>-DTPA hybrid nanocomposites [1]. In another approach, peroxidase enzymes were first immobilized on magnetite nanoparticles, and later encapsulated within a surface silica layer using sol-gel method. The encapsulation of enzymes enhanced their thermal stability and improved the activity over 20 consecutive cycles for 20 days at 55°C [2]. To produce cost-effective and green nanoadsorbents, in our latest work natural silicates were tested as enzyme substrates for core-shell immobilization techniques. With the natural silicate as a core and silica layer as a shell it was possible to encapsulate enzymes for removal and degradation of three different pharmaceuticals: diclofenac, carbamazepine and paracetamol. The biocatalysts demonstrated great oxidation rates for the selected pollutants. The enzyme acted differently in the three chosen supports due to their complex chemical composition which could have effect on overall enzyme activity.

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(O-18)

## FUNCTIONAL SILICA-BASED SORBENTS FOR COMBINED WASTEWATER TREATMENT IN REMOVAL OF POLY- AND / OR PERFLUORINATED COMPOUNDS

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Perfluoroalkyl and polyfluoroalkyl substances (PFAS) have caused widespread pollution of the aquatic environment because they are very stable, toxic and bioaccumulative. PFAS contain extended hydrophobic groups but are easily dissolved in aqueous medium due to their anionic nature. An approach for their removal can be based on using polycationic sorbents with pH-sensitive surface charge, such as poly-amino functionalized silica, permitting their facile regeneration. Efficiency of PFAS removal in this case is due to the synergistic effect of the surface and amino groups, which strengthens the electrostatic interaction of PFAS molecules with the functional groups of the sorbent, and hydrophobic interaction of the sorbent surface and PFAS molecules. The adsorption capacity of PFAS on inorganic porous materials is influenced by the molecular structure of PFAS itself (size, hydrophobicity/hydrophilicity, nature) also. SBA-15 samples based on sodium metasilicate were synthesized using different aminoalkoxysilanes [1,2]. Sorbents with ordered structure and high concentrations of protonated aminogroups ( $1.25\text{-}2.00\text{ mmol g}^{-1}$ ) on the surface were obtained.

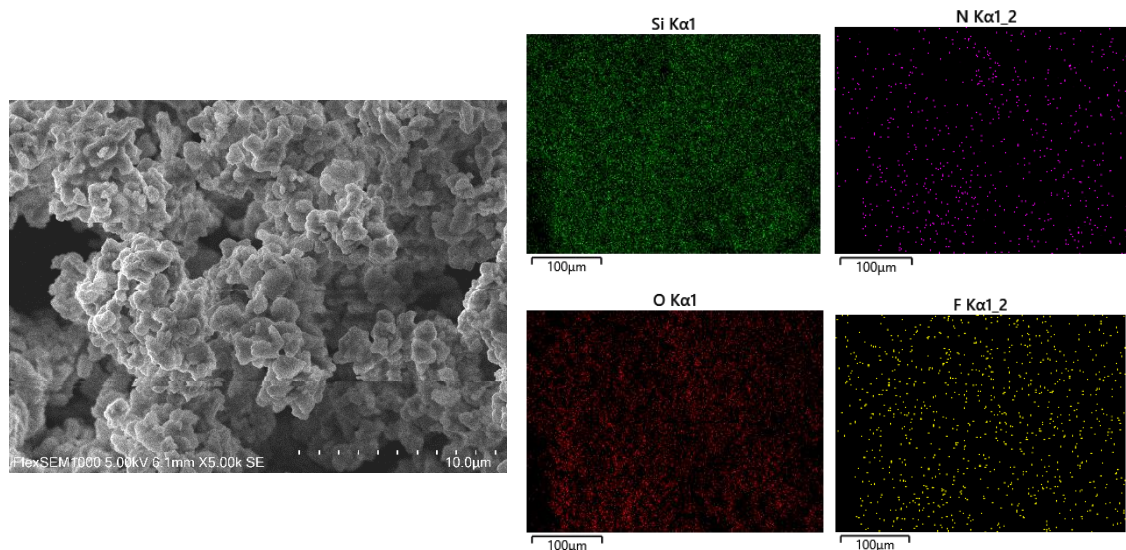


Fig. 1. SEM and EDX- of the SBA sample with triethyltriamine groups after sorption PFOA. The authors are grateful to the Werner-Gren Foundation for financial support

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**(O-19)**

**MICROPLASTIC IN THE ARCTIC**

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Industrial plastic production has grown rapidly since the 1950s, reaching 368 million tonnes globally per year by 2019. Because of its low price, plastic has become one of the most widely used materials, especially in the packaging industry, and now forms an integral part of municipal waste. Every year, 19–23 million metric tonnes of mismanaged plastic waste are transferred from land-based sources to water globally (Bergmann et al. 2022). The term "microplastics" (MP) was first used in environmental sciences two decades ago (Thompson et al. 2004) to indicate plastic fragments of 1 µm to 5 mm in size. According to their origin, MP can be distinguished into two types - primary and secondary. Primary MP can be seen from tyre wear and tear, wastewater and sea ice. Since the last decade, plastic debris has accumulated in the Arctic, including around the Svalbard area (Tekman et al. 2017). Plastic dominates the number of observations of marine litter in the Arctic (Grøsvik et al. 2018) and has been suggested to have negative effects on the Arctic biota and threaten the ecosystem (Tanaka et al. 2020). The lethal interactions of the organisms with plastic litter are entanglement and ingestion (Derraik 2002). In this presentation I will present the current knowledge on the sources of MP found in the European Arctic, its distribution, and its effects on Arctic biota, as well as knowledge gaps. The focus will be on the MP effects on Arctic seabirds.

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**(O-20)**

## **EXPOSURES AND HEALTH OF ARCTIC POPULATIONS**

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The Arctic is connected tightly to the rest of the globe. The effects of warming climate are present in the Arctic, found as permafrost thaw, melting glaciers, increase of wildfires, changes of long-range contaminant transport, increased human activities, and existing and newly emerging infections (such as the COVID-19 pandemic). In the Arctic, there are around seven million inhabitants, about one million of these are Indigenous, and three-quarters of the Arctic populations are living in settlements of more than 5000 people, and 5 million people are living in permafrost regions. Because the Arctic is a diverse landscape, One Health, a holistic approach to public health, is prudent for circumpolar Arctic human health research.

The One Health concept recognizes that human health, animal health and ecosystem are interrelated and interdependent in complex ways. It shows that responses to human mental, physical, cultural, and social wellbeing demand interdisciplinary and holistic approaches, where experts of human health, animal health (domestic and wildlife) work closely with ecosystem health scientists. One Health is the intuitive world view of Indigenous people everywhere, and it is a concept worldwide when populations face the complex challenges associated with global climatic and environmental changes. These include changes in land-use, urbanization, invasive species, biodiversity and worldwide circulation of anthropogenic contaminants and existing infectious diseases. The bridging of contact between animals and humans frequently results in the emergence and re-emergence of zoonoses from wildlife reservoirs, and it has been found that 58% of infectious diseases confronted by humanity worldwide have been at some point aggravated by climatic hazards. The usefulness of the One Health paradigm was recognized by public health agencies and wildlife resource managers as a means to improve the ability of Arctic residents to respond to the existing and emerging environmental threats at an early stage. Warming and permafrost thaw may influence both contaminant exposure and the spread of zoonotic infectious diseases, and population migration from smaller to larger communities and urban centers. The migration process may be accompanied by changes in exposure to contaminants and zoonotic diseases.

The monitoring of zoonotic diseases and permanent organic pollutants, toxic metals and emerging contaminants (e.g. plastics and associated chemicals) as well as emerging infections is important for human and animal health. Models showed different climate change scenarios impact disease distribution and contaminant exposure. Indeed, a holistic model integrating epidemiological, demographic and ecological models is urgently needed in order to estimate the risk and magnitude of human and wildlife health impacts both in the Arctic and globally. The proposed integrated model needs multi- and interdisciplinary research on lifetime contaminant accumulation, lifetime exposure to zoonotic pathogens, and health consequences for wildlife and human consumers.



(O-21)

## **WHOLE BLOOD CONCENTRATIONS OF SELECTED ESSENTIAL AND NON-ESSENTIAL ELEMENTS AMONG RURAL RESIDENTS OF NENETSIA, RUSSIA**

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Data on concentrations of essential and non-essential elements among inhabitants of the Arctic regions are still missing in several places. In order to fill in one of the gaps, this study in the Nenets Autonomous Okrug in Northern Russia was launched in 2018. The aims were to assess element concentrations in a population of the area, to assess regional differences in the concentrations, and to search for nutritional factors and other factors that could contribute to explain the measured concentrations.

Participants (N=297) were recruited from seven villages, and 204 were women and 93 were men. The Nenets population consisted of 161 subjects, while 136 participants were classified as non-Nenets. Whole blood (B) concentrations of lead (Pb), mercury (Hg), cadmium (Cd), arsenic (As), copper (Cu), zinc (Zn), cobalt (Co), manganese (Mn) and selenium (Se) were determined.

Large difference in blood concentrations were observed between inhabitants of coastal villages as compared to villages located inland, the concentrations of B-Pb, B-As, B-Zn and B-Mn being substantially lower in inland communities, while B-Hg and B-Cu concentrations were higher.

The Nenets had lower concentrations of B-Se and B-Zn, while B-Cu, B-Mn, B-Hg, B-Cd and B-Pb concentrations were higher when compared to the non-Nenets participants. Further analysis showed that B-As concentrations were associated with the consumption of some local fish species. The concentrations of B-Hg were associated with the consumption of local pike, although the local pike are relatively low in Hg. The concentrations of B-Se were substantially higher among those subjects having the highest B-Hg and B-As concentrations, indicating that local fish consumption is an important source of Se for this population. The B-Pb concentrations were mainly related to the consumption of goose and reporting to be a hunter. Non-hunters not eating goose had an average B-Pb concentration of around 17 µg/L compared to around 33 µg/L among those reporting to be a hunter and eating 8-30 goose meals/month.

B-Pb was also significantly associated with several of the other element concentrations in blood. Manganese and Co in blood were both negatively associated with the serum biomarker of iron status ferritin, and subjects with low ferritin in serum had on average the highest concentrations of B-Co and B-Mn.

In conclusion, the differences in element blood concentrations observed between Nenets and non-Nenets and living in coastal or inland regions may at least partly be explained by differences in food items consumed, lifestyle habits like hunting and iron status.

**(O-22)**

**CHEMICALS OF EMERGING ARCTIC CONCERN AS INDICATORS OF ANTHROPOGENIC FOOTPRINT IN A CHANGING ARCTIC**

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Environmental pollutants are reported in Arctic samples since the late 1800s after the first description of “dirty snow” in the Eastern Arctic, originated from long-range atmospheric transport of early industrial atmospheric emission from the industrializing countries. Since the 1980s, however, only a selected number of persistent organic semi-volatile pollutants (POPs) are monitored regularly in Polar environments after they have been identified as relevant Arctic pollutants. Today highly sensitive trace analytical methods enabled the identification and quantification of an increasing number of contaminants of emerging concern in the Arctic environment (CEAC = contaminants of emerging Arctic concern). The newly published and updated Arctic Monitoring and Assessment Programme (AMAP) report on CEACs is an impressive testimony of the wide array of contaminants currently investigated and monitored in the Arctic Environment. In total 12 pollutant groups comprising of several hundreds of contaminants are currently listed by AMAP as priority CEACs for future environmental monitoring. This report revealed that also local sources are contributing to the pollutant profile in Arctic environments.

Hence, comprehensive environmental studies on the fate, environmental toxicology, and distribution profiles of CEACs should be given high priority by national and international authorities and funding agencies in order to provide a sound baseline for regional risk regulation. This is also of specific concern to ensure that local food sources can also be harvested by the future generations of indigenous populations without any concern for health and well-being.

Possible implications of the currently ongoing complex research and assessment strategies for risk assessment of CEACs in Polar environmental research will be discussed. The close linkage between modern environmental chemistry, toxicology, fate modelling on the one side and monitoring, environmental assessment, and regulation will be highlighted for sustainable pollution regulations in the Arctic. Potential conflict scenarios between environmental concerns and geopolitical, economic, and strategic interests in the region will be addressed in the planned presentation.

(O-23)

## LEVELS AND SEASONAL VARIATIONS OF PER- AND POLYFLUOROALKYL SUBSTANCES (PFAS) IN SURFACE SNOW IN SVALBARD

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Per- and polyfluoroalkyl substances (PFAS) is a group of persistent anthropogenic organofluorine contaminants, some of which are known to be toxic and bioaccumulative. Perfluoroalkyl carboxylic acids (PFCAs) and perfluoroalkyl sulfonic acids (PFSAs) can form from the atmospheric degradation of precursors such as fluorotelomer alcohols (FTOHs) as well as hydrofluorocarbons (HFCs) and other ozone-depleting chlorofluorocarbon (CFC) replacement compounds. Since PFCAs and PFSAs will readily be removed from the atmosphere during wet deposition, surface snow can be used to understand PFAS atmospheric processes in the Arctic.

Surface snow samples (n = 32) from 7 sites, including 5 high elevation glaciers, on Svalbard were collected during January – August 2019 (i.e. polar night to 24-hour daylight). This was with the aim to understand the levels and seasonal variations in PFAS deposition in the Arctic as well as the geographical extent of local sources from the main settlement, Longyearbyen. The widespread detection (in 75 – 100% of snow samples), including at remote reference sites, of C<sub>2</sub> – C<sub>9</sub> PFCAs, PFUnDA, PFTrDA, HFPO-DA (GenX), TFMS, PFHxS, PFOS, 6:2 FTSA, FBSA, FHxSA and FOSA, suggests that PFAS contamination in the remote terrestrial Arctic is widespread and chemically diverse. Surface snow in Longyearbyen was influenced by local sources of C<sub>4</sub> – C<sub>11</sub> PFCAs, PFHxS and PFOS, whose concentrations were 2.3 – 22 times higher compared to the remote reference sites. In contrast, surface snow from Foxfonna (800 m.a.s.l.), a high elevation ice cap outside of Longyearbyen, was found to receive PFAS input from long-range atmospheric processes.

On Foxfonna, the median deposition fluxes of C<sub>2</sub> – C<sub>11</sub> PFCAs, PFHxS, PFOS and HFPO-DA (GenX) were found to be 2.0 – 38 times higher during 24-hour daylight. All these PFAS were found to positively correlate with solar radiation. This suggests seasonal light in the Arctic is important in enabling photochemistry for the atmospheric degradation of PFAS precursors, and the subsequent deposition of their degradation products in the remote Arctic environment. Direct particle-bound transport and marine aerosols were considered to be unimportant to the deposition of PFAS on Foxfonna.

This study provides the first empirical evidence for the atmospheric formation PFOS and HFPO-DA (GenX) from a precursor source. TFMS was also ubiquitously detected in Arctic surface snow. This suggests that TFMS is globally distributed, however, its transport mechanism to the Arctic environment remains unknown.

(O-24)

**CHANGES IN THE ATMOSPHERIC CHEMICAL COMPOSITION AND IMPACTS ON CLIMATE, HEALTH, AND ECOSYSTEMS**

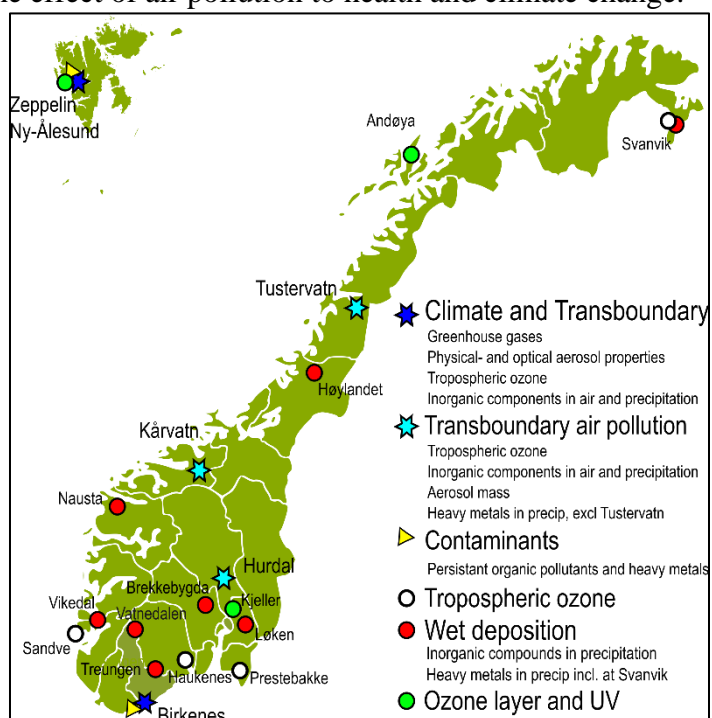
Wenche Aas, Sabine Eckhardt, Cathrine Lund-Myhre, Stephen Platt, Sverre Solberg, Tove Svendby, Kjetil Tørseth, Karl Espen Yttri

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Monitoring of atmospheric composition in Norway was initiated in the early 1970s, and the activity has generated comprehensive datasets which allow for evaluation of regional and spatial trends of air pollution during a period of nearly 50 years. The program has developed from being focused on acid rain and the depletion of the ozone layer, to address environmental problems related to contaminants, the effect of air pollution to health and climate change.

This talk will give an overview of the extensive Norwegian monitoring program (Figure) and set the results in an international perspective, and show how the development in the atmospheric composition are related to changes in emissions.

The overall picture is that the most important greenhouse gases are increasing steadily while other air pollutants are generally decreasing, except replacements gases for the ozone depleting gases as well as an increase in some new contaminants.



**(O-25)**

**TIRE AND ROAD WEAR PARTICLES IN THE ENVIRONMENT - CURRENT KNOWLEDGE AND FUTURE NEEDS**

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Norwegian Institute for Water Research, Oslo, Norway

Tire and road wear particles have been estimated to be one of the largest sources of microplastic particles to the environment, with particles being transported mainly through runoff, “splash and spray”, sludge and air deposits. Levels of tire and road wear particles have been reported from different environmental compartments the last few years, such as road-side soils, sediments, water bodies and air. However, due to analytical challenges and no current standardization, a large range of sampling, pre-treatment and analytical methods have been used in different studies, making comparison between them difficult.

This presentation will give a brief overview of the current knowledge of tire and road wear particles in different environmental compartments, their potential as a pollutant in the environment, possibilities for reducing the release of these particles and their associated chemicals and point out some of the key aspects needed to move forward within this field of research.

(O-26)

**DEPOSITION OF TIRE WEAR PARTICLES NEAR A MOTORWAY IN GERMANY**

Stephan Weinbruch<sup>1</sup>, Linyue Zou<sup>1</sup>, Jeannette Matthies<sup>1</sup>, Konrad Kandler<sup>1</sup>, and Martin Ebert<sup>1</sup>

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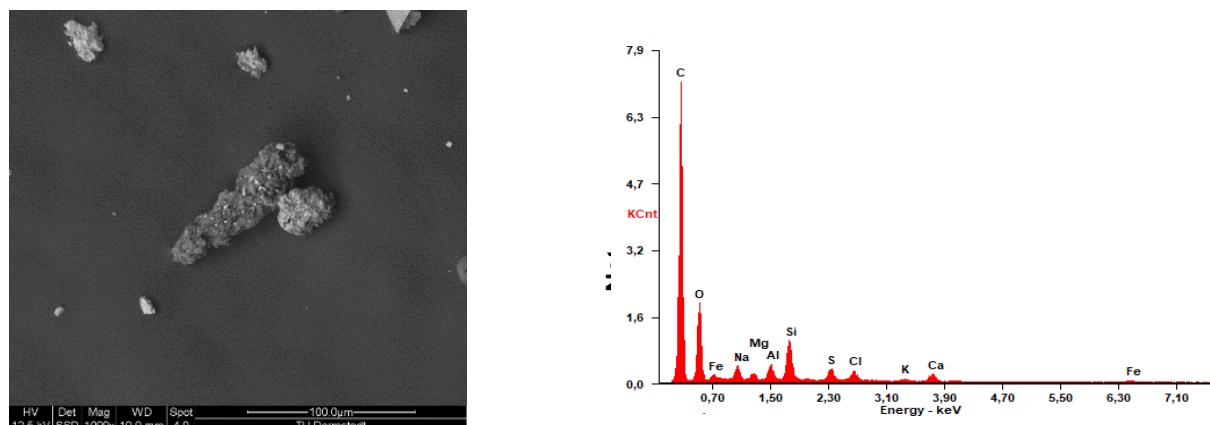
Tire wear particles are a major component of microplastic introduced into the environment with a share of approximately 43 % in Germany. Despite their strong contribution, information on atmospheric concentrations as well as deposition rates of tire wear particles is scarce.

We measured deposition rates of tire wear particles near a congested motorway (daily traffic volume of about 110.000 vehicles per day) in two field campaigns (June/July 2020 and March till June 2022). Particles were collected with passive samplers (Sigma 2 or flat plate) at distances between 0 and 27 m from the kerbside. Sampling time varied between 6 and 8 days. Particles were analysed by environmental scanning electron microscopy (ESEM) and energy-dispersive X-ray microanalysis (EDX). Tire wear particles larger 1 – 2  $\mu\text{m}$  (equivalent projected area diameter) can be recognised in electron microscopy by their typical morphology and their elemental composition determined by EDX (Figure 1).

The fraction of tire wear particles increases with particle size from  $\approx 10$  % in the size range 5 – 10  $\mu\text{m}$  to  $\approx 50$  % in the size range 40 – 100  $\mu\text{m}$ . The number deposition rate directly at the kerbside was about 115 particles/( $\text{cm}^2 \cdot \text{day}$ ) and decreased to a value of approximately 35 particles/( $\text{cm}^2 \cdot \text{day}$ ) at a distance of 27 m perpendicular to the motorway.

The corresponding mass deposition rates (calculated from the measured particle size and assuming a density of 1.8  $\text{g}/\text{cm}^3$ ) are  $8.8 \pm 1$   $\text{mg}/(\text{m}^2 \cdot \text{d})$  directly at the kebside and  $3.3 \pm 1$   $\text{mg}/(\text{m}^2 \cdot \text{d})$  at a distance of 27 m. The mass deposition rate will reach a value of zero at a distance of approximately 40 – 50 m.

Atmospheric concentrations of tire wear particles were calculated from the measured deposition rates to enable comparison with previous work. The values observed in our study ( $3.5 - 7.3$   $\mu\text{g}/\text{m}^3$  at the kerbside and  $2.7$   $\mu\text{g}/\text{m}^3$  at 27 m distance) are in the same range as those reported in the literature for other traffic sites ( $1 - 14$   $\mu\text{g}/\text{m}^3$ ).



**Figure 1:** Secondary electron image and energy-dispersive X-ray spectrum of a typical tire wear particle.

(O-27)

## EMISSION OF VOCs FROM WOOD BUILDING MATERIALS AND IMPACT ON INDOOR AIR QUALITY

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Wood is known to emit a considerable amount of volatile organic compounds (VOCs) into its surroundings. Many VOCs are associated with Sick-Building-Syndrome (SBS), and up to 10% of the population experience symptoms of SBS. However, wood is generally regarded to be a suitable material for indoor surfaces, as multiple studies indicate positive psychological effects from exposure to wood. In addition, wood surfaces are beneficial regarding their hygroscopic properties, as wood building materials have the potential to reduce seasonal fluctuations in temperature and relative humidity.

To assess the suitability of wood as a building material for indoor use it is important to identify the size and profile of VOC emissions from wood materials. In this study, emission rates of six VOCs were measured during construction of student housing in Bjølstad, Fredrikstad in 2020. The main frame of the building was *Norwegian Spruce* cross-laminated timber (CLT), and air samples were collected from rooms with either ceiling or ceiling and one wall in visible CLT. The sampling was performed during nine weeks of construction, and the air samples were analyzed using TD-GC-MS. All emission rates of the VOCs, namely camphene,  $\alpha$ -pinene,  $\beta$ -pinene,  $\beta$ -myrcene, 3-carene and hexanal, were below recommended lowest concentrations of interest (LCI), indicating no adverse health impact in the indoor environment. However, the analysis performed was not comprehensive regarding VOC species in the sampled air and the set of limit values does not account for cocktail effects of the VOCs present in the indoor air.

Emissions of all six VOCs followed similar trends, indicating a common source, although emission trends during the nine weeks of sampling did not resemble those previously reported for wood surfaces. That is, a decrease in VOC emissions over time after installation. To consider the contribution of VOC emission from CLT compared to other possible sources at the construction site CLT samples from Bjølstad were collected for further analysis. A VOC emission test lab containing 20L emission chambers followed by TD-GCxGC-ToFMS analysis was established for performing these measurements.

*Acknowledgment:* The author acknowledges the Norwegian University of Life Sciences and the Student Welfare Organization in Østfold for funding this project.

**(O-28)**

**DO THERMOCHEMICAL PROCESSES EMIT TOXINS INTO THE AIR?**

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Population growth led to increased per capita energy demand, fossil fuel consumption, and greenhouse gas emissions. Waste conversion to heat, electricity, or fuel through thermochemical processes, is a renewable, possibly efficient, and attractive alternative to fossil fuels. Gasification is one of the most energy-efficient, and flexible methods for the extraction of energy from waste.

Thermochemical processes may emit hazardous compounds into the air, among which dioxins and furans (PCDD/Fs) are of great public concern. While the amount of PCDD/Fs emissions produced by gasification is often within acceptable limits set by international laws as compared to other thermochemical processes, our latest investigation of the literature indicates that gasification cannot always reduce PCDD/Fs emissions to standard levels. This presentation discusses the available data from the existing experimental work on the levels of PCDD/Fs formed by gasifying different waste streams such as sewage sludge, plastics, wood, animal, and municipal solid wastes. This presentation will review PCDD/Fs formation in gasification and the operational parameters that can be controlled during the process to minimize their formation.

Carbon, oxygen, and chlorine together form PCDD/Fs in all thermochemical processes at the temperature range of 200–800°C. Nevertheless, without oxygen, PCDD/Fs formation is significantly reduced if a high-temperature reactor is used at above 1000°C and shock-cooling of gases is combined. PCDD/Fs formation can be reduced with the aid of high-temperature gasification of fuels with a high content of chlorine.



**(O-29)**

**ENVIRONMENTAL DNA ANALYSIS (eDNA) – PRINCIPLES AND APPLICATIONS**

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Conserving biodiversity has been identified as a critical tasks for humankind in the Anthropocene. However conservation efforts are hampered by our lack of basic information on species occurrence, distribution, abundance, habitat requirements, and threats. Obtaining this information requires efficient and sensitive methods capable of detecting and quantifying diversity at various levels. Environmental DNA (eDNA) is an emerging technique that can increase our ability to detect and quantify biodiversity, by overcoming some of the challenges of labor-intensive traditional surveys. The application of eDNA in ecology and conservation has grown enormously in recent years, but there are still knowledge gaps when it comes to current strengths and limitations of various eDNA approaches. In many situations, an eDNA approach may either not work, or it may work but not provide the information needed. Problems with (1) imperfect detection, (2) abundance quantification, (3) taxonomic assignment, (4) eDNA spread and turnover, (5) data analysis and interpretation, and (6) assessing ecological status have all been identified.

Here, I will show examples on how technical challenges and complexities involved can be minimized, and where eDNA approaches are the appropriate method for question of interest. I will give examples on how results can be interpreted in environmental risk assessment and conservation efforts. I identify potential ways of reducing limitations in eDNA analysis, and demonstrate how eDNA and traditional surveys can complement each other.

(O-30)

**RISK-DRIVING PFAS COCKTAIL IN SWEDISH HUMAN BLOOD**

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Per- and polyfluoroalkyl substances (PFASs) are a group of anthropogenic chemicals used because of their unique combination of both lipophilic, hydrophobic and heat resistant properties. Perfluorooctanoic acid (PFOA) and perfluorooctane sulfonate (PFOS) are regulated by the Stockholm Convention. Based on epidemiological studies, human biomonitoring guidance values (HBM-GVs) for PFOA and PFOS in human blood have been derived, above which a risk of adverse effects cannot be excluded. The HBM-GV for PFOA and PFOS are 2 and 5 ng/mL, respectively.<sup>1</sup> The aim of this study was to see how many individuals were above risk threshold for PFOA and PFOS in the general population of Stockholm.

In this study, 60 individuals were analysed (30 females, 30 males), along with a pooled sample of 100 individuals. The samples were taken from healthy blood donors in Stockholm 2020. The PFASs analysis was done according to Miaz et al 2020.<sup>2</sup> In short, 0.5 mL serum was extracted using 4 mL acetonitrile and ultrasonicated for 15 minutes, and repeated once. Granular ENVI-Carb (25 mg) and 50  $\mu$ L glacial acetic acid was used for clean-up. The samples were analysed on a high-resolution Q Exactive Orbitrap MS (ThermoFisher Scientific, Waltham, MA). Hazard Index (HI) was used for the mixture risk assessment (MRA) by adding the hazard quotient (HQ) of each chemical. The HQ was calculated by dividing the individual blood concentration of one chemical by the HBM-GV of the same chemical.

All samples had quantifiable levels of both PFOA and PFOS. Eighteen percent of the individuals were above the risk threshold for either PFOA or PFOS ( $HQ \geq 1$ ). The MRA (PFOS and PFOA) showed that the pooled sample and 65% of the individuals were above the risk threshold of 1 indicating that a risk of adverse effects cannot be excluded, see Figure 1. Blood levels of PFOA and PFOS were among the highest compared to other PFASs analysed. Even though the levels of these chemicals are decreasing in humans, the levels are still of concern. Also, many more chemicals are present in human blood, many for which no HBM-GVs are available.<sup>3</sup> Together, levels of PFASs and other chemicals constitute a risk related to e.g. reproductive, developmental and immunological effects in humans.

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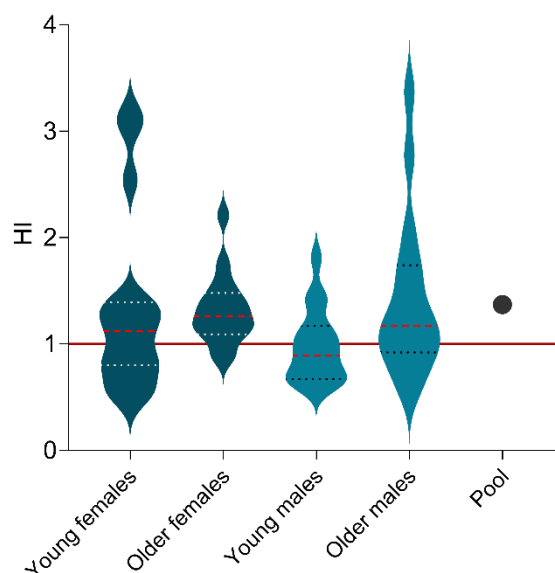


Figure 1. Hazard index of PFOS and PFOA separated into four groups. The risk threshold of 1 is shown as a red line, the median of each group is a dashed red line and the 25th and 75th quartile is shown as white/black dashed lines.

(O-31)

## **INTERVENTIONS TO REDUCE CADMIUM EXPOSURE IN LOW- AND MIDDLE-INCOME COUNTRIES DURING PREGNANCY AND CHILDHOOD: A SYSTEMATIC REVIEW**

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Exposure to the toxic metal cadmium is widespread globally and especially prevalent in low- and middle-income countries (LMICs). Early life (from pregnancy through childhood) is a vulnerable window for exposure. Therefore, interventions in low- and middle-income countries to prevent or reduce early life exposure to cadmium may be relevant for improving public health.

This systematic review of 5 databases (Scopus, Web of Science, Global Health Medicus, Greenfile, and PubMed) found a total of n=4098 articles, of which n=26 were relevant and extracted for this review. Synthesis without meta-analysis (narrative synthesis) was used for data analysis due to the wide heterogeneity of included studies. Study quality and risk of bias was assessed using modified GRADE criteria.

A total of 26 studies from 21 LMICs were identified, ranging from policies to clinical treatment, rehabilitation and clean-up methods for agricultural soil, interventions for nutrition and cooking, and anti-pollution strategies at the household level. The interventions targeted children, pregnant and postpartum women, and/or women of child-bearing age. While several studies provided some evidence of effectiveness, none appeared to offer a realistic solution for cadmium pollution at scale. Agricultural and food preparation studies were relatively frequent, particularly related to rice. Air filtration studies during pregnancy indicated some effectiveness in reducing indoor cadmium exposures.

Cadmium pollution is a persistent and widespread threat to children's health with too few identified solutions. Long-lasting damage to children's health starting in the earliest years should motivate investment in higher-quality interventions, innovations, and further research.

Registration. Systematic review methods were registered with PROSPERO (CRD42021235435).

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(O-32)

## **FUTURE DRINKING WATER LEVELS OF NITROSAMINES AND NITRAMINES NEAR A CO<sub>2</sub> CAPTURE PLANT (FuNitr)**

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Technology for CO<sub>2</sub> capture is considered one of the necessary abatement actions to limit global warming to 2 °C. The currently most feasible way of capturing CO<sub>2</sub> is using amines. However, risk is associated with the amine-method since it may lead to contamination of nearby waters. This occurs as small amounts of amines inevitably escape the capture plant with the cleaned flue gas. In the atmosphere, the amines will rapidly degrade to produce, amongst others, carcinogenic and potentially carcinogenic nitrosamines and nitramines, respectively. Local deposition is expected, and with subsequent partitioning to the aqueous phase.

In Norway, CO<sub>2</sub> capture operations must comply to strict amine emission permits. These are set to protect nearby waters from exceeding the national recommended drinking water limit for the sum of nitrosamines and nitramines. However, to set sensible amine emission permits, numerous complex processes must be considered, i.e., going backwards from nitrosamine and nitramine concentrations in a lake – to levels of amines emitted from a nearby CO<sub>2</sub> capture plant. For several of the processes, knowledge is limited, and thus so-called “worst case scenarios” are applied. This may result in unnecessary strict amine emission permits, adding constraint to the CO<sub>2</sub> capture technology.

In this new project, an interdisciplinary team of researchers and industry stakeholders will work together to improve the knowledge behind the amine emission permits. Numerical modelling will be combined with laboratory experiments and *in situ* measurements. A fundamental new atmospheric model will be developed to describe the dynamic nature of the flue gas. Accurate incorporation of plume turbulent dispersion and mixing is key to produce realistic chemical reaction rates. Validation of the model will be done through *i*) experimental studies on the chemical transformations in an amine-treated flue gas and *ii*) *in-situ* measurements in the plume gas emitted from a full-scale CO<sub>2</sub> capture plant. Subsequently, the atmospheric model will, for the first time, be run in conjunction with a catchment model. Only then can the whole picture from plume emission to lake conditions be considered as well as the potential for nitrosamines and nitramine to accumulate with time in the catchment. So far, no efficient degradation pathway has been identified for the nitramines, while the nitrosamines are prone to photodegradation. Hence, laboratory experiments will be conducted to assess the biodegradability of the nitramines. The results will feed into the catchment model. Finally, to make the advanced atmospheric-catchment model accessible to stakeholders, a user-friendly web-interface will be developed. The goal is to aid decision makers and the industry in setting sensible amine emission permits and operating conditions, respectively.

(O-33)

**ACRYLAMIDE INTAKE IN A NORWEGIAN GROUP FROM FOOD ESTIMATED VIA HAEMOGLOBIN ADDUCTS AND PROBABILISTIC MODELLING OF SELF-REGISTERED DIET DATA**

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There is an exposure to acrylamide (AA) in the general population via food. AA is generated when food rich in carbohydrates is cooked with high heat, and the amino acid asparagine degrades as part of the Maillard process. AA is an electrophilic compound that is classified as probably carcinogenic to humans, thought to be due to its metabolite glycidamide, and thus the exposure is of concern.

In this study, intake of AA was estimated for a group of 144 non-smoker adults from Norway by: a) laboratory analysis of blood samples of the participants with regards to haemoglobin (Hb) adduct levels from AA; b) probabilistic modelling of food frequency questionnaire (FFQ) data of the participants; and c) probabilistic modelling of data from weighted food diaries (WFD) of the participants for two days where the participants listed their daily consumptions and its weight. Acrylamide concentration data in food were from Norway.

Hb adducts were analysed with the FIRE procedure, which utilizes a modified Edman degradation method to cleave N-terminal amino acid from proteins. Fluorescein isothiocyanate is used as the derivatization reagent that results in cleaved adducted N-terminal valines as fluorescein thiohydantoin (FTH) derivatives. The FTH derivatives are extracted from the derivatized blood samples with solid phase extraction and analysed by liquid chromatography - mass spectrometry. The measured Hb adduct levels were used to calculate the individual AA intake.

For the probabilistic methods, Monte Carlo simulation was used for probabilistic calculations of AA-intake from the self-registered dietary data and using data on AA content in different food from the Norwegian Institute of Public Health, and computed in R. The dietary data were used to calculate the individual AA intake.

On average the AA-adduct level was measured to be 36 pmol/g Hb (median = 33). The AA-intake of the median adduct level corresponds to 0.24 µg/kg bw and day, and the median AA-intake from the FFQ and WFD data were calculated to be 0.30 and 0.26 µg/kg bw and day, respectively.

Good agreement was observed for the median intake calculated from the adduct levels and AA-intake estimations from the probabilistic methods. Even though the median of AA-intake estimates from the three methods is very close, no correlation was observed between the methods for the data for individuals.

**(O-34)**

**DDT IN BLUE MUSSELS FROM FRUIT GROWING AREAS IN WESTERN NORWEGIAN FJORDS 2021**

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DDT was a legally and much used pesticide in Norway in time period from the second world war until the ban in 1970. Because Sjørfjord in Hardanger is one of the most concentrated fruit growing areas in Norway, large amounts of DDT were applied for pest control in this area. The fjord has therefore historically been particularly contaminated with DDT, and several monitoring programs and efforts to find a source have been made in the area.

During 2021/2022, the Institute of Marine Research, on behalf of the County Governor of Vestland, performed a detailed survey of DDT levels in blue mussels from 28 stations in Sjørfjorden and from seven reference stations in Hardangerfjord outside of Sjørfjord as well as eight reference stations in fruit growing areas in Sognefjord.

The results showed that there are still high levels of DDT in the Sjørfjord area, and significantly higher levels in the Sjørfjord than in both reference areas. Average concentrations of sum DDT were 13.1 µg/kg wet weight in Sjørfjord, 3.44 µg/kg in Hardangerfjord outside Sjørfjord, and 3.06 µg/kg in Sognefjord. Thus, the levels were about the same in Hardangerfjord outside Sjørfjord as in Sognefjord. In Sjørfjord, there were relatively high levels at most stations. Stations that stood out with higher levels than the others were especially Espe with sum DDT of 60.1 µg/kg wet weight, followed by Indre Aga with 26.3 µg/kg, Trones with 20.2 µg/kg and Kråkevik with 19.9 µg/kg.

The DDT levels found in this study varied around the levels from previous measurements. However, the levels are well below the Environmental Quality Standard of 610 µg/kg wet weight, indicating that they are not high enough to affect the ecosystem. Also, the DDT levels measured in mussels do not affect food safety. The results give no means to conclude that there is a specific source. The generally elevated levels instead indicate that pollution due to former DDT use is bound in the soil and is transported into the fjord with freshwater runoff. If one should follow up with an even more detailed survey, we suggest focusing on the localities where the highest concentrations in mussels were found, particularly Espe, Indre Aga and Trones.

**(P-1)**

## **DETERMINATION OF VOLATILE EMISSIONS FROM COATED INDOOR WOOD SURFACES**

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This project is a collaboration between Norwegian University of Life Sciences (NMBU) and Norwegian Institute for Air Research (NILU), thence the chemical analysis and data acquisition is carried out at NILU.

Wood is rapidly increasing in popularity as a building material in Norway. For preservation and to improve durability, tree materials are often treated with different coatings, additives, or glues. Correspondingly, treated wood emits various volatile organic compounds like xylene, ethylbenzene, or toluene that can negatively affect indoor air quality and be a potential health hazard to humans. At the same time, trees naturally emit diverse types of ketones, aldehydes, acids, and terpenes like 3-carene, benzaldehyde, or formaldehyde that can add higher VOC levels to the indoor environment.

An article written by the European Environment Agency asserts that people spend about 90% of their time indoors, accordingly indoor air quality can directly affect health. However, VOC emission profiles from coated wood are not sufficiently characterized. Therefore, the characterization of indoor VOC profiles is essential for exposure and risk assessment.

The first part of the project was to create “Personal Compound Database and Library” (PCDL) that consists of Mass Spectra of various VOC standards. It was necessary to reproduce high-quality MS spectra for efficient MS spectra matching when identifying the unknown analytes. For this purpose, High-Resolution GC-QTOF-MS has been exploited for its ability to identify and generate accurate MS data.

The second part of this project will be the determination and quantification of VOC emissions from the four coated wood samples placed in 20L emissions chambers. The analysis will be carried out on GC-QTOF-MS, where NIST and created PCDL will be applied to identify unknown VOCs. To determine the concentration of emitted VOC levels, the internal standard method will be applied.

*Acknowledgement:* The author acknowledges the Norwegian University of life Sciences and Norwegian Institute for Air Research for providing this master's degree project.

**(P-2)**

**DETERMINATION OF CLINKER IN THORACIC DUST AT WORKPLACES IN CEMENT PRODUCTION BY POSITIVE MATRIX FACTORIZATION**

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Clinker is the major constituent of cement. It is believed that the strong increase of pH after hydration of clinker minerals is responsible for the adverse health effects observed among cement production workers. Exposure to clinker at workplaces in the cement production industry was studied only in a few cases. Therefore, we aim at quantifying workplace exposure to clinker in cement production.

Based on the elemental composition determined separately for water-soluble and insoluble fraction, the clinker content was estimated in 1227 personal thoracic samples from workplaces in 15 plants located in 8 countries using positive matrix factorization (PMF). PMF is a factor analysis technique in which all factor profiles and factor contributions are constrained to be non-negative (Paatero & Tapper, 1994).

We inspected PMF solutions with 3 – 7 factors. The best solution (as judged from several mathematical properties as well as mineralogical interpretability) yielded five factors which were interpreted as Ca, K, Na sulfates, silicates, soluble Ca-rich, insoluble clinker and soluble clinker-rich. Interpretation of the factors obtained by PMF is supported by the apparent solubility of the elements Al, K, Si, Fe, and Ca measured in 107 material samples.

The total clinker content was defined as sum of the insoluble clinker and soluble clinker-rich factors. The clinker content of the samples was highly variable (range 0 – 95 %). The median clinker fraction varied between 20 and 70 % for individual plants. These values are lower than estimates based on Ca concentrations in a sample (Peters et al., 2009) or obtained from a selective leaching scheme (Hahn et al., 1998) but these studies probably overestimated the clinker content. In contrast, a good agreement was found with results of a recent electron microscopy study carried out in one of the plants also investigated in the present contribution (Ervik et al., 2022).

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**(P-3)**

**NONTARGET WORKFLOW FOR NOVEL COMPOUND IDENTIFICATION WITH ION MOBILITY-HIGH RESOLUTION MASS SPECTROMETRY: EXAMPLES AND IDEAS**

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High-resolution mass spectrometry allows for identification of novel compounds by collecting full-scan spectra with high mass accuracy. However, the scans produce an immense amount of data where it is very time-consuming to process and evaluate all the unique features, especially when analyzing a complex tissue matrix.

Recently, an effective workflow was developed to prioritize features and screen for metabolites using ion mobility-high resolution mass spectrometry (Bijlsma et al., 2019). First, we created a library containing suspected metabolite products that were predicted *in silico*. Then, retention time (RT) and collision cross section (CCS, a measure of ion mobility) of each suspect metabolite were predicted using trained mathematical models and added to the library. Finally, the data were processed via suspect screening against the library. Further filtering for mass error criteria, theoretical fragments, *etc.* reduces the number of candidates down to a number that can reasonably be investigated further. Moreover, the predicted RT and CCS strengthen the confidence in the identification of the suspects. Novel compounds are accordingly reported with RT, accurate mass, confirmed chemical formula, fragment data and a compound specific CCS value.

Here we report preliminary findings after applying the novel workflow to discover metabolites in three new, diverse contexts. First, we screened for metabolites of two mycotoxins that can contaminate seafood and aquafeed supplies. Second, we applied the workflow to identify novel metabolites of alkylated PAHs, a less-well studied class of chemicals found in crude oil. Finally, we analyzed insect larvae, used as novel feed ingredients, for their ability to metabolize the insecticide pirimphos-methyl. For each case, we present the different challenges, along with how we adjusted the workflow to be fit-for-purpose for each application. These three applications illustrate how ion mobility-HRMS and *in silico* prediction tools can provide new knowledge towards a wide range of environmental contaminants.

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**(P-4)**

**DEVELOPMENT OF A HIGH THROUGHPUT METHOD FOR SCREENING OF READILY BIODEGRADABLE CHEMICALS**

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Substitution of hazardous chemicals with safer and greener chemicals is part of the EU strategy for a non-toxic environment and a circular economy. Part of the definition of being safe and sustainable is that the chemical is not persistent, meaning that it will biodegrade in the environment. However, current standard test methods are laborious and not suited for high throughput screening of chemicals because of both the required volume of the test systems, and the limited possibility of automation of the analytical methods. A high throughput method should preferably be in a miniaturized system to minimize footprint in the laboratory, be based on an analytical method suitable for automation, and based on a generic parameter.

The aim of this study was to develop a high throughput biodegradation test for non-volatile and water-soluble organic chemicals based on growth of bacteria as an indicator of biodegradation, measured by flow cytometry (FCM). A set of eight reference chemicals were included in the test method development and four sources of environmental bacterial communities. To allow for high throughput and automation, incubation of environmental inoculum with test chemicals were performed in deep 96-well plates which could be sampled directly by a multi pipette to 96-well plates that were compatible with FCM.

In most cases, the positive controls aniline and sodium benzoate gave significant increased bacterial counts in some or all concentrations of added test chemical. However, the rest of the reference chemicals did not, or only to a very limited extent, induce significantly increased growth of bacteria. This is likely due to the stringent test conditions of this set up with only one ml volume of test medium, low bacterial numbers, and these chemicals being only moderately biodegradable. However, since both positive controls induced significant growth compared to the blank control in most experiments, the method showed potential for being used to identify readily biodegradable chemicals.

A total of 24 96-well plates with different inoculum variations were included in the experiment, with each well plate containing eight test chemicals at three different concentrations in experimental triplicates. Thus, a total of 576 experiments were run in triplicates on one instrument by one person over a seven-week period. This demonstrated the high throughput potential for this method that should be included in the toolbox for developing new green chemicals.

(P-5)

## TAILORING A BIO-BASED ADSORBENT FOR SEPARATION OF LATE TRANSITION AND RARE EARTH ELEMENTS

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The increasing demand for exhaust-free transportation, renewable energy generation and improved energy storage, require ever increasing quantities of Rare Earth (REE) and Late Transition (LTM) elements. This has resulted in an increase in mining activities in order to meet demand, which is inherently unsustainable. In order to become environmentally sustainable, an efficient, environmentally-friendly, recycling technology is required. Here, the design approach, synthesis and evaluation of a bio-based adsorbent material is reported. Cotton-derived cellulose nanoparticles were functionalized with a tripodal polyamino-ligand, tris(2-aminoethyl)amine, achieving a ligand content of ca. 0.8 mmol/g. The structure and morphology were investigated by AFM, PXRD, SEM-EDS and FTIR analysis. Investigations of the adsorption capacity and kinetics revealed quick uptake, high adsorption capacity and pronounced selectivity towards LTM compared to REE. Molecular insights into the mode of action of the adsorbent were obtained via the investigation of a model compound containing Ni(II) using single crystal x-ray crystallography. The bio-based adsorbent nanomaterial presented herein opens perspectives for the tailoring of specific bio-based adsorbents in the sequestration of REE and LTMs for their sustainable recycling.

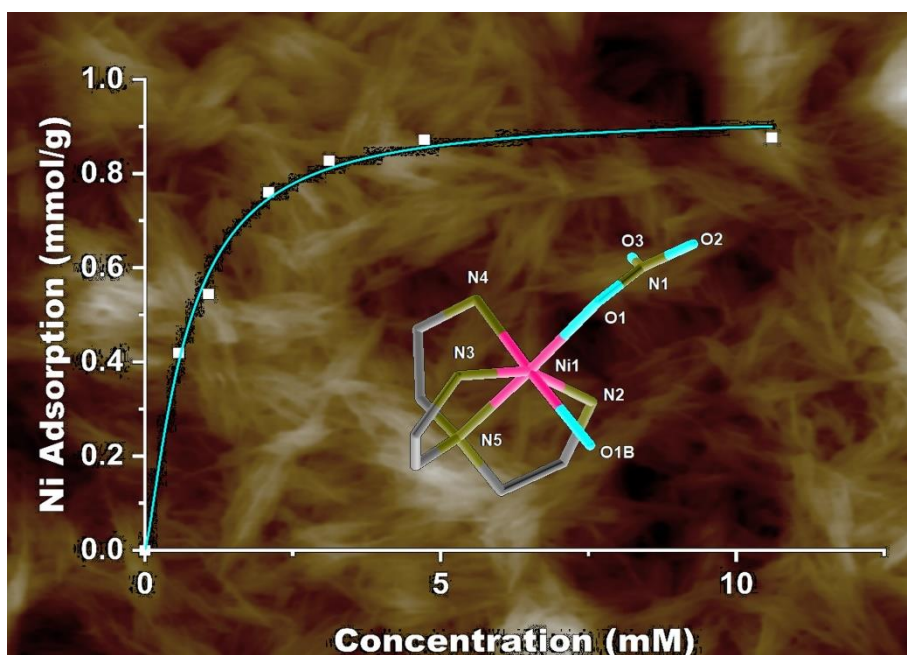


Figure 2. Bio-based adsorbent material with enhanced selectivity towards Late Transition Metals was constructed via grafting a poly-amino ligand on a nano cellulose matrix.

Breijaert, T. C.; Budnyak, T. M.; Kessler, V. K.; Seisenbaeva, G. A. Tailoring a Bio-Based Adsorbent for Sequestration of Late Transition and Rare Earth Elements. *Dalton Trans.* **2022**, *51* (47), 17978–17986. <https://doi.org/10.1039/D2DT03150G>.

**(P-6)**

**SVALBARD ICE CORE REVEALS LEVELS AND DISTRIBUTION PROFILES OF PER- AND POLYFLUOROALKYL SUBSTANCES (PFAS) IN THE HIGH ARCTIC**

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Several Svalbard ice cores have been used to investigate the long-range atmospheric transport of contaminants to the Arctic. We drilled, dated and analysed a 12.3 m ice core (2006 – 2019) from Lomonosovfonna, the highest elevation ice cap on Svalbard (1198 m.a.s.l.), to investigate the atmospheric deposition of poly- and perfluoroalkyl substances (PFAS). PFAS is a group of persistent anthropogenic organofluorine contaminants, of which some are known to be toxic and bioaccumulative. However, their long-range transport mechanisms to the Arctic are less well understood.

Of the 45 PFAS targeted by this study, 26 were detected in at least one core section. This suggests that PFAS contamination is chemically diverse and geographically widespread in the Arctic. C<sub>2</sub> – C<sub>11</sub> perfluoroalkyl carboxylic acids (PFCAs) were detected continuously in the ice core and their fluxes ranged from 2.5 – 8200 ng m<sup>-2</sup> yr<sup>-1</sup> (9.51 – 16,500 pg L<sup>-1</sup>). The distribution profile of PFCAs suggested that fluorotelomer alcohols (FTOHs) were likely the atmospheric precursor to C<sub>8</sub> – C<sub>11</sub> PFCAs, whereas C<sub>2</sub> – C<sub>6</sub> PFCAs had alternative sources, such as hydrofluorocarbons (HFCs). In addition, the detection of fluorotelomer unsaturated carboxylic acids (FTUCAs) confirmed the role of FTOHs as atmospheric precursors to PFCAs.

HFCs were thought to be responsible for the high levels of trifluoroacetic acid (TFA) observed in the ice core (4.2 – 16.5 ng L<sup>-1</sup>) and TFA had increasing temporal trends in deposition. HFCs and associated compounds were introduced in the 1990s after the Montreal protocol banned ozone depleting chlorofluorocarbons (CFCs). However, HFCs are also known to undergo a radical mediated atmospheric degradation to TFA and other short-chain PFAS.

Perfluorooctanesulfonic acid (PFOS) was also widely detected in 82% of ice core subsections, and its isomer profile (81% linear) indicated an electrochemical fluorination (ECF) manufacturing source. In comparison with another Arctic ice core from the Devon Ice Cap, Canada (2007 – 2014), fluxes for C<sub>2</sub> and C<sub>3</sub> PFCAs were typically lower, but fluxes were similar or higher for C<sub>4</sub> – C<sub>13</sub> PFCAs and PFOS on Lomonosovfonna.

Comparisons of PFAS concentrations with a marine aerosol proxy showed that marine aerosols were insignificant for the deposition of PFAS on Lomonosovfonna. Comparisons with a melt proxy showed that TFA and PFOS were mobile during meltwater percolation. This indicates that seasonal snowmelt and runoff from post-industrial accumulation on glaciers could be a significant seasonal source of PFAS to ecosystems in Arctic fjords.

(P-7)

## SOURCES AND AIR-WATER EXCHANGE OF HALOMETHOXYBENZENES IN THE SWEDISH SUBARCTIC

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Halomethoxybenzenes (HMBs) are compounds which have natural and anthropogenic origins. Here we focus on bromoanisoles (BAs) and drosophilin A methyl ether, 1,2,4,5-tetrachloro-3,6-dimethoxybenzene, (DAME). BAs are O-methylation products of the bromophenols produced in oceans and seas, while DAME is one of many HMBs found in terrestrial fungi. These relatively volatile HMBs are transported long distances through air and redeposited by precipitation, enabling them to reach remote ecosystems.<sup>1</sup> In our 2016 study, BAs were found in water and black fly larvae from streams in Subarctic Sweden, hundreds of km from their probable source in the ocean.<sup>2</sup> To further examine atmospheric transport and deposition of HMBs, we sampled water from streams and Lake Torneträsk (68° 22'N, 19° 06'E) in Abisko National Park, Sweden in September, 2022.

Water was collected in stainless steel cans and 4-L samples were processed through glass fiber filters and solid phase extraction cartridges (Isolute 200 mg ENV+). Cartridges were eluted with dichloromethane and the solvent was exchanged to isooctane. Ground litter (e.g., leaves, needles, humus) was collected near the water sampling sites and extracted by soaking in ethyl acetate.<sup>1</sup> Analysis was done by capillary GC with mass-selective detection.<sup>1</sup>

HMBs in six streams discharging into Lake Torneträsk averaged  $41 \pm 21$  pg/L for 2,4-dibromoanisole (DiBA),  $44 \pm 11$  pg/L for 2,4,6-tribromoanisole (TriBA) and  $101 \pm 40$  pg/L for DAME. Similar levels of BAs in stream water were measured in 2016.<sup>2</sup> Concentrations at four stations in the western basin of the lake averaged  $45 \pm 6$  pg/L (DiBA),  $18 \pm 4$  pg/L (TriBA) and  $90 \pm 12$  pg/L (DAME). DAME in 7 samples of ground litter ranged from 0.002 – 0.5 mg/kg wet weight (ww) with mean  $\pm$  SD =  $0.09 \pm 0.20$ ; similar to levels in ground litter collected further south, in Västerbotten County, Sweden.<sup>1</sup> BAs in litter were below the detection limit of 0.001 mg/kg ww. Discovery of DAME in ground litter at Abisko, as well as a positive relationship between air concentrations and temperature at Pallas, Finland (68° 00' N, 24° 15'E)<sup>1</sup>, is evidence of regional terrestrial sources.

Air-water exchange of the HMBs in Lake Torneträsk was estimated from concentrations in lake water ( $C_w$ ) and air ( $C_a$ ) at Pallas<sup>1</sup>, using Henry's law constants ( $H$ , Pa m<sup>3</sup>/mol) and assuming a lake temperature of 278K. Water/air fugacity ratios ( $FR = C_w H / C_a R T$ ) were 1.3 for DiBA, 3.3 for TriBA and 2.3 for DAME, where  $FR = 1$  indicates air/water equilibrium. The  $FRs > 1$  for TriBA and DAME suggest oversaturation in the lake and net water-to-air flux.

<sup>1</sup>Bidleman, T., Andersson, A., Brorström-Lundén, E., Brugel, S., Ericson, L., Hansson, K., Tysklind, M. 2023. Halomethoxybenzenes in air of the Nordic region. *Environ. Sci. Ecotechnol.* 13, 100209.

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**(P-8)**

## **HALOGENATED NATURAL PRODUCTS IN COMMERCIAL AND WILD MACROALGAE**

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Macroalgae are growing in popularity, as human food, animal feed and supplements and for production of bioactive products<sup>1,2</sup>. Concerns for food safety in Europe are usually for elements: arsenic, iodine, and heavy metals such as cadmium, lead, and mercury, while emerging issues are bacteria, marine toxins, persistent organic pollutants (POPs), pharmaceuticals, microplastics, and radionuclides.<sup>1</sup>

Here we present the case for halogenated natural products (HNPs), which are produced by marine bacteria, phytoplankton, macroalgae and invertebrates.<sup>3,4</sup> Some bioaccumulating and toxic HNPs are “bromophenolic” compounds, which arise from transformation of precursor bromophenols; i.e. bromoanisoles (BAs), hydroxylated and methoxylated bromodiphenyl ethers (OH-BDEs and MeO-BDEs), and polybrominated dibenzo-*p*-dioxins (PBDDs).

In this pilot study, we compare levels of 2,4-dibromoanisole, 2,4,6-tribromoanisole, 6'-MeO-BDE47 and 2'-MeO-BDE68 in commercial and wild macroalgae. Commercial products were purchased from farms on the Swedish west coast (Skagerrak) and from other countries, wild macroalgae were harvested from Skagerrak and along the Norwegian coast in 2017-2018.<sup>4</sup> Extraction and analysis were conducted as described.<sup>4</sup>

In 12 commercial products comprising 9 species, the  $\Sigma_2$ BAs ranged from 0.01-6.7 ng/g wet weight (ww), while the  $\Sigma_2$ MeO-BDEs ranged from <10-138 pg/g ww. Ranges in 10 wild samples comprising 8 species were  $\Sigma_2$ BAs 0.4-68 ng/g wet weight (ww) and  $\Sigma_2$ MeO-BDEs <10-305 pg/g ww. In general, differences were greater among species than between commercial and wild. The same species of commercial and wild were analysed in four cases and levels of these HNPs were similar. Some bromophenolic HNPs bioaccumulate and have toxic effects: A survey of OH- and MeO-BDEs in the serum of Japanese women found compound profiles that were consistent with a diet of fish and macroalgae.<sup>5</sup> We suggest conducting a broader survey of these compounds in commercial and wild macroalgae and food products derived from them, and developing Certified Reference Materials for analytical quality control.

1. Banach, J.L. et al., 2022. *Foods* 11, 1514. 2. Hasselström, L. et al., 2020. *Nat. Sci. Rep.* 10, 1610. 3. Bidleman, T.F. et al., 2020. *Environ. Sci. Technol.* 54, 6468-6485. 4. Bidleman, T.F. et al., 2019. *Environ. Sci. Proc. Impacts* 21, 881-892, 5. Haraguchi, K. et al. 2016. *Environ. Internat.* 97, 155-162.

**(P-9)**

**VALIDATION OF A LC-MS/MS METHOD FOR THE QUANTIFICATION OF PHENANTHRENE METABOLITES IN HADDOCK EMBRYO**

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Much of the toxicity mediated by crude oil in the marine environment has been attributed to polycyclic aromatic hydrocarbons (PAHs). Although toxicity correlates closely with PAH exposures, the precise molecular initiating events have not been resolved. For many PAHs, the metabolites are reported to be more toxic than the PAHs themselves, including for phenanthrene, the prototypical 3-ring PAH. However, methods with the specificity and sensitivity for metabolite analysis in early life stage fish are limited.

We developed and validated a method using liquid-chromatography tandem mass spectrometry for the analysis of hydroxyl and dihydrodiol phenanthrene metabolites in Atlantic haddock embryos. The sample preparation consisted of phospholipid removal, solid-phase extraction, and quantitation using stable isotope-labelled internal standards.

Method linearity was demonstrated to be satisfactory by the application of suitable statistical diagnostic tools. Across the concentration range, the method provided relative standard deviations of 7% to 50% under repeatability conditions and 16 % to 78% under intermediate precision conditions. Initial bias, as quantified by recovery, ranged from 28% to 174% and is likely a cumulative effect from surrogate corrections and matrix effects. Moreover, as method linearity was deemed satisfactory, there was evidence for consistent bias, allowing the application of bias correction factors. LODs ranged from 0.05 to 0.12 ng/mL (equivalent to 1.15 to 2.75 ng/g wet weight). LOQs were determined to be satisfactory at 0.25ng/mL and 1 ng/mL (5.73 and 22.93 ng/g ww) for the monohydroxys. LOQs for the dihydrodiols were higher, at approximately 5 ng/mL and 10 ng/mL (115 and 229 ng/g ww). Method selectivity was deemed adequate on the basis of satisfactory accuracy.

Overall, the developed method will be used to help understand the role of PAH metabolites in crude oil toxicity in early life stage fish.

**(P-10)**

**METHANE AND TRACE GAS EMISSIONS FROM CLOSED LANDFILLS INVESTIGATED BY CAVITY RING-DOWN SPECTROSCOPY AND PROTON TRANSFER REACTION-MASS SPECTROMETRY FROM A MOBILE LABORATORY**

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Landfills emit gases into the atmosphere for several decades after their closure, due to the slow decomposition processes occurring in the landfill mass. Although the composition of the landfill gas may vary over time, the major constituents are usually methane, carbon dioxide and hydrogen sulfide. In addition to these, landfill gas contains a small fraction (> 1 %) of trace gases, which is a complex and diverse mixture of volatile organic gases and some inorganic species. The aim of this project is to investigate the methane and trace gas emissions from two closed landfills, Brånåsdalen avfallsdeponi in Lillestrøm and Grønmo avfallsdeponi in Oslo.

Two separate instruments were used to conduct the measurements, a cavity ring-down spectrometer for the detection of methane and a proton transfer reaction-mass spectrometer (PTR-MS) for the detection of trace gases. The instruments were installed in a custom-made car for mobile *in-situ* measurements at the landfill sites. Additionally, samples of the landfill gas were collected in cannisters and analyzed by PTR-MS in the laboratory to validate the benefit of *in-situ* measurements compared to conventional sample collection followed by *ex-situ* measurements.

Preliminary results suggest that compounds such as methanol, dimethyl sulfide and monoterpenes were present in the landfill gas, however the concentrations varied with sampling location, time, and temperature. Comparison of the two sampling methods suggested that *in-situ* and *ex-situ* measurements may give similar concentration values, however *ex-situ* measurements were more prone to sampling errors and impurities from the cannister.



(P-11)

## REDUCTION MECHANISM OF CHROMIUM (VI) IN HIGH ACIDIC NITRO-PHOSPHATE SOLUTIONS

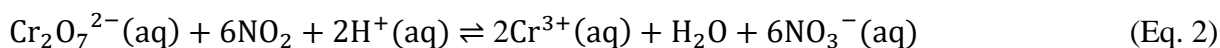
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Phosphorus fertilizers from sedimentary rock has become important in the recent years due to the depletion of phosphorus from igneous rock. However, these sedimentary rock sources can contain toxic impurities such as hexavalent chromium. Chromium in nature occurs predominantly in trivalent form (Cr(III)), but extensive use of chromium compounds results in progressive built-up of hexavalent chromium (Cr(VI)) leading to environmental contamination. Hence, chromium extraction from industrial solutions is of severe interest due to the high toxicity of Cr(VI) compounds. In comparison to Cr(III), Cr(VI) is 100 times more toxic, human carcinogen and it has high solubility in aqueous solutions and mobility in soil. Detection limits for Cr speciation with current analytical methods and variation of Cr species due to changing conditions of its media (e.g. pH, redox potential) makes it difficult to ensure the potential risks. Hence, maximum allowed total chromium concentration in drinking water is 0.05 mg/L (WHO).

Cr(VI) reduction by hydrochloric acid has been known since the discovery of the element by Vauquelin in 1797. Although the Cr(VI) reduction in strong oxidizing acids has been reported, there has not been a satisfactory reduction mechanism proposed. In this study, the reduction mechanism of Cr(VI) in acidic nitrate and nitro-phosphate solutions was investigated by measuring redox potential and UV-VIS spectra. Nitric acid and nitro-phosphate solutions were placed in a sealed batch type reactor, and Cr(VI) was added when desired temperature was reached. The reduction system is sensitive to light, air and changes in the partial pressure due to the decomposition of nitric acid (Eq. 1). In order to reduce large errors, present work is conducted using a sealed batch type reactor, where all measurements are made without opening the PTFE lid during the reduction.



This study attempts to improve our understanding of Cr speciation in high acidic and saline nitro-phosphate solutions. Consequently, the toxicity of the Cr contamination can be determined. The results show that Cr(VI) is not stable in these acidic nitrate solutions. Reduction of Cr(VI) species decreased with decreasing acid concentration, temperature, NO<sub>2</sub> concentration and absence of light. In view of these findings, the indirect reduction of Cr(VI) in acidic nitrate solutions is proposed (Eq. 2):



(P-12)

## MERCURY IN ORGANISMS EXPOSED TO MERCURY POLLUTION FROM U-864

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The German WW2 submarine U-864 was transporting a cargo of up to 67 tons of metallic mercury in its hull, when it was torpedoed and sunk by the British submarine *Venturer* off the coast of Norway in February 1945. In 2003, the wreck was found lying in two parts at about 150 m depth off the island of Fedje. Sediment sampling showed high concentrations of Hg on the seabed around the wreck parts, and an area of about 30000 m<sup>2</sup> was estimated to be significantly polluted. It is unknown how much Hg is still inside the wreck and how much has been spilled. Monitoring of Hg in seafood sampled around the wreck was initiated and since 2005, on behalf of the Norwegian Coastal Administration, annual monitoring has taken place around the wreck and at reference sites some distance from the wreck. Every year since 2008, samples of the demersal fish tusk (*Brosme brosme*) and the edible crab (*Cancer pagurus*) have been sampled using baited pots close to the wreck and approximately 4 nautical miles south of the wreck and 4 nautical miles north of the wreck. In 2016, a number of other organisms were also sampled near the wreck, using special fishing nets. Samples of edible tissues (fish fillet, claw meat and brown meat of crab) were analysed for total Hg (also Cd, As, Pb, Se) using ICP-MS after microwave digestion.

The results show that in muscle of fish, concentrations of Hg are similar to other locations at the south-west coast of Norway. Tusk is a species with a potential to accumulate high Hg levels, but still, levels are low compared to tusk sampled in fjords of western Norway. There is no indication of any increase over time. In brown meat or hepatopancreas of crab, high Hg concentrations have been found in some individual crabs. MeHg was not elevated, indicating that the crabs may have ingested the metallic Hg directly. Also, Hg isotopic analyses have shown that the Hg in hepatopancreas likely originates from U-864. There is no indication of any temporal increase of Hg concentrations in crab, although different sampling treatment over time makes a direct comparison challenging. All in all, the results show that the Hg surrounding U-864 is not much methylated and bioavailable, and that despite high Hg concentrations in the sediment this seems to affect seafood safety to a very low degree.

(P-13)

**DOM AND TURBIDITY REGARDING *IN SITU* MEASUREMENTS OF COMPENSATION DEPTHS VERSUS SECCHI DEPTHS IN LAKES**

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**Abstract**

Many boreal and hemiboreal lakes have had a distinct browning due to increased concentrations of allochthonous dissolved organic matter (DOM) over the past few decades. This increase in DOM has been linked to climate change, land use changes and the decline in acid rain. Climate change and land use changes also impact land erosion processes and the turbidity of rivers and lakes. We have examined a set of data from a lake district in Norway and looked for differences on how changes in DOM concentrations and turbidity have influenced measurements of Secchi depths (SD) and compensation depths (CD), using *in situ* measurements and integrated cores of water from 23 lakes in Southeastern Norway. CD was strongly influenced by light absorbance from allochthonous DOM, and relatively less by scattering caused by particles (turbidity). SD was in contrast relatively less affected by DOM. We also found that the CD:SD ratios were well explained by the ratios between DOM and turbidity ( $r^2 = 0.70-0.94$ ). Hence, by superimposing the recent increase in lake concentrations of allochthonous DOM in Southeastern Norway, the CD:SD ratios have most probably subsequently declined. Using long term series of SD to describe such as previous light regimes and estimates of primary production in lakes, should from this hence be done with care.



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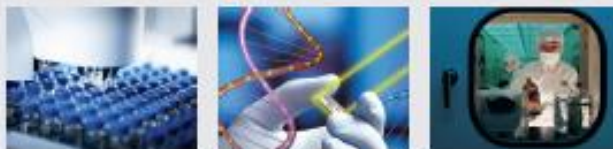
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