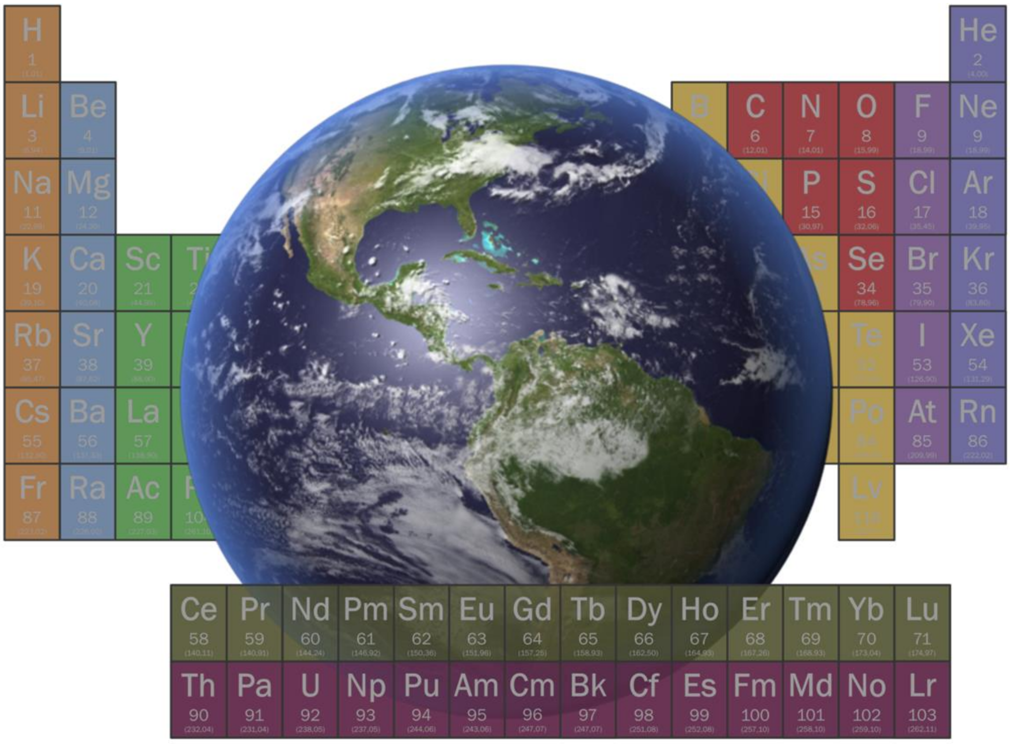
Norwegian Environmental Chemistry Symposium - NECS

NECS 2025

The Norwegian Environmental Chemistry Symposium 2025

10 March – 12 March
Vestlia Resort
Geilo, 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 2025) at Geilo.

This symposium builds upon a long-lasting tradition of Norwegian environmental chemistry conferences dating back to the annual winter meetings (1998 – 2013). In this tradition, NECS 2025 will provide an inspiring platform for interdisciplinary knowledge transfer and scientific discussions among Norwegian and international specialists. The NECS symposium is organised as an independent organisation under the auspices of the Norwegian Chemical Society's Division for Analytical Chemistry (NKS-FAK)

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 will attract you and complement the scientific endeavour. 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
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

Lindis Skipperud
Norwegian University of Life Sciences, Ås

General Information

Conference Desk

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

Sunday	9 March	15:00 – 20:00
Monday	10 March	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 18:00) (all included in their accommodation package).

Social Programme

Monday, 10 March 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 15 minutes in length, respectively (including discussion).

Posters

The posters should be mounted from Sunday afternoon in the poster area located in the lecture hall. 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.

Exhibitors

The following companies have registered for display and demonstration:

ThermoFisher
SCIENTIFIC

HOUM

LECO

Correspondence after the symposium

Yngvar Thomassen
National Institute of Occupational Health
Oslo, Norway
Tel: +47 23 10 53 20/+47 99510521
E-mail: Yngvar.Thomassen@stami.no

Scientific Programme:

Monday, 10 March 2025

Time **Abstract**

08:00-08:10

Welcome/Opening remarks
Roland Kallenborn: Conference Vice-Chair

Session I: Climate Change and the Environment

Session Chair: Yngvar Thomassen

08:10-08:40 **O-1**

Boreal biogeochemistry at the catchment level: Dissolved organic carbon as determinant of lake optics, lake metabolism and emissions of greenhouse gases
Dag O. Hessen, IBV, University of Oslo, Norway

08:40-09:10 **O-2**

Developing tools to study the climate impacts of a hydrogen economy: An ultrasensitive hydrogen analyzer and a tracer-based emission quantification method
Armin Wisthaler[1,2], Victoria Krohl[3], Tomas Mikoviny[1,2], Felix Piel[1], Malgven Roudot[3], Nikita Sobolev[2]
[1] Advanced Monitoring Solutions AS, Oslo, Norway
[2] Department of Chemistry, University of Oslo, Norway
[3] Equinor ASA, Stavanger, Norway

09:10-09:25 **O-3**

Is it possible to easily distinguish the effects of climate change and the decline in acid rain on trends in water chemistry?
Rolf D. Vogt[1], Øyvind Kaste[1], Jan-Erik Thrane[1], Areti Balkoni[1], François Clayer[1], Heleen de Wit[1], and Ann Kristin Schartau[2]
[1] Norwegian Institute for Water Research, Oslo, Norway,
[2] Norwegian Institute for Nature Research, Trondheim, Norway

Session II: Air Pollution

Session Chair: Lindis Skipperud

09:25-09:55 **O-4**

Polycyclic aromatic compounds – atmospheric fate and environmental exposure
Gerhard Lammel[1,2]
[1] Max Planck Institute for Chemistry, Multiphase Chemistry Dept., Hahn-Meitner-Weg 1, 55128 Mainz, Germany
[2] Masaryk University, Faculty of Science, RECETOX, Brno, Czech Republic

09:55-10:10 **O-5**

Investigating tire wear particles with online mass spectrometry
Nikita Sobolev, Felix Benjamin Blixt Hasle, Tomas Mikoviny, and Armin Wisthaler
Department of Chemistry, University of Oslo, Norway

10:10-10:40 **Coffee break, exhibition and poster viewing**

10:40-11:10 **O-6** **Occupational exposure to dust and quartz when drilling with tunnel boring machines in Oslo's new water supply tunnels**

Torunn K. Ervik, Kari Dahl, Mina Marthinsen Langfjord and Nils Petter Skaugset
National Institute of Occupational Health, Oslo, Norway

11:10-11:40 **O-7** **Identification of chemical and biological determinants, their sources, and strategies to promote healthier homes in Europe**

Pernilla Bohlin-Nizzetto[1], Maja Nipen[1], Alexander Håland[1], Jean Froment[1], Vasileios Salamalikis[2] and Pawel Rostkowski[1]
[1]NILU, Department of Environmental Chemistry and Health Effects, Kjeller, Norway
[2]NILU, Department of Urban Environment and Industry, Kjeller, Norway

11:40-12:10 **O-8** **Atmospheric microplastics in the Arctic and mainland Norway, occurrence, composition and sources**

Natascha Schmidt[1], Dorte Herzke[1], Dorothea Schulze[1], Sam Celentano[2], Are Bäcklund[2], Nikolaos Evangeliou[2], Sabine Eckhardt[2]
[1]NILU, Tromsø, Norway
[2]NILU, Kjeller, Norway

12:10-12:25 **O-9** **Mapping of airborne microplastics and endotoxins as a potential combined workplace hazard**

Alessio Gomiero[1], Kjell Birger Øysæd[1], Adrián Jaén-Gil[1], Bjørg Meling[2], Geir Skogerbø[2]
[1]Dep of Climate and Environment, Norwegian Research Centre (NORCE), Mekjarvik, Randaberg, Norway
[2] IVAR IKS, Stavanger, Norway

12:25-12:40 **O-10** **Land-sea-air exchange of natural halogenated compounds in Northern Sweden**

Terry Bidleman[1], Kathleen Agosta[1], Agneta Andersson[2,3], Sonia Brugel[2,3], Lars Ericson[2], Olle Nygren[4], Emma Shipley[5], Mats Tysklind[1], Penny Vlahos[5], Linda Zetterholm[1]
[1]Department of Chemistry, Umeå University (UmU), Umeå, Sweden; [2]Department of Ecology and Environmental Sciences, UmU, Umeå, Sweden; [3]Umeå Marine Science Centre, UmU, Hörnefors, Sweden; [4]Damina AB, Holmön, Sweden; [5]Department of Marine Sciences, University of Connecticut Avery Point, Groton, CT, U.S.A.

13:00 **Lunch**

Session III: The Arctic Environment

Session Chair: Roland Kallenborn

15:30- 16:00	**O-11**	**Arctic pollution – new approaches to identifying emerging concerns** Katrin Vorkamp Aarhus University, Department of Environmental Science, Roskilde, Denmark
16:00- 16:30	**O-12**	**Persistent organic pollutants (POPs), emerging contaminants, metals, and energy in the Barents Sea food chain** [1]Meier S.,[1]Frantzen S.,[1]Wiech M.,[1]Ali A.M.,[1] Valdersnes S.,[1]Nilsen, B.M.,[1] Varunjikar M.S.,[1]Boitsov S.,[2]Jensen H.K.B.,[3]Close H.,[1]Aguirre G.E.,[1]Bagøien E.,[1]Lindstrøm U., [1]Sanden, M. [1]Institute of Marine Research, Bergen, Norway. [2]Geological Survey of Norway, Trondheim, Norway. [3]Rosenstiel School of Marine and Atmospheric Science, University of Miami, Miami, Florida, USA.
16:30- 17:00	**O-13**	**From the Cold War to the present day: The legacy of the sunken nuclear submarine Komsomolets** Justin P. Gwynn[1], Hilde Elise Heldal[2], Andrey Volynkin[2], Hans-Christian Teien[3], Simon Jerome[3], Ole Christian Lind[3] [1] Norwegian Radiation and Nuclear Safety Authority, Tromsø, Norway [2] Institute of Marine Research, Bergen, Norway [3] Norwegian University of Life Sciences, Norway
17:00- 17:30		**Coffee break, exhibition and poster viewing**
17:30- 17:45	**O-14**	**Three decades of Arctic pollution research and monitoring - steps towards solutions** Lars-Otto Reiersen[1], Katrin Vorkamp[2], Arja Rautio[3], Christian Sonne[4], Roland Kallenborn[5], Jon Øyvind Odland[6] [1]Arctic Knowledge AS, Oslo, Norway [2]Aarhus University, Department of Environmental Science, Roskilde, Denmark [3]University of Oulu, Arctic Health, Oulu, Finland [4]Aarhus University, Department of Ecoscience, Roskilde, Denmark [5]University of Life Sciences, Faculty of Chemistry, Biotechnology and Food Science, Ås, Norway [5]Nord University, Faculty of Biosciences and Aquaculture, Bodø, Norway
17:45- 18:00	**O-15**	**Four-year study of microplastics in the fjords of Svalbard and in the open waters of the Arctic** Svetlana Pakhomova, Anfisa Berezina and Evgeny Yakushev Norwegian Institute for Water Research, Oslo, Norway.

18:00-18:15 **O-16** **Changes of soil organic matter along thaw transects of permafrost peat plateaus in Finnmark, Norway**
Mats R. Ippach[1,2], Anfisa Pismeniuk[1,2], Frans-Jan W. Parmentier[1,2], Rolf D. Vogt[2,3], Sebastian Westermann[1,2], Helge Hellevang[1,2]
[1] Department of Geosciences, University of Oslo, Norway,
[2]Centre of Biogeochemistry in the Anthropocene, University of Oslo, Norway
[3]Norwegian Institute for Water Research, Oslo, Norway

18:15-18:30 **O-17** **Analyses of PFAS, inorganic arsenic and methylmercury in selected seafood samples**
Sylvia Frantzen, Stig Valdersnes, Martin Wiech and Monica Sanden
Institute of Marine Research, Bergen, Norway

18:30-19:10 **Vendor Session**
Presentations from HOUM AS, LECO AB and Thermo Fisher Scientific

V-1
PFAS screening with combustion-IC
Hanne Svergja[1], Jan Schäffer[1] and Takuro Kato[2]
[1] Houm AS, Oslo, Norway
[2] Nittoseiko Analytech Europe GmbH, Düsseldorf, Germany

V-2
Innovative PFAS analysis – from automated sample preparation to confident quantitation using LC-HRMS
Bénédicte Gauriat[1], Aristide Ganci[1], Tony Wikilund[2], Jean-François Garnier[1]
[1]Thermo Fisher Scientific, Villebon/Yvette, France
[2]Thermo Fisher Scientific, Stockholm, Sweden

19:10 **Informal Get-together**

20:00 **Dinner**

Tuesday, 11 March, 2025

Time **Abstract**

Session IV: Modelling and Monitoring

Session Chair: Rolf D. Vogt

08:15-08:45 **O-18** **Modelling environmental exposure to micro- and nano-plastic with open source mass balance models**
Matthew MacLeod[1], Xiaoyu Zhang[1], Karen Larkina[2], Claudio Linhares[2], and Maria del Prado Domercq[1]
[1]Department of Environmental Science, Stockholm University, Sweden
[2]InfraVis, Linnaeus University, Sweden

08:45-09:15 **O-19** **Automatic trace metal monitoring: Electrochemical sensors for real-time environmental analysis**
Øyvind Mikkelsen and Ingrid Naterstad Haugen
Department of Chemistry, NTNU, Trondheim, Norway

09:15-09:30 **O-20** **Environmental impact of plastic leachates in terrestrial environments: An effect-based study at Lisle Lyngøyna**
Adrián Jaén-Gil[1], Lúcia H.M.L.M. Santos[2], Veslemøy Navrestad[1], Emanuela Frapiccini[3], Sara Rodriguez-Mozaz[4] and Alessio Gomiero[1]
[1]NORCE Norwegian Research Centre, Randaberg, Norway
[2]Institute of Natural Resources and Agrobiology of Salamanca (IRNASA-CSIC), Spain
[3]Institute for Biological Resources and Marine Biotechnologies, Ancona, Italy
[4]Catalan Institute for Water Research (ICRA-CERCA), Girona, Spain

09:30-09:45 **O-21** **Progress achieved in EURAMET project 21GRD09 MetroPOEM: Metrology for the harmonisation of measurements of environmental pollutants in Europe**
Simon Jerome[1] *and others, see abstract*
[1] Norwegian University of Life Sciences, Ås, Norway

09:45-10:00 **O-22** **Understanding the pollution composition and dispersion from an old landfill to the environment through a suspect screening approach: the Brånåsen case**
Luigi Mastrodonato[1], Sara Abdelli[2], Vian Yasin[2], Niroshan Gajendra[2], Sissel O. Viig[2], Paola Calza[1], Davide Vione[1], Laura Ferrando-Climent[2]
[1] Univeristat di Torino, Via Verdi, 8 - 10124 Turin, Italy
[2] Institute for Energy Technology, Instituttveien 18, 2007 Kjeller, Norway

10:00-10:15 **O-23** **Seasonal monitoring of per- and polyfluoroalkyl substances (PFAS) in surface waters and implications for Managed Aquifer Recharge systems**
Tabea Mumberg[1,2], Lutz Ahrens[3], Dolly Kothawala[4], Philip McCleaf[5], Britt-Marie Pott[6], and Philipp Wanner[1,2]
[1]Department of Earth Sciences, University of Gothenburg, Sweden
[2]Centre for Future Chemical Risk Assessment and Management (FRAM) in Gothenburg, University of Gothenburg, Sweden
[3]Department of Aquatic Sciences and Assessment, Swedish University of Agricultural Sciences (SLU), Uppsala, Sweden
[4]Department of Ecology and Genetics - Limnology, Uppsala University, Evolutionary Biology Centrum (EBC), Uppsala, Sweden
[5] Uppsala Water and Waste Ltd, Uppsala, Sweden
[6] Southern Sweden Water Supply Ltd., Malmö, Sweden

10:15-10:45 **Coffee break, exhibition and poster viewing**

Session IV: The Aquatic Environment

Session Chair: Georg Becher

10:45-11:15 **O-24** **The Oslo Fjord environmental status, challenges and perspectives**
Andre Staalstrøm, NIVA, Oslo, Norway

11:15-11:45 **O-25** **Circular waste and wastewater management technologies for a sustainable aquaculture industry**
Nazli Pelin Kocatürk Schumacher
Norwegian University of Life Sciences, Ås, Norway

11:45-12:15 **O-26** **Lowering bioavailability with carbonaceous materials: From science to large-scale applications**
Gerard Cornelissen[1,2], Erlend Sørmo[1], Espen Eek[1], Hans Peter Arp[1,3]
[1]The Norwegian Geotechnical Institute, Oslo, Norway
[2]Norwegian University of Life Sciences (NMBU), Ås, Norway
[3]Norwegian University of Science and Technology (NTNU), Trondheim, Norway

12:15-12:30 **O-27** **Chemicals of emerging concern (CECs) in coastal waters**
Roland Kallenborn[1], Aasim A. Ali [2], Yi-Fan Li[3]
[1]Faculty of Chemistry, Biotechnology and Food Sciences, Norwegian University of Life Sciences, Ås, Norway
[2]Marine Research Institute, Bergen, Norway
[3]Dalian Maritime University (DMU), Dalian, PR China

12:30-12:45 **O-28** **Integrated assessment of pollution sources of metals and PFAS in Smålandsfarvandet, Denmark**
Martin M. Larsen, Sabrina J. Hvid, Jakob Strand, Zhanna Tairowa, Janus Larsen and Maria Maar
AU Ecoscience, DK-4000 Roskilde

12:45-13:00 **O-29** **Determination of nanoparticles and elements in blue mussels (*mytilus edulis*) along the Norwegian coastline**
Are Sæle Bruvold[1], Stig Valdersnes[1,2], André Marcel Bienfait[1], Monica Sanden[1] and Katrin Loeschner[3]
[1] Institute of Marine Research (IMR), Bergen, Norway
[2] Department of Chemistry, University of Bergen, Norway
[3] National Food Institute, Technical University of Denmark, Kgs Lyngby, Denmark

13:00 **Lunch**

Session IV: The Aquatic Environment *cont.*

Session Chair: Georg Becher

17:00-17:15 **O-30** **Demonstration of *in situ* real-time monitoring of PAHs from produced water in the North Sea –enhance selectivity and sensitivity with membrane extraction**
Espen Eek[1], Christian Totland[1], Stephen Hayes[1], Bent Frode Buraas[1], Axel Walta[1], Ivar-Kristian Waarum[1], Erlend Leirset[2], Harald Lura[3], Rolf Christian Sundt[4], Arne Pettersen[1], Nicolas Estoppey[1], Gerard Cornelissen[1,5]
[1]Norwegian Geotechnical Institute, Oslo, Norway
[2]Norsk Elektro Optikk AS, Oslo, Norway
[3]ConocoPhillips Skandinavia AS, Tananger, Norway
[4]Equinor ASA, Stavanger, Norway
[5]NMBU, Ås, Norway

17:15-17:30 **O-31** **Elevated levels of mercury and POPs in demersal fish from Ytre Sklinnadjupet, an open sea area in the Norwegian Sea**
Bente M. Nilsen, Sylvia Frantzen[1], Quang Tri Ho and Stepan Boitsov,
Institute of Marine Research, Bergen, Norway

17:30- 17:45	**O-32**	**A software toolkit to facilitate FAIRification of chemical pollution monitoring data** Sam A. Welch, Walter Zobl, and Knut Erik Tollefsen Norwegian Institute for Water Research, Oslo, Norway
17:45- 18:15		**Coffee break, exhibition and poster viewing**

Session IV: Human Health and Environmental Pollutants

Session Chair: Yngvar Thomassen

18:15- 18:45	**O-33**	**Time trends in the chemical exposome measured with human biomonitoring** Cathrine Thomsen[1] and Amrit K. Sakhi[1] [1] Norwegian Institute of Public Health, Oslo, Norway
19:00		**Dinner**

Wednesday, 12 March, 2025

Session V: Risk Assessment and Fate of Environmental Pollutants

Session Chair: Oddvar Røyset

Time	**Abstract**	
08:15- 08:45	**O-34**	**Transport of pesticides in the environment** Roger Holten[1, 2] [1]Norwegian Institute of Bioeceonomy Research, Ås, Norway [2]Norwegian University of Life Sciences, Ås, Norway
08:45- 09:00	**O-35**	**Risk governance of per- and polyfluroalkyl substances (PFAS) as a chemical class** Xenia Trier[1], Anna Kärrman[2] and Stefan van Leeuwen[3] [1]University of Copenhagen, Denmark [2]University of Örebro, Sweden [3]Wageningen Food Safety Research, Amsterdam, The Netherlands
09:00- 09:15	**O-36**	**Next generation risk assessment (NGRA) of chemicals and chemical mixtures** Knut Erik Tollefsen, Sam Welch, Li Xie, Walter Zobl and Viviane Girardin Norwegian Institute for Water Research, Oslo, Norway
09:15- 09:30		**Coffee break, exhibition and poster viewing**

09:30-09:45 **O-37** **Fate of PFAS and other contaminants in full scale relevant pyrolysis of organic wastes**

Erlend Sørmo[1,2], Gerard Cornelissen[1,2], and Hans Peter H. Arp[1,3]
[1]Norwegian Geotechnical Institute (NGI), Oslo, Norway
[2]Norwegian University of Life Science (NMBU), Ås, Norway
[3]Norwegian University of Science and Technology (NTNU), Trondheim, Norway

09:45-10:00 **O-38** **Bioaccumulation and effects of legacy and novel PFAS in blue mussels exposed to an extract of AFFF impacted soil**

Camilla Kirkeli[1], Stig Valdersnes[1,2], Bjørn Einar Grøsvik[2], and Aasim Ali[2]
[1] University of Bergen, Department of Chemistry, Bergen, Norway
[2] Institute of Marine Research, Bergen, Norway

10:00-10:15 **O-39** **Identification, relative uptake, and effects of PFAS from AFFF and AFFF-impacted soil in Atlantic Salmon Hepatocytes**

Aasim M. Ali[1], Stig Valdersnes[1,2], Eveline Munnikhof[3,4], Kai Kristoffer Lie[1], Liv Søfteland[1]
[1]Institute of Marine Research, Bergen, Norway
[2]University of Bergen, Department of Chemistry, Bergen, Norway
[3]Department of Marine Toxicology at the Institute of Marine Research, Bergen, Norway
[4]Department of Aquaculture and Fisheries at the Wageningen University and Research, The Netherlands

10:15-10:30 **Closing remarks and farewell**

12:00 **Lunch**

Poster Presentations

Abstr.

P-1 **Unravelling tire wear particles in the atmosphere: On the of use of PTR-MS for detecting rubber additives as marker compounds**
Felix Benjamin Blixt Hasle, Nikita Sobolev, Tomas Mikoviny, and Armin Wisthaler
Department of Chemistry, University of Oslo, Norway

P-2 **Emission profiles of polycyclic aromatic Compounds (PAHs and their major transformation products) from energy production in Longyearbyen, Svalbard**
Thea Louise Tingstad[1], Krystyna Koziol[2], Xize Min[3] and Roland Kallenborn[1]
[1]Norwegian University of Life Sciences, Ås, Norway
[2]Faculty of Geographical Sciences, Kazimierz Wielki University, Bydgoszcz, Poland
[3]Harbinn Institute of Technology (HIT), School of Environment, Hq arbin PR China

P-3 **Advanced quantification of tire ware additives: 6PPDQ as an example**
Maren Krog, Fedor Kryuchkov, Roland Kallenborn and Tomasz Ciesielski
Norwegian University of Life Sciences, Ås, Norway

P-4 **Introduced changes in pH and reduction-oxidation potential in mire soils from discontinued firing range of Vaterholmen camp in Verdalen, Norway**
Bendik Brodshaug and Bjørn Frengstad
Norwegian University of Science and Technology, Trondheim, Norway

P-5 **Carbon and organic matter cycling in soil and soilwater in Boreal and Subarctic ecosystems**
Sunniva Bratli Sheffield[1], Mats Rouven Ippach[2], Armin Wisthaler[1],
Helge Hellevang[2], Frans-Jan Parmentier[2] and Rolf David Vogt[3]
[1] Department of Chemistry, University of Oslo, Norway
[2] Department of Geosciences, University of Oslo, Norway
[3] Norwegian Institute for Water Research, Oslo, Norway

P-6 **Air-surface exchange of halomethoxybenzenes in Northern Sweden**
Terry Bidleman[1], Kathleen Agosta[1], Agneta Andersson[2,3], Sonia Brugel[2,3], Lars Ericson[2], Olle Nygren[4], Emma Shipley[5], Mats Tysklind[1] and Penny Vlahos[5]
[1]Department of Chemistry, Umeå University, Sweden
[2]Department of Ecology and Environmental Sciences, UmU, Umeå, Sweden
[3]Umeå Marine Science Centre, UmU, Hörnefors, Sweden
[4]Damina AB, Holmön, Sweden
[5]Department of Marine Sciences, University of Connecticut Avery Point, U.S.A.

P-7 **Active air sampling with polyurethane foam: Comparing field observations with a breakthrough model**
Terry F. Bidleman[1], Fiona Wong[2], Helena Dryfhout-Clark[2], Hayley Hung[2] and Mats Tysklind[1]
Department of Chemistry, Umeå University, Sweden
Air Quality Processes Research Section, Environment and Climate Change Canada, Toronto, Canada

P-8 **The potential role of epigenetic biomarkers in risk management of occupational exposure to Cr(VI)**

Jelle Verdonck[1], Manosij Ghosh[1], Katrien Poels[1], Lode Godderis[1,2], Beata Janasik[3], Paul T. J. Scheepers[4], Sophie Ndaw[5], Radia Bousoumah[5], An Van Nieuwenhuyse[1,6], Radu Corneliu Duca[1,6], Susana Viegas[7], Henriqueta Louro[8], Maria João Silv[8], Simo P. Porras[9], Tiina Santonen[9], Wojciech Wasowicz[3] and HBM4EU Chromates Study Team
[1] KU Leuven (University of Leuven), Belgium
[2] IDEWE, External Service for Prevention and Protection at Work, Belgium
[3] Nofer Institute of Occupational Medicine, Poland
[4] Radboudumc, Netherlands
[5] French National Research and Safety Institute, France
[6] Laboratoire National de Santé (LNS), Luxembourg
[7] Universidade NOVA de Lisboa; Comprehensive Health Research Center (CHRC), Portugal
[8] National Institute of Health Dr. Ricardo Jorge; Universidade NOVA de Lisboa, Portugal
[9] Finnish Institute of Occupational Health, Helsinki, Finland

P-9 **The fate of heavy metals in the environment of e-waste sites**

Jelle Verdonck[1], Katrien Poels[1], Erik Smolders[1], Jeroen Vanoirbeek[1] and Lode Godderis[1,2]
[1] KU Leuven (University of Leuven), Belgium
[2] IDEWE, External Service for Prevention and Protection at Work, Belgium

P-10 **Screening of PFAS in wastewater and sewage sludge from WWTPs in Bergen, Norway**

Are Sæle Bruvold[1], Nachiket Marathe, Didrik Grevskott, Nawaf Al Shehri[2], Stig Valdersnes[1], Aasim M. Ali[1]
[1] Institute of Marine Research, Bergen, Norway
[2] Department of Marine Chemistry, King Abdulaziz University, Jeddah, Saudi Arabia

P-11 **Synthesis and testing of catalysts for green ammonia production**

Tina Eliassen Valøen[1], Leif Eric Hertwig[1], Jonas Himmelstrup[1] and Vidar Remi Jensen[1]
[1] Department of Chemistry, University of Bergen, Norway

P-12 **Challenges and advances in the detection and quantification of neutral per- and polyfluoroalkyl substances (PFCs)**

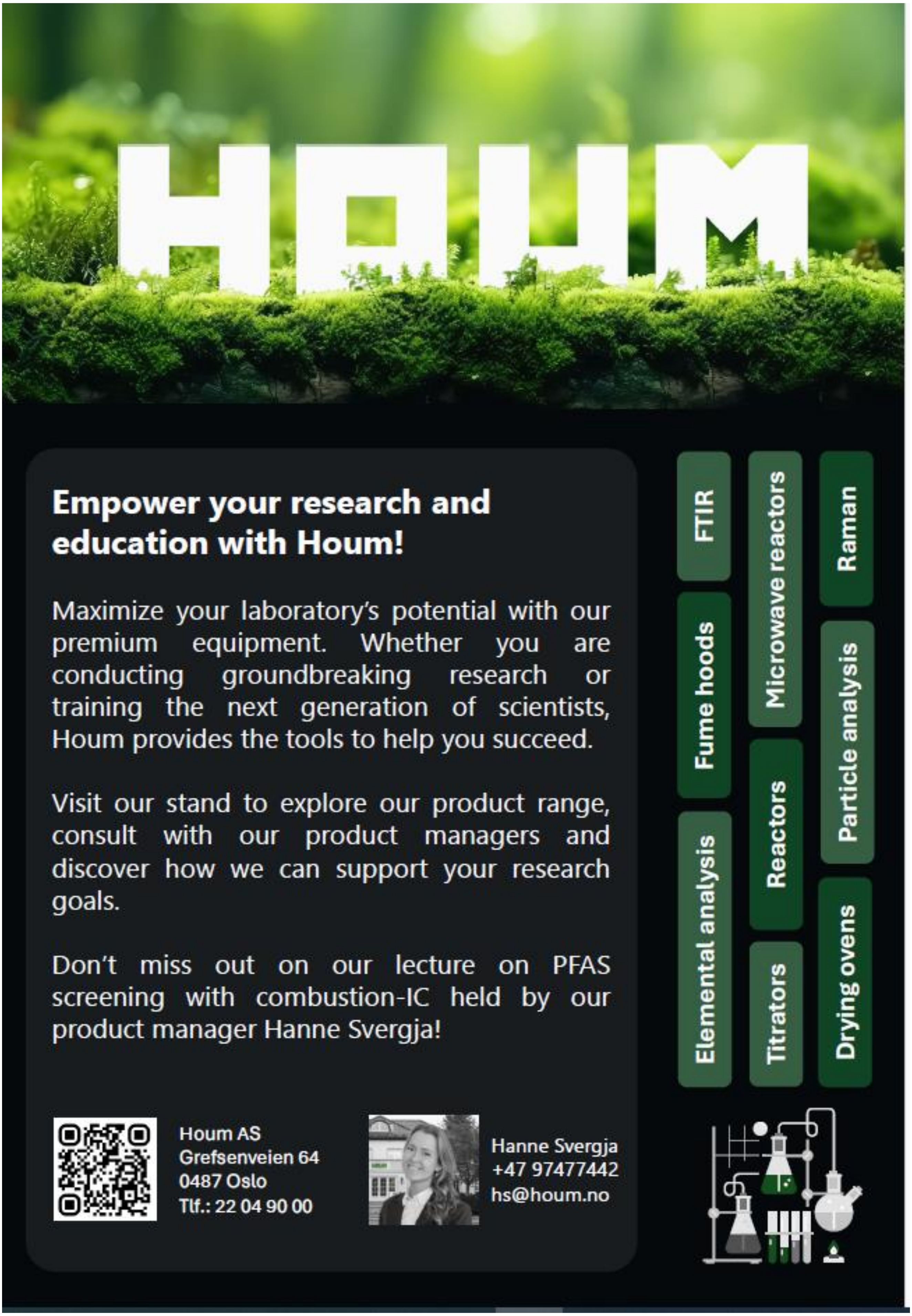
Fedor Kryuchkov[1], Aasim M. Ali[2] and Roland Kallenborn[1],
[1] Norwegian University of Life Sciences, Ås, Norway
[2] Institute of Marine Research, Bergen, Norway

P-13 **Non-targeted screening of household dust for PFAS and other pollutants using GCxGC-HR-TOF-MS and scaled mass defect plots**

Linus Sveberg and Lennart Schwartz,
Leco, Sweden

P-14 ENCORE: a probabilistic framework for environmental co-exposure and risk estimation

Jannicke Moe[1], Karel P.J. Viaene[2], Karel Vlaeminck[2], Jos Van Gils[3], Merete Grung[1], Samantha Martins[1], Sophie Mentzel[1], Anders L. Madsen[4, 5], Luka Snoj[6], Gašper Šubelj[6], Frederik Verdonck[2]
[1]Norwegian Institute for Water Research, Oslo, Norway
[2]ARCHE Consulting, Ghent (Wondelgem), Belgium
[3]Deltares, Delft, The Netherlands
[4]HUGIN EXPERT AS, Aalborg, Denmark
[5]Department of Computer Science, Aalborg University, Denmark
[6]TC Vode, Ljubljana, Slovenia




LECO

Oral Abstract

O-1

Boreal biogeochemistry at the catchment level: Dissolved organic carbon as determinant of lake optics, lake metabolism and emissions of greenhouse gases.

Dag O. Hessen, IBV, University of Oslo

The presentation will focus on the large Biogov project at UiO, a collaborative effort between the institutes of Bioscience, Chemistry, Geoscience as well as NMBU and NIVA. The project primarily assess the mobilization of soil organic carbon (C) in the boreal biome as a consequence of warming and changes in precipitation, soil acidity, growing forest biomass (greening), and thawing of permafrost. The microbial transformation of C-stores is prone to boost greenhouse gas (GHG) emissions, while thawing and increased precipitation will affect the flux of organic matter (OM) into lakes. However, knowledge gaps on sensitivities of C cycling to climate change and shifts in ecosystem traits restrict our ability to make robust predictions of GHG trajectories using Land System Models (LSM). In particular, microbial and geochemical controls of OM processing under expected ecosystem transitions are poorly understood.

BioGov aims to provide a process-based understanding of how organic C from biomass is processed and determine the fate of organic matter how this is related to catchment properties, regarding its conversion to GHG, including its transport along a land to water continuum at various spatial and temporal scales. This project links terrestrial, aquatic and atmospheric processes, and unifies researchers from biology, geosciences and chemistry with modelers to address these complex issues of vital importance to climate and ecosystems. It also involves analysis at various spatial and temporal scales, from genetic analysis to remote sensing.

The presentation will give examples on main findings regarding mobilization and flux of organic C and other key elements to lakes, and how it affects optical properties and production of recipient waters, including coastal waters, and not the least how this process pose feedbacks to the climate by microbial production of GHGs; CO_2, CH_4 and N_2O.

O-2

Developing tools to study the climate impacts of a hydrogen economy: An ultrasensitive hydrogen analyzer and a tracer-based emission quantification method

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Efforts to mitigate global warming hinge on substantially reducing emissions of greenhouse gases, particularly carbon dioxide (CO_2) and methane (CH_4). Achieving these reductions requires a broad transformation of the global economy, in which hydrogen (H_2) is envisioned to play an important role as an important energy carrier. However, the anticipated widespread deployment of hydrogen technologies is expected to increase atmospheric hydrogen emissions through processes such as intentional venting and unintentional fugitive releases.
While hydrogen itself is not an infrared-absorbing gas, studies indicate that its increased presence in the atmosphere can still result in a net warming effect. This occurs through several mechanisms. First, hydrogen reacts with hydroxyl (OH) radicals, thereby slowing the removal of methane -a potent greenhouse gas- and effectively prolonging methane's atmospheric residence time. Second, hydrogen can lead to the formation of ozone (O_3), which is also a greenhouse gas. Lastly, when hydrogen migrates into the stratosphere, it is oxidized to form additional water vapor (H_2O), a process that can also lead to increased heat-trapping in the atmosphere.

Increased hydrogen levels in the atmosphere could thus offset some of the anticipated climate benefits of moving away from fossil fuels. Current model estimates of hydrogen's warming impact range from minimal to significant, reflecting substantial uncertainty around hydrogen leakage rates - values that remain unknown and heavily reliant on assumptions. This uncertainty arises partly from the absence of large-scale hydrogen infrastructure, which makes it difficult to measure realistic leak rates, and from limited progress in developing measurement technologies designed specifically for quantifying hydrogen emissions to the atmosphere.
Equinor, a prominent leader in the energy transition, is proactively exploring how increased hydrogen emissions to the atmosphere could reduce the expected climate benefits of a hydrogen-based energy system. In pursuit of this goal, Equinor has provided support to Advanced Monitoring Solutions (adMS) in the development of an ultrasensitive, highly precise (sub-ppb) mass spectrometry–based hydrogen analyzer, along with a new measurement strategy centered on tracer gases that present minimal environmental and climatic impacts. Collaborating with the University of Oslo (UiO), adMS conducted demonstration trials that confirmed the effectiveness of these novel analytical approaches. Building on this success, the team also completed a hydrogen emission quantification study at a hydrogen production and processing facility, offering valuable insight into potential leakage levels and informing risk mitigation efforts for the expanding hydrogen economy.

O-3

Is it possible to easily distinguish the effects of climate change and the decline in acid rain on trends in water chemistry?

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The study investigates whether trends in climate variables - such as precipitation, runoff, temperature, and actual evapotranspiration (AET) - can explain changes in water chemistry in 78 Norwegian lakes from 1990 to 2020. AET has increased significantly in almost all catchments, but there are large discrepancies between modelled and calculated AET. Temperature has also risen significantly at 79 % of the stations, while precipitation and runoff show significant trends in only 15 and 19 lakes, respectively. This is reflected in the explanatory power of these variables for changes in water chemistry.

Differences in climate trends correlate spatially and temporally with the decline in acid rain, making it challenging to distinguish the effects of these drivers in simple correlation analyses. The explanatory power of trends in climate parameters on water chemistry trends is generally weak. However, through multivariate RDA, we find a non-significant indication that increases in precipitation and runoff may have an opposite effect to temperature increases on water chemistry trends.

The presentation is based on a recent (4 - 2024) article in the Norwegian journal VANN. Read VANN digitally here - Vannforeningen

O-4

Polycyclic aromatic compounds – atmospheric fate and environmental exposure

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Many polycyclic aromatic hydrocarbons (PAHs) and their nitrated (NPAHs), oxygenated (OPAHs) and halogenated (XPAHs) derivatives are toxic and ecotoxic. NPAHs and OPAHs are co-emitted with PAHs from fossil fuel and biomass combustion processes, or are formed in photochemical and microbiological reactions of PAHs in air and soil. Despite laboratory and field studies of these pollutants' sources, photochemistry and occurrence in air, little is known about atmospheric lifetimes and environmental fate on large spatial scales. As semi volatiles resisting biodegradation in soils and surface waters, their long-range transport potential is enhanced by multihopping (grasshopper effect).

Features of large-scale distributions and atmospheric cycling of selected PAHs and NPAHs are highlighted based on recent advances in modelling of sources, transports and photochemistry. Some PAHs and OPAHs are found to be globally distributed, but overall, little is known about large-scale distributions and exposure of remote environments, including the open oceans. The multihopping potential was explored in soils of source and receptor sites, and in surface seawater. Because of neglected re-emissions (secondary sources), PAH emission inventories may be underestimated, in particular in receptor areas.

O-5
Investigating tire wear particles with online mass spectrometry

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Tire wear particles (TWP) represent a critical source of microplastic pollution, with global emissions estimated to reach millions of tons per year. The growing adoption of electric and hybrid vehicles, whose high instant torque at start-up can accelerate tire wear, further amplifies concerns about TWP's potential effects on both human health and the environment. Although much of the existing research has focused on TWPs in aquatic environments, there is a growing need to understand their presence and impacts in the atmosphere.

A principal challenge in studying atmospheric TWPs lies in their complex chemical composition, which includes a variety of polymers, additives, and inorganic fillers. Their makeup and mixing ratios can vary significantly even within a single manufacturer, complicating both qualitative and, especially, quantitative analyses. This underscores the need for an optimal analytical approach. Current methods, such as Fourier-transform infrared spectroscopy (FTIR) and thermal desorption or pyrolysis-gas chromatography-mass spectrometry (GC-MS) provide valuable insights but may lack the sensitivity and selectivity needed for airborne TWP, which can usually be less than one micron in size. Furthermore, matrix effects from other atmospheric particles can obscure or overwhelm TWP signals.

Proton-transfer-reaction mass spectrometry (PTR-MS) offers a promising alternative, providing both high sensitivity and selectivity, along with the capability for real-time measurement – an advantage for tracking the sources and fate of TWP in the atmosphere. In this work, we explore two PTR-MS-based strategies. First, we analyze bulk tire polymers using a custom-built, precise temperature-controlled pyrolysis method, which enables the detection of characteristic thermal decomposition products (e.g., polyisoprene, polybutadiene, polystyrene-polybutadiene). Next, we investigate key organic additives that can serve as distinctive "fingerprint" markers, enhancing quantitative capabilities and reducing false-positive signals from outdoor air. For this purpose, we combine headspace on-filter sample analysis with a proposed online approach targeting nanosized TWP.

These complementary strategies pave the way for semi-continuous and real-time TWP monitoring in the atmosphere, offering a more comprehensive understanding of their distribution and potential impacts. Ultimately, the insights gained from these methods could inform more effective environmental monitoring and mitigation measures, helping to address the growing challenge of TWP pollution.

O-6

Occupational exposure to dust and quartz when drilling with tunnel boring machines in Oslo's new water supply tunnels

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Fine mineral dust is produced when the bedrock is excavated by tunnel boring machines (TBMs). Depending on petrology, the mineral dust that the TBM workers are exposed to may contain quartz particles. The finest particles can be inhaled into the alveolar region of the lung and are called respirable particles. Long-term exposure to respirable quartz particles can eventually lead to adverse lung diseases.

Currently, two TBMs are drilling from either side of a 20-kilometer water supply tunnel in Oslo. Rhomb-porphyry, shale, and limestone are among the igneous and sedimentary rocks that predominate in this region. Respirable dust and quartz exposure measurements have been performed for workers on the TBMs. In addition, stationary equipment, including an aerodynamic particle sizer (APS), has been used to measure particle concentrations in the tunnel. To date, 180 person-borne respirable dust samples have been collected during 5 sampling campaigns spread over autumn 2023 - autumn 2024. Material samples of the bedrock have also been collected. The dust collected with respirable samplers and the material samples have been analyzed for quartz content using X-ray diffraction (XRD).

The preliminary results show that for the first five sampling campaigns, the geometric mean (GM) for the concentration of respirable dust was 0.53 mg/m^3, whereas the GM concentration for quartz was 0.016 mg/m^3. There are, however, large variations, which may be caused by different degrees of drilling throughout the shift, varying work tasks and differences in quartz content in the bedrock as the TBM advances. The APS measurements demonstrated that TBM drilling activities influenced the particle concentrations in the tunnels. The respirable dust contained an average of 3.1% quartz, and this was comparable to the quartz percentage measured in the collected rock samples.

It is important to note that even relatively low quartz contents in the rock can have an impact on exposure concentrations of respirable quartz. The quartz concentrations in the tunnel may also be influenced by the quartz content of drilling in the concrete segments and from handling pea gravel.

O-7

Identification of chemical and biological determinants, their sources, and strategies to promote healthier homes in Europe (INQUIRE)

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Air pollution has been identified as a driver for early death risk, and air quality standards for a range of pollutants in outdoor air have thus been established. However, the indoor environment may be more relevant for human exposure to pollutants as European citizens spend up to 90% of their time indoors, and concentrations of many air pollutants are higher indoors than in urban outdoor air. Existing indoor air quality (IAQ) guidelines are limited, and there is an evidence-based consensus that the determinants of IAQ are more numerous and complex than the existing guidelines account for.

To address this, the Horizon Europe funded project INQUIRE is committed to investigate the impact of chemical and biological factors on indoor air quality and to develop strategies to promote healthier homes across Europe. We do this by deploying a comprehensive R&I program in homes with young children across eight diverse European countries plus Australia. The monitoring combines i) non-intrusive measurements in residential indoor environments using IAQ sensor data, passive air samples for volatile and semi-volatile organic compounds (indoors and outdoors), collection of settled dust and urine samples, with ii) gathering of personal and house-specific data. Supplemental sampling will be conducted to identify sources of the chemical and biological determinants by screening three source categories: i) The outdoor environment. ii) The built structure, and iii) Furnishings, consumer products, and personal behaviors. The collected samples will undergo suspect and nontarget screening for volatile and semi-volatile organic chemicals and microbiome, and target analysis of chemicals and allergens. Comprehensive toxicological effect-studies, including in-vitro effect screening and assessment of respiratory toxicity, endocrine disruption, and impaired immunity; along with in-vivo validation of local and systemic toxicity effects, will be carried out. Adverse Outcome Pathways (AOPs) and virtual Effect-Directed Analysis (EDA) will be applied to apportioning risk to its main determinants. Following up on the initial phase, homes will be revisited to implement strategies for improving IAQ based on air purifier and ventilation systems, behavioral changes, renovations, and use of consumer products.

The findings from INQUIRE aim to resolve knowledge gaps on the identity, sources, exposure and health risks of hazardous chemical and biological determinants in residential indoor environments and provide effective strategies to reduce the risk for residents. All data generated in the study will be made available as FAIR data.

O-8

Atmospheric microplastics in the Arctic and mainland Norway, occurrence, composition and sources

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Small microplastic (MP) particles can be subject to atmospheric transportation or wash out of the atmosphere during precipitation. A growing amount of evidence suggests that MPs are ubiquitous in the air as they are in other environmental compartments, such as the marine environment. However, little is known on local sources and temporal trends. The majority of studies on the transport of microplastics to the Arctic have focused on ocean pathways. Ocean currents originating in the south of Europe have been proposed to function as major transport routes, carrying microplastics from the more densely populated southern areas in Europe to the Arctic. However, given the limited empirical data and lack of harmonized methodologies for sample collection, it is not yet possible to estimate the magnitude, composition and sources of atmospheric microplastics transported to the Arctic.

Here we present the outcomes of a study applying passive and samplers for wet and dry deposition on two remote monitoring stations, Ny Ålesund (Svalbard) in the High Norwegian Arctic, and at Birkenes in mainland Norway. We further present data on the occurrence and composition of atmospheric microplastics in two Norwegian cities, Oslo and Tromsø. Samples were collected in 2023 and 2024, with each sampling period covering 14 days. Samples were analyzed for 10 polymers using pyrolysis-gas chromatography–mass spectrometry (Py-GC/MS). Results were further analyzed with respect to their spatial origin and long-range transport using the Lagrangian particle dispersion model FLEXPART. Styrene-butadiene rubber (SBR) was the dominant polymer in samples from both cities, representing 80-90% by mass of detected polymers in all samples. This suggests that car traffic is the predominant source of airborne microplastic contamination in urban areas, independent of the longitude of the study area. The population size of Tromsø is roughly 10 times less than the population size of Oslo, but SBR concentrations were similar or only slightly lower in samples from Tromsø. Possible explanations might be bad road conditions in Tromsø (as typical for cold climate regions) leading to a higher production of tire and road wear particles (TRWP) or a higher availability and use of public transportation in the capital.

While SBR and Nylon dominated in the samples from Birkenes, almost every of the measured polymers contributed to the samples from Zeppelin. These differences can be explained by the closeness to urban regions being a source of car tire particles and synthetic textiles for Birkenes in Southern Norway, while Zeppelin is rather impacted by long-range transport of a broad range of polymers. Arctic samples were in general lower than samples from the Norwegian mainland.

O-9

Mapping of airborne microplastics and endotoxins as a potential combined workplace hazard

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The increasing use of plastic items in everyday products has resulted in the widespread presence of plastic waste in the natural environment (Horton et al. 2017). Plastics are one of the major waste articles globally and constitute 12% of solid municipal waste. The increasing presence and accumulation of plastics in the environment inevitably leads to demonstrably increased unwanted exposures and thus unknown and unforeseeable toxicological consequences. Although visually the most apparent form of plastics pollution are macro plastics, the highest health concern has been attributed to smaller fractions - microplastics (1 µm - 5 mm) and even more so, to nano plastics (≤1 µm).

Potential health risks related to microplastics are not limited to indirect exposure via food and water, but also airborne micro- and nano plastics in both inside and outdoor environments. This poses a risk to humans directly through inhalation. Indeed, recent evidence indicates that the number of plastic particles inhaled is even higher than the amount ingested by a human through food or water. Although some data suggest biological adverse effects of microplastics in controlled conditions, these data originate from highly artificial model systems. Consequently, their translation to actual exposure conditions, including relevant particle types and sizes, exposure scenarios and durations, is lacking.

An additional level of complexity arises from chemicals present as additives/contaminants/vibrios and pathogens in/on the plastics. Collectively, these unknowns do not allow for the full understanding and estimation of health risks caused by microplastics for humans. The utilization of biological waste products (wastewater sludge, food waste, and spent digestate from biogas production) as a source of agricultural fertilizer and soil amendments has high priority in national and European circular economy strategies. However, reutilization of biological waste materials commonly requires extensive processing, causing substantial exposure in the work environment to dust containing potential health hazards, and the sustainability of such approaches has thus been questioned.

In the present study, the indoor air of an industrial unit turning sewage sludge into fertilizer products has been characterized for microplastics content. Collected samples have been investigated by a vibrational microscopy (µ-FTIR) method. Synthetic fragments and fibers accounted, on average, for 9% of the total identified particles in the analyzed air. Polyester was the predominant synthetic polymer in all samples (31-61%), followed by polyethylene (4-58%), polypropylene (1–15%), nylon (2– 34%) and acrylic paints (1–20%). Microplastics typically ranged from > 10 µm (size limit of the current spectroscopic method) to 270 µm. As the identified microplastics can be inhaled, these results highlight the potential direct human exposure to microplastic contamination via indoor air in the working environments.

O-10

Land-sea-air exchange of natural halogenated compounds in Northern Sweden

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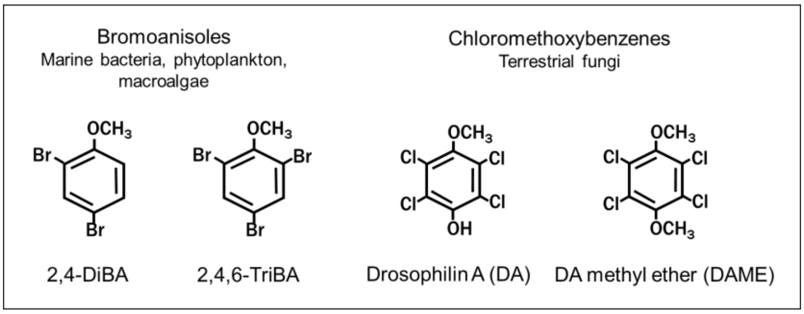
Climate change is expected to increase precipitation in northern Sweden, leading to higher riverine discharge of dissolved organic matter (DOM).[1] We are using halomethoxybenzenes (HMBs) to follow land-river-estuary transfer and exchange with air: brominated anisoles (BAs), produced by marine algae and bacteria[2], and drosophilin A methyl ether (DAME) and its precursor drosophilin A (DA) (Figure 1), secondary metabolites of terrestrial fungi[3-5]. Studies were conducted in rivers and estuaries of Bothnian Bay (BB) in Västerbotten County (VC), Sweden[2] and at Lake Torneträsk (LT) (68° 22’N, 19° 06’E) and streams in subarctic Sweden[3].

Concentrations of BAs in water followed the order: estuaries > offshore > VC rivers > LT and streams. Highest concentrations in estuaries can be attributed to local production. DAME concentrations were highest in VC rivers (land runoff) followed by estuaries > offshore > LT and streams. Preliminary estimates of riverine discharge of DAME + DA into BB are in the tens of kgy^{-1}. In contrast, input of BAs to BB by rivers appears minor relative to *in situ* production.[2] Fugacity calculations suggest net evaporation of BAs and DAME from water bodies and DAME from soils.[5] HMBs disperse through the atmosphere and return via precipitation and rivers, in cycles that connect ecosystems and provide widespread exposure to organisms[7]. HMBs bioaccumulate[6-9] and may provide indicators of accumulation pathways in the coastal zone. DAME has the potential for toxicity that is characteristic of persistent organic pollutants (POPs).[6]

1. Andersson, A. et al., 2023. *Front. Mar. Sci. 10*, 11700544. 2. Bidleman, T. et al., 2023, *Front. Mar. Sci. 10*: 1161065. 3. Bidleman, T.F. et al., 2024, *Sci. Total Environ. 948*, 1748492.
4. Bidleman T.F. et al., 2023. *Chemosphere* 347, 140685. 5. Bidleman, T.F. et al., NECS 2025, poster presentation. 6. Zhan, F. et al., 2023, *Sci. Adv. 9*, eadi8082. 7. Kupryianchyk, D. et al., 2018, *Environ. Toxicol. Chem. 37*, 3011-3017. 8. Dahlgren, E. et al., 2016, *Chemosphere 144*, 1597-1604. 9. Renaguli, A. et al., 2020, *Environ. Sci. Technol. 54*, 15035-1504.

Figure 1. Structures and sources of HMBs.



O-11

Arctic pollution – new approaches to identifying emerging concerns

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The Arctic has been known as a sink of persistent organic pollutants (POPs) and heavy metals for several decades. POPs are transported from industrial and agricultural emission regions at temperate latitudes to the Arctic where they can accumulate in Arctic food webs and cause considerable exposure to local populations relying on natural resources in their diet. In recent years, several non-regulated Chemicals of Emerging Arctic Concern (CEACs) have been detected in the Arctic, which may originate from long-range transport, but also local emissions. These have typically been analysed with target screening methods, aiming at specific compounds which might be of regulatory interest, for example current-use pesticides (CUP) or emerging per- and polyfluoroalkyl substances (PFAS).

Non-target and suspect screening techniques offer new possibilities of approaching a wide spectrum of pre-defined (suspect) compounds or identifying unknown (non-target) compounds in a sample. They are based on High Resolution Mass Spectrometry (HRMS), ideally in combination with both gas chromatography (GC) and high-performance liquid chromatography (HPLC) to cover a range of physical-chemical properties. Thus, selectivity is introduced at the stage of the instrument rather than in the sample preparation, which should be as non-selective as possible. Comparisons of mass fragments with experimental or predicted mass spectra in databases can give indications of compound identities, supported by retention times and isotope patterns. The identification process is time consuming and relies on expert judgement, however, with many developments towards more harmonization.

A suspect and non-target screening study on Arctic samples of biota, air and human serum, resulted in tentative identification of plasticizers, CUPs, PFAS, pharmaceuticals and personal care products, aromatic hydrocarbons, current-use flame retardants and other industrial chemicals. A preliminary risk characterisation indicated persistence, toxicity, mobility or bioaccumulation potential for many compounds. Focussing on PFAS, many emerging compounds beyond commonly analysed PFAS were found in a suspect screening of Arctic biota. Semi-quantification attempts indicated relatively high concentrations of some of them, e.g. perfluorooctylphosphonic acid (PFOPA).

Arctic pollution encompasses several other emerging concerns. Plastic pollution is widespread in the Arctic, leading to risks of leaching of added chemicals to Arctic ecosystems. A newly started suspect screening project will focus on this diverse group of chemicals. In addition, climate change can lead to the remobilisation of POPs and CEACs from previously frozen reservoirs and to enhanced use of chemicals in the Arctic along with increasing industrial activities, tourism and shipping.

O-12

Persistent organic pollutants (POPs), emerging contaminants, metals, and energy in the Barents Sea food chain

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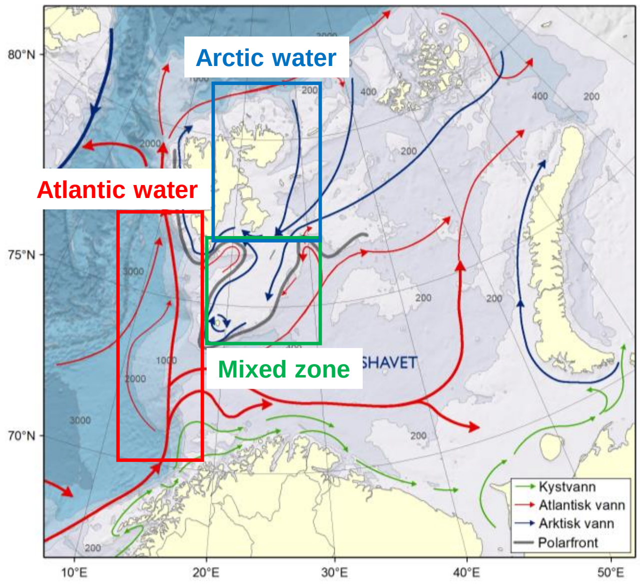
The Barents Sea is one of the most productive oceans in the world and serves as a nursery area for several commercially exploited fish stocks. Climate warming in the Arctic region has occurred at a rate at least two times higher than globally. The Arctic amplification of global warming is changing the biogeochemical and physical settings of the ocean, affecting contaminant fate and transport dynamics in ways that are not yet well understood. A newly started project, CLIMESEAFOOD, aims to do a comprehensive assessment of contaminants in the Barents Sea food web to evaluate, test, and validate mechanistic marine ecosystem and trophic transfer model capabilities. As part of this, we will establish baseline data on trophic magnification factors (TMFs) for the Barents Sea, including key organisms from both the boreal and arctic communities and covering both the benthic and pelagic food webs. In addition to analyses for contaminants, detailed lipid-, energy- and stable isotope analyses will be conducted. Samples of 6 zooplankton species, 4 benthic invertebrate species, 22 fish species, and minke whales have been collected from three different areas of the Barents Sea, Atlantic water, Mixed zone and Arctic water (Fig. 1).

Persistent organic pollutants (POPs) such as lipophilic poly-chlorinated biphenyls (PCBs) and poly-brominated diphenyl ether (PBDE) and protein-associated per- and poly-fluoroalkyl substances (PFASs), as well as heavy metals (mercury, methyl-mercury, cadmium, lead, and arsenic) will be included as target contaminants for the modelling.

Fig.1 The Barents Sea. The colored boxes show the three areas that are compared.



O-13

From the Cold War to the present day: The legacy of the sunken nuclear submarine Komsomolets

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The Soviet nuclear submarine Komsomolets sank in the Norwegian Sea on the 7th of April 1989 following the outbreak of a fire and now lies at a depth of 1673 m, south-west of Bear Island. Of the 69 crew members, 42 were killed as a result of the accident and eventual sinking. Komsomolets carried two nuclear warheads, which were held within the torpedo compartment when it sank. The total inventory of the reactor at the time of sinking has been estimated at 29 PBq with a further 16 TBq of plutonium-239,240 (Pu-239,240) within the two nuclear warheads. By 2019, the remaining activity in the reactor (~3 PBq) was almost entirely due to cesium-137 (Cs-137) and strontium-90 (Sr-90).

In July 2019, an expedition to Komsomolets was carried out using the advanced ROV Ægir 6000. Using the ROV, the condition of Komsomolets was visually documented and samples of seawater, sediment and biota were taken around the submarine. Releases of radionuclides from the reactor were detected via a ventilation pipe, as previously reported by Russia, but these releases were not continuous. When elevated levels of radionuclides were detected, a simultaneous visual release could be observed, but the cause of this is not known.

Our findings indicate that releases from the reactor vary in intensity but are still occurring 30 years after Komsomolets sank. The maximum observed activity concentrations of Cs-137 and Sr-90 were around 800 000 and 400 000 times higher, respectively, than typical values for the Norwegian Sea. The releases of radionuclides that have occurred since Komsomolets sank in 1989 appear to have had little impact on the surrounding sediments. There is some evidence that marine biota growing on the hull of Komsomolets have accumulated Cs-137 that has been released from the reactor, but the observed activity concentrations were low and not at a level where any significant effects would be expected. Pu-240/Pu-239 atomic ratio data in sediment and seawater indicate no release of Pu from the two nuclear warheads. The elevated levels of Cs-137, Sr-90, Pu-239, Pu-240 and uranium-236 as well as atom ratios of Pu-240/Pu-239 that have been detected in releases from the reactor in Komsomolets would suggest that the nuclear fuel assemblies have been damaged, and that nuclear fuel is in direct contact with seawater and deteriorating.

Elevated concentrations of several trace elements in releases from or near the ventilation pipe and metal grill, in sediment around Komsomolets and in marine biota growing on the hull likely indicates other ongoing corrosion processes within the submarine. Any impacts due to the elevated levels of some trace elements (e.g., Ni, Cu and Zn) in the releases and in sediments around the submarine are likely to be limited to the immediate area around the submarine.

O-14

Three decades of Arctic pollution research and monitoring - steps towards solutions

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The pollution of the Arctic with heavy metals, persistent organic pollutants (POPs) and radionuclides has been monitored and assessed by the Arctic Monitoring and Assessment Programme (AMAP) since the 90-ties. The AMAP work has documented that pollutants are transported to the Arctic by the atmosphere, ocean currents and large rivers and that they bioaccumulate and biomagnify in ecosystems to the top predator – humans.

Building on the vast knowledge generated by AMAP over decades, the Horizon Europe project ArcSolution will address Arctic pollution in a One Health framework and develop solutions. The One Health approach integrates information on environmental, animal and human health as well as local knowledge and scientific knowledge from different disciplines. The project will mainly proceed at four locations in Northern Norway (Tromsø), Northern Finland (Inari), Greenland (East and West coast) and on Svalbard (Longyearbyen), representing the diversity of Arctic communities with different lifestyles, pollution sources and effects of climate change. Priority pollutants in ArcSolution include per- and polyfluoroalkyl substances (PFAS), mercury (Hg), plastics and plastic additives. In addition, locally prioritized pollutants and pollution issues will be considered. Citizen science will be incorporated at the four sites, involving local populations and especially schools and teenagers in the work. A key activity will be their involvement in outreach activities to ensure that we can reach the young generation both at local, national and international level.

The project will develop locally based technological solutions and improve the scientific basis for chemicals management. The results and recommendations for actions to reduce Arctic pollution and the human exposure will be presented to local, national and international audiences.

O-15

Four-year study of microplastics in the fjords of Svalbard and in the open waters of the Arctic

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The distribution of microplastics was studied over four years in the Svalbard fjords (July 2021-2024) and in the open waters of the Eurasian Arctic (August-October 2019-2022). The goals were to reveal spatiotemporal trends and to assess the role of different sources, particularly rivers, in the fate of microplastics in Arctic coastal waters. Surface microplastics (0-20 cm depth, 0.5-5 mm size) were sampled with a neuston net, alongside subsurface microplastics sampled with a pump system (1.5 m depth, 0.1-5 mm size). The central part of Isfjorden and its branches, including populated and unpopulated fjords, were studied in Svalbard.

Maximum concentration of surface microplastics (190 µg/m^3) was found along the river plume border in the middle of populated Adventfjorden indicating importance of both local sources and surface hydrodynamics in the formation of microplastics accumulation hotspots. All other unpopulated fjords were free of the floating on the sea surface microplastics as river discharge prevented transport of microplastics inside the fjords. The highest concentration of subsurface microplastics was found in the central part of Isfjorden and the lowest – in river plume waters, which also indicates the removal of microplastics from the inner part of fjords during an intensive coastal discharge.

It was revealed that MPs pollution on sea surface significantly decreases from the West to East in the Eurasian Arctic, from 19.0 µg/m^3 in the Barents Sea to 11.2 µg/m^3 in the Kara Sea, 3.6 µg/m^3 in the Laptev Sea and 2.0 µg/m^3 in the East-Siberian Sea. Less MPs were found in the Great Siberian River plumes than in high saline water for all four years of studies. The same tendency was found for subsurface MPs while mass concentration was 10 times lower. The maximum concentration of MPs was found in the Kara Gate Straight (640 µg/m^3) in the current waters flowing from the Barents Sea. This can indicate that the main source of MPs in the Siberian Arctic is located in the Barents Sea.

Our results may suggest that Arctic rivers flowing through unpopulated areas bring clean water and thereby reduce level of microplastic pollution in the coastal waters. In contrast to the rest of the world’s ocean, rivers are not the main source of microplastic pollution in the Arctic Ocean. Interannual variability in the spatial distribution and concentration levels of microplastics has been found, with hydrodynamic conditions thought to be a major factor.

O-16

Changes of soil organic matter along thaw transects of permafrost peat plateaus in Finnmark, Norway

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The thawing of permafrost peat plateaus, driven by global warming, holds the potential for a substantial release of greenhouse gases (GHG) into the atmosphere by releasing priorly frozen soil carbon – thus exacerbating climate change. This carbon (C) release into the atmosphere is governed not only by environmental conditions, and the present microbial communities but also by the composition and the state of the soil organic matter (SOM).

Therefore, we characterize and compare the composition of SOM along thaw transects at currently degrading permafrost peat plateaus in Iškoras and Áidejávri in Finnmark, Northern Norway. Samples of SOM pools were taken along chronosequences and were investigated using organic element analysis, FTIR spectroscopy, and biomarker analysis. Compositional differences of the SOM pools are evaluated using the traditional van Krevelen diagram, additional elemental ratios considering nitrogen (N), spectral indices based on organic functionalities, and relevant biomarkers. From the analytical results, the oxidation state and the degree of unsaturation can be calculated directly, while a linear mixing model is used to estimate the fractional macromolecular composition of the SOM.

Preliminary results indicate site-specific compositional changes along the chronosequences, whereby the N-content is suspected to govern observed compositional trends of degrading strata. While compositional changes between intact permafrost and post-thaw permafrost samples are insignificant, the active layer samples are relatively depleted in N-content with plateau degradation in Aidejavri (N-rich) and relatively enriched in Iskoras (N-poor). Although there are notable changes in the oxidation state of C and the degree of unsaturation in Iskoras (N-poor), no comparable pattern was found in Aidejavri (N-rich).

Visualizing the samples in the van Krevelen diagram implies macromolecular differences between the main strata, while changes during thaw can’t be resolved. The estimated fractional macromolecular compositions indicate the expected lignin-dominated composition on the plateaus, while amino sugars & -acids are relatively enriched in the surrounding wetlands.

O-17

Analyses of PFAS, inorganic arsenic and methylmercury in selected seafood samples

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In this project we collected data on inorganic arsenic, methylmercury and per- and polyfluoroalkyl substances (PFAS) in ten different fish species and shrimp from Norwegian sea areas, on behalf of the Norwegian Food Safety Authority. The sample material was collected during various projects and were retrieved from the Institute of Marine Research's storage of backup-samples. The samples originated from different geographic regions of Norwegian waters. In 2023, maximum levels for food safety were set for four PFAS substances (perfluorooctanesulfonate, PFOS, perfluorooctanoic acid, PFOA, perflurononanoic acid, PFNA and perfluorohexanesulfonate, PFHxS) and the sum of these (sum PFAS4). Because of an urgent need to increase the knowledge base on quantified levels of these substances in Norwegian fish, concentrations of these four PFASs and 46 others were determined in a total of 206 samples. Among the fish species, plaice had the highest concentrations of sum PFAS4, with a mean value of 1.73 µg/kg, followed by Atlantic halibut with 0.74 µg/kg. Whole and peeled shrimp also had relatively high concentrations with a mean sum PFAS4 of 1.44 and 0.83 µg/kg, respectively. Two samples of Atlantic halibut and one plaice were above the maximum level for sum PFAS4 and some of these were also above the maximum levels for PFNA and PFHxS. Of the different PFASs, PFOS was the predominating substance in most species.

Concentrations of the sum PFAS4 and the sum of all 50 measured PFASs varied between areas in different ways for the different species with no consistent pattern.
In EU a process is going on to develop maximum levels for inorganic arsenic in seafood. For this process it is important to collect data, even though earlier studies have shown that inorganic arsenic levels in seafood are very low even when total arsenic levels are high. Inorganic arsenic is the most toxic arsenic species, and the results from analyses of a total of 459 samples confirmed that the concentrations of inorganic arsenic are indeed very low in Norwegian fish species. The highest measured concentration of inorganic arsenic in fish muscle was 4.1 µg/kg wet weight, and only between <0.0006% and <0.59% of the total arsenic concentrations were inorganic arsenic.

Methylmercury is the most toxic mercury species and the one on which most health risk assessments are based. Total mercury is most often used as a proxy for methylmercury and there is limited data on the actual concentrations of methylmercury in fish from Norwegian sea areas. In this project, methylmercury and total mercury were measured simultaneously. Analyses of 459 seafood samples showed that methylmercury makes up a large percentage of the total mercury concentration in fish muscle and peeled shrimp, with mean values varying among species between 95.7% in tusk and 98.9% in haddock. Whole shrimp, containing viscera, had a mean percentage of only 61.5% methylmercury. There is no maximum level in the EU for methylmercury, but these data show that analysis for total mercury is a good proxy for methylmercury levels in muscle samples.

V-1
PFAS screening with combustion-IC

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Per- and polyfluoroalkyl substances (PFAS) are a large group of synthetic chemicals that are widely used in industries and consumer products due to their water- and grease-resistant properties. However, their persistence in the environment and potential health risks have led to strict regulations and increased monitoring efforts. Conventional analytical techniques, such as LC-MS/MS, face challenges in providing a complete picture of PFAS contamination due to limitations in reference standards and extraction methods.[1]

In this lecture, we present Combustion Ion Chromatography (C-IC) as an alternative approach for PFAS screening. By measuring Total Fluorine (TF) and related sum parameters like Adsorbable Organic Fluorine (AOF) and Extractable Organic Fluorine (EOF), C-IC offers a broader assessment of fluorinated compounds in various environmental and industrial samples.[2] The method involves a three-step process – combustion, absorption, and quantification. This allows for an accurate detection of fluorine in solids, liquids, and gases.

Results show that C-IC detects significantly higher levels of fluorine compared to LC-MS/MS, indicating the presence of additional fluorinated compounds beyond commonly analyzed PFAS.[3] These findings highlight the importance of sum parameter analysis in regulatory compliance and environmental risk assessment. As the need for comprehensive PFAS monitoring grows, C-IC provides a reliable and efficient tool for detecting fluorine-based contaminants, supporting efforts to protect public health and the environment.

[1] Schultes et al, Environ. Sci. Technol. Lett. **2019**, 6, 2, 73-78
[2] Roesch, P. et al. , Environ Sci Pollut Res 29 **2022**, 26889–26899
[3] von Abercron E. et al: Sci Total Environ. **2019**, 673:384-391

V-2

Innovative PFAS analysis – from automated sample preparation to confident quantitation using LC-HRMS

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Per- and Polyfluoroalkyl substances (PFAS) are a group of man-made chemicals that have been in use in various industries due to their resistance to heat, water, and oil. However, their environmental persistence and potential adverse health effects has led to a growing concern on PFAS contamination monitoring in the environment. Therefore, the analysis of PFAS in different matrices has become increasingly important. PFAS include several chemical classes, which adds to the complexity of extracting and analysing them in a single workflow. Further, regulations and different matrices are based on discrete lists of PFAS.
The choice between direct injection and the need for (automated) sample preparation is an important consideration in PFAS analysis. This largely depends on the instrument's dynamic range and detection limits compared to the one required by regulation, as well as the complexity of the analysed matrix. Direct injection conducted on a high sensitivity Thermo Scientific™ TSQ Altis™ Plus allows for rapid analysis to meet very low regulatory limits for drinking water.

More complex matrixes, such as waste/industrial water and food require specific sample preparation techniques to overcome matrix effects and achieve accurate quantification. Sample preparation, such as Dispersive Liquid Liquid Microextraction (DLLME) can drastically improve the concentration factor and reduce matrix interference, enhancing the overall method performance. DLLME is a miniaturized form of liquid-liquid extraction that uses minimal amounts of extraction solvent, making it a greener and environmentally friendly alternative. Furthermore, it can be easily automated, improving reproducibility and reducing potential for human error. This automation was conducted on a Thermo Scientific TriPlus™ RSH SMART liquid handling station.

To measure the obtained extracts, we created a dual LC channel PFAS method on the Thermo Scientific Orbitrap™ Exploris MX, which has recently become popular within laboratories requiring expansion of PFAS analysis beyond the scope of regulated methods. The dual column set-up used columns of differing stationary phase on each channel and then subsequently combined them into a single data file, offering Full Scans at 2 different retention times for each target PFAS. The Orbitrap provided high resolution, high mass accuracy data, and allows for retrospective analysis, along with the ability to easily add new targets to the method.

O-18
Modelling environmental exposure to micro- and nanoplastic with open source mass balance models

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In exposure assessment of chemicals, it has long been accepted that it is useful to analyze and compare pollutants by modelling their behaviour in “unit world evaluative environments" with imaginary but realistic properties such as size and composition of compartments, temperature, windspeeds and water flow rates. Unit world chemical fate models based on multimedia evaluative environments have long proven useful for screening-level risk assessment, calculating exposure metrics, and for comparative assessment of chemicals.

Here, we describe ongoing research to develop a new generation of unit world exposure models for micro- and nanoplastic pollution. These models include the FullMulti model for lakes, rivers and oceans, and UTOPIA, a multimedia unit world fate model. Both the FullMulti and UTOPIA describe micro and nanoplastic in the environment in five logarithmically defined size bins from the scale of millimeters to hundreds of nanometers, and in four aggregation states (pristine, heteroaggregated, biofouled and biofouled & heteroaggregated). Emissions, fragmentation, discorporation, and advective transfer of plastic is tracked in discrete environmental compartments representing aquatic systems in the FullMulti, and air, open ocean, coastal zones, beaches, background soils and impacted soils in UTOPIA.

Mathematically, the models are composed of simultaneous mass balance equations; in the case of UTOPIA there are 340 equations representing 17 model compartments x 5 size classes x 4 aggregation states. Both UTOPIA and the FullMulti are coded in Python, and UTOPIA has a web-based user interface coded in JavaScript, HTML and CSS. Inputs specifying plastic properties and emission rates drive model calculations of the steady-state distribution of plastic in the 5 size classes and 4 aggregation states in the evaluative environment. The models are useful for identifying dominant fate, transport and fragmentation processes and for calculating exposure metrics such as overall persistence of the plastic pollution, its potential for transport to remote regions, and potential for transport and deposition in target locations such as remote beaches, the remote ocean surface, and deep ocean sediments. Sensitivity and uncertainty analysis using Monte Carlo methods supports identification of key controlling processes for different model-calculated endpoints, and for targeting research to constrain uncertainties.

This presentation will introduce the FullMulti and UTOPIA, provide examples of their application, and direct the audience to an online version of the UTOPIA model where they can explore their own model scenarios.

O-19

Automatic trace metal monitoring: Electrochemical sensors for real-time environmental analysis

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Accurate and continuous monitoring of trace metals in aquatic environments is critical for assessing pollution levels and mitigating environmental risks. This presentation highlights research and advancements in automatic trace metal monitoring systems. Research focuses on the development of electrochemical sensor technologies, particularly voltammetric methods, to enable continuous and online trace metal analysis. The presentation will include designed and implementation of automatic monitoring system which provides high sensitivity and selectivity for metals such as lead, cadmium, copper, and zinc. The use of solid electrodes, including alloys, enhances analytical performance while ensuring environmental safety compared to conventional mercury-based systems.

Field deployments of automatic monitoring stations in rivers and coastal areas have demonstrated their efficacy in detecting pollution events, offering crucial data for environmental decision-making. The ability to provide continuous, unattended measurements represents a significant step toward improving early warning systems for industrial and mining-related metal contamination.

The application of automatic trace metal monitoring systems (ATMS) in aquaculture, particularly in recirculating aquaculture systems (RAS), presents a promising avenue for ensuring water quality and fish health. RAS environments require stringent water quality management to prevent toxic metal accumulation that could affect fish growth and survival. Implementing ATMS in these closed-loop or semi-closed systems enables early detection of trace metal fluctuations, facilitating prompt corrective actions. Our recent research explores the integration of ATMS into RAS facilities to optimize monitoring efficiency and enhance sustainable aquaculture practices.

This presentation will discuss sensor design, material innovations, and real applications of the monitoring systems. Additionally, we will explore ongoing research aimed at integrating these systems with broader environmental monitoring networks and improving miniaturization and robustness. Our work underscores the potential of electrochemical sensors in advancing environmental analytical chemistry and supporting sustainable pollution management strategies.

O-20

Environmental impact of plastic leachates in terrestrial environments: An effect-based study at Lisle Lyngøyna

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In the last decade, the environmental effects of plastic pollution in the aquatic and terrestrial ecosystems have already been reported worldwide, emphasizing the adverse effects of the generated microplastics after decomposition of plastic litter under natural conditions. The distribution and accumulation of plastic waste at several sites along the West Coast of Norway have received special attention due to their classification as “open lab” fields, where a large amount of stranded marine litter has been buried in time and several ecological processes are still occurring. However, despite the already known consequences of plastic pollution to freshwater and terrestrial organisms, studies on the composition of leachates and their distribution in the soil environment are still missing.

This study investigates the occurrence and environmental impact of leachates from buried plastic waste at the Norwegian 'plastic island' Lisle Lyngøyna, using *non-target* and *suspect screening* methodologies combined with *in vitro* effect-based approaches. Soil samples were collected from three ≈20 cm layers at sites characterized by high, medium, and low plastic pollution, and subsequently exposed to pure water for two weeks to produce the leachates. Their chemical composition was analyzed using liquid chromatography coupled with high-resolution mass spectrometry (LC-Orbitrap MS). Leachate toxicity was assessed using standardized methods involving ecologically relevant test species. Finally, a multivariate statistical approach was employed to explore correlations between measured ecotoxicity and the presence of non-targeted plastic additives in the soil extracts.

The *non-target* and *suspect screening* results revealed the presence of several plastic additives in the collected samples, including antioxidants, lubricants, flame retardants, plasticizers, colorants, and perfluoroalkyl substances. Among them, phthalate esters and their metabolites were identified as potential contributors to the total measured ecotoxicity. However, while phthalate esters were most prevalent in topsoil layers, their potentially hazardous metabolites were predominantly detected in deeper layers. Although metabolite compounds are often overlooked in monitoring studies, they should also be considered due to their unexplored contribution to ecotoxicological effects. These findings highlight the need for a deeper understanding of the degradation processes and ecological consequences of plastic pollution to properly define mitigation and remediation strategies for contaminated sites.

O-21

Progress achieved in EURAMET project 21GRD09 MetroPOEM: Metrology for the harmonisation of measurements of environmental pollutants in Europe

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Rationale: 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, where mass spectrometry is a key method for determination of non-radioactive polluting elements and long-lived radionuclides. The MetroPOEM project bridges the traceability gap between activity and mass-based measurements – particularly estimation of mass bias.

Underlying studies: SI-traceable high-precision methods were developed for isotope ratio determination of Li, B, Cr, Cd, Ni, Sb, Pb, and U in environmental matrices, focused on seawater as the model solution. Method development encompassed manual and automated methods for separating analytes from the matrix, evaluating different calibration approaches and instrumental isotope fractionation corrections, and estimating uncertainty budgets. Single and multi-collector ICP-MS systems such as MC-ICP-MS, sector field ICP-MS, quadrupole ICP-MS and ICP-MS/MS techniques, as well as accelerator mass spectrometry (AMS), were used and their performances compared. These findings support the development of methods for radioactive isotope determination. Radioactive standard solutions (^{90}Sr, ^{237}Np, ^{234}U, ^{236}U, ^{239}Pu, ^{240}Pu, ^{241}Am) were distributed to partner laboratories for measurement. The results and data analysis were compiled as a comparison report, leading to a peer-reviewed publication draft.

Reference materials: A 250 litre of sea water sample was taken from the German EEZ (North Sea) as a basis for the development of two different certified reference materials (CRMs). The raw material was subjected to further processing steps, including spiking with additional elements where necessary based on preliminary analysis and homogenisation. Part of this candidate reference material was characterised for isotope ratios of Li, B, Cr, Cd, Ni, Sb, Pb, and U to generate a reference material with SI traceability for isotope ratios. Additionally, ČMI generated ~50×0,5L liquid RM aliquots of sea water spiked with natural U, ^{237}Np, ^{239}Pu, ^{240}Pu and ^{241}Am. A solid silica-based reference material, produced by sol-gel synthesis at CEA spiked with ^{234}U, ^{235}U, ^{236}U, ^{238}U, ^{237}Np, ^{239}Pu, ^{240}Pu and ^{241}Am, as well as ~10 kg of an inactive material for testing dissolution procedures. These materials were characterised in accordance with the requirements of ISO 17034 by interlaboratory studies between the project partners, using techniques developed in the project.

Outputs: Peer-reviewed papers describing science achievements are in draft. To support end users interested in developing or upgrading their capabilities. two Good Practice Guides on (i) the measurement of radioactivity by mass spectrometric techniques, and (ii) sample treatment, uncertainties and mass bias quantification, are at the final draft stage. Project outcomes also support standards and metrology organisations, including BIPM (particularly the CCRI/CCQM task group on mass spectrometry), ISO and CEN.

O-22

Understanding the pollution composition and dispersion from an old landfill to the environment through a suspect screening approach: the Brånåsen case.

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The old Brånåsdalen landfill, which it is located in Skedsmo municipality in Norway, contains around 1 million cubic meters of waste. To the date, the composition remains quite unknown, but it is well-known its heterogeneity and the recurrent waste disposal during years from a local chemical company (manufacture of glues and polymers). This landfill was built in the 70s and closed in the 90s, therefore it was constructed prior to the new Landfill Regulations adopted on 21 March 2002 (through the EU Landfill Directive). Consequently, it is lacking any barrier and/or treatment (i.e. landfill leachate treatment) that avoids that the contamination spreads to the surrounding environment. Moreover, a residential construction was permitted in the area and several detached houses were built right up to the edge of the landfill. Since 2015, large amounts of gas have been experienced in the area to the point of being necessary to remove several family-houses for their safety. Despite of several years of gases emissions as well as monitoring of methane and regulated contaminants (i.e. BETX, heavy metals) at landfill leachate and surrounding surface waters, there is still lack of knowledge about the composition and the potential leaks and infiltrations from the landfill to the environment.

To the date, there is missing a comprehensive characterization of the organic pollutants (including emerging contaminants and transformation products) at landfill leachate and near surface water. Previous unpublished work performed by the authors pointed out the presence of specific contaminants such as acrylamide-based components at landfill leachate, as well as at water samples immediately collected at the outlet from the urban rain collectors that discharge into the Nitelva river. The current study with help to understand the occurrence of pollutants as well as the potential infiltrations (if any) from the landfill to the surface waters in the Lillestrøm area. A very comprehensive monitoring was performed by intensive collection of water samples during one week across the Nitelva river. Water samples from several meters' river up and down the landfill site as well as the landfill leachate were collected every day. A list of suspected contaminants was performed and screened in the samples; this was used to select and prioritize target contaminants for further quantification. The analytical approach was based on a suspect screening analytical methodology followed by quantification of selected contaminants using several techniques: i) Gas chromatography coupled to MS/MS and ii) Ultra High-Performance Liquid Chromatography coupled to High Resolution Mass Spectrometry (Orbitrap-based). Among others, several contaminants acrylamide-based were detected at landfill leachate and in the immediate waters samples collected in the river. This study will help the municipality to prioritize contaminants for monitoring and control, as well as facilitate decision-making by recommending optimal treatment technologies tailored for the real composition of the landfill.

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O-23

Seasonal monitoring of per- and polyfluoroalkyl substances (PFAS) in surface waters and implications for Managed Aquifer Recharge systems

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Per- and polyfluoroalkyl substances (PFAS) comprise a group of several thousand anthropogenic, fluorinated compounds that pose a threat to human health and the environment, even at low ng L-1 concentrations [1]. Surface waters are often used either directly for drinking water production or are artificially infiltrated into groundwater systems and eventually drinking water supplies. With drinking water guidelines approaching ng L-1 levels for PFAS [2,3], small seasonal variations of PFAS in surface waters become highly relevant. This study therefore (1) monitored the surface water PFAS concentrations at two managed aquifer recharge sites, where surface water is artificially infiltrated into the underlying groundwater system, as well as (2) monitored the corresponding artificially recharged groundwater over one year.

The investigated sites are hydrogeologically different. At the first site, lake water is infiltrated into a shallow aquifer, while at the second site, river water is infiltrated into a thick esker. The PFAS surface water concentrations show differences between the two sites, corresponding to the degree of anthropogenic impacts in the vicinity of the sites. The shallow aquifer site is in a remote area with Σ4PFAS (PFOA, PFNA, PFHxS, PFOS) of 1-2 ng L-1, while the river at the thick esker site showed concentrations varying between 2-7 ng L-1 Σ4PFAS. At both sites, highest PFAS concentrations were measured in months with temperatures below 0°C and after snow melting. After infiltration through the managed aquifer recharge system, Σ4PFAS concentrations increased to occasionally reaching 5 ng L-1 at the shallow aquifer site and were above 4-5 ng L-1 Σ4PFAS at the thick esker site in all months except for July and September. Further, seasonal peaks observed in the surface waters in winter could be detected in the artificially recharged groundwater after the respective groundwater travel time of 2-3 months in the shallow aquifer and 4-6 months in the esker.
The results are highly relevant with respect to upcoming lower drinking water guidelines such as the proposed Swedish limit of 4 ng L-1 Σ4PFAS [3] or the Danish limit of 2 ng L-1 Σ4PFAS [2]. The seasonal monitoring results can hereby assist in the operational planning of managed aquifer recharge systems as a cost-efficient drinking water treatment step, while the insight into mobility and retention of PFAS during infiltration can help optimize these systems accordingly.

1] Evich et al. 2022. Per- and polyfluoroalkyl substances in the environment. *Science* 375(6580).
[2] Miljøministeriet, M. 2024. Grænseværdier for PFAS i miljøet.
[3] Livsmedelsverkets föreskrifter om dricksvatten - LIVSFS 2022:12, 2022.

O-24

The Oslo Fjord environmental status, challenges and perspectives

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The marine ecosystem in the Inner Oslofjord is threatened from several directions. This can be summarized in six points: overfishing, eutrophication, climate change, physical disturbances, environmental toxins, and alien species. In an overall assessment of the fjord, it is important that all these points are considered simultaneously.

Fishing was important for the establishment of human settlements in the Oslo Fjord over 10,000 years ago. There are indications that there have existed periodic variations in fish stocks in Skagerrak with period of 50-150 years going on for at least 900 years. These fluctuations now seem to be broken. The last 150 years we have seen a sharp increase in the amount of organic matter in the benthic sediments, that coincide with the growth in population.

In the Inner Oslofjord the increase in phytoplankton started more than 100 years ago until it reached extreme levels in the 1970-ties. This development was reversed by taking extensive measures, which included building wastewater treatment plants. The last 20 years the abundance of phytoplankton has remained on a high but acceptable level. In the same period the temperature of the surface water has increased with about 0.5 degrees. This appears to be an important factor in the vigorous growth of opportunistic filamentous benthic algae – "lurv". Lurv is the most important cause of the sharp decline in the distribution and health status of eelgrass beds. Important nature types like eelgrass beds are simultaneously threatened by physical disturbances. For instance, in the water body outside Sandvika in the Inner Oslofjord, more than 10 % of the shallow areas are lost during the last 50 years.

No water bodies in the Oslofjord region are classified to have a good condition regards to environmental toxins. And we are constantly finding new alien marine species in the fjord system that threatens the native species.
To successfully restore the coastal ecosystem, a holistic approach will probably have the best chance of success.

O-25

Circular waste and wastewater management technologies for a sustainable aquaculture industry

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The aquaculture industry is amongst the fastest-growing food production sectors worldwide, playing a crucial role in global food security. Norway, as one of the global leaders in aquaculture, generates large volumes of wastewater and sludge, which are often treated as waste rather than as valuable resources. To ensure long-term sustainability, innovative strategies for resource recovery and waste valorization are essential.

At NMBU, the Resource Recovery Research Group is leading efforts to develop circular solutions for aquaculture waste management through the Sustainable Aquaculture Industry Waste Valorization through Recycling (SEA-CYCLE) project. Recognized by the UN Ocean Decade Action, SEA-CYCLE focuses on transforming aquaculture waste streams into valuable products through practical technologies. The project integrates biogas production, pyrolysis, and biochar technologies to recover nutrients and energy from recirculating aquaculture system (RAS) effluents.

By addressing key challenges such as sludge treatment and wastewater discharge, SEA-CYCLE promotes on-site, decentralized solutions that convert waste into valuable resources. The project aims to:

- Recover nutrients and organic matter from sludge and wastewater, reducing environmental pollution
- Convert waste into biogas, digestate, and biochar for use as bio-based fertilizers and soil enhancers
- Assess the environmental and economic feasibility of these technologies using Life Cycle Assessment (LCA) and socioeconomic cost-benefit analysis.

This presentation will illustrate the SEA-CYCLE project concept, highlighting how innovative process integration and circular technologies can make aquaculture waste management more sustainable and environmentally responsible, supporting Norway’s ambitions for sustainable aquaculture.

O-26

Lowering bioavailability with carbonaceous materials: From science to large-scale applications

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In the 90s the discovery was made that organic compounds in soils and sediments could be bound so strongly to the solid matrix that they were hardly desorbed, and showed low available for uptake in plants and organisms, and slow transport into the groundwater. At the end of the decade it turned out that this strong binding was due to the presence of carbonaceous "black carbon" geosorbents, in particular soot and charcoal. Another important consequence in the form of limited biodegradation was revealed.

Gradually the concepts of bioavailability and bioaccessibility entered the policy domain, and technologies such as passive sampling and infinite-sink desorption, as well as bioavailalibility-inclusive models, were developed to include these in risk assessment procedures.
From an engineering perspective, carbonaceous materials were engineered and designed and amended to soils and sediments to reduce bioavailability and thus environmental risk. The most recent innovation is the use of biochar from organic waste materials such as sewage sludge for PFAS, PAH, PCB and dioxin remediation. Waste-based biochars have the additional advantages that they contribute to the circular economy and sequester up to half of the carbon present in the original feedstock.

Notable projects that will be presented include the pilot remediation of Europe's largest dioxin contamination in the Grenlandsfjords, where thin layers of carbonaceous materials reduced dioxin bioavailability by up to 90%, as well as the recent discovery that PFAS-contaminated sludge can be turned into clean biochars, that can be used for PFAS remediation of contaminated soils, while sequestering carbon. Reductions in PFAS leaching of > 99% have been found for these sludge-based biochars (Fig. 1), and this could open up a whole new industry around the circular handling of current negative-value waste fractions. Finally, a novel "Virtuous Cycle" will be presented, coupling phytoremediation, pyrolysis and biochar amendment for the remediation of diffuse soil contamination with PFAS and other contaminants.

O-27

Chemicals of emerging concern (CECs) in coastal waters

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The presence of many Chemicals of Emerging Concern (CECs) in coastal waters has gained significant attention due to their potential adverse effects on aquatic ecosystems and human health worldwide. Such CECs include poly- and perfluoroalkyl substances (PFAS), pharmaceutical and personal care product residues (PPCPs), plastic additives like bisphenols and antioxidants, as well as agricultural chemicals (novel pesticides and veterinary drugs). This study summarizes results from our own research and scientific literature on identifying and quantifying CECs such as PFAS, PPCPs, and industrial compounds in coastal regions.

The Presentation will highlight concentration patterns and distribution profiles from Northern regions, and source-near coastal regions in Northern, and Western Europe. Pollution sources, transport pathways and exposure scenarios will be presented and discussed. This will include also examples for source elucidation and coastal emission profiles along the Norwegian coast (i.e., Oslo fjord) and the Polar regions.

This scientific summary highlights the environmental fate, source elucidation, and distribution pathways of selected CECs in the coastal marine environment (both biotic and abiotic) under various environmental and source-associated conditions. The information presented underscores the challenges in monitoring and managing these pollutants, given their diverse sources and chemical properties. Furthermore, we discuss the effectiveness of waste processing, including wastewater treatment processes, in mitigating the release of CECs into coastal environments.

O-28

Integrated assessment of pollution sources of metals and PFAS in Smålandsfarvandet, denmark

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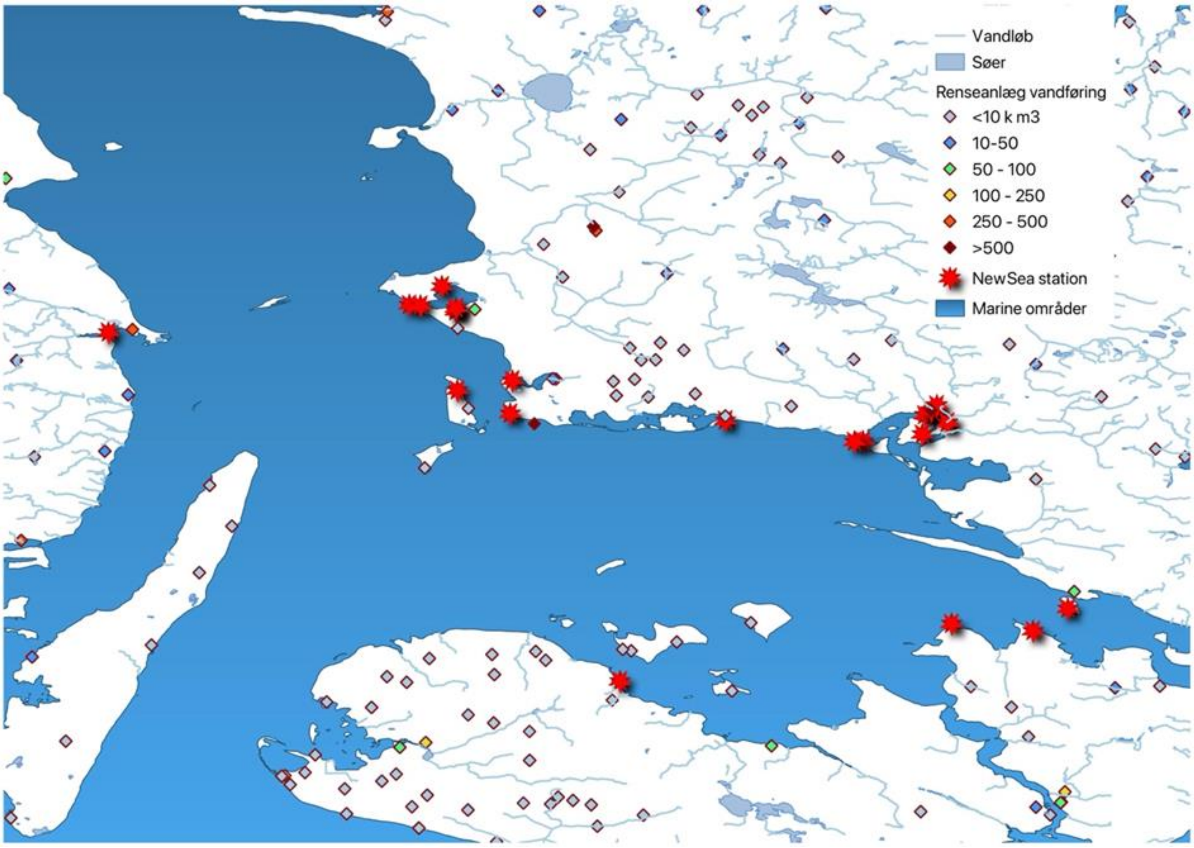
The project "New concept for integrated assessment of pollution sources in the Sea" at Aarhus University, Ecoscience (https://projects.au.dk/newsea) are using a combination of spot and passive sampling of metals and PFAS in water, measurements in fish and mussel tissue of both contaminants and biological effects, collection of data from potential industrial and wastewater treatment plants as a background for a hydro-dynamic pollution modelling tool to track discharged hazardous substances taking into account the dispersal, fate and combined toxicity in the south-eastern part of Great Belt (Smålandsfarvandet). The project runs from 2023 to 2026, and some initial results from three rounds of water sampling using spot samples and DGTs for metals and PFAS will be presented, together with the initial assessment of pollution load from point sources and run-off for metals and PFAS.

On top of the coastal stations in map below, deployments of caged mussels and passive samplers was made close to Korsør, the WWTP south of Stignæs and outflow from Karrebæk Fjord, to be analysed for metals, PFAS and biological effects. A preliminary hydrodynamic model and results of water and DGTs will be presented, discussing the use of DGTs vs spot samples, and if results are ready the mussel concentrations and biological effects.



O-29

Determination of nanoparticles and elements in blue mussels (*Mytilus edulis*) along the Norwegian coastline

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The blue mussel (*Mytilus edulis*) is both a common food source and a bioindicator used in coastal water pollution monitoring. However, no surveys have investigated the concentrations and patterns of nanoparticles in mussel populations over extensive geographic regions.
The present work examined 69 samples of pooled mussels distinct in time or location along the Norwegian coastline. Samples were taken from a variety of environmental settings, including natural locations, potentially polluted areas such as cities or in the vicinity of submarine tailings deposition, and mussel farms.

Single particle ICP-MS was utilized to determine particle mass and number concentrations of eleven elements: aluminum, barium, cerium, copper, iron, manganese, lead, silicon, titanium and zirconium. Total metal concentrations were also determined. Some urban or industrially impacted locations were associated with increased levels of NPs containing silver, lead, zirconium and titanium. However, levels of NPs were overall low in comparison to total metals, NP mass concentrations between ng/g to tens of µg/g and number concentrations in the range of 10^6 to 10^9 particles/g (wet weight). Natural variation was also substantial, the highest levels in pristine locations comparable to levels at impacted locations. This first comprehensive survey of 11 elements in blue mussels shows evidence of increased levels of NPs correlated to anthropogenic activities. It also demonstrates a method for surveillance or monitoring of NPs, that may be of relevance e.g. for submarine tailings deposition or deep-sea mining.

O-30

Demonstration of *in situ* real-time monitoring of PAHs from produced water in the North Sea –enhance selectivity and sensitivity with membrane extraction

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We present the development and field demonstration of a novel sensor system to measure PAHs in water. This system was designed using continuous membrane extraction (250 µm silicone membrane) of PAHs from the water phase to a solvent phase and subsequent quantification of PAHs using fluorescence[1]. Using continuous membrane extraction before optical quantification has the benefits of separating the analytes from potentially interfering constituents in the matrix, thus reducing matrix interferences. This sensor system was deployed in 2021 and 2024 at two different locations in the North Sea and used to trace the plume of discharged produced water in the water column from 0.2 - 1 km from the discharge point.

The sensor system was calibrated with PAH-16 standards from 10 to 500 ng/L, with dilutions of produced water and was compared to detection of fluoresceine tracer added to the produced water and measured in the water column with a fluorescein sensor (simultaneously with but independent from the PAH-sensor). The sensor was tested at different pressures, at different temperatures and at different salinities. Pressure and salinity had little to no influence on the signal, but temperature reduced the sensitivity with about 40 % from 19 °C to 3 °C. The measured concentrations were therefor corrected for this effect based on continuously measured temperatures.

The sensor system showed similar capability to detect the produced water plume in the ocean as the fluorescein sensor (but without the need for adding an artificial trace compound). Groups of PAHs (fluorene equivalents (FLU-eq. = fluorene and methylated fluorenes), phenanthrene-equivalents (PHE-eq. = phenanthrene and methylated phenanthrenes) and larger PAHs (PAH-11-eq. = 4, 5, and 6-ring PAHs) was detected at ng/L level in the water column. Comparison with concentration calculated by independently measured concentration in the produced water before discharge and measured degree of dilution of the produced water was in the same order of magnitude for PHE-eq and PAH-11 eq.

The approach to *in situ* and real time measurement described here, where we miniaturize selected steps from laboratory methods and build them into a field deployable system, has the potential to be developed for other chemicals of environmental concern to enhance real-time environmental monitoring capabilities.

[1] Eek, E., et al. (2024). Environ Sci Technol **58**(49): 21794-21803.

O-31

Elevated levels of mercury and POPs in demersal fish from Ytre Sklinnadjupet, an open sea area in the Norwegian Sea

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Between 2013 and 2016, we conducted a survey of contaminants in Atlantic halibut (*Hippoglossus hippoglossus*) in several shelf areas of the Norwegian and Barents Seas and found elevated levels of mercury and chlorinated persistent organic pollutants (POPs) in halibut from Ytre Sklinnadjupet, an open sea area between 65° and 66°N in the Norwegian Sea. Contaminant levels in this area were higher than in all other areas investigated, and the area was therefore closed for halibut fishing from October 2017. A follow-up survey in 2019 confirmed these findings, showing that halibut from within the closed area still had significantly higher levels of mercury and POPs, compared to those from other regions examined. Mercury concentrations were of particular concern, with 53% of the halibut sampled within the closed area in 2019 exceeding the maximum level for mercury in halibut fillet for human consumption. Overall, the data suggested a trend where contaminant levels in Atlantic halibut are highest within the closed area and gradually decrease with increasing distance from this area.

Despite several follow-up-studies conducted to investigate possible causes for the elevated contaminant levels, the underlying reasons remain unknown. The elevated levels could not be explained by biological factors such as size, age or muscle fat content of the fish, and analysis of stable isotopes of nitrogen and carbon provided no evidence of dietary or trophic level differences that might account for the elevated contaminant levels in halibut from Ytre Sklinnadjupet. Furthermore, no local point source for these contaminants have been identified, and analyses of sediment samples and samples of sea cucumbers (*Parastichopus tremulus*) from this area did not show elevated levels of mercury or POPs.

In recent studies, we have compared congener patterns of dioxins, PCBs and PBDEs in Atlantic halibut muscle from the closed area and other areas, and results from these analyses will be presented. Also, to investigate if elevated levels of contaminants could be found in other fish species present in Ytre Sklinnadjupet, samples of the demersal fish species tusk (*Brosme brosme*) were collected from this and several other areas between 2019 and 2024. These samples were analyzed for several contaminants, including mercury in fillet and dioxins, PCBs, and PBDEs in liver. The results indicate that not only Atlantic halibut but also tusk caught in Ytre Sklinnadjupet may contain elevated levels of some contaminants relative to other open sea areas.

O-32

A software toolkit to facilitate FAIRification of chemical pollution monitoring data

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Pragmatic, effective response to the pollution of today requires comprehensive and well-documented exposure data. Norway has a long history of environmental monitoring and a rich back catalogue of data. However, much existing data is heterogenous, fragmented, and difficult to access.

The concept of FAIR data – data that are Findable, Accessible, Interoperable and Reusable – aims to maximise the scientific and societal value of new and existing data resources. In this study, we demonstrate prototype tools to facilitate data conversion to FAIR formats, to empower use, reuse and dissemination. As part of the Source to Outcome Pathway (STOP) concept, this approach can take data from the lab to an efficient, comprehensive overview of a given substance's impact on the natural environment, enabling chemists, risk assessors and environmental scientists to produce high-impact science with a minimum of overhead.
As example, we present the classical stressor copper, a well-characterized pollutant that poses an emerging environmental challenge in Norway due to increased mining and aquacultural activity. Despite 30 years' extensive monitoring data collected by Miljødirektoratet, no comprehensive assessment of copper's environmental impact exists for Norway's coastline. We demonstrate how our modular design enables the (1) harmonization of exposure data with existing metadata standards, the (2) exploration and examination of exposure data for trends and gaps, and (3), how this data can be integrated into later stages of environmental risk assessment.

This proof-of-concept study establishes a foundation for systematic, data-driven environmental assessment that can be readily adapted to evaluate diverse contaminants and datasets as Norway navigates the complexities of sustainable development in a rapidly changing world.

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O-33

Time trends in the chemical exposome measured with human biomonitoring

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Non-communicable diseases (NCDs) account for about 70% of deaths globally. Major risk factors are tobacco use, physical inactivity, the harmful use of alcohol and unhealthy diets. Additionally, known environmental risks (air pollution, occupational) are estimated to contribute around 25% of non-communicable diseases (NCDs). However, these estimates are likely to represent only the tip of the iceberg as the full impact of pollution, especially chemical pollution, on NCD development is not known or underestimated. One of the reasons for this is the absence of sufficiently robust evidence for many exposures and health outcomes. Human biomonitoring (HBM) of environmental contaminants is emerging as an important tool to gain information about exposures to toxic substances.

NIPH has thus established a high through-put platform to perform chemical analytical research on human exposure to persistent and non-persistent organic pollutants with a focus on biomonitoring of breast milk, blood and urine. All the methods available are using tandem mass spectrometry as the detection technique. State of the art instrumental methods available include GC-MS/MS, APGC-MS/MS, and several LC-MS/MS systems using online extraction and clean-up methods, as well as a LC-QTOF that can be used both for targeted and non-targeted analyses. The platform provides high-throughput, high sensitivity assays to accurately measure exposure to a set of about 100 chemical compounds from different exposure families in human samples, i.e. Per- and polyfluoroalkyl substances (PFASs), persistent organic pollutants (PCBs, organochlorine pesticides and flame retardants), environmental phenols (like bisphenols, parabens, triclosan), UV filters (benzophenones), plasticizers (phthalates, DINCH), polycyclic aromatic hydrocarbons (PAHs), glycol ethers, organophosphate pesticides and flame retardants. This targeted approach provides specific, validated detection and quality-assured quantification of chemicals present at very low concentrations.

NIPH performs biomonitoring in large cohort studies linking exposure to chemicals/pollutants to different health outcomes, and is involved in several EU-funded projects. The ATHLETE project in combination with its predecessor project HELIX comprises a longitudinal study that is well set to study time trends in the chemical exposome. Examples for six European cohorts using comparable data from mothers (in-utero, year 2003-2009), children (year 2015) and adolescents (year 2023) will be presented. The exposure is clearly reduced for some of the pollutants, but time trends for others are more variable.

The accurate and sensitive data from the targeted chemical analyses will be further used by researchers throughout the consortium to study e.g. time trends, determinants of exposures, and associations with different health outcomes or biomarkers of effect.

O-34

Pesticide transport in the environment

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It is well documented that pesticides are transported away from where they have been applied and thereby pose a possible threat to terrestrial and aquatic organisms. The Norwegian Agricultural Environmental Monitoring Programme (JOVA) have since 1992 documented pesticide concentrations in surface water in major agricultural regions. Concentrations higher than ecotoxicological toxicity endpoints are regularly demonstrated for certain compounds, in some areas more often than others.

To reduce pesticide concentrations in soil and water, different mitigation measures are being used, some more efficient than others and some might not work at all. Some measures have been documented to be efficient in one situation but not necessarily in other situations, resulting in questions raised on some more generally applied mitigation measures. To be able to implement the most efficient mitigation measures under different conditions, detailed knowledge on the fate and behaviour of pesticides in the environment is crucial. We know that the fate and behaviour of pesticides depend on a range of factors, ranging from the agronomical practices to soil and climate conditions, factors that vary a great deal over relatively short distances.

In this presentation, examples from field studies performed by NIBIO in recent years together with data from the JOVA program and other surveys will illustrate some of the challenges faced with regard to pesticide use, exposure, risk and risk management complicating everything by putting it all in a climate change context.

O-35

Risk governance of per- and polyfluoroalkyl substances (PFAS) as a chemical class

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What causes the harm of chemicals, how can we assess them, and which risk governance tools are effective in reducing them?

These questions are central to the EU regulation of chemicals, and became apparent during the preparation of the chapter on chemical pollution[1] *for the European Environment Agency's 2020 State and Outlook Report (SOER2020)*, and later in the preparation of the EU *Chemicals Strategy for Sustainability – towards a toxic-free environment*[2] and its supporting documents on the PFAS Strategy[3] and on Mixtures[4].

While regulations for the past decades typically have addressed single substances, evidence now clearly shows that organisms respond to the chemical mixtures they are exposed to, whether we measure all the chemicals or not. Meanwhile, tools like accurate mass spectrometry combined with other 'PFAS Total' methods such as Combustion Ion Chromatography, show large 'analytical gaps' and 'PFAS dark matter'[5, 6] in most matrices, due to chemicals not included in routine monitoring. In parallel, the lack of pure chemicals (exist for only about 2% of PFAS) undermines the ability to generate toxicological and exposure data, and thereby risk assessments[7]. In addition, such data is very time-consuming and costly to produce. This introduces the undesirable incentive of 'drop-in' chemical substitution, which over and again have led to regrettable substitution, for instance when PFOA was substituted by HFPO-DA (GenX).

Evidence hence shows, that regulation aimed at single chemicals neither is accurate as a proxy for chemical harm, nor effective or efficient.

To address such shortcomings, EU regulations increasingly aim to address PFAS as a class or as a group. Examples for PFAS cover different *types of grouping*, for which there is a long tradition in European legislations:

a. **Uses of PFAS:** Danish PFAS ban in paper and board food contact materials, PFAS in textiles, ski-waxes or firefighting foams, F-gases – and the proposed universal PFAS restriction under REACH
b. **Sum of PFAS**, i.e groups of single PFAS: EU PFAS drinking water directive on Sum of PFAS20; EU food regulation on PFAS4; EU Water Framework directive under negotiation, 2025 EU Packaging and Packaging Waste Regulation (PPWR)
c. **Class of PFAS**: DWD on PFAS Total, 2025 EU Packaging and Packaging Waste Regulation (PPWR)
d. **Phys-Chem of PFAS**: vPvB and vPvM in REACH; PFAS DWD (mobility), EU PFAS restriction proposal
e. **Effects of PFAS**: F-gases (ozone depleting, global warming effects), EU Water Framework directive under negotiation

Pros/Cons of these groups, including group-based effect methods and relative potency factors (RPFs) will be discussed. Finally we will present a PFAS monitoring strategy aimed at various purposes, such as early warning screenings, risk assessment, enforcement and for input to indicators. The approach will be illustrated for the EU Soil mission project **ARAGORN[8],** where the objective is to produce step-wise fit-for-purpose monitoring methods, that are sufficiently fast and affordable for land-managers to use – and hence relevant for the forthcoming EU Soil Monitoring and Resilience Law.

References

O-36

Next Generation Risk Assessment (NGRA) of chemicals and chemical mixtures

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The increasing complexity of chemical pollution in environmental systems necessitates innovative approaches that extend beyond traditional environmental monitoring. Emerging computational tools and knowledge frameworks now offer promising avenues for connecting environmental exposure to chemical hazard for the purpose of predicting environmental risk of single chemicals and mixtures of these.

This work presents a comprehensive approach that integrates environmental monitoring data into a Source-To-Outcome Pathway (STOP) knowledge framework consisting of Aggregated Exposure Pathways (AEPs) and Adverse Outcome Pathways (AOPs) that elucidate causal relationships from source to adverse outcomes (i.e. risk). This integrated framework allows for qualitative and quantitative assessment of cumulative risk, identification of risk drivers, susceptible ecological targets (e.g. species or species-groups) and relevant toxicological mode of action (MoA) for real-world exposure scenarios.

This presentation will highlight how the STOP can extend chemical analysis and offer actionable insights into environmental impacts, exemplified by relevant Norwegian case studies. By integrating diverse datasets into a unified risk assessment framework, this work supports the transition towards more mechanistically informed Next Generation Risk Assessment (NGRA) that can complement traditional exposure assessment of chemical pollutants.

Acknowledgements: This work is supported by the Research Council of Norway (RCN-315969 EXPECT), EU-HEU-101057014 Project "PARC", and NIVA's Computational Toxicology Program (NCTP, RCN-160016).

O-37

Fate of PFAS and other contaminants in full scale relevant pyrolysis of organic wastes

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General treatment options for organic waste contaminated with poly- and perfluoroalkyl substances (PFAS) are currently limited to incineration, composting or landfilling, all leading to eventual emissions to the environment. Dry pyrolysis is emerging as a promising new waste handling alternative for contaminated organic wastes, as it recycles waste to biochar, condensate and syngas products that can have various useful applications. However, the fate of persistent organic contaminants like PFAS, OPFRs, PCBs, and PCDD/Fs, in addition to heavy metals during full scale pyrolysis operations is still uncertain.

In the present work, a mass balance for 56 different PFAS was established during the pyrolysis of sewage sludges, food waste reject, garden waste and waste timber. Data on the fate of OPFRs, PCBs, PCDD/Fs, PAHs and heavy metals were furthermore collected. Pyrolysis was done in a medium-scale unit (5-20 kg feedstock /hr, 500-800 °C) with syngas combustion.

All wastes contained PFAS (56 to 3651 ng g^{-1}), but pyrolysis led to a ≥98% removal. PFAS residuals (0.1-3.4 ng g^{-1}) were detected in biochars produced at temperatures up to 750 °C. Loads of emitted PFAS increased with temperature in a range from 0.01 to 3.1 mg $tonne^{-1}$ of biochar produced and were mainly associated with aerosols. Emissions accounted for <3% of the total mass of PFAS in the wastes. The presence and potential environmental impact of thermal degradation products are the main remaining uncertainties. OPFRs, PCBs and PCDD/Fs were removed from the solid phase (>99%) and either decomposed or volatilized and scavenged in the pyrolysis condensate. PAHs are typically generated during pyrolysis, but technological modifications could be used to lower the concentrations of PAHs in biochar products. Heavy metals mainly accumulated in the biochars, except for Cd which was fully volatilized at >500 °C. Mobility of heavy metals were generally low at ambient pH (<1% leachability) in all biochars. At low pH (<4), however, leaching was significant from wood based biochars (up to 100%), but not from sludge based biochars (<10%).

This work demonstrates the potential for integrating pyrolysis as a thermal treatment in organic waste management, which can provide environmental benefits and creation of new value chains in the circular economy.

O-38

Bioaccumulation and effects of legacy and novel PFAS in blue mussels exposed to an extract of AFFF impacted soil

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Per- and polyfluoroalkyl substances (PFAS) is a collective term of exclusively anthropogenic substances. According to the new OECD definition there are more than 7 million compounds with a perfluorinated methyl (-CF3) or methylene (-CF2-) group. Being produced since the late 1940s, PFAS exists in a wide range of industrial and consumer products, e.g. fire-fighting foams, food packaging, cosmetics and textiles such as raincoats and leather. The Stockholm Convention has listed PFOS (Annex B) and PFOA (Annex A) as persistent organic pollutants and today PFAS are called “forever chemicals” due to their long half-lives in the environment. The highest environmental concentrations of PFAS are reported at hot spots, such as airports due to the use of aqueous film-forming foams (AFFF) in fire drills.

Flesland airport in Bergen used PFOS based firefighting foams up until 2001. Between 2001 and 2012 FTS based foams were in use. In 2016 Avinor estimated that 15-45 kg PFOS still remained at the firefighting sites even though some of the compounds are said to have been transported into fresh waters and the coast surrounding the airport. Clean-up was started in 2022.

Herein, *in vivo* exposure using blue mussels (*Mytilus edulis*) under appropriate laboratory conditions was conducted. Blue mussels in holding tanks were exposed to an extract of AFFF impacted soil from Flesland airport for a total of 84 hours in the span of three weeks. Exposure was semi-chronic as the mussels were given time to rest between exposures.

Quantitative analysis of the soil using triple quadrupole mass spectrometry (QqQ-MS) revealed high concentrations of PFOS (1516 ± 335 ng/g) and 8:2 FTS (160 ± 13 ng/g). Several other PFAS were also detected, including PFOA, PFNA, PFDA, L-PFHxS and L-PFHpS. Analysis using Total Oxidizable Precursor (TOP) Assay showed an increase in several perfluoroalkyl carboxylic acids (PFCA) indicating the presence of PFAS precursors in the soil.

Blue mussels were sampled at nine time points to assess bioaccumulation over time: daily during the first week (6-30 hours), twice the second week (36, 48 hours), once in the third week (66 hours) and at the end (84 hours). Quantitative analysis using QqQ-MS showed an increase over time of 14 PFAS detected during the experiment, suggesting bioaccumulation, with PFOS, L-PFNS, L-PFDS, PFDA and FOSA showing the highest levels. An increase in PFCAs after TOP Assay in mussels exposed for 84 hours aligned with the findings in the soil, indicating the bioaccumulation potential of the precursors.

O-39

Identification, relative uptake, and effects of PFAS from AFFF and AFFF-impacted soil in Atlantic salmon hepatocytes

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The environmental persistence and toxicity of per- and polyfluoroalkyl substances (PFAS) associated with aqueous film-forming foam (AFFF) have raised significant concerns due to their bioaccumulative potential and health risks.

This study investigates the toxicological effects of PFAS from 3M AFFF and extract of AFFF-impacted soil on primary hepatocytes derived from Atlantic salmon (*Salmo salar*). Key assessments included metabolic activity and membrane fluidity to evaluate cellular impacts. RNA sequencing was used to analyze transcriptional changes in exposed hepatocytes, revealing molecular pathways influenced by PFAS exposure. High-resolution liquid chromatography-mass spectrometry (LC-HRMS) was employed for both target quantification and non-target screening of both hepatocyte lysates and surrounding media, enabling both the identification of various PFAS classes and estimation of their relative uptake within hepatocytes. Predicted biotransformation products of identified PFAS were also screened, providing insights into their metabolic fate.

This study demonstrates the value of combining advanced molecular and chemical analyses to comprehensively assess the impact of PFAS on aquatic organisms. The findings highlight the patterns of relative uptake, biotransformation potential, and toxicological effects of PFAS, contributing to improved environmental monitoring, risk assessments, and strategies for managing PFAS contamination in aquatic systems.

Poster Presentations

P-1

Unravelling tire wear particles in the atmosphere: On the of use of PTR-MS for detecting rubber additives as marker compounds

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The release of tire wear particles (TWP) into the environment is a significant source of pollution, raising concerns for both human health and ecological integrity. While research has traditionally focused on detecting and assessing TWPs in aquatic ecosystems, there is a growing emphasis on their presence and impacts in the atmospheric compartment. Moreover, as the use of electric vehicles (EVs) continues to surge, the release of tire wear particles into the environment is expected to intensify, making this issue even more urgent. Under these circumstances, Norway stands out as an ideal study location, given its high EV adoption rate and robust commitment to environmental stewardship.

A primary reason for our limited understanding of atmospheric TWP is the chemical-analytical challenges they present. Existing sampling and detection techniques often lack the necessary sensitivity, and the chemical complexity of airborne particles complicates the resolving and quantification of distinct TWP signatures. In this context, organic rubber additives or residual synthesizing agents, such as thiazoles, sulphenamides, dithiocarbamates, phenylene diamines, and phenols, hold promise to serve as specific markers for TWP.

Proton-transfer-reaction mass spectrometry (PTR-MS) is nowadays widely employed for detecting organic trace substances in the environment and has been utilized for characterizing the organic composition of atmospheric particles, both online and offline. In this study, we explored the detectability of organic rubber additives by PTR-MS with the ultimate goal of identifying and quantifying these compounds in atmospheric particulate matter. To optimize ionization and other PTR-MS operating conditions, we first analyzed authentic standards of target analytes and examined the dynamic headspace of heated tire macroparticles. We subsequently developed a method for generating airborne tire wear nanoparticles in the laboratory and for collecting them on filters. The PTR-MS was capable of detecting rubber additives when laboratory-generated filter samples were heated under nitrogen and the resulting effluent was introduced into the analyzer. We are currently collecting and analyzing atmospheric filter samples to assess whether organic rubber additives can also be detected in particles collected from the real urban atmosphere.

P-2

Emission profiles of polycyclic aromatic compounds (PAHs and their major transformation products) from energy production in Longyearbyen, Svalbard

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Recently the municipality of Longyearbyen (Svalbard) has changed the electric power production for the own. The earlier used coal fired power plant was decommissioned in 2023 and replaced by diesel driven generators. The aim of the here-reported study is to investigate the emission profile and distribution patterns of polycyclic aromatic hydrocarbons (PAHs) and their major thermal transformation products (i.e., oxy- and nitro-PAHs in Longyearbyen air). This is of particular interest for environmental scientists as well as the public since the emission characteristics of PAH related contaminants were investigated in an earlier study in 2019, when the coal-fired power plant was still in operation (Drotikova, 2021).

In this early investigation, the coal-fired power plant was identified as one of the main emission sources. By comparing the here reported results, where atmospheric emissions were measured in defined distances from the diesel driven generators as well as on the roof of the research park in Longyearbyen, specific pattern differences and characteristic emission profiles will be elucidated and discussed. The results will also contribute to identify source-specific concentration differences compared to the 2019 study and will discuss the associated changes in air quality due to possible source specific level changes in PAH related emissions in recent years.

Drotikova, T.,;Ali, A.M; Halse, A.K.; Reinardy, H.C.; Kallenborn, R; (2021). Polycyclic aromatic hydrocarbons (PAHs) and oxy- and nitro-PAHs in ambient air of the Arctic town Longyearbyen, Svalbard. *Atmos. Chem. Phys., 20, 9997–10014, 2020, https://doi.org/10.5194/acp-20-9997-2020*

P-3
Advanced quantification of tire ware additives: 6PPDQ as an example

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Tire ware residues, produced by mechanical release from vehicles, are important anthropogenic pollutant sources in road associated environments. The aim of this study is to analyze the content of selected antioxidants which are often added to tire as conservation agents and UV-protection. Such additives are regularly reported as indicators for traffic related pollution. However, also in arctic regions polymeric rubbers are utilized for vehicle-based transportation such as snow mobiles, snowcats and car-based transportation. However, tire ware additives (such as 6PPDQ and other quinones) have not yet been investigated in settlements, snowmobile tracks and roads in the Artic. Therefore, we collected soil and surface water, in the vicinity of Longyearbyen, Svalbard to investigate the presence and distribution profile of selected antioxidants utilized as rubber additives to polymeric rubber. We chose several relevant quinones reported as additives (see figure 1) and released into road associated environments through mechanical abrasion. Among the most investigated quinones, 6-PPDQ (2-((4-Methylpentan-2-yl)amino)-5-(phenylamino)cyclohexa-2,5-diene-1,4-dione) is the major transformation product of the additive 6-PPD (*N*-(1,3-dimethylbutyl)-*N'*-phenyl-1,4-benzenediamine) usually added to the polymer. This contaminant has been detected in several environmental media such as water, soil and air particles. Previous studies confirmed that 6-PPDQ at environmental concentration levels may even induce toxicity as neurotoxicity, and reproductive toxicity in fish [1].

The goal of the here reported study is to provide a first general overview of such type tire ware associated polymer-additives, their concentration and their distribution profile in Artic surface soil and water samples from Roads in Longyearbyen (Svalbard, Norwegian Arctic). The concentration of selected associated quinones was determined and quantified with an optimized and validated analytical method using high performance liquid chromatography coupled to triple quadrupole mass spectrometric detection (HPLC/QqQ-MS)

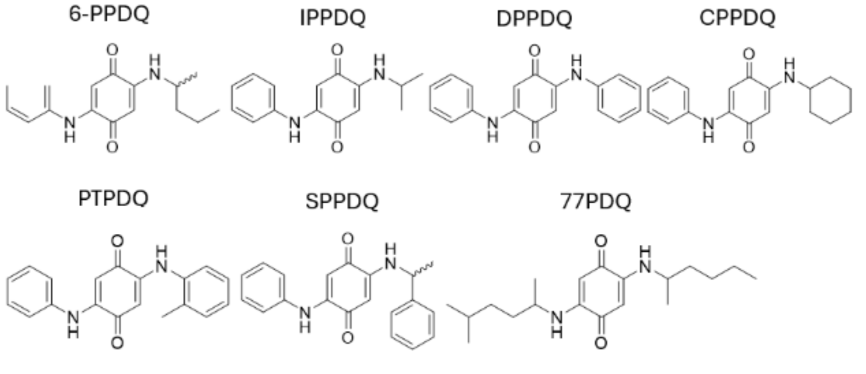

Figure 1 Selected quinones studied in this study

[1] X. Hua and D. Wang, "Tire-rubber related pollutant 6-PPD quinone: A review of its transformation, environmental distribution, bioavailability, and toxicity,"*Journal of hazardous materials*, p. 132265, 2023.

P-4

Introduced changes in pH and reduction-oxidation potential in mire soils from discontinued firing range of Vaterholmen camp in Verdalen, Norway

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Metals leaching from lead-based ammunition are a well-documented problem from both civilian and military firing ranges continuously in operation, or possible discontinued ranges. Such former, discontinued ranges are situated in Verdalen near the former military camp of Vaterholmen, which already has been attempted cleaned over several years. Ammunition is still found and as the ranges are situated on mire and the property is to be sold, more cleaning is necessary to alleviate the contaminated soils. If the topmost, most contaminated soil is removed, oxygen will be introduced and thus potentially mobilize the chemically stable metal contaminants remaining in the system.

Six samples of assumed non-polluted mire were dug from the mire and placed in containers with simple spigots in stable non-freezing temperatures for measuring changes in the soil water for four months. Lead-based ammunition is buried some centimeters into the four of the mire soil samples, mire water from Vaterholmen is poured into two of these samples and a solution of acetic acid is poured into two others. Half of the samples, one mire water soil sample and one acetic acid solution soil sample, has the ammunition saturated in the solution, while the other half, also one mire water soil sample and one acetic acid solution soil sample, has the ammunition not saturated in the solution. The control group is based on mire water and acetic acid solution-logged mire soil samples without ammunition.

Regular water analyses will describe the changes in pH, oxygen content, conductivity and reduction potential, while metal content will be analysed from selected water samples based on strategically determined temporal milestones.

The experiment is set to end in February 2025, but results from the first two months show a quickly stabilised pH in the water affected by the acetic acid solution, potentially pointing towards buffering reactions in the soil. A steady decline in measured oxidation-reduction potential, may reveal decomposition even outside the natural environment. The metal content in the selected soil water samples is to be analysed in February 2025.

The purpose of the experiment is to investigate which conditions most likely agitate ammunition in waterlogged and non-waterlogged stagnant waters to leach metals. This will help to decide whether cleanup by soil removal will accelerate further contamination by introduction of e.g. oxygen to the system.

P-5

Carbon and organic matter cycling in soil and soilwater in boreal and subarctic ecosystems

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The primary goal of the main project is to investigate the biogeochemical processes and their governing factors that regulate the turnover of soil organic matter (SOM) in boreal and subarctic ecosystems. The study seeks to enhance our understanding of carbon cycling and its responses to climate change, from whole-ecosystem dynamics to microbial-level processes.

This master thesis focuses on the transport of dissolved organic matter (DOM) in porewater within peatlands. Peats and mires are major carbon reservoirs and significant sources of dissolved organic carbon (DOC) [1] across boreal and subarctic systems. By deconvoluting the contributions of various peat types to DOM and mapping of these sources, the study aims to quantify their role the overall carbon budget. This approach will elucidate the hydrological conductivity between different types of peat and their respective contribution to lateral carbon fluxes in representative boreal lakes and catchments. Of particular interest is understanding how the carbon budget of the peatlands relates to DOM flux at the main inlet of Langtjern and subsequently into the lake.

The research leverages two distinct field sites: the Langtjern Ecological monitoring site [2], a dystrophic boreal ecosystem northwest of Oslo, and the Iškoras permafrost research site in Finmark, representing a subarctic ecosystem. This comparative approach will clarify how carbon storage and mobilization differ across the boreal-to-artic transition, specifically from SOM to lateral DOC transport. A central focus is lateral carbon flux to understand the role of soil water, soil, and lakes as carbon sources or sinks of carbon under current climate conditions. While the lateral flux of DOM is important, the study also considers the vertical flux of carbon in the form of CO_2, which directly contributes to atmospheric greenhouse gas (GHG) emissions. By integrating these lateral flux studies with concurrent research on vertical fluxes, the master study aims to contextualize carbon dynamics across spatial and temporal scales, shedding light on the fate of dissolved gases within the carbon budget of Langtjern and Iškoras.

Acquired field data reveal a general trend of increasing pH with depth, except for the deepest layers, possibly due to the oxidation of sulfides to sulfuric acids in deep peat water. Seasonal patterns show a slight decrease in pH and an increase in conductivity. Precipitation influences conductivity, with values rising during dry periods and dropping following rain events. Data on DOC concentrations and DOM characteristics are forthcoming and will be presented in the final analysis.

1. Crapart, C., A. G. Finstad, D. O. Hessen, R. D. Vogt and T. Andersen (2023). Spatial predictors and temporal forecast of total organic carbon levels in boreal lakes. Science of The Total Environment 870: 161676Norway, LTER. (2023). Langtjern - Norway. DEIMS - SDR. https://deims.org/2610fbc1-8eee-4223-8c27-367aa67feddc.
2. CBA (2022), *CBA Annual Report - 2022*. C.f.B.i.t.A., University of Oslo. p. 100.

P-6

Air-surface exchange of halomethoxybenzenes in Northern Sweden

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Halomethoxybenzenes (HMBs) are "semivolatile" and exchange between the atmosphere, oceans and seas, and terrestrial surfaces (soil, vegetation, rivers, lakes).[1,2] Here we focus on natural brominated anisoles (BAs), produced in marine ecosystems by algae and bacteria[3], and drosophilin A methyl ether (DAME = 1,2,4,5-tetrachloro-3,6-dimethoxybenzene), a secondary metabolite of terrestrial fungi[4]. Studies were conducted in Lake Torneträsk (LT) (68° 22'N, 19° 06'E) and streams in subarctic Sweden[2] and in rivers and Baltic estuaries of Västerbotten County (VC)[3]. HMBs in air, soil and ground litter were also measured.[3,4] Air-surface exchange was assessed by calculating the water/air and soil/air fugacity ratios (FR_{WA}, FR_{SA}) from their environmental concentrations and physicochemical properties of the HMBs.[1,2] $FR = 1$ indicates equilibrium, while net deposition and volatilization are indicated by $FR < 1$ and $FR > 1$.

Concentrations of BAs in water and FR_{WA} followed the order: estuaries > offshore > VC rivers > LT and streams. The highest concentrations and FR_{WA} in estuaries can be attributed to local production. DAME concentrations were highest in VC rivers (land runoff) followed by estuaries > offshore > LT and streams. Net volatilization was found at most sites ($FR_{WA} > 1$), in agreement with studies in Canada[1], where DAME in air was related to proximity to water bodies. Exchange of DAME with soil/litter was assessed at sites in VC and near LT. Net volatilization ($FR_{SA} > 1$) was found at most sites. HMBs are released from sea and land, disperse through the atmosphere, and return via precipitation and rivers (Figure 1), cycles that connect ecosystems and provide widespread exposure to organisms.[1,5]

1. Zhan, F. et al., 2023, *Sci. Adv. 9*, eadi8082. 2. Bidleman, T.F. et al., 2024, *Sci. Total Environ. 948*, 1748492. 3. Bidleman, T.F. et al., 2023, *Front. Mar. Sci. 10*, 1161065. 4. Bidleman T.F. et al., 2023, *Chemosphere 347*, 140685. 5. Kupryianchyk, D. et al., 2018. *Environ. Toxic. Chem. 37*, 3011-3017.

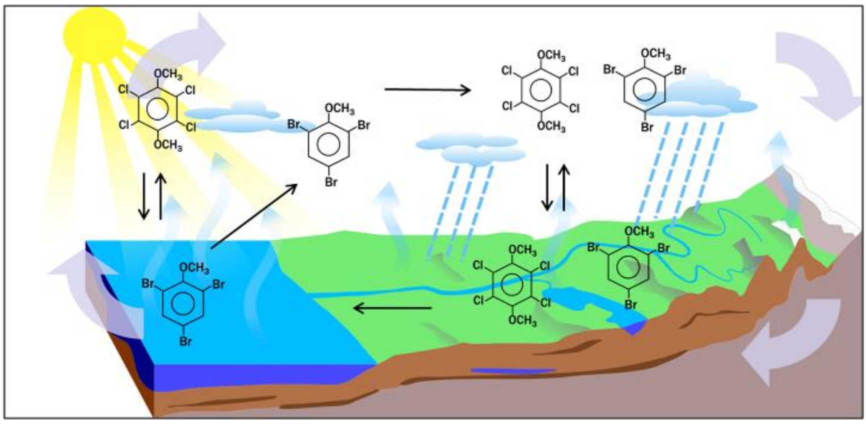

Figure 1. "What goes around comes around". BAs are produced in estuaries, DAME and DA are delivered to the sea by terrestrial runoff. Air connects marine and terrestrial ecosystems.

P-7

Active air sampling with polyurethane foam: Comparing field observations with a breakthrough model

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Polyurethane foam (PUF) is widely used for active air sampling (AAS) of gaseous semivolatile organic compounds (SVOCs)[1,2]. PUF efficiently collects SVOCs with moderate to low volatility, but applications are limited for the more volatile compounds due to breakthrough from the PUF trap. The collection efficiency can be predicted by frontal chromatography theory with knowledge of several parameters: the sampled air volume, the breakthrough volume which depends on the PUF/air partition ratio (K_{PA}) as a function of temperature, and the number of theoretical plates (N) in the PUF trap[3-5].

Here we evaluate data from a Canadian air monitoring program in which front and back PUF traps (P1 and P2) were used to check for breakthrough, as indicated by the back/front ratio (P2/P1) of collected hexachlorobenzene (HCB). A frontal chromatography model was used to relate the collection efficiency of HCB to its observed P2/P1 ratio under assumed scenarios of K_{PA} and N, and apparent N-values for the PUF traps were derived[6,7]. Results were applied to correct observed air concentrations of HCB for breakthrough loss using K_{PA} from the literature. The choice of K_{PA} greatly influenced the adjusted air concentrations and the apparent enthalpy of surface-air exchange (ΔH_{SA}, kJ mol^{-1}) (Figure 1), showing that critical judgement is needed when applying corrections of this type.

1. Li, Y.; Wania, F. *Environ. Sci. Proc. Imp.* **2021**, 23, 723-734. 2. Bidleman, T.F.; Melymuk, L. *Bull. Environ. Contam. Toxicol.* **2019**, *102*, 447-499. 3. Lövkvist, P.; Jönsson, J.-Å. *Anal. Chem.* **1987**, *59*, 818-821. 4. Xiao, H. et al. *Environ. Sci. Technol.* **2007**, *41*, 250–256.
5. Cai, Q-L. et al. *J. Chromatogr. A* **2024**, 1738, 465474. 6. Bidleman, T.F., Tysklind, M. *Chemosphere* **2018**, *192*, 267–271. 7. Bidleman, T.F. et al. **2025**, submitted.

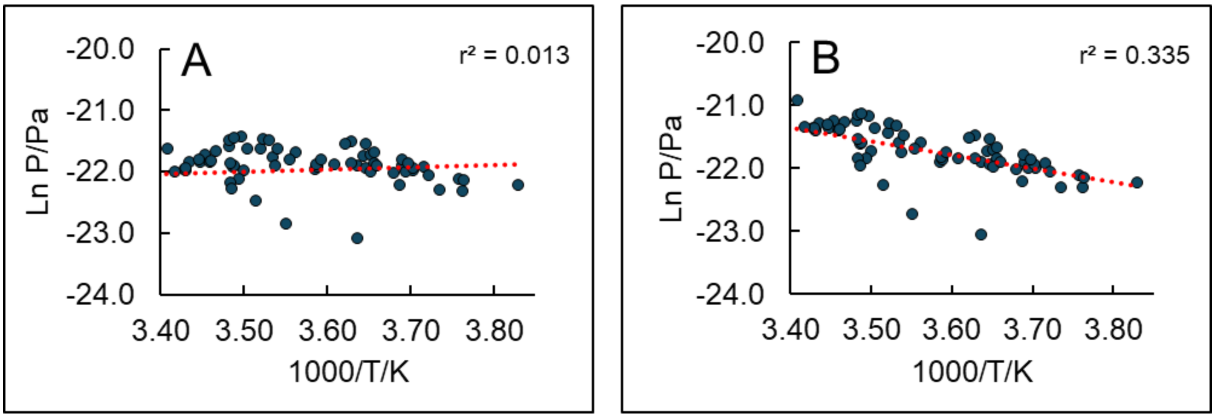

Figure 1. Clausius-Clapeyron (CC) plots of HCB partial pressure (ln P/Pa) at Pt. Petre, ON, Canada related to sampling event temperature (1000/(T/K). Panel A shows the uncorrected air data (mean concentration 37 pg m^{-3}), where the HCB collection efficiency was reduced in warmer events. Panel B shows the same air data (mean concentration 51 pg m^{-3}) adjusted for collection efficiency using the breakthrough model. Apparent enthalpies of surface-air exchange (ΔH_{SA}) were -7.2 kJ mol^{-1} (not significant) in A and 41 kJ mol^{-1} (p <0.0001) in B.

P-8

The potential role of epigenetic biomarkers in risk management of occupational exposure to Cr(VI)

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Approximately 900,000 workers in the European Union are exposed to carcinogenic hexavalent chromium (Cr(VI)). Genotoxic effects, such as oxidative stress and DNA lesions, have been recognized as crucial events in the carcinogenic process of Cr(VI) compounds. Moreover, it has been suggested that, in addition to the induced genotoxic effects, epigenetic mechanisms like DNA methylation may contribute to the carcinogenicity of Cr(VI) compounds.

Therefore, we investigated the epigenetic effects induced by occupational exposure to Cr(VI). We employed a cross-sectional study design and measured chromium in urine to characterize exposure to Cr(VI). Additionally, we investigated the effect of occupational Cr(VI) exposure on 8-hydroxy-2’-deoxyguanosine (8-OHdG), global DNA methylation and global DNA hydroxymethylation in blood. We included workers (n=254) from seven European countries with potential exposure to Cr(VI). As controls (n=114), we recruited healthy adult office workers from the same companies as the exposed workers (referred to as "within-company controls") or from other companies with no activities associated with Cr(VI) exposure (referred to as "outwith-company controls").

Overall, each exposed subgroup displayed significantly higher mean urinary Cr levels than the total controls, the within-company controls, or the outwith-company controls ($p < 0.007$, Mann-Whitney test). The within-company controls had significantly higher internal exposure levels than the outwith-company controls ($p < 0.001$, Mann-Whitney test). The outwith-company controls exhibited significantly higher global DNA methylation levels and lower levels of 8-OHdG than all other exposure subgroups ($p < 0.01$, Mann-Whitney test).

Overall, these findings reinforce the results of exposure biomarkers, highlighting that in Cr-related industries, (office) workers' exposure to Cr is associated with detectable alterations in biological effect markers. Furthermore, characterizing epigenetic effects like global DNA methylation could improve risk management.

P-9
The fate of heavy metals in the environment of e-waste sites

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Occupational hygiene (respirable and inhalable airborne dust, settled dust and wipe samples) and human biomonitoring samples (urine and blood) were collected. Exposed workers were recruited who worked in industrial recycling of e-waste. Four target activities within e-waste processing were identified to have associations with exposure to chromium, cadmium, mercury and lead, (i) sorting of e-waste (ii) dismantling of e-waste, (iii) shredding and pre-processing e-waste, and (iv) metal processing for example melting for re-use. Workers were grouped into the following exposure groups: batteries, metals and plastics, white goods (such as refrigerators and washing machines), brown goods (such as TV, audio equipment and similar household appliances) and miscellaneous e-waste.

Samples were also collected from workers who were not occupationally exposed to chromium, cadmium, mercury and lead through e-waste processes to form a comparison control group. Urine samples were collected from exposed workers at the beginning (pre-shift) and end (post-shift) of the workweek. Hair samples were collected in the morning preferably before the start of the workweek. Venous blood samples were collected towards the end of the workweek.

Chromium, cadmium, mercury and lead has been measured in urine and hair samples. Venous blood samples were collected for the measurement of cadmium and lead in whole blood and chromium in red blood cells. Air and wipe samples are used to identify exposure routes and risk reducing measures. Wipe samples were collected at the beginning and end of the air measurements (ca. 8h) to investigate the increase in dermal contamination. Inhalable and respirable personal aerosol fractions, hand wipes and settled dust samples were collected for the measurement of chromium, cadmium, mercury and lead.

P-10
Screening of PFAS in wastewater and sewage sludge from WWTPs in Bergen, Norway

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Per- and polyfluoroalkyl substances (PFAS) are a diverse class of environmental pollutants with widespread use and persistence. This study presents a comprehensive assessment of PFAS in influent, effluent, and sewage sludge from three main wastewater treatment plants (WWTPs) in Bergen, Norway. The WWTPs receive wastewater from diverse sources, including municipal, hospital, and airport facilities. Target analysis of PFAS, including ultrashort-chain PFAS, was performed using liquid chromatography coupled to triple quadrupole mass spectrometry (LC-MS/MS), while non-target screening was conducted using high-resolution mass spectrometry (LC-HRMS) to identify unknown PFAS and emerging fluorinated compounds.

The poster highlights levels and profiles of both target and non-target PFAS across different WWTP compartments. It reveals insights into their behavior during wastewater treatment, accumulation in sewage sludge and release into the marine environment. The findings contribute to understanding the fate of PFAS in WWTPs and inform strategies for mitigating their environmental impact.

P-11

Synthesis and testing of catalysts for green ammonia production

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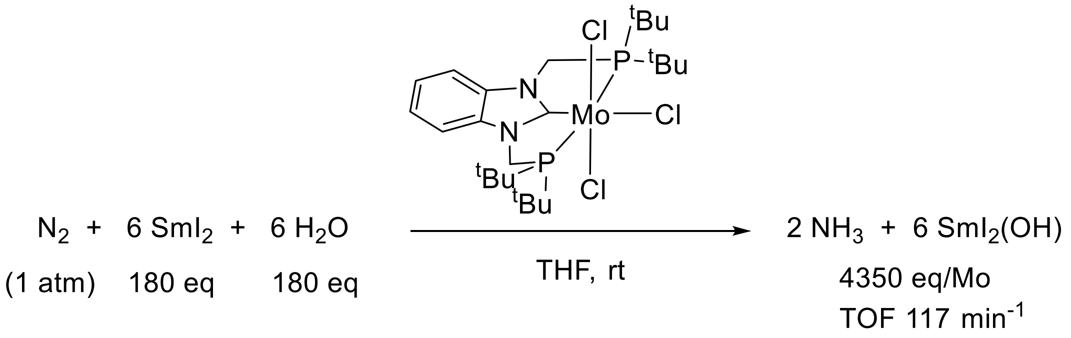
Ammonia is a crucial feedstock used to produce fertilizers and nitrogen-containing materials such as pharmaceuticals, plastics, textiles, and explosives. Currently, ammonia is produced industrially via the energy intensive Haber-Bosch process:

$$N_2 \quad + \quad 3\,H_2 \quad \xrightarrow[\text{50 - 100 atm, 300 - 900°C}]{\text{cat. Fe/Al}_2\text{O}_3\text{/K}_2\text{O}} \quad 2\,NH_3 \qquad (1)$$

The goal is to replace the Haber-Bosch process with a less energy-demanding one. Extensive studies have been conducted on nitrogen fixation catalysed by homogeneous catalysts to achieve the production of ammonia at a low temperature and pressure. Nishibayashi *et al.* have developed a class of catalysts with PLP-type pincer ligands, bonded to the metal molybdenum, which all have shown activity toward nitrogen fixation of ammonia. The most active has a PCP-type pincer-ligand shown in reaction (2)[1,2].



$$\underset{(1\text{ atm})}{N_2} + \underset{180\text{ eq}}{6\,SmI_2} + \underset{180\text{ eq}}{6\,H_2O} \xrightarrow[\text{THF, rt}]{} 2\,NH_3 + 6\,SmI_2(OH)$$

4350 eq/Mo
TOF 117 min^{-1}

(2)

Understanding the mechanistic reaction pathway of the catalysts is crucial in order to develop novel catalysts suitable for industrial applications [3]. Guided by quantum chemical calculations we are developing novel molybdenum based catalysts to facilitate dinitrogen reduction in an effective manner.

[1] Ashida, Y., Arashiba, K., Nakajima, Y. Nishibayashi. *Nature* **568**, 536–540 (2019). https://doi.org/10.1038/s41586-019-1134-2
[2] Ashida, Y., Mizushima, T., Arashiba, K. *et al. Nat. Synth* **2**, 635–644 (2023). https://doi.org/10.1038/s44160-023-00292-9
[3] Himmelstrup, J., Jensen, V. R. J. Phys. Chem. A 2023, 127, 3796-3803 DOI: https://doi.org/10.1021/acs.jpca.3c00418

P-12

Challenges and advances in the detection and quantification of neutral per- and polyfluoroalkyl substances (PFCs)

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Per- and polyfluoroalkyl substances (PFAS) are a class of man-made chemicals that have attracted increasing attention since the early 2000s due to their water and oil repellence properties. Recently, these chemicals have been linked to various negative health outcomes and have become ‘emerging’ global environmental pollutants. Due to the vast number of these toxicants, they present a significant challenge to analytical chemists, chemical regulators, and environmental fate modelers.

Some poly- and perfluoroalkyl substance (PFAS) groups, such as perfluoroalkyl sulfonates (PFSs), perfluoroalkyl carboxylic acids (PFCAs), fluorotelomer sulfonates (FTSs), and perfluoroalkyl sulfonamides (PFSAs), usually referred to as polar PFCs, can be routinely quantified by standardized methods (such as US EPA Methods 533 or 1633). These methods are based on the application of weak anion exchange solid-phase extraction (WAX-SPE) for clean-up and up-concentration, and liquid chromatography–mass spectrometry (LC–MS) for sensitive quantification (<1 pg per injection).

Other PFAS groups, such as fluorotelomer alcohols (FTOHs), fluorotelomer iodides (FTIs), fluorotelomer olefins (FTOs), and fluorotelomer acrylates and methacrylates (FTAcs and TFMAcs), are typically referred to as volatile or neutral PFASs. These are usually measured by custom in-lab methods and gas chromatography–mass spectrometry (GC–MS) instruments. These methods are much more diverse than standardized methods for polar PFASs. First, due to the variety of properties of neutral PFCs, up-concentration and clean-up might require several parallel procedures. Second, different PFAS groups tend to behave differently on ion sources and might requires different instrument configurations. Lastly, quantification on GC–MS using mass-labelled standards can be challenging due to the absence of commercially available standards and/or fragmentation overlap between native and labelled compounds, leading to ion interference and quantification issues.

In this presentation, we will discuss the challenges and our progress in developing a universal method for the detection and quantification of the most common neutral PFASs and its application for the quantification analysis of these emerging pollutants in fish tissue.

P-13

Non-targeted screening of household dust for PFAS and other pollutants using GCxGC-HR-TOF-MS and scaled mass defect plots

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Per- and polyfluorinated alkyl substances (PFAS) are ubiquitous and persistent compounds that are detrimental to human health. It is critically important to regularly monitor PFAS and other toxic persistent organic pollutants (POPs) such as phthalates, polychlorinated biphenyls (PCBs), polybrominated diphenyl ethers (PBDEs), and pesticides. In this study, we used enhanced chromatographic resolution, a novel multi-mode ionization source, high-resolution time-of-flight mass spectrometry, and powerful software tools for the non-targeted analysis of PFAS and other pollutants in dust. Dust is a repository of a wide array of substances and is an excellent indicator of chemical exposure.

The analytical methodology resulted in the confident annotation of numerous compounds including hydrocarbons, acids, amines, alcohols, aldehydes, ketones, phenols, terpenes, fatty acids, steroids, phosphates, illicit drugs, and over-the-counter drugs. The data was additionally processed using advanced Spectral Analysis Tools (SAT) to search for trace-level PFAS, POPs, and pesticides in the complex dust matrix. These lower level pollutants were characterized using multidimensional contour plots, high-resolution accurate mass data, and scaled mass defect plots. For example, annotated PFAS included fluorotelomer alcohols (FTOHs), and polyfluorinated alkyl alkanes. The EI spectra for a homologous series of FTOHs were very similar resulting in incorrect annotations. However, the complementary PCI data provided molecular formula information and helped characterize the FTOHs. The described methodology is a very valuable tool for the effective monitoring of human chemical exposure.

P-14

ENCORE: a probabilistic framework for environmental co-exposure and risk estimation

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EU's Chemicals Strategy for Sustainability aims to incorporate "combined exposure" risks, stemming from unintentional chemical mixtures in the environment, into regulatory risk assessments. A Mixture Allocation Factor (MAF) has been proposed to lower all safety limits for single chemicals. However, recognising the shortcomings of MAF for the management of co-exposures of environmental relevance, CEFIC-LRI called for a project ECO66 for next generation risk assessment methods supporting the identification of environmental co-exposures of potential concern. The resulting project ENCORE (ENvironmental CO-exposure and Risk Estimation, 2025-2027) aims to develop a probabilistic modelling framework to identify priority chemicals for co-exposure risk at the watershed level.

In chemical fate modelling, epistemic uncertainty and natural variability are both unavoidable, in areas such as usage information, model parameters and processes, monitoring data, and more. Environmental risk characterisation also involves uncertainty associated with the effect (hazard) data. In ENCORE, a probabilistic framework will be developed to characterise and integrate the uncertainty from several components throughout the whole risk assessment model. In addition, the ENCORE framework will allow for integration of multiple sources of information, such as monitoring data and model simulations. More specifically, Bayesian network (BN) models will be used to update prior probabilities from process-based simulation data with new evidence from monitoring data, to enhance the robustness of model predictions. Furthermore, the BN methodology will be applied to case studies for efficient exploration of alternative emission scenarios, alternative approaches to mixture risk characterisation, and other modelling aspects.

The ENCORE framework builds upon an environmental fate model originally developed in the EU project SOLUTIONS for large-scale European domains, but is adaptable to specific regions, such as the Rhine and Danube river basins. One key part of the ENCORE project is to improve the accuracy of model predictions for specific watersheds through improving the quality of model input data, and by integrating national chemical use and emission information, tonnage data over time and local monitoring data, in combination with verified hazard data. For this purpose, key data sources include the pan-European publicly available datasets Waterbase Emissions (WISE-1) and Waterbase Water Quality (WISE-6), hosted by the European Environment Agency (EEA). Ultimately, ENCORE aims to prioritize high-risk co-exposure chemicals by accounting for spatial and temporal exposure patterns across large regions of Europe.