AIRMON 2025

The 11th International Symposium on Modern Principles of Air Monitoring and Biomonitoring

15-19 June 2025 in Loen, Norway

Programme and Abstracts

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2 Welcome Letter

Dear colleagues,
It is a great honour and pleasure to welcome you to Loen and the 11th International Symposium on Modern Principles of Air Monitoring and Biomonitoring. Both the local and the international scientific committees have done its utmost to follow up on the success of the ten previous Airmon conferences by covering the latest developments in human exposure assessment and strategies with special focus to air sampling, biomonitoring and new analytical methodologies. The aim of Airmon 2025 is to provide a forum to encourage the exchange of ideas and knowledge about recent developments and state-of-the-art knowledge. The conference brings together 130 international participants experienced in fundamental aspects, instrumentation and applications to examine recent progress.

The plenary programme has been planned with a view of furnishing a comprehensive overview of the latest developments in this scientific field. Since some of the world's leading authorities are present, the conference will hopefully also be a stimulating forum for communication across borders and between scientific disciplines.

Short tutorial courses are offered by leading scientists to all participants during the four and a half day meeting which may be attractive. This concept is meant to stimulate especially students and young scientists to learn more about theoretical and practical issues as well as to obtain specialists recommendations for method improvements and novel applications for human environmental and occupational exposure assessments.

There's something extraordinary about meeting *in-person*. Great minds coming together in one place fuels creative energy and innovation, but I also know that the natural beauty of the area will captivate you. I sincerely hope that the conference excursions, social events, and outdoor farewell dinner may complement the scientific endeavours. For many of you, this event will be a first-time Airmon conference. It thrills me and the other members of the organising committees to provide this moment for you all.

Warmly
Nils Petter Skaugset

Conference Chair

3 Organising and Scientific Committees

Local Organising Committee:

Nils Petter Skaugset	(Conference Chair), National Institute of Occupational Health, Oslo, Norway
Torunn Kringlen Ervik	National Institute of Occupational Health, Oslo, Norway
Yngvar Thomassen	National Institute of Occupational Health, Oslo, Norway
Pål Graff	National Institute of Occupational Health, Oslo, Norway
Margrethe Schøning	National Institute of Occupational Health, Oslo, Norway

International Scientific Committee:

Alena Bartonova	NILU Norwegian Institute for Air Research, Kjeller, Norway
Balazs Berlinger	University of Veterinary Medicine Budapest, Hungary
Mariella Carrieri	University of Padova, Italy
Axel Eriksson	Lund University, Lund, Sweden
Martin Harper	Department of Environmental Engineering Sciences, University of Florida, Gainesville, USA
Keld Alstrup Jensen	National Research Centre for the Working Environment, Copenhagen, Denmark
Taekhee Lee	NIOSH National Institute for Occupational Safety and Health, Pittsburgh, USA
Elizabeth Leese	HSE Health and Safety Executive, Buxton, UK
Ilse Ottenbros	TNO, Utrecht, The Netherlands
Katrin Pitzke	IFA Institute for Occupational Safety and Health of the German Social Accident Insurance, Sankt Augustin, Germany
Tiina Santonen	Finnish Institute of Occupational Health, Helsinki, Finland
Xavier Simon	INRS National Research Institute on Occupational Safety and Health, Nancy, France
Urs Schlüter	BAuA Federal Institute for Occupational Safety and Health, Dortmund, Germany
Giovanna Tranfo	INAIL Istituto Nazionale per L’Assicurazione Contro gli Infortuni sui Lavoro, Rome, Italy

4 General Information

Conference Desk

The conference desk is situated in the conference foyer of Hotel Alexandra. It will operate as follows:

Saturday	14 June	15:00 - 18:00
Sunday	15 June	08:00 - 09:00
Monday	16 June	07:30 - 08:00
Tuesday	17 June	07:30 - 08:00
Wednesday	18 June	07:30 - 08:00
Thursday	19 June	08:00 - 09:00

Participants are requested to register as soon as possible upon arrival to the conference venue, Hotel Alexandra, Loen.

Conference Venue

All oral and poster sessions will be held in the various auditoriums of Hotel Alexandra.

Tel: +47 57 87 50 00 Fax: +47 57 87 50 51 Email: alex@alexandra.no
Homepage: www.alexandra.no

Meals

Participants staying at Hotel Alexandra are served breakfast, lunch and dinner (all included in their accommodation package).

5 Social Programme

Saturday, 14 June, 17:00 - 19:00 Informal get-together in the Hotel Alexandra Bath & Spa

All delegates and accompanying persons are invited to enjoy the heated outdoor swimming pool and refreshments.

Sunday, 15 June, 14:00: Half-day excursion to Geiranger

This tour encompasses a mountain plateau above the tree and snow lines, the summit of Dalsnibba (1746 m), and a sail of 25 km along the spectacular Geirangerfjord.

Sunday, 15 June, 14:30: Boat tour at Loen Lake

The MS Kjenndal II takes you on a trip from Sande at the lower end of the Loen Lake to Kjenndalsanden, where Kjenndalstova is located. A one-hour stop allows for a walk or you can enjoy delicious waffles and hot coffee before the boat returns to Sande.
The trip takes around 4 hours.

Sunday, 15 June, 14:00: The Skåla Challenge

Those who want to challenge the Norwegian mountains after lunch may visit the Kloumann Tower at Skåla Mountain. This is the hardest uphill walk in entire Norway, approx. 1800 m straight up (8 km). Hikers are advised to bring appropriate footwear and clothing for this walk.
Free of charge, but you will sweat!

Sunday, 15 June, 14:00: Loen Skylift

Loen Skylift is a spectacular attraction and adventure arena in the inner part of the Nordfjord. A cable car will lift you from the fjord to 1011 m above sea level. Here you can enjoy the views of the fjord landscape – from the restaurant table, or while exploring in the mountains.

Sunday, 15 June, 14:00: Via Ferrata Loen

Via Ferrata Loen is a climbing path secured with wire right behind Hotel Alexandra. The climbing trail takes you to the top of Hoven at 1011 meters above sea level, with a phenomenal view of Loen and Olden Vally.
As part of the route you can cross Gjølmunn Bridge, the longest Via Ferrata bridge in Europe**.** The bridge is located 750 meters above sea level and is 120 meters long.

Monday, June 10, 21:00: Bring your own to the poster viewing beverage tasting

You are invited to bring your favourite beverage to be enjoyed by you and others!

Wednesday, 18 June 16:40: Excursion to the Briksdal Glacier with a conference outdoor dinner

You are invited to visit the heart of Norway - an **Unforgettable** trip to the Briksdal Glacier. Participants can enjoy a walk to view the glacier arm.
Afterwards there will be an outdoor barbeque at "Kleivane" (weather permitting - otherwise the grill party will be held at Briksdalen Inn).

6 Scientific Programme

Oral presentations
Invited plenary lectures and submitted oral contributions will be 30 and 20 minutes in length, respectively (including discussion).
Video projectors will be provided in all lecture rooms.

Posters
The posters should be mounted afternoon Saturday 14 June or early Sunday morning 15 June, in the poster and exhibition area located next to the auditorium. Materials for poster mounting are available in the poster mounting area.

Language
The working language of the conference is English.

7 Liability

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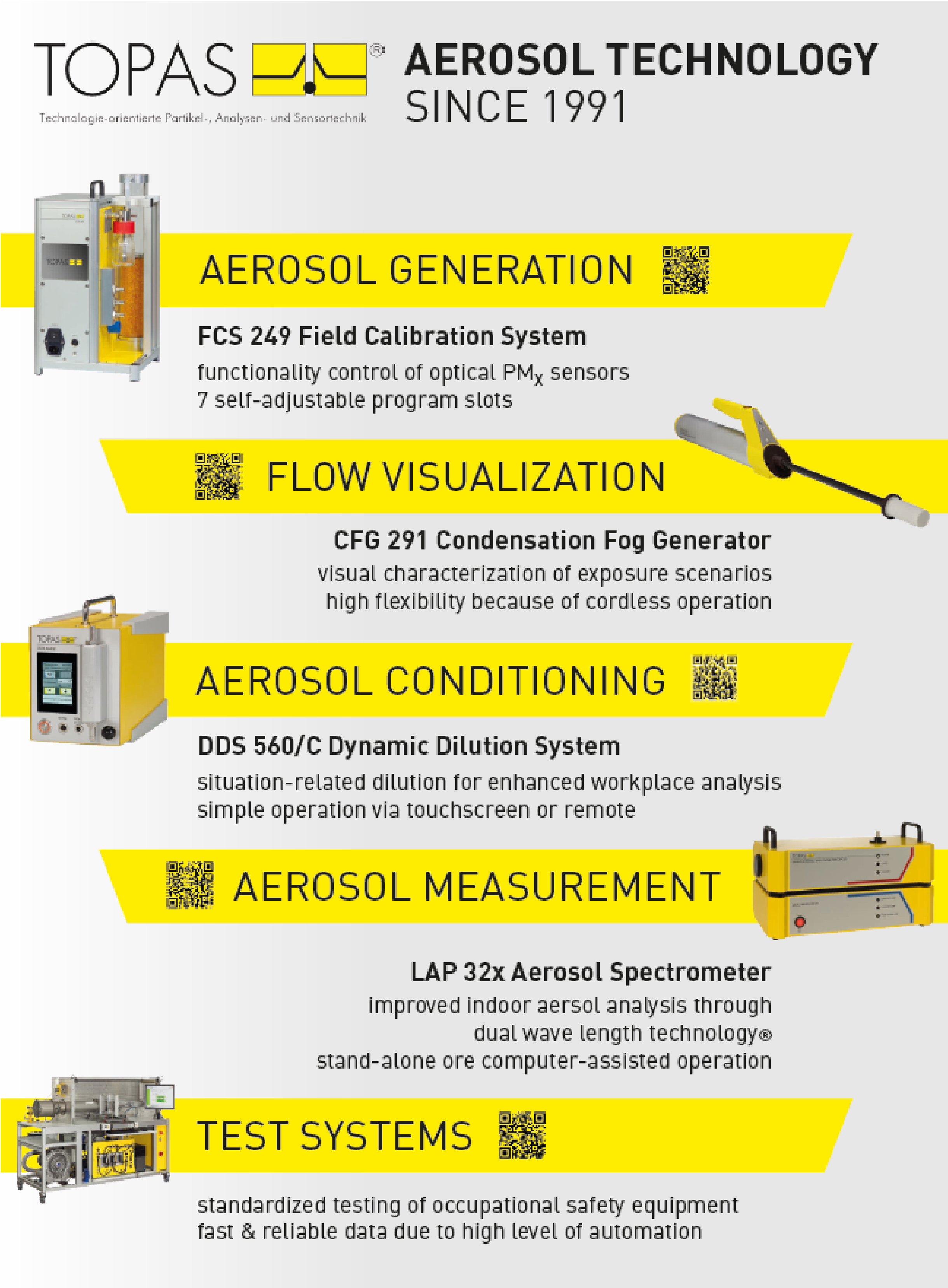
8 Exhibitors

The exhibition of scientific instrumentation, literature and consumables is located next to the auditorium at the first floor.
The following companies have registered for display and demonstration:

MARKES international
SKC Europe
Teknolab forskernes førstevalg!
AAAR American Association for Aerosol Research | Aerosol Science and Technology
DEKATI
Sunset Laboratory BV
TOPAS® Technologie-orientierte Partikel-, Analysen- und Sensortechnik
Swisens

9 Correspondence After the Conference

National Institute of Occupational Health
Gydas vei 8, 0369 Oslo, Norway,
E-mail: airmon2025@stami.no


TOPAS
Technologie-orientierte Partikel-, Analysen- und Sensortechnik
AEROSOL TECHNOLOGY
SINCE 1991
AEROSOL GENERATION
FCS 249 Field Calibration System
functionality control of optical PMx sensors
7 self-adjustable program slots
FLOW VISUALIZATION
CFG 291 Condensation Fog Generator
visual characterization of exposure scenarios
high flexibility because of cordless operation
AEROSOL CONDITIONING
DDS 560/C Dynamic Dilution System
situation-related dilution for enhanced workplace analysis
simple operation via touchscreen or remote
AEROSOL MEASUREMENT
LAP 32x Aerosol Spectrometer
improved indoor aersol analysis through
dual wave length technology®
stand-alone ore computer-assisted operation
TEST SYSTEMS
standardized testing of occupational safety equipment
fast & reliable data due to high level of automation

10 Schedule of Events

Saturday 14 June 2025	
15:00 - 18:00	**Registration**
17:00 - 19:00	**Informal get-together in the Hotel Alexandra Bath & Spa**
From 19:00	**Dinner**

Sunday 15 June 2025	
08:00 - 09:00	**Registration**
08:15 - 08:45	**Welcome and opening remarks**
08:45 - 11:00	**Session I: Progress in aerosol sampling, measurements and modelling**
11:00 - 11:30	**Coffee break, poster viewing and exhibition**
11:30 - 13:00	**Session I continues: Progress in aerosol sampling, measurements and modelling**
13:00 - 14:00	**Lunch**
14:00 -	**Excursion to Geiranger, The Skåla Challenge, Loen Skylift and boat trip at Loen Lake**
From 19:00	**Dinner**

Monday 16 June 2024			
08:00 - 09:30	**Session II: Novel sensor technologies and performances**		
09:30-10:30	**Session III: Measurement and exposure assessment to airborne biological agents**		
10:30 - 11:00	**Coffee break, poster viewing and exhibition**		
11:00 – 13:00	**Session III: continues: Measurement and exposure assessment to airborne biological agents**		
13:00 - 14:00	**Lunch**		
14:00 - 16:30	**Session IV: Characterisation of ambient, indoor and occupational environments**		
16:30 – 17:00	**Coffee break, poster viewing and exhibition**		
	Short Course Session I		
17:00 – 18:45	**Short Course SC-1**	**Short Course Sc-2**	**Short Course SC-3**
From 19:00	**Dinner**		

21:00	**Poster viewing and discussions with beverage tasting (Bring your own beverage).**

Tuesday 17 June 2025

08:00 - 10:30	**Session V: Fate and reactions of inhaled airborne particulate matter**
10:30 - 11:00	**Coffee break, poster viewing and exhibition**
11:00 - 13:30	**Session VI: Biomonitoring of environmental exposure**
13:30 - 14:30	**Lunch**
14:30 - 17:30	**Session VII: Occupational exposure and risk assessment**
17:30 - 17:45	**Coffee break, poster viewing and exhibition**

Short Course Session II

17:45 - 19:30	**Short Course SC-4**	**Short Course SC-5**	**Short Course SC-6**	**Short Course SC-7**

From 19:00	**Dinner**

Wednesday 18 June 2025

08:00 - 10:30	**Session VIII: Novel analytical and sampling methods**
10:30 - 11:00	**Coffee break, poster viewing and exhibition**
11:00 - 13:45	**Session VIII continues: Novel analytical and sampling methods**
13:45 - 14:45	**Lunch**
14:30 - 16:20	**Short Course Session III**
16:30	**Departure for the excursion to the Briksdal Glacier with a conference outdoor dinner**

Thursday 19 June 2025

08:30 - 10:15	**Short Course Session IV**
10:15 - 10:30	**Coffee break**
10:30 - 11:45	**Session IX: The role and work of the International Sampler Comparison Group (ISCG)**
11:45	**Closing remarks and farewell**
12:00	**Lunch**

11 Daily programme

Sunday 15 June 2025

Time	Abstr.	
08:15-08:45		**Welcome/Opening Remarks**

Session I: Progress in aerosol sampling, measurements and modelling

Chair: Nils Petter Skaugset and Yngvar Thomassen

Time	Abstr.	
08:45-09:15	**O-1**	**Distinguished speaker lecture:** **The evolution of the inhalability convention** Lorenz Armbruster, *TSU – Verein für Technische Sicherheit und Umweltschutz e.V., Gotha, Germany.*
09:15-09:45	**O-2**	**Keynote:** **Aerosol sampling – from the past to the future** Carsten Möhlmann, *Institute for Occupational Safety and Health of the German Social Accident Insurance Sankt Augustin, Germany.*
09:45-10:00	**O-3**	**Asbestos analytics in relation to changes of the European Directive** Bianca Gasse, *Institute for Occupational Safety and Health of the German Social Accident Insurance, Sankt Augustin, Germany.*
10:00-10:15	**O-4**	**Measurements of respiratory aerosols: Challenges and opportunities** Jonathan P. Reid,[1] Bryan R. Bzdek,[1] Nan Zhou,[1] Andrew J. Shrimpton[2] and Anthony E. Pickering[2], [1]*School of Chemistry, University of Bristol, UK.* [2]*School of Physiology, Pharmacology & Neuroscience, University of Bristol, UK.*
10:15-10:30	**O-5**	**Advancing occupational exposure models: insights from a case study** Remy Franken, Tanja Krone, Calvin Ge, Wouter Fransman and Ilse Ottenbros, *Netherlands Organisation for Applied Scientific Research (TNO), Risk Assessment for Prevention, Innovation and Development (RAPID), Princetonlaan, CB Utrecht, The Netherlands.*
10:30-10:45	**O-6**	**PEROSH-International Comparison of Sampling Strategies - Hazardous Substances: (PEROSH-ICSS-HS) – an explorative feasibility study and first results with airborne wood dust** Christina Samel[1], Till Wagner[2], Carsten Möhlmann[1], Markus Mattenklott[1], Viola Schmidt[1] and Frank Bochmann[1], [1]*Institut für Arbeitssicherheit der Deutschen Gesetzlichen Unfallversicherung (IFA), Sankt Augustin, Germany.* [2]*Berufsgenossenschaft Holz und Metall (BGHM), Mainz, Germany.*
10:45-11:00	**O-7**	**Recommended flow rate of aluminum cyclone for improved exposure assessment** Harper, Martin, *Department of Environmental Engineering Sciences, ESSIE, University of Florida, Gainesville, FL, USA.*

11:00-11:30		**Coffee, exhibition and poster viewing**
11:30-11:45	**O-8**	**A novel concept for aerosol collection: dielectrophoretic actuation and trapping of aerosolised microspheres** Etelka Chung, Milad Heidari-Koochi, Lanka Weerasiri, Ian Johnston, Ian Munro and Loic Coudron, *Wolfson Centre for Biodetection Instrumentation Research (WCBIR), School of Physics, Engineering and Computer Science, University of Hertfordshire, Hatfield, UK.*
11.45-12:00	**O-9**	**Overall sampling efficiencies of selected filter-based samplers used for analysis by electron microscopy: data from a few nanometers to around 30 µm** *Xavier Simon, Alexis Boivin, Marielle Pfrimmer and Sébastien Bau,* *Institut National de Recherche et de Sécurité (INRS), Laboratory of Aerosol Metrology, Vandoeuvre-lès-Nancy, France.*
12:00-12:15	**O-10**	**Direct analysis of workers' exposure to metals and metalloids using portable XRF and LIBS tools** Zeinab Abboud[1,2], N. Gaudel[1], V. Matera[1], S. Merouane[1], D. Rousset[1], C. Fabre[2] and J. Cauzid[2], *[1]National Institute for Research and Safety, Department of Pollutant Metrology,Vandoeuvre-les-Nancy, France.* *[2]GeoRessources CNRS-University of Lorraine, Vandoeuvre-les-Nancy, France.*
12:15-12:30	**O-11**	**Design and evaluation of a novel wet electrostatic precipitator for aerosol capture using charged liquid droplets** Priya Chopra, L. Coudron, I. Munro, R. Kaye, L. Urbano, D. McCluske and I.D. Johnston, *University of Hertfordshire, Hatfield, Hertfordshire, UK.*
12:30-12:45	**O-12**	**Comprehensive hexamethylene diisocyanate (HDI) evaluation method comparison in an automotive collision repair facility** Hugues Ahientio, Loïc Wingert, Sébastien Gagné, Livain Breau, Jacques Lesage and Simon Aubin, *Occupational Health and Safety Research Institute (IRSST, Montréal, Canada.*
12:45-13:00	**O-13**	**Sampling of a bio-aerosol using electrowetting-enhanced electrostatic precipitation** Lanka Weerasiri[a], Ian Munro[a], Loïc Coudron[a], Timothy Foat[b] and Ian Johnston[a], *[a]University of Hertfordshire, School of Physics, Engineering and Computer Science, Hatfield, Herts, UK.* *[b]Defence Science and Technology Laboratory, Porton Down, Salisbury, Wiltshire, UK.*
13:00		**Lunch**
14:00		**Excursion to Geiranger, Boat trip at Loen Lake, the Skåla Challenge and Loen Skylift**
From 19:00		**Dinner**

Monday 16 June 2025

Session II: Novel sensor technologies and performance

Chair: Martin Harper

08:00-08:30	**O-14**	**Keynote:** **The role of novel (low-cost) sensor technologies in air quality monitoring and exposure assessment** Amirhossein Hassani and Nuria Castell, *The Climate and Environmental Research Institute NILU, Kjeller, Norway.*
08:30-08:45	**O-15**	**How to use the correct low-cost PM sensors for assessing occupational exposures correctly – an overview of recent guidance initiatives** Sander Ruiter[1], Hasnae Ben Jeddi[1], Miranda Loh[2], Karen S. Galea[2], Rebecca Canham[2], Janne Goossens[3], Eelco Kuijpers[1], Emanuele Cauda[4], Dustin Bennett[5] and Maaike le Feber[1], *[1] TNO, Utrecht, The Netherlands, [2] IOM, Edinburgh, UK, [3] IDEWE, Leuven, Belgium, [4] CDC, NIOSH, Pittsburgh, USA, [5] GCG, Brisbane, Australia.*
08:45-09:00	**O-16**	**Performance evaluation of low-cost PM sensors against NOAA aerosols** Benjamin Sutter[1], C. Asbach[2], A.M. Todea[2], C. Möhlmann[3], Eelco Kuijpers[4], Jan Pieter Lollinga[4] *[1]INRS, Vandoeuvre, France; [2]Department of Filtration and Aerosol Research, IUTA, Duisburg, Germany; [3]IFA, Sankt Augustin, Germany; [4]TNO, Utrecht, The Netherlands.*
09:00-09:15	**O-17**	**Calibrating low-cost PM sensors for compliance testing – obstacles and the road ahead** Sander Ruiter, Remy Franken and Maaike le Feber, *TNO, Utrecht, The Netherlands.*
09:15-09:30	**O-18**	**Supporting the global security by sniffing the threat** Licia Dossi, *Faculty of Engineering and Applied Sciences, Cranfield University, Defence Academy of UK, Shrivenham, SN6 8LA, UK.*

Session III: Measurement and exposure assessment to airborne biological agents

Chair: Pål Graff

09:30 – 10:00	**O-19**	**Keynote:** **Measurement methods and strategies for airborne biological agents at the workplace: Future challenges in a prevent context** Phillippe Duquenne, *The National Research and Safety Institute for the Prevention of Occupational Accidents and Diseases (INRS), Nancy, France.*
10:00-10:15	**O-20**	**Fluorescence-based suppression of water-induced noise in automated pollen monitoring** Kilian Koch, Yanick Zeder, Elias Graf, Andreas Schwendimann and Erny Niederberger, *Swisens AG, Emmen, Switzerland.*

10:15-10:30 **O-21** **Airborne fungi and bacteria in sorting plants for recycling plastic - Occupational exposure over three years**

Kerstin Karlsson[a], Anne Mette Madsen[b] and Anna Dahlman-Höglund[a],
[a]*Occupational- and Environmental Medicine, Sahlgrenska Academy at University of Gothenburg, Sweden.*
[b]*The National Research Center for Work Environment, Copenhagen, Denmark.*

10:30-11:00 **Coffee break, exhibition and poster viewing**

11:00-11:15 **O-22** **Fungal contamination in schools: Key insights and assessment strategies**

Renata Cervantes[1,2], Pedro Pena[1,2], Carla Viegas[1,2],
[1]*H&TRC—Health & Technology Research Center, ESTeSL—Escola Superior de Tecnologia e Saúde, Instituto Politécnico de Lisboa, Lisbon, Portugal.*
[2]*NOVA National School of Public Health, Public Health Research Centre, Comprehensive Health Research Center, CHRC, REAL, CCAL, NOVA University Lisbon, Lisbon, Portugal.*

11:15-11:30 **O-23** **Study of the airborne microbiome in buildings using air handling unit extraction filters as a sampling tool**

Delphine Deshayes, Yves Andres, Pierre Le Cann and and Aurélie Joubert,
IMT Atlantique, Nantes, France.

11:30-11:45 **O-24** **Preventing polyexposure in cheese dairies: A large-scale study to identify high-risk workstations in the workplace**

Patricia Battais, S. Jacquenet, S. Lechêne, J. Kunz-Iffli, J. Grosjean, N. Monta, E. Monnoyer, M. Dieudonné, A. Coiscaud, J. Mathiot, S. Muller, N. Veith, L. Alonso, P. Loison, C. Dziurla, L. Albers, C. Coulais, P. Duquenne and F. Battais,
The National Research and Safety Institute for the Prevention of Occupational Accidents and Diseases (INRS), Nancy, France.

11:45-12:00 **O-25** **Portuguese primary schools: Dust filter samples, a simple tool for assessing bacterial contamination indoors?**

Pedro Pena[1,2], Renata Cervantes[1,2]and Carla Viegas[1,2],
[1]*H&TRC—Health & Technology Research Center, ESTeSL—Escola Superior de Tecnologia e Saúde, Instituto Politécnico de Lisboa, Lisbon, Portugal.*
[2]*NOVA National School of Public Health, Public Health Research Centre, Comprehensive Health Research Center, CHRC, REAL, CCAL, NOVA University Lisbon, Lisbon, Portugal.*

12:00-12:15 **O-26** ***Aspergillus* section *Nigri* in indoor environments: A silent public health sentinel for occupational and community exposure**

Renata Cervantes[1,2], Claúdia Rodrigues[1], Pedro Pena[1,2] and Carla Viegas [1,2],
[1]*H&TRC – Health & Technology Research Center, ESTeSL – Escola Superior de Tecnologia e Saúde, Instituto Politécnico de Lisboa, Lisbon, Portugal.*
[2]*NOVA National School of Public Health, Public Health Research Centre, Comprehensive Health Research Center, CHRC, NOVA University Lisbon, Lisbon, Portugal.*

12:15-12:30 **O-27** **Small is beautiful – progress of the bioaerosol-working group of CEN TC 137**

Annette Kolk[1], Philippe Duquenne[2], Alan Beswick[3], Brian Crook[3], Anne Mette Madsen[4], Clara Pogner[5], Carla Viegas[6,7], Inge M. Wouters[8],
[1]Institute for Occupational Safety and Health of the German Social Accident Insurance, Sankt Augustin, Germany.
[2]Institut National de Recherche et de Sécurité (INRS), Vandoeuvre-les-Nancy, France.
[3]Health and Safety Executive Science and Research Centre, United Kingdom.
[4]National Research Centre for the Working Environment, Copenhagen, Denmark.
[5]AIT Austrian Institute of Technology, Tulln, Austria.
[6]H&TRC—Health & Technology Research Center, ESTeSL – Escola Superior de Tecnologia e Saúde, Instituto Polit´ecnico de Lisboa, 1990-096, Lisbon, Portuga.l
[7]NOVA National School of Public Health, Public Health Research Centre, Comprehensive Health Research Center, CHRC, NOVA University Lisbon, Lisbon, Portugal.
[8]Institute for Risk Assessment Sciences (IRAS), Utrecht University, Utrecht, Netherlands.

12:30-12:45 **O-28** **Use of video exposure monitoring (VEM) for monitoring the activity of workers in charge of brushing cheese in a maturing cellar**

Karine Gérardin[1], Nathalie Judon[2] and Philippe Duquenne[1],
[1]Laboratoire d'Analyses Spatiales et Temporelles des Expositions Chimiques, INRS, 54519 Vandœuvre-lès-Nancy Cedex, France.
[2]Recherche en Ergonomie Centrée sur les Activités et la Prévention, INRS, Vandœuvre-lès-Nancy Cedex, France.

12:45-13:00 **O-29** **Fungal degradation of historical pigments: Evidence from culture experiments and elemental analysis**

Balazs Berlinger[1], W. Goessler[2], L. Füleki[3], H. Allaga[4], L. Kredics[4], M. Horváth[3], Z. May[3], Gy. Oros[5] and [6]D. Magyar,
[1]Department of Animal Hygiene, Herd Health and Mobile Clinic, University of Veterinary Medicine, Budapest, Hungary, [2]Department of Chemistry, University of Graz, Graz, Austria, [3]National Museum Conservation and Storage Centre, Museum of Fine Arts, Budapest, Hungary, [4]Department of Biotechnology and Microbiology, Faculty of Science and Informatics, University of Szeged, Szeged, Hungary, [5]Hungarian Academy of Sciences, Budapest, Hungary, [6]National Center for Public Health and Pharmacy, Budapest, Hungary.

13:00 14:00 **Lunch**

Session IV: Characterisation of ambient, indoor and occupational environments

Chair: Axel Eriksson

14:00-14:30 **O-30** **Keynote:**
From IAQ monitoring to risk mitigation: Developing data-driven action plans for healthier buildings

Marta Gabriel,
Institute of Science and Innovation in Mechanical and Industrial Engineering (INEGI), Porto,Portugal.

14:30-14:45 **O-31** **New developments for the assessment of odours in indoor air.**

Kirsten Sucker,
Institute for Occupational Safety and Health of the German Social Accident Insurance (IFA), Sankt Augustin, Germany.

14:45-15:00 **O-32** ***In vitro* bioaccessibility method for endocrine disruptors pollutants in indoor dust**
Marie Dufresne[1], Gaëlle Raffy[1], Camille Duguépéroux[1], Matthieu Delannoy[2] and Barbara Le Bot[1],
[1]Univ Rennes, Inserm, EHESP, Irset (Institut de recherche en santé, environnement et travail) – UMR, Rennes, France.
[2]Université de Lorraine, L2A, Nancy, France.

15:00-15:15 **O-33** **PM_{10} oxidative potential and chemical composition at an urban background and an urban industrial site in Serbia during the heating period**
M. Jovanović[1], M. Živković[1], B. Petrović[1], R. Kovačević[2], B. Radović[2], M. Davidović[1], A. Bartonova[3] and Milena Jovašević-Stojanović[1],
[1]VIDIS Centre, Vinča Institute of Nuclear Sciences, National Institute of the Republic of Serbia University of Belgrade, Belgrade, Serbia.
[2]Mining and Metallurgy Institute Bor.
[3]NILU, Kjeller, Norway.

15:15-15:30 **O-34** **Source apportionment of equivalent black carbon in Belgrade: Preliminary results from an urban background site**
Miloš Davidović[1], M. Živković[2], D. Stojanović[1], Ž. Ćirović[1], S.M. Platt[2], M. Pandolfi[3] and M. Jovašević-Stojanović[1],
[1]VIDIS Centre, Vinča Institute of Nuclear Sciences, National Institute of the Republic of Serbia, University of Belgrade, Serbia.
[2]NILU, Kjeller, Norway.
[3]Institute of Environmental Assessment and Water Research, Barcelona, Spain.

15:30-15:45 **O-35** **Snow DUMP-ing: Direct TD-GC-MS for the analysis of urban snow pollution**
Cleo Davie-Martin[a], Kristine Bondo Pedersen[b], Anne Katrine Normann[c], Alexander Håland[a] and Hannah Calder[d],
[a]NILU, Norway; [b]Akvaplan-niva, Norway; [c]UiT – The Arctic University of Norway, Tromsø, Norway; [d]Markes International, Wales, UK.

15:45-16:00 **O-36** **Indoor workplaces: Procedure for investigation of the working environment**
Kirsten Sucker and Simone Peters,
Institute for Occupational Safety and Health of the German Social Accident Insurance (IFA), Sankt Augustin, Germany.

16:00-16:15 **O-37** **Real-time VOCs measurements by PTR-MS in parallel with particles counting by SMPS and APS in Norwegian woodworking factories. A study on workroom air recirculation**
Erika Zardin Brinchmann, Torunn Kringeln Ervik, Anne Straumfors, Ine Pedersen and Nils Petter Skaugset,
National Institute of Occupational Health, Oslo, Norway.

16:15-16:30 **O-38** **Modelling air pollution from industrial sources in "Chile's sacrifice zones": A fuzzy clustering approach**
Miguel Ángel Lugo Salazar and Héctor Iván Jorquera González,
Department of Chemical Engineering and Bioprocesses, Pontifical Catholic University of Chile, Santiago, Chile.

16:30-17:00 **Coffee break, exhibition and poster viewing**

Short Course Session I

		SC-1	SC-2	SC-3
17:00-19:00	**SC-1-4**	Giovanna Tranfo **Human biomonitoring basic**	Lorenz Armbruster **Behaviour of particles in the human respiratory tract and in sampling instruments**	Amir Hossein Hassani **Low-cost sensors for air quality monitoring**

From 19:00 **Dinner**

From 21:00 **Poster viewing and discussions with beverage tasting and exhibition. (Bring your own beverage)**

Tuesday 17 June 2025

Time **Abstr.**

Session V: Fate and reactions of inhaled airborne particulate matter

Chair: Elizabeth Leese

08:00-08:30 **O-39**
Keynote:
The pulmonary surfactant system as target and dealer of inhaled airborne materials
Jesús Pérez-Gil,
Department of Biochemistry and Molecular Biology, Faculty of Biology, Complutense University, Madrid, Spain.

08:30-09:00 **O-40**
Keynote:
Particle lung deposited surface area (LDSA) as an additional metric for fine particle pollution monitoring: Location-dependency, potential health-relevance and measurement methodologies
Teemu Lepistö,
Tampere University, Finland.

09:00-09:15 **O-41**
Occupational exposure to welding fumes is associated with changes in the lipid-profile- and increased inflammatory activity in the lining fluid of small airways, as well as small airway dysfunction
Alexander Holm[1], Sanna Kjellberg[1], Per Larsson[2], Spela Kokelj[1], Linus Schiöler[1], Mats Josefsson[3] and Anna-Carin Olin[1],
[1]Occupational and Environmental Medicine, Inst. of Medicine, Gothenburg University, Sweden.
[2]Chalmers Mass Spectrometry Infrastructure (CMI), Chalmers University of Technology, Gothenborg, Sweden.
[3]Oral Product Development, Pharmaceutical Technology & Development, AstraZeneca, Sweden.

09:15-09:30 **O-42**
Inflammatory biomarkers in diesel exhaust exposed electricians
Dag G. Ellingsen, Bente Ulvestad, Stine Hammer Eriksen and Nils Petter Skaugset,
National Institute of Occupational Health, Oslo, Norway.

09:30-09:45 **O-43** **The impact of air pollution on DNA damage in humans: a comparative study of two cities in Slavonia, Croatia**

Marko Gerić[1], Cvitković A[2,3,4], Sanković M[5], Matković K[1], Kašuba V[1], Milić M[1], Kazensky L[1], Jurič A[1], Brčić Karačonji I[1], Jakovljević I[1], Davila S[1], Pehnec G[1], Domijan AM[6], Šumanovac A[3,7], Wild P[8,9], Guseva Canu I[8], Hopf NB[8] and Gajski G[1],
[1]Institute for Medical Research and Occupational Health, Zagreb, Croatia.
[2]Teaching Institute of Public Health Brod-Posavina County, Slavonski Brod, Croatia.
[3]Faculty of Medicine, J. J. Strossmayer University of Osijek, Osijek, Croatia.
[4]Faculty of Dental Medicine and Health, J. J. Strossmayer University of Osijek, Osijek, Croatia.
[5]City of Vinkovci, Vinkovci, Croatia.[6]Faculty of Pharmacy, University of Zagreb, Zagreb, Croatia.[7]County General Hospital Vinkovci, Vinkovci, Croatia.[8]Center for Primary Care and Public Health, University of Lausanne, Lausanne, Switzerland.
[9]PW Statistical Consulting, Laxou, France.

09:45-10:00 **O-44** **Exploring the impact of air pollution on genomic instability and health: A study from Zagreb, Croatia**

Goran Gajski[1], Marko Gerić[1], Gordana Pehnec[1], Katarina Matković[1], Mirta Milić[1], Vilena Kašuba[1], Luka Delić[1], Andreja Jurič[1], Irena Brčić Karačonji[1], Ivana Jakovljević[1], Silvije Davila[1], Jasmina Rinkovec[1], Ranka Godec[1], Silva Žužul[1], Ivan Bešlić[1], Ana-Marija Domijan[2], Ante Cvitković[3,4,5], Mandica Sanković[6], Antun Šumanovac[5,7], Pascal Wild[8,9], Irina Guseva Canu[8] and Nancy B. Hopf[8],
[1]Institute for Medical Research and Occupational Health, Zagreb, Croatia.
[2]Faculty of Pharmacy and Biochemistry, University of Zagreb, Zagreb, Croatia.
[3]Teaching Institute of Public Health Brod-Posavina County, Slavonski Brod, Croatia.
[4]Faculty of Dental Medicine and Health, J. J. Strossmayer University of Osijek, Osijek, Croatia.[5]Faculty of Medicine, J. J. Strossmayer University of Osijek, Osijek, Croatia.
[6]City of Vinkovci, Department of Physical Planning, Construction and Environmental Protection, Vinkovci, Croatia. [7]County General Hospital Vinkovci, Vinkovci, Croatia.
[8]Center for Primary Care and Public Health (Unisanté), University of Lausanne, Lausanne, Switzerland. [9]PW Statistical Consulting, 54520 Laxou, France.

10:00-10:15 **O-45** **Effect of occupational exposure to respirable crystalline silica dust on inflammatory lipid mediators**

Alexander Hedbrant[1,2,3], Lena Andersson[2,3], Eva Särndahl[1,2], Samira Salihovic[1,2],
[1]School of Medical Sciences, Faculty of Medicine and Health, Örebro University, Örebro, Sweden. [2]Inflammatory Response and Infection Susceptibility Centre (iRiSC), Faculty of Medicine and Health Örebro University, SE-701 82 Örebro, Sweden.
[3]Department of Occupational and Environmental Medicine, Faculty of Medicine and Health, Örebro University, Örebro, Sweden.

10:15-10:30 **O-46** **Response of DTT and FOX-based on-line systems for oxidative potential monitoring**

T. Audoux[1,2], J.J Sauvain[3], M. Ghanem[2], J-B. Lily[2], E. Perdrix[1], G. Suarez[3], L. Y. Alleman[1] and Davy Rousset[2],
[1]Centre for Energy and Environment, IMT Nord Europe, Institut Mines-Télécom, Université de Lille, Lille, France.[2]Pollutants Metrology Department, Institut National de Recherche et de Sécurité (INRS), Vandœuvre-lès-Nancy, France.
[3]Department of Occupational and Environmental Health, Centre for Primary Care and Public Health (Unisanté), University of Lausanne, Epalinges, Switzerland.

10:30-11:00 **Coffee break, exhibition and poster viewing**

Session VI: Biomonitoring of environmental exposure

Chair: Yngvar Thomassen

11:00-11:30	**O-47**	**Keynote:** **Planning and conducting HBM studies for exposure to chemicals** Giovanna Tranfo, *Department of Occupational and Environmental Medicine, Epidemiology and Hygiene, INAIL, Rome, Italy.*
11:30-12:00	**O-48**	**Keynote:** **Biological guidance values and exposure mitigation. Where biomonitoring can make the difference to protect the health of workers** Paul T.J. Scheepers, *Radboud Institute for Biological and Environmental Sciences, Radboud University, Nijmegen, The Netherlands.*
12:00-12:15	**O-49**	**An overview over biomonitoring practices in EU member states and the making of EU guidance** Elke Schneider, *European Agency for Safety and Health at Work, Bilbao, Spain.*
12:15-12:30	**O-50**	**Biomonitoring for respirable crystalline silica: The determination of Si-containing particles in exhaled breath condensate** Elizabeth Leese, Graeme Hunwin, Samantha Hall and Jackie Morton, *Health and Safety Executive Science and Research Centre, Harpur Hill, Derbyshire, UK*
12:30-12:45	**O-51**	**Targeting human proteins in airborne particles twice – exhaled and indoors** Susann Meyer, Carl Firle and Dierk-Christoph Pöther, *Federal Institute for Occupational Safety and Health, Unit 4.II.2 – Bioaerosols, Berlin, Germany.*
12:45-13:00	**O-52**	**Enhance real-time spores monitoring through advanced image feature extraction for classification of fibrous and elongated airborne particles** Yanick Zeder[1], Amanda Malvessi Cattani[2], Markus Rienth[2] and Erny Niederberger[1], [1]*Swisens AG, Emmen, Switzerland.* [2]*University of Sciences and Art Western Switzerland, Changins College for Viticulture and Enology, Nyon, Switzerland.*
13:00-13:15	**O-53**	**German firefighters' exposure to dioxins** Stephan Koslitz, Thomas Behrens, Holger Martin Koch, Heiko Udo Käfferlein, Thomas Brüning and Dirk Taeger, *Institute for Prevention and Occupational Medicine of the DGUV, Ruhr University Bochum (IPA), Bochum, Germany.*
13:15-13:30	**O-54**	**Study of the exposure to pesticides using wristbands and biomonitoring Preliminary results from the SPRINT project** Paul T.J. Scheepers[1], Nina Wieland[1], Martien Graumans[1], Hans Mol[2], Jonatan Dias[2] and Daniel Martins Figueiredo[3], [1]*Radboud University Nijmegen, The Netherlands.* [2]*Wageningen Food Safety Research, Wageningen, The Netherland.* [3]*Institute for Risk Assessment Sciences, Utrecht University, The Netherlands.*
13:30-14:30		**Lunch**

Session VII: Occupational exposure and risk assessment

Chair: Balazs Berlinger

14:30-15:00 **O-55** **Keynote:**
Enhancing workplace exposure assessment and control with artificial intelligence
Jun Wang,
University of Cincinnati, USA.

15:00-15:15 **O-56** **One measurement is enough, isn't it? – A statistical point of view on small sample sizes and large variances**
Jörg Rissler,
Institut für Arbeitsschutz der DGUV, Sankt Augustin, Germany.

15:15-15:30 **O-57** **Composition of occupational exposure to PAH differs between asphalt millers and asphalt pavers**
Lina Hagvall[1,2], Carina Nilsson[1,2], Karin Lovén[1,2], Johannes Rex[3], Merve Polat[4,5], Jakob K. Nøjgaard[4,5], Joakim Pagels[3], Bo Strandberg[1,2], Maria Hedmer[1,2],
[1]*Occupational and Environmental Medicine, Lund University, Lund, Sweden.*
[2]*Occupational and Environmental Medicine, Region Skåne, Lund, Sweden.*
[3]*Ergonomics and Aerosol Technology, Lund University, Lund, Lund, Sweden.*
[4]*Department of Chemistry, University of Copenhagen, Copenhagen, Denmark.*
[5]*The National Research Centre for the Working Environment, Copenhagen, Denmark.*

15:30-15:45 **O-58** **Occupational exposure to carcinogen metals and particles in additive manufacturing processes**
Diana Torremocha Garcia, Agurtzane Zugasti, Araceli Sánchez and Beatriz Pérez,
National Institute for Safety and Health at Work, The National Center for Machinery Verification (CNVM), Barakaldo, Spain.

15:45-16:00 **O-59** **Assessment of waste isoflurane gas exposure during the surgery on rats**
Natalia Grytsyk[a], Céline Brochard[a], Francis Bonthoux[b], Eddy Langlois[a], Eric Pelletier[a] and Christel Ravera[a],
[a]*Department of Metrology of Pollutants, French National Research and Safety Institute (INRS), Vandoeuvre-lès-Nancy, France.*
[b]*Process Engineering Department, French National Research and Safety Institute (INRS), Vandoeuvre-lès-Nancy, France.*

16:00-16:15 **O-60** **Formaldehyde exposure in pathology laboratories – A best practice approach**
Benedikt Thomas, Wolfgang Wegscheider and Johannes Gerding,
Department for Occupational Medicine, Hazardous Substances and Public Health, German Social Accident Insurance, Institution for the Health and Welfare Services (BGW), Hamburg, Germany.

16:15-16:30 **O-61** **Assessment of nitrous oxide exposure in health care activities and prevention means**
Eddy Langlois[1], Francis Bonthoux[2], Virginie Govaere[3], Eric Pelletier[1] and Sandrine Mélin[1],
[1]*Pollutants metrology department,* [2]*Process engineering department,* [3]*Sciences applied to work and organizations department, French National Research and Safety Institute (INRS), Vandoeuvre-lès-Nancy, France.*

16:30-16:45	**O-62**	**Inhalative heroin exposure of workers at supervised drug consumption facilities in Germany** Daniel Köster, *Institute for Occupational Safety and Health of the German Social Accident Insurance Deutsche Gesetzliche Unfallversicherung e.V. (DGUV), Sankt Augustin, Germany.*
16:45-17:00	**O-63**	**Striking a balance: Establishing effective occupational exposure limit values for nickel in Norway** Steven Verpaele, *The Nickel Institute, Brussels, Belgium.*
17:00-17:15	**O-64**	**The GESTIS biological agents database – Compact information for occupational safety and health protection** Gerd Schneider, Caroline von Oppen and Laura Becker, *Institute for Occupational Safety and Health of the German Social Accident Insurance (IFA), Sankt Augustin, Germany.*
17:15-17:30	**O-65**	**Occupational lead exposure among Pb handlers in a Cu mining company, Zambia** Kasyimbi Pauline Hayumbu[1,2], Nompumelelo Ndaba[1,3], Patrick Hayumbu[4] and Goitsemang Keretetse[1], *[1]University of the Witwatersrand, School of Public Health, South Africa.* *[2]Ministry of Health, Zambia.* *[3]National Institute of Occupational Health, Occupational Medicine, South Africa.* *[4]Copperbelt University, School of Mathematical and Natural Science, Zambia.*
17:30-17:45		**Coffee break, exhibition and poster viewing**

Short Course Session II

17:45-19:30	**SC-4-7**	**SC-4** Philippe Duquenne	**SC-5** Paul Scheepers	**SC-6** Carsten Möhlmann	**SC-7** Marta Gabriel
		Measurement strategies for airborne biological agents at the workplace	**Biomonitoring, more than the analysis of biomarkers**	**Occupational exposure monitoring: Samplers and monitors for particles**	**Building knowledge to guide industry in planning, conducting, and interpreting occupational exposure assessments**

From 19:00		**Dinner**

Wednesday 18 June 2025

Session VIII: Novel analytical and sampling methods

Chair: Carsten Möhlmann and Torunn Ervik

08:00-08:30 **O-66** **Keynote:**
Advancements in real-time analytical aerosol instrumentation for exposure measurement
Pramod Kulkarni,
Environmental and Public Health Science, College of Medicine, University of Cincinnati, Cincinnati, Ohio, USA.

08:30-09:00 **O-67** **Keynote:**
Proton-transfer-reaction mass spectrometry (PTR-MS) in air monitoring: From fundamentals to real-life applications in tire wear particle analysis
Nikita Sobolev, Felix Benjamin Blixt Hasle, Keerthana Balashankar, Tomas Mikoviny, and Armin Wisthaler,
Department of Chemistry, University of Oslo, Oslo, Norway.

09:00-09:15 **O-68** **Automatic and real-time airborne microplastic detection based on UV-LIF measurements**
N.D. Beres[1,2], J. Burkart[1,3], E. Graf[4], Y. Zeder[4], L.A. Dailey[5], B. Weinzierl[1],
[1]Faculty of Physics, Aerosol Physics and Environmental Physics, University of Vienna, Austria.
[2]Division of Atmospheric Sciences, Desert Research Institute, USA.
[3]Sonnblick Observatory, Geosphere Austria, Vienna, Austria.
[4]Swisens AG, Switzerland.
[5]Department of Pharmaceutical Sciences, University of Vienna, Austria.

09:15-09:30 **O-69** **Improvements in the determination of di-isocyanates using a new gradient elution HPLC methodology**
James Forder,
HSE Science and Research Centre, Buxton, United Kingdom.

09:30-09:45 **O-70** **Method development for the speciation of organotin compounds in workplace air samples via HPLC-ICP-MS**
Carina Cläsgens, Tobias Schwank and Katrin Pitzke,
Institute for Occupational Safety and Health of the German Social Accident Insurances – IFA, Saint Augustin, Germany.

09:45-10:00 **O-71** **Determination of nanomaterials in air samples by means single particle inductively coupled plasma mass spectrometry**
Guillermo Grindlay[1], Carlos Gómez-Pertusa[1,2] Adela Yañez[2], Luis Gras[1], Ricardo Pedraza, [2] María del Carmen García Poyo,[2] María José Vázquez[2],
[1]University of Alicante, Department of Analytical Chemistry, Nutrition and Food Sciences, Alicante, Spain. [2] LABAQUA S.A.U., Polígono industrial Las Atalayas, Alicante, Spain.

10:00-10:15 **O-72** **Detection and identification of plastic nanoparticles in a PET recycling facility**
Pål Graff[1], Jan Schwarzbauer[2], Øyvind P. Haugen[1], Shan Zienolddiny-Narui[1], Torunn Kringlen Ervik[1] and Anani J.K. Afanou[1],
[1]National Institute of Occupational Health, Oslo, Norway.
[2]RWTH Aachen University, Aachen, Germany.

10:15-10:30	**O-73**	**Modifications to the phase-contrast microscopy (PCM) method for fibre-counting to support a new occupational exposure limit value** Martin Harper[1] and Thomas WS Pang[2], *[1]Dept. of Environmental Engineering Sciences, ESSIE, U. of Florida, Florida, USA.* *[2]Ryerson University, Toronto, Ontario, Canada.*
10:30-11:00		**Coffee break, exhibition and poster viewing**
11:00-11:15	**O-74**	**Occupational exposure assessment criteria for metal compounds in airborne dusts differentiated by "solubility" - an analytical perspective** Michael Krämer, Cornelia Wippich, Tobias Schwank and Katrin Pitzke, *Institute for Occupational Safety and Health of the German Social Accident Insurance, Sankt Augustin, Germany*
11:15-11:30	**O-75**	**Evaluation of the passive air samplers PUF and SPMD to mimic firefighters' skin uptake of polycyclic aromatic compounds** Bo Strandberg[a,b], Lina Hagvall[a,b], Karin Broberg[a], Annette Krais[a], Per Malmberg[c], Jennie Özdemir[b], Lars Ekberg[d], Sarka Langer[d,e], *[a]Division of Occupational and Environmental Medicine, Department of Laboratory Medicine, Lund University, Sweden, [b]Department of Occupational and Environmental Medicine, Region Skåne, Lund, Sweden [c]Chemistry and Chemical Engineering, Chalmers Technical University, Gothenburg, Sweden, [d]Chalmers Technical University, Gothenburg, Sweden [e]IVL Swedish Environmental Research Institute, Gothenburg, Sweden.*
11:30-11:45	**O-76**	**Comparative analysis of air sampling strategies for VOC monitoring** Hannah Calder[1], Aaron Davies[1], Kiran Piduru[1] and Praveen Arya[2], *[1]Markes International Ltd., 1000B Central Park, Bridgend, UK.* *[2]Agilent Technologies (India) Pvt. Ltd., Plot No. CP-11, Sector – 8, IMT, Manesar, Gurgaon – 122 051, Haryana, India.*
11:45-12:00	**O-77**	**Comparison of passive and active sampling of benzene, toluene, ethylbenzene, and xylenes in the oil and gas industry** Raymond Olsen, Dag G. Ellingsen, Hanne Line Daae and Pål Graff, *National Institute of Occupational Health, Oslo, Norway.*
12:00-12:15	**O-78**	**Validation of diffusive sampling methods for nitrogen dioxide concentration measurements in ambient air and at the workplace** Laura Zaratin[1], Franco Quaglio[1], Paolo Sacco[1], Caterina Boaretto[1], José Alberto Gonzalez Lorente[1], Marco Pattaro[1], Elena Grignani[2], *[1]Istituti Clinici Scientifici Maugeri IRCCS, Environmental Research Centre, Padova, Italy.[2]Istituti Clinici Scientifici Maugeri IRCCS, Environmental Research Centre, Pavia, Italy.*
12:15-12:30	**O-79**	**Measurement uncertainty? You MUST do it** Cornelia Wippich, Jörg Rissler and Jana Dospil, *Institute for Occupational Safety and Health of the German Social Accident Insurance (IFA), Saint Augustin, Germany.*
12:30-12:45	**O-80**	**Characterization of occupational air exposure during different metal enrichment processes** Karin Lovén[1,2], Bengt O Meuller[3,4], Christina Isaxon[3,4] and Axel C Eriksson[3,4], *[1]Occupational and Environmental Medicine, Lund University, Lund, Sweden.* *[2]Occupational and Environmental Medicine, Region Skåne, Lund, Sweden.* *[3]Ergonomics and Aerosol Technology, Lund University, Lund, Sweden.* *[4]NanoLund, Lund University, Lund, Sweden.*

12:45-13:00	**O-81**	**Evaluation of size and composition of particulate matter generated at multiple cop per processing operations in Europe** Michelle Kelvin[1]. Y. Gopalapillai, S. Verpaele, S. Brindle, M. Leybourne, D. Matthews-Layton, D. Peters and E. Scanlan, *[1]XPS Expert Prosess Solutions, Toronto, Canada.*
13:00-13:15	**O-82**	**Determination of quartz in bulk samples by X-ray diffraction with internal standard method.** Viola Schmidt, *Institute for Occupational Safety and Health of the German Social Accident Insurance, Sankt Augustin, Germany.*
13:15-13:30	**O-83**	**An evaluation of validation schemes for the direct-on-filter X-ray diffraction method for analysis of respirable crystalline silica** Pieter Bertier[1] and Steven Verpaele[1,2], *[1]Belgian Center for Occupational Hygiene (BeCOH), Leuven, Belgium.* *[2]The Nickel Institute, Brussels, Belgium.*
13:30-13:45	**O-84**	**Mineral composition as a function of particle size in airborne dust samples from indoor demolition** Johanne Ø. Halvorsen[1,2], Pål Graff[1,2], Elin Lovise Folven Gjengedal[2], and Torunn K. Ervik[1], *[1]National Institute of Occupational Health, Oslo, Norway.* *[2]Faculty of Environmental Sciences and Natural Resource Management, Norwegian University of Life Sciences, Ås, Norway.*
13:45-14:45		**Lunch**

Short Course Session III:

14:45-16:30	**SC-8**	**Pulmonary surfactants and the fate of inhaled particulate matter.** Jesús Pérez-Gil, *Complutense University of Madrid, Spain.*
16:40		**Departure for excursion to Briksdal**

Thursday 19 June 2025

Short Course Session IV:

08:30-10:15	**SC-9**	**Sampling, analysis and monitoring emerging air pollutants in workplace** Jun Wang, *University of Cincinnati, USA.*
10:15-10:30		**Coffee break**

Session IX: The role and work of the International Sampler Comparison Group (ISCG)

Chair: Karen Galea

10:30-10:45	**O-85**	**Consensus recommendation for aerosol sampler selection** Martin Harper, *Department of Environmental Engineering Sciences, ESSIE, University of Florida, Gainesville, FL, USA.*
10:45-11:00	**O-86**	**Validation results of a multi-fraction sampler for recovering inhalable and respirable dust mass, and metals in workplace air** Steven Verpaele, *The Nickel Institute, Brussels, Belgium.*
11:00-11:15	**O-87**	**Sampler selection tool** Pieter Bertier, *Belgian Center for Occupational Hygiene (BECOH), Leuven, Belgium.*
11:15-11:30	**O-88**	**The Western Australian sampler comparison project** Marcus Cattani, *Edith Cowan University, Perth, Australia.*
11:30-11:45	**O-89**	**Aerosol sampler performance - laboratory protocol development and related field studies** Darrah Sleeth, *Division of Occupational & Environmental Health, University of Utah, Salt Lake City, UT, USA.*
11:45-12:00		**Closing remarks and farewell**
12:00		**Lunch**

Poster Presentations

Sunday 15 June - Thursday 19 June 2025

Abstr.

P-1 **OMEGAone: A digitalization benchmark for workplace exposure assessment**
Chantal Wagner, Manuel Kühn and Moritz Schneider,
Institute for Occupational Safety and Health of the German Social Accident Insurance (DGUV), Sankt Augustin, Germany

P-2 **Determination of quartz by direct-on-filter analysis of FSP-10 samples**
Viola Schmidt,
Institute for Occupational Safety and Health of the German Social Accident Insurance, Sankt Augustin, Germany.

P-3 **Uptake rates of VVOCs on passive sampling systems in the indoor air – GerES**
Luise Klein[1], Wolfgang Horn[1], and Robert Bethke[2],
[1]*Bundesanstalt für Materialforschung und -prüfung (BAM), Berlin, Germany.*
[2]*Umweltbundesamt (UBA), Berlin, Germany.*

P-4 **Development and validation of a method for measuring toluene di-isocyanate in accordance with the ACGIH® inhalable fraction and vapor (IFV) notation**
Charles Larocque, Pierre-Luc Cloutier, Sebastian Gagné, Loïc Wingert, Sylvain Canesi, Jacques Lesage and Simon Aubin,
Occupational Health and Safety Research Institute (IRSST, Montréal, Canada.

P-5 **Qualitative and quantitative analysis of crystalline silica by differential scanning calorimetry (DSC)**
Davy Rousset,
Pollutants Metrology Department, Institut National de Recherche et de Sécurité (INRS), Vandœuvre-lès-Nancy, France.

P-6 **Evaluation of the performance of Raman spectroscopy for the determination of different forms of silica. Comparison with French regulatory techniques**
William Vauquoy[1], Sihane Merouane[1], Céline Eypert-Blaison[1], Davy Rousset[1] and Manuel Dossot[2],
[1]*INRS, Centre de Lorraine, Département Métrologie des Polluants, Vandœuvre Les Nancy Cedex, France.*
[2]*Laboratoire LCPME, UMR CNRS-Université de Lorraine n°7564, Villers-les-Nancy, France.*

P-7 **High-volume sampling of simultaneously occurring aerosols and vapour – is that possible?**
Jürgen Fauss,
German Social Accident Insurance Institution for the foodstuffs and catering industry (BGN), Mannheim, Germany.

P-8 **Design and investigation of a high flow personal sampler for respirable fraction**
Dzmitry Misiulia[1], Sergiy Antonyuk[1] and C. Möhlmann[2],
[1]*Institute of Particle Process Engineering, University of Kaiserslautern-Landau (RPTU), Kaiserslautern, Germany.*
[2]*Institute for Occupational Safety and Health, German Social Accident Insurance, Sankt Augustin, Germany.*

P-9 **Study of OPC-N3 low cost sensors: Suitability for occupational exposure assessment**
O.Carrivain, A.Boivin and Xavier Simon,
INRS, Aerosol Metrology Laboratory, Vandoeuvre Cedex, France.

P-10 **Towards metagenomic approaches to the molecular characterization of indoor air**
Robert M. Leidenfrost and Dierk-Christoph Pöther,
Federal Institute for Occupational Safety and Health, Berlin, Germany.

P-11 **LIBS – An advanced spectroscopic method for microplastic identification**
Aida Fazlić[1], Pavel Pořízka[1,2], Mark Starin[3], Janja Novak[3], Ula Rozmn[3], Lukas Brunnbauer[4], Gabriela Kalčíková[2,3], Michaela Vykypělová[5], Ondřej Adamovský[5], Sanam Rezvani[1], Miroslava Seewaldova[6], Andreas Limbeck[4] and Jozef Kaiser[1,2],
[1]*Central European Institute of Technology (CEITEC), Brno University of Technology.*
[2]*Faculty of Mechanical Engineering, Brno University of Technology.*
[3]*Faculty of Chemistry and Chemical Technology, University of Ljubljana,*
[4]*TU Wien, Institute of Chemical Technologies and Analytics, Austria.*
[5]*RECETOX, Masaryk University.*
[6]*Faculty of Chemistry, Brno University of Technology.*

P-12 **Speciation of organotin compounds in workplace air samples via HPLC-ICP-MS**
Carina Cläsgens, Tobias Schwank and Katrin Pitzke,
[1]*Institute for Occupational Safety and Health of the German Social Accident Insurances – IFA, Sankt Augustin, Germany.*

P-13 **Atmospheric microplastics in the Arctic and mainland Norway: Occurrence, composition, and sources**
Natascha Schmidt[1], Cleo L. Davie-Martin[1], Dorothea Schulze[2], Sam Celentano[2], Are Bäcklund[2], Nikolaos Evangeliou[3], Sabine Eckhardt[3], Dorte Herzke[1],
[1]*NILU, Department of Environmental Chemistry and Health Effects, Tromsø, Norway.*
[2]*NILU, Department of Monitoring and Instrumentation Technology, Kjeller, Norway.*
[3]*NILU, Department of Atmosphere and Climate, 2007 Kjeller, Norway.*

P-14 **HBM4EU – E-Waste study: Occupational assessment to chromium, cadmium, mercury and lead during e-waste recycling**
Elizabeth Leese[1], Jelle Verdonck[2], Simo P Porras SP[3], Jaakko Airaksinen[3], Tiina Santonen[3], and the HBM4EU E-waste Study Team,
[1]*Health & Safety Executive, Buxton, UK.*
[2]*Centre for Environment & Health, KU Leuven, Belgium.*
[3]*Finnish Institute of Occupational Health, Helsinki, Finland.*

P-15 **MRSA environmental surveillance: The need for standardized protocols**
Pedro Pena[1,2], Renata Cervantes[1,2] and Carla Viegas[1,2],
[1]*H&TRC—Health & Technology Research Center, ESTeSL—Escola Superior de Tecnologia e Saúde, Instituto Politécnico de Lisboa, Lisbon, Portugal.*
[2]*NOVA National School of Public Health, Public Health Research Centre, Comprehensive Health Research Center, CHRC, REAL, CCAL, NOVA University Lisbon, Lisbon, Portugal.*

P-16 **Occupational exposure to respirable dust and quartz during tunnel excavation with tunnel boring machines**
Torunn K. Ervik[1], Stephan Weinbruch[1,2], Kari Dahl[1], Mina Marthinsen Langfjord[1] and Nils Petter Skaugset[1],
[1]*National Institute of Occupational Health, Oslo, Norway,*
[2]*Technical University of Darmstadt, Institute of Applied Geosciences, Darmstadt, Germany.*

P-17 **The influence of diet on biological monitoring in the arsenic occupational exposure assessment**
Andrea Martinelli[1], Fabiola Salamon, Gambalunga A.[1,2], Angelo Moretto[1,2] and Mariella Carrieri[1,2],
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P-18 Assessment of personal PM2.5 exposure of children living in Bandung, Indonesia and Kathmandu, Nepal

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P-19 Characterization of selected elements and element species in size resolved urban aerosol samples by (HPLC-)ICP-MS/MS

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P-20 Reprogramming of the GESTIS-ILV and GESTIS-AMCAW databases: Optimisation and modernisation of the IFA's information systems

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P-21 Monitoring of exposure to polyamide powders used for additive manufacturing processes: Laboratory emission and toxicity testing

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P-22 Monitoring of indoor air quality in Cyprus

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P-23 Spatio-temporal mapping of occupational exposures to airborne chemical using a physics-informed neural network method with sparse observations

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P-24 Low-odour and low-emission indoor products - Nose vers. odour threshold values

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P-25 Determinants of indoor ventilation rates in South African clothing and textile factory workspaces using low-cost CO2 sensors

Itumeleng Ntatamala, R.N. Naidoo, R. Baatjies, T. Van Reenen and M.F. Jeebhay,
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P-26 Toxicological implications of nanoparticle inhalation: The pulmonary surfactant perspective

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P-27 Lung surfactant in respiratory pathologies: Alterations, assessments and implications for airway health

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P-28 Efficiency of traditional low-pressure mercury lamps and modern light-emitting diodes in inactivation of bacterial, viral, and fungal aerosols

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P-29 The wind speed and direction dependence of personal aerosol sampler aspiration efficiency

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P-30 Occupational exposure and health effects in offshore drilling waste treatment plants

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P-31 In-animal performance testing of surgical smoke management technologies for laparoscopic surgery

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P-32 Tackling fungal contamination for safer farming

Bianca Gomes [1,2], Marta Dias[2,3], Renata Cervantes[2,3], Pedro Pena[2,3], Magdalena Twarużek[4], Robert Kosicki[4], Susana Viegas[3] and Carla Viegas[2,3],
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P-33 Non-invasive breath sampling for occupational hygiene biomonitoring

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P-34 From data to decision: Wearable sensors transforming workplace health

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12 Oral Abstracts

(O-1)

The evolution of the Inhalability Convention

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In the years 1950 to 1960 measures with the aim to avoid or reduce occupational diseases caused by airborne dust at workplaces had been started by law. Part of these measures has been dust sampling. Two dust fractions had to be sampled:

- Respirable dust, and total dust

The scientific problem at that time: there were no experimental data about the behaviour of particles during the inhalation process and deposition of inhaled particles in the human respiratory tract.
In practice there had been several conventions in use, so far gravimetric sampling was used. An assumption was, that a typical air velocity at mouth and nose during inhalation may be 1,25 m/s ± 10%. This assumption then was used for long years as the convention for total dust sampling.
First studies on the intake efficiency for particles of the human head during inhalation had been carried out by T. L. Ogden et al., the results had been presented at the IV. Conference on Inhaled particles and Vapours. Additional studies were then started by L. Armbruster et al. and J. H. Vincent et al. The result of those working groups were presented at the V. Conference on Inhaled Particles and Vapours.

The working groups used different experimental equipment:

- Ogden et. al.: wind tunnel (0,5m²), model head 1:1, wind speed: 1 – 2,75m/s, monodisperse DES-particles, max. particle size: ca 30 µm.

- Armbruster et al.: wind tunnel (0,5m2) model head 1:1, wind speed: 1 – 8 m/s, polydisperse coal dust, max. aerodynamic particle size: ca. 60 µm

- Vincent et.al.: wind tunnel (rectangular, 1,5 x 2,5m), wind speed: 1 – 4m/s, torso with model head 1:1, polydisperse aloxit-particles, max. aerodynamic particle size: ca. 100µm.

The “breathing patterns” had been comparable.
The results of the three working groups are in a good agreement:
- The average inhalability of airborne particles (integrated over 360º) is independent of wind speed.
- There is no significant difference between mouth and nose breathing.
- The averaged inhalability decreases from 1,0 (small particles) to 0,5 (30 – 100µm, aerodynamic size).

This was accepted as a new definition of inhalability and taken into the standards EN 481 and ISO 7708, published in the year 1993.

(O-2)

Aerosol sampling – from the past over the present to the future

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Exposure to hazardous substances appeared since mankind developed separate professions to produce food, households or weapons. Mining, melting and processing metals or using minerals for paints showed an early potential for health effects. Attempts to measure dust in air reach back to the nineteenth century, either by sedimenting on white sheets and collecting the dust or by optical methods like the Tyndall effect. More activities were applied in mining industries for coal and metal ores, as they were identified as sources for pneumoconiosis. First dust samplers were used to collect airborne substances followed by chemical analysis. Some used a bed of sugar to easily transfer sampled particles into the extraction liquid.

To assess the exposure directly on site, the Konimeter played an important role over decades. Particles were impacted onto a microscopy plate and counted directly under the built-in microscope. A first definition for the dust fraction reaching the alveoli was described at the pneumoconiosis conference in Johannesburg 1959, proposed by the British Medical Research Council. It represented the penetration curve of a horizontal separator, the MRE from Casella. Since the seventies, additional research had been performed on inhalability and more samplers had been developed like the static instruments VC 25 and PM 4 in Germany, the French CIP 10 and especially other personal samplers like the German PGP system (with GSP and FSP), the British IOM inhalable dust sampler, the Dutch PAS 6 or the Higgins-Dewell cyclone (HD, also called SIMPEDS). An additional cyclone type GK came up in the nineties (Kenny, Gussman) that follows the respirable convention better than HD.

From 1993 on the dust fraction conventions in EN 481 (in parallel ISO 7708) have been in force giving a reference for sampler tests, which are described in EN 13205. EN 481 is under revision (2024) establishing different inhalability conventions for different wind speeds at workplaces.

Besides running developments for personal air samplers using a high flow of 20 l/min, further developments had led to small low-cost aerosol sensors that could find wide applications for overviews of respirable or thoracic dust concentrations assessing the work processes over time or locate sources of dust release. This could open the field of big data together with other sensing instruments for various chemical or physical exposures.

All these efforts need to be seen in the context of new toxicological effects and changes in occupational exposure limit values to meet those requirements.

(O-3)

Asbestos analytics in relation to changes of the European Directive

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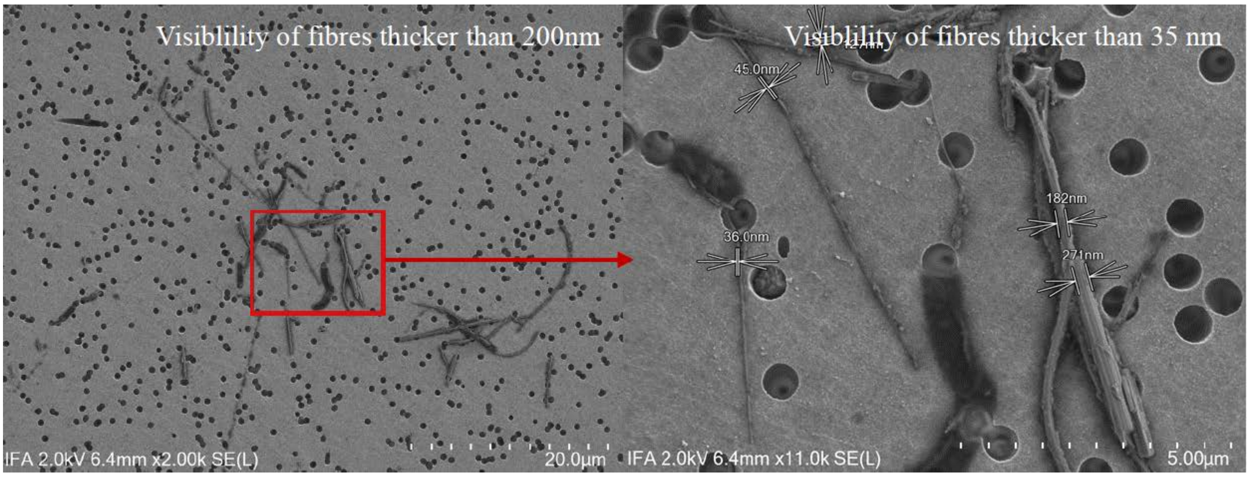
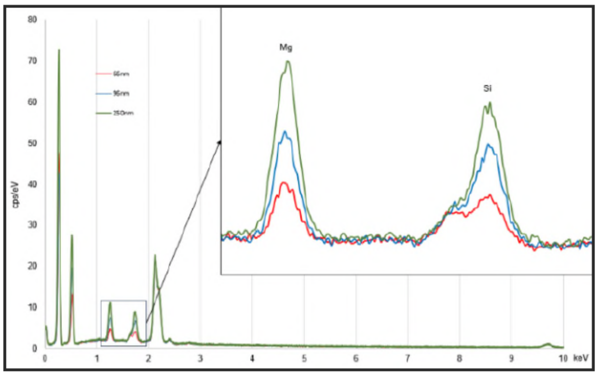
In 2023, the EU Parliament passed a resolution to amend the Asbestos Directive. Within a transitional period of 6 years, laboratories must either implement a detection limit of 2000 F/cm³ for the evaluation of workplace measurements and or determine fibres thinner than 200 nm (lower limit has not been defined!) using electron microscopic methods (phase contrast microscopy is no longer applicable) in order to be able to apply a limit value of 10,000 F/m³. This poses challenges for analysis. On the one hand, not every laboratory has suitable equipment to fulfil the requirements, on the other hand, the users of the equipment are usually not scientists who are fully familiar with the equipment, but users who follow laboratory instructions. The lecture presents the pitfalls of SEM/EDS analysis in relation to air samples that are to be expected when detecting thin asbestos fibres.
If the detection limit is lowered, at least a semi-automatic evaluation is necessary, as otherwise the analysis times will be unacceptable.
When evaluating asbestos fibers with a diameter of less than 200 nm, two basic distinctions must be made. These are the visibility of the fibers in the SEM and the identification by means of EDS. The former certainly depends on the choice of device (device with tungsten cathode or field emitter), but also on the choice of detector (SE or BSE detector), primary energy, working distance, brightness, contrast and other parameters.
The evaluation effort increases significantly at higher evaluation magnifications, as the image area becomes smaller, and more image fields have to be evaluated for the same evaluation area.





Settings in which fibres with a diameter of 200 nm or larger can be displayed may not be optically recognizable for significantly thinner fibres. If an acceleration voltage that is too low is selected, this may mean that the fibres cannot be detected, depending on the EDS system. In addition, the filter background also plays an increasingly important role in the identification of fibers with decreasing diameters.

(O-4)

Measurements of respiratory aerosols: Challenges and opportunities

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The amount of exhaled aerosol by respiratory and vocal activities and the concentration of carbon dioxide are often used to assess the risk of indoor transmission of respiratory pathogens by inhalation in the absence of quantitative information on airborne infectious and viable pathogen concentration. Measurements of exhaled aerosols present considerable and unique challenges that must be overcome when measuring exhaled aerosols. For example, the number of particles exhaled is extremely low and cannot be discriminated from the ambient concentration of particles in an indoor environment. The low number present challenges such as overcoming the Poisson arrival statistics for particles at such low concentrations, requiring long sampling times.

The University of Bristol Aerosol Research Centre has led 2 measurement campaigns collecting data on respiratory aerosol and respiratory parameters (such as minute ventilation and forced vital capacity) from almost 400 participants, the PERFORM and AERATOR studies. Further, we are currently undertaking a longitudinal study to investigate how exhaled aerosols from an individual change over time. Distinctively, our studies have quantified the absolute amount of aerosol generated by a range of respiratory and vocal activities, including speech and language therapy, the correlation between particle emission rates and the amount of carbon dioxide exhaled, and the impact of pre-existing lung conditions and infection on emission.

By synchronous measurement of exhaled aerosol and respiratory parameters (e.g. minute ventilation), we will report on the relationship between the absolute amounts of exhaled aerosol and carbon dioxide for breathing, exercising, speaking and singing for healthy individuals and those with pre-existing lung conditions. We will demonstrate that although carbon dioxide is considered a good measure of indoor ventilation, it is a poor indicator of the amount of aerosol exhaled. Indeed, the activity (e.g. speaking) can lead to 1-3 orders of magnitude more aerosol for no change in exhaled carbon dioxide. We will also show that there is no correlation between exhaled aerosol, participant age and body mass index, and that the aerosol number concentrations between emitted by those with pre-existing lung conditions and healthy subjects are similar.

As well as providing an assessment of the variation in exhaled aerosol between participants, we will also report on early data from the longitudinal study of individuals. Measurements of exhaled aerosols over day, week and month timescales will be used to examine the importance of physiological factors in determining exhaled aerosol and to answer the question: are individuals who are high emitters of aerosol particles always high emitters?

In summary, the amount of carbon dioxide in an indoor environment does not necessarily reflect the amount of airborne aerosol and pathogen, and can lead to an under-representation when individuals are speaking loudly. This is in addition to previous airborne survival studies where we have shown that the level of carbon dioxide can impact on the survival of airborne pathogens. Both factors must be considered and are crucial to implementing effective mitigations to reduce airborne viral transmission

(O-5)

Advancing occupational exposure models: insights from a case study

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Occupational exposure assessments under REACH (EC 1907/2006) can be conducted quantitatively using exposure measurements or using exposure modelling tools. Regulatory guidance (ECHA R14, EN 689) explicitly supports the use of modeling, provided that the appropriate and validated models are used. With a growing number of these models available the critical question is their reliability and validity, as regulators and users depend on these models to make informed decisions about workers' exposure. Currently used models in occupational exposure assessment are mostly mechanistic based and their performance varies.

The potential of more advanced statistical modelling approaches such as Machine Learning (ML) in occupational exposure assessment was explored within a case study of asbestos exposure. Specific attention was given to the performance of these models compared to the current linear regression model, to the ease of development of the model (e.g. complexity of the models, expertise required etc.), and to the possible regulatory acceptance. Within this case study five different ML or hybrid modelling approaches were used to recalibrate the existing mechanistic model: the Asbestos Removal Exposure Assessment Tool, which was previously calibrated with linear regression modeling. Multiple Linear Regression, Random Forest, Gradient Boosting Machines, Bayesian Network and Neural Network models were applied and their performance was compared (by calculating the models' error, correlation with measurements and bias). Random Forest and Gradient Boosting Machines performed best with regards to accuracy, followed by Bayesian Network, Multiple Linear Regression, the original model and Neural Network.

The asbestos case study presented in this paper illustrates possible advancements and promises for occupational exposure modeling through the application of ML or hybrid modelling techniques. The challenge with the application of these models is a trade-off between interpretability and predictive power, moreover before implementation in regulatory context. Hybrid models such as Bayesian Networks integrate expert knowledge on the exposure determinants with probability distributions based on measured data. This approach prevents the model from making non-physical or unrealistic predictions while still leveraging data-driven improvements. Bayesian Networks allow relatively easy model updates when e.g. control measures improve, handling missing input data, and the extension to model multiple routes of exposure. Hybrid modeling showed promise to improve current- or develop new occupational exposure models, with several advantages compared to conventional modelling approaches.

(O-6)

PEROSH-International comparison of sampling strategies - hazardous substances (PEROSH-ICSS-HS) – an explorative feasibility study and first results with airborne wood dust

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The objective of this project is to systematically quantify the extent of deviations in measured values resulting from the use of different sampling systems and measurement strategies across EU member states, using parallel measurements. These methodological differences can lead to significant discrepancies in exposure assessments, even when evaluating identical exposure scenarios. Consequently, national variations in exposure limit derivation hinder the establishment of a uniformly high level of worker protection and a level playing field within the European Union, as required by Directive (EU) 2017/2398. The long-term aim is to enable comparability of exposure measurements across the EU, regardless of the sampling systems and measurement strategies applied.

Parallel measurements were conducted to determine whether the sampling systems used in different countries for assessing wood dust concentrations (specifically the inhalable fraction, as defined in EN 481) differ in their collection characteristics. To optimize the test setup and minimize potential confounding factors, a custom-built sampling box was constructed. The box was placed on a turntable and rotated at regular intervals by a defined angle to ensure a homogeneous distribution of airborne particles across all sampling devices. All systems operated simultaneously under identical exposure conditions within this setup. Between 2021 and 2024, 37 parallel stationary measurements and 11 parallel personal measurements were carried out in typical wood-processing facilities in Germany. To evaluate the relationships between the sampling systems, scatter plots with linear regression analyses were created, using the commonly applied German standard sampler (GSP10) as a reference. In addition, conventional Bland-Altman plots were used to assess agreement between the devices and to identify potential non-constant biases. Upon visual inspection, several comparisons showed atypical patterns in the residuals, suggesting systematic deviations depending on the exposure level. To explore these observations further, linear trend lines were fitted within the Bland-Altman plots as a means of approximating and characterizing these deviations.

Due to the presence of multiple confounding factors that could not be sufficiently controlled, the personal monitoring measurements were excluded from the analysis. The results presented here are therefore based exclusively on stationary parallel measurements. Linear regression analyses showed a moderate to good fit between the devices. Regressions forced through the origin, however, yielded poorer fits compared to models allowing an intercept. This is somewhat unexpected, as one might assume that if one device detects no exposure, the others should also indicate zero. A closer examination of the Bland-Altman plots revealed indications of a non-constant bias in some of the device comparisons. In particular, the difference between devices appeared to vary depending on the level of exposure, although no definitive pattern could be confirmed at this stage.

Several devices exhibited a significant slope in the linear approximation of the Bland-Altman plots. This suggests the presence of a non-constant bias in comparison to the GSP10, particularly for the GSP3.5, the Button sampler, and potentially the Woodcheck device. As a result, the use of a simple conversion factor or a linear approximation does not appear to be sufficient to describe the relationship between these samplers. Further analyses are therefore necessary to better understand and quantify the comparability of the sampling systems and their respective strategies.

(O-7)
Recommended flow rate of aluminum cyclone for improved exposure assessment

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The most common technique for sampling the respirable fraction of aerosols in the workplace, especially for respirable crystalline silica (RCS), is to use a miniature cyclone pre-selector, for example the "aluminum (or aluminium) cyclone". This cyclone was intended for use at a flow rate of 1.9 $l.min^{-1}$ to meet an older recommendation for size-separation. Contrary to earlier predictions and studies, a study (not peer-reviewed) suggested 2.5 $l.min^{-1}$ (recommended by manufacturers) as the appropriate flow rate for the ISO convention.

The aluminum cyclone was tested recently in three laboratories at 2.5 $l.min^{-1}$ and in all three the 50% cut-point (D_{50}) of the separation curve was below expectation and the bias not in accordance with EN13205 requirements. Two of the laboratories gave D_{50} within 8%, and one has performed further investigation. Firstly, three aluminum cyclone units from each of two manufacturers were tested side-by-side at 2.5 $l.min^{-1}$ and had identical performance. One cyclone was then further tested at 2.3 and 2.2 $l.min^{-1}$ to determine the optimal flow rate.

EN13205 considers an area of interest for performance studies that is characterized by a combination of a range of mass median aerodynamic diameters and geometric standard deviations. The objective of EN13205 is to have a bias <±10% over as wide an area as possible in that range. The flow rate of 2.2 $l.min^{-1}$ is consistent with earlier predictions and studies, and gave bias <±10% over the whole area of size distributions of interest. It should be the flow rate applied for most accurate sampling. 2.3 $l.min^{-1}$ has the lowest overall mean bias and also meets the specification of EN13205 in that the area of bias >±10% is minimal, so either flow rate should give acceptable results. However, using the aluminum cyclone at 2.5 $l.min^{-1}$ gives an under-estimate of exposure compared to the ISO convention.

(O-8)

A novel concept for aerosol collection: dielectrophoretic actuation and trapping of aerosolised microspheres

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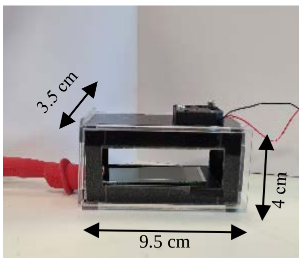
Transmission of pathogens through aerosols significantly impacts human and animal health and agricultural productivity, highlighting the importance of effective aerosol sampling methods. Electrostatic precipitation is highly regarded as a promising collection method. However, the technique generates ozone as a byproduct, potentially compromising the viability of collected bioaerosol samples [1]. Herein, dielectrophoresis was investigated as an alternative method for aerosol collection.

The dielectrophoretic collection of aerosolised 1 µm diameter fluorescent polystyrene latex (PSL) microspheres were explored in an 8 m^3 aerosol chamber equipped with optical particle counters (OPCs, Alphasense) to monitor aerosol concentration. Indium tin oxide (ITO) coated glass slides were connected to four plates with different applied potentials: negative, positive, grounded and floating, at voltages between -10 kV to +10 kV. The collected particle count was normalised against the chamber concentration. The slides were imaged with an M7000 fluorescent microscope and then processed using Celeste 6 software. A simple collection device with a fan for directed airflow (Fig 1a) was built. The fan speed and positioning of the collection device were adjusted to gain insight into collection efficiency and optimisation.

Firstly, we found that dielectrophoretic collection was achieved and that positive and negative biases significantly outperformed grounded and floating plates in the PSL collection, with the positive bias showing a slight advantage (Fig 1b). A positive correlation was also observed between the applied voltage and PSL collection. Higher voltages create a stronger electric field, thus producing a greater dielectrophoretic force and increased particle collection. Moreover, the simple collection device achieved up to 15.7 % collection efficiency. Through the characterisation of the device, we determined that increasing the distance between the fan and collection slide, or reducing the fan speed, can increase the collection efficiency to 21.6 %.

Overall, these findings demonstrate the potential of dielectrophoresis as an alternative aerosol collection method. This approach may preserve the viability of bioaerosols more effectively than electrostatic collection, making it a promising alternative.

1a)



1b)

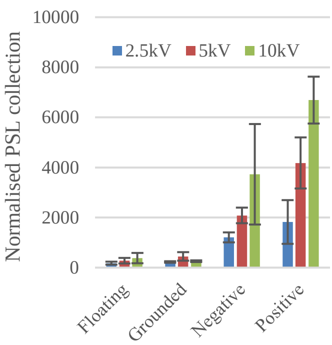


Figure 1: a) Simple collection device,
b) Comparison of dielectrophoretic collected PSL microspheres at different applied potentials.

This work was supported by Research England-funded Biodetection Technologies Hub and the Engineering and Physical Sciences Research Council [grant number EP/X017591/1].

Reference: [1] Ouyang, H. *et al.* Control technologies to prevent aerosol-based disease transmission in animal agriculture production settings: a review of established and emerging approaches. *Front Vet Sci* **10**, 1291312 (2023).

(O-9)

Overall sampling efficiencies of selected filter-based samplers used for analysis by electron microscopy: Data from a few nanometers to around 30 µm

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Beyond the diversity expected in physico-chemical composition and morphology, airborne nano-objects and their agglomerates and aggregates (NOAA) in the workplaces are composed of particles, which cover the size range from a few nanometers to several tens of micrometres. Consequently, the sampling devices used for microscopic observation should cover this wide size range. The overall sampling efficiency of a filter-based sampler is the fraction of particles of the original aerosol passing through the inlet orifice and collected by the collection media. Only the objects (individuals, aggregates or agglomerates) able to reach and to be collected on the collection media will be observed by electron microscopy (EM).

The objective of this experimental study was to measure the complete overall sampling efficiency curves of four selected filter-based samplers: 37-mm (NIOSH) open-face cassette, 37-mm PGP-FAP (FAP 37mm), 25-mm VDI 3492 (FAP 25mm) and Particlever's sampling head. The data combine measurement of the collection efficiency of 0.8-µm and 0.4-µm pore size Au-coated Nuclepore^{TM} polycarbonate membranes for submicronic particles from ~30 nm and the sampling (inlet and transport) efficiency for micronic particles up to ~30 µm.

Collection efficiencies of Au-coated membranes were based on the comparison between upstream and downstream number concentrations measured using SMPS (TSI classifier 3082 and CPC 3752 combined) with polydisperse DEHS particles and using CPC 3752 only with monodisperse DEHS aerosol selected by DMA classifier 3752. Sampling efficiencies were based on comparison of size distributions and number concentrations of glass microspheres between the sampler and reference probes using a Coulter Multisizer 4e particle counter.

The sampling efficiencies of the 37-mm open face cassette (3 or 5 l/min, 90° downward orientation) and of the FAP 25 mm and 37 mm samplers (2 l/min, 90° downward orientation) for micronic particles are higher than the thoracic fraction. Micronic particles (including agglomerates and aggregates) up to 10 µm are sampled with 100% efficiency and would therefore be observable by EM. The sampling efficiency of the sampling head of the Particlever (1 l/min, 90° upward orientation) is close to the respirable fraction. Moreover, 0.4-µm pore size membrane is recommended because of the higher collection efficiency of NOAA presenting aerodynamic diameter between around 20 nm and 600 nm.

Acknowledgements:
This work was carried out within CEN mandate M/461. The results are in accordance with the draft standard CEN/TS 18117 Workplace exposure - Detection and characterization of airborne NOAA using electron microscopy - Rules for sampling and analysis. The authors would like to thank Olivier Witschger for his involvement in the initial project setup and for discussion linked with the preparation of the experiments, Raphaël Payet and Benjamin Sutter for their valuable help in carrying out some of the measurements, Céline Eypert-Blaison and Davy Rousset for advice and discussion regarding electron microscopy.

(O-10)

Direct analysis of workers' exposure to metals and metalloids using portable XRF and LIBS tools

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The study of workers' exposure to metal and metalloid aerosols is of paramount importance in occupational health. Traditional methods for assessing exposure, such as aerosol sample acid digestion and ICP-OES analysis, are time-consuming and require significant laboratory resources. While these methods are essential for comparing concentrations with regulatory limits, they often fail to provide the timely results needed for immediate workplace safety assessments. This research aims to develop and refine robust, efficient techniques for metal aerosol analysis in workplace environments, enabling faster and more reliable assessments of worker exposure to hazardous metals. This study seeks to establish the optimal conditions for conducting such analyses effectively. Thus, we selected portable spectroscopic instruments - X-ray fluorescence (XRF) and laser-induced breakdown spectroscopy (LIBS) - due to their proven efficacy for in situ analyses. This study will firstly focus on qualitative and semi-quantitative approaches, gradually advancing toward quantitative analysis for comparing concentrations against occupational exposure limits.

The general project approach consists of several key stages. The first stage involves aerosol generation and sampling followed by spectral processing using both traditional and AI-based approaches. Following this, the measurements will be validated through laboratory experiments, where elemental concentrations in complex matrices will be predicted and compared with gravimetric and chemical analyses. The final field validation phase will deploy portable XRF and LIBS instruments on-site to analyze aerosol samples, with results compared to reference values.

The first LIBS analysis results for virgin PVC membranes including the optimization of the protocol of the LIBS analyses (laser parameters, laser/matter distance) and the role of the support under the membrane will be presented. The first tests on welding fume-loaded PVC membranes (Figure 1) highlight challenges related to aerosol dispersion under the multiple laser shots. Strategies to mitigate these effects were explored, ultimately guiding the choice of optimal measurement conditions.

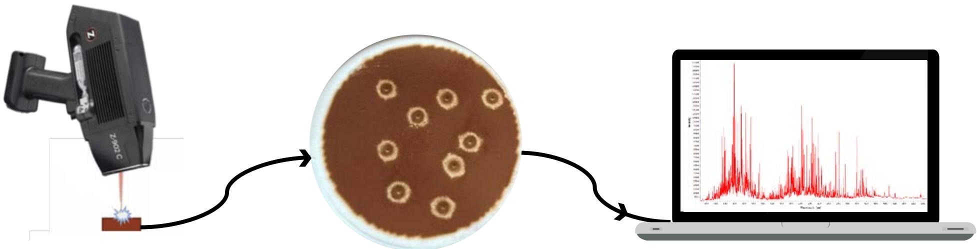

Figure 1: (left) Membrane analyzed by LIBS instrument; (middle) Tested PVC membrane (37 mm diameter); (right) LIBS spectrum

(O-11)

Design and evaluation of a novel wet electrostatic precipitator for aerosol capture using charged liquid droplets

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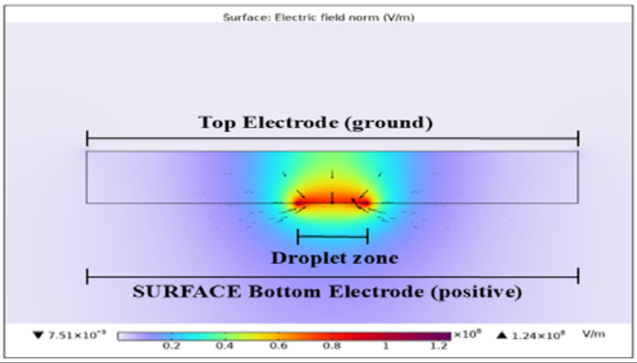
Aerosols, comprising suspended solid and liquid phases within a gaseous medium, pose significant health and environmental challenges. This research introduces a novel Wet Electrostatic Precipitator (WESP) prototype designed to capture harmful aerosols by concentrating them into microliter-sized liquid droplets for subsequent analysis. Developed at the University of Hertfordshire, the WESP leverages an innovative electrostatic lensing approach, termed SURFACE (Selective Upper Region for Aerosol Collection Electrostatically), to focus charged aerosols into a liquid droplet region. This enables efficient sample concentration and facilitates downstream analyses such as Fourier Transform Spectroscopy and q-PCR. To optimise the aerosol collection process, tests were conducted using four liquid types: De-ionised Water (DIW), DIW with 0.05% Tween20 (DIT), Phosphate Buffered Saline (PBS), and PBS with 0.05% Tween20 (PBST). These experiments aimed to determine the most effective liquid medium for capturing aerosols, including bioaerosols. The in-line collection method of the WESP allows for sample concentration and streamlining sample recovery, positioning this technology as a potential next-generation solution for environmental monitoring and early detection of airborne threats.
The prototype's functionality was evaluated using a comprehensive testing rig consisting of a commercial aerosol generator, a pressure-regulated Aerosol Box, and the Mini AeroZone (MAZ), which houses the WESP prototype and its components. Calibration of the SURFACE mechanism revealed that maximum aerosol collection occurred when the region was positively charged, and the opposite electrode was grounded. This configuration was validated both experimentally and through COMSOL simulations with results aligning closely with theoretical models (Figure 1), showing maximum potential concentrated at the droplet zone.



Sno.	Top electrode polarity	Bottom electrode (SURFACE) polarity	Total number of microspheres collected on the droplet region
1.	Negative	Positive	23.34 ± 52.64
2.	Negative	Negative	0.33 ± 1.58
3.	Negative	Ground	94.67 ± 16.18
4.	Positive	Positive	251.34 ± 12.62
5.	Ground	Positive	695.33 ± 198.33

Figure 1: SURFACE calibration results with different electrostatic combinations. Left- COMSOL proof indicating maximum potential at the droplet region. Right- Experimental proof backing up COMSOL results.

The new WESP prototype successfully demonstrated the capability to collect aerosols into charged liquid droplets. Furthermore, it provides an in-depth insight into the kind of charged liquids adept at collecting harmful aerosols into droplets. With its outlook to work on advanced early-detection capabilities, this technology creates fresh opportunities for improved air quality information, surveillance and understanding.

(O-12)

Comprehensive hexamethylene diisocyanate (HDI) evaluation method comparison in an automotive collision repair facility

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Isocyanates are widely recognized as irritants and sensitizers, and monitoring their airborne levels in the workplace is difficult due to their high chemical reactivity and semi-volatile properties. This current research aims to apply an evaluation method comparison protocol (1), previously performed under controlled laboratory conditions, to an automotive collision repair facility (2).

Three methods were compared to the reference method - an impinger with a backup glass fiber filter (GFF) and 1,2-methoxyphenylpiperazine (MP) based on ISO 16702/MDHS 25 - during ten spray paint applications on three different days: (1) Swinnex cassette 13 mm GFF MP (MP-Swin); (2) closed-face cassette 37 mm GFF (end filter and inner walls) MP (MP-37); and (3) denuder and GFF dibutylamine (DBA) (ISO 17334-1, Asset). Between 20 and 30 samples were collected for each method, analyzing monomeric HDI and isocyanurate (IC, the major oligomer). Each sample was divided into sections prior to analysis to determine the spatial distribution of isocyanates in the samplers.

Particle size distribution was measured using a Marple cascade impactor and additional samples were analyzed by scanning electron microscopy (SEM) to visualize droplet accumulation on filters. Clear trends were observed in the spatial distribution of HDI and IC in each sampler, mostly related to the physical phase (vapor vs. particle) and particle size. For HDI, MP-Swin showed a significant negative bias compared to the impinger method, while MP-37 and Asset showed no significant bias. For IC, all three methods showed a significant negative bias compared to the impinger method. For both HDI and IC, the three methods showed limits of agreement beyond the acceptable range of ±30% compared to the reference method. Further data analysis showed that the curing rate of the sprayed product was the main determinant of the bias between the methods and the reference.

SEM analysis allowed visualization of the accumulation of collected droplets in real samples, supporting the negative bias observed between the candidate methods and the reference. In terms of bias, the conclusions of this study differ from those of a similar comparative study conducted under laboratory conditions.

Although laboratory-controlled atmospheres allow for more practical method comparisons, evaluation methods for monitoring reactive chemicals such as isocyanates still seem to require real-world settings to evaluate their performance.

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(O-13)
Sampling of a bio-aerosol using electrowetting-enhanced electrostatic precipitation

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One of the main challenges facing in-field detection of harmful aerosol is the low concentration of target airborne material. Hence, generating concentrated samples (within small liquid volumes) is key to providing low limit-of-detection. In previous work, we have demonstrated a novel system combining an Electrostatic Precipitator (ESP) sampler with an Electrowetting-on-Dielectric (EWOD) elution device that generated samples with between a 33 to 1000 times greater concentration than from an SKC BioSampler [1]. However, testing[1] has also shown that the ESP-EWOD system can perform poorly when background aerosol concentrations are high. This work presents an overview of the development and characterisation of ruggedised and weather-proofed ESP and EWOD systems built for future field trials. In addition, the impact of Tween-80 surfactant in improving aerosol recovery in EWOD elution was examined.
The handheld ESP [1] was redesigned to incorporate a commercial PM10 inlet and weatherproofing. The ESP housing has improved sealing to cope with the increased pressure drop from the PM10 inlet. The EWOD included larger electrodes, enabling them to cope better with high aerosol concentration on the collection surface and reduce complexity. *Bacillus atrophaeus* (BG) spores were aerosolised within a negative-pressure aerosol chamber to produce a 0.7 particle count/cm^3 concentration. Three ESP devices were examined using a flow rate of 16.7 L/min for a collection time of 30 minutes. The spores collected on the ESP slides were imaged by an EVOS M7000 microscope and counted using image processing software. The EWOD device performs the elution of the samples with a 2.7 µl droplet with 0, 1.4E-4 and 1E-2 % of Tween-80 in deionised (DI) water. Flow cytometry analysis determined the absolute count of BG spores in the droplet sample.
Microscopy revealed that the field trial ESP had a 49 % average aerosol collection efficiency, with a 20 % standard deviation from 17 results. The elution process removed, on average, 51 % of the spores on the collection surface, with no notable improvement when Tween-80 was introduced for the elution. Tween-80 also negatively impacted the EWOD droplet's actuation performance with a lower completion rate of the elution process. The ESP-EWOD system produced an average concentration rate of 1.1E+5 /min, which is more than an order of magnitude greater than the theoretical maximum of the commercial-off-the-shelf personal samplers and on par with the previous generation ESP-EWOD system [2].
The field trial ESP and EWOD system retained BG spore concentration rate performance despite the ruggedisation of the devices. Introducing the Tween-80 surfactant in the elution process showed no improvement in BG spore removal and was detrimental to the EWOD droplet actuation. The ESP-EWOD devices were involved in a successful outdoor field trial after the conclusion of this study.

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(O-14)

The role of novel (low-cost) sensor technologies in air quality monitoring and exposure assessment

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Air quality monitoring and exposure assessment have traditionally relied on reference-grade monitoring stations, which provide high-accuracy measurements but suffer from limitations in spatial coverage and cost. The advent of novel low-cost sensor (LCS) technologies has significantly expanded the potential for dense air quality monitoring networks, allowing for real-time, high-resolution spatiotemporal assessments of air pollution. These sensors, based on electrochemical, optical, or metal oxide technologies, offer a cost-effective alternative to conventional stations and are increasingly deployed for regulatory, research, and citizen science applications.

Despite their advantages, LCS devices have challenges related to their data accuracy, calibration, sensor drift, and environmental influences, which must be addressed through quality control and correction techniques. Advances in data assimilation, machine learning, and sensor fusion methods have improved the reliability of LCS data by integrating them with reference station observations. Additionally, exposure assessment studies benefit from mobile and wearable sensors, providing individual-level pollution exposure insights, which are critical for epidemiological studies and public health interventions.

In this talk, the role of LCS technologies in air quality monitoring, including recent advancements, challenges, and future directions will be discussed. Case studies from urban deployments demonstrate how LCS networks enhance exposure assessments and supplement traditional monitoring frameworks. As these technologies have a wider use by authorities, citizen science initiatives, they have the potential to generate large datasets that contribute to in-situ environmental monitoring. Advances in automatic validation make it possible to generate Analysis Ready Data (ARD) — data that has been validated and assigned a defined quality level. This ARD can then be more easily transformed into Decision Ready Information (DRI), supporting policymaking by providing more comprehensive and accessible air pollution data.

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(O-15)

How to use the correct low-cost PM sensors for assessing occupational exposures correctly – an overview of recent guidance initiatives

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The use of low-cost optical particulate matter sensors (hereafter referred to as simply *sensors*) for measuring exposure to hazardous substances in the workplace is becoming more popular, shown for example by the increased number of commercial devices being introduced to the market in recent years. End-users, such as occupational hygienists, acknowledge the potential benefits of sensors (cheaper, more informative measurements and quicker results). However, they also expressed questions on how to correctly implement sensors in their daily practice, such as which sensors are ‘good,’ how to select a sensor and what sensors can (not) be used for. This slows down the adoption of using sensors for characterizing workplace exposures or may result in incorrect conclusions due to wrongly applied sensors or interpreted data.

Several guidance initiatives have been started in the last few years, of which this presentation will provide an overview. Also, remaining knowledge gaps and next steps for scientific development and end-user application will be discussed.

In collaboration with a working group of occupational hygienists in The Netherlands and Belgium, the guideline “*Particulate Sensors in the Workplace* was developed. This guideline combines practical information with theoretical explanations to guide readers into correctly using the correct sensors for measuring occupational exposures.
In the EU-project EPHOR, six infosheets were developed to inform occupational safety and health professionals on the use of low-cost air sensors. The infosheets were developed in a human-centered design thinking approach in collaboration between European scientists and OSH professionals.

Lastly, in a global collaboration, a *playbook* is being developed to share best practices among sensor and direct-reading instrument (DRI) users. This playbook consists of a collection of individual “*plays*”, where each play describes an example of how sensors/DRI have been successfully used for characterizing occupational exposures. The playbook will be introduced to IOHA’s International Community of Practice (CoP) on Particulate Matter Sensor Technologies, to share experiences among sensor/DRI users.

(O-16)

Performance evaluation of low-cost PM sensors against NOAA aerosols

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Over the past decade, the emergence of low-cost PM sensors, characterized by compact size and high temporal resolution of data, has opened new possibilities for developing dense monitoring networks in occupational settings. These sensors, primarily employing light scattering methods, measure particulate concentrations in different size fractions. However, their calibration is usually done, assuming typical refractive indices and particle densities of atmospheric particles to deliver ambient particulate matter fractions ($PM_{2.5}$, PM_{10}). In contrast, workplace air quality assessments require specific fractions based on the inhalable, thoracic, and respirable convention, respectively. Additionally, workplace environments often generate aerosols with distinct physicochemical properties influenced by specific industrial processes, thus challenging the direct applicability of sensors calibrated for environmental monitoring.

To address this, a comprehensive study supported by the European Commission (mandate M/461) was conducted by a consortium comprising INRS, IFA, IUTA, and TNO. The project consisted of three distinct but complementary experimental approaches:

- A laboratory-based comparative evaluation of six commercially available low-cost sensors against ten different NOAA (Nano-Objects and their Aggregates and Agglomerates) aerosol powders, focusing on accuracy, sensitivity, and consistency across various aerosol types.
- A round-robin trial aiming to determine reproducibility and coherence among multiple sensor units, assessing their potential for integration into sensor networks in real workplace environments.
- A simulated field study designed to evaluate operational advantages and limitations of deploying these sensors for continuous air quality monitoring, particularly focusing on their capability to identify emission sources and concentration fluctuations.

The results demonstrated a robust linear correlation between sensor outputs and reference measurements, emphasizing the necessity of sensor-specific calibrations tailored to the particular workplace aerosol characteristics. Although deviations from reference instruments were observed, especially in size distribution assessments below 1 µm, low-cost sensors proved effective in detecting real-time concentration changes, thus providing valuable temporal insights for occupational safety management.

The presentation will summarize the key findings from each experimental stage and discuss recommendations formulated in the recently published technical specification CEN/TS 18086. These recommendations aim at guiding occupational health professionals in effectively employing low-cost sensors for enhanced and cost-efficient aerosol monitoring in workplaces, although compliance measurements with occupational exposure limit values cannot be recommended.

(O-17)

Calibrating low-cost PM sensors for compliance testing – obstacles and the road ahead

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Determining if a worker is exposed below the legal or self-defined exposure limit value of a hazardous particulate (i.e., compliance testing) is one of the main motivations for performing exposure measurements in a workplace. These measurements, based on collecting material on a filter followed by laboratory analysis, are costly and therefore typically only performed when necessary.

Low-cost optical particulate matter sensors (hereafter referred to as simply *sensors*) have several benefits compared to filter-based samplers: cheaper, more informative measurements and quicker results. Sensors can provide valuable insights for understanding what might cause an increased exposure, but their use for compliance testing remains unknown. Although sensors are calibrated by the manufacturer, they show variation in performance when applied in different occupational exposure situations. Therefore, sensors require additional, situation-specific calibration before measurements can be used for quantitative applications, such as compliance testing. Consensus on how to calibrate sensors for compliance testing and how to interpret calibrated measurements is lacking.

This poses two challenges for occupational hygienists:

- Occupational hygienists will refrain from using sensors since calibration is too costly or difficult. This may result in fewer measurements being performed or missing out on useful information.
- Occupational hygienists will use sensors for compliance testing without proper calibration, potentially underestimating exposure levels and increasing workers health risks.

The presentation will dive further in the accuracy of sensors by providing examples on sensor performance in different applications, such as differences in performance between occupational sectors or between different types of sensors. Additionally, some early examples of a recently started project on calibrating sensors for welding fume exposure will be discussed, as well as the steps ahead.

(O-18)
Supporting the global security by sniffing the threat

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Chemicals can be detected and identified by using their specific molecular properties combined with a variety of smart-advanced technologies. Cranfield University is offering the handheld CRIM-TRACK mechanical sniffer device, able to detect illicit chemicals, such as explosives and controlled drugs and their precursors at ppt level in the air and support the fight against organised crime and terrorism and contribute to global security.
The detection technology is based on a colorimetric sensor which monitors chromic dyes changing colour when in contact with the vapours of illicit chemicals.

The detection data were organised as datasets, where each dataset has its own measurement conditions and analytes. Several machine learning classifiers such as Convolutional Neural Networks (CNN) were used to perform a multi-class classification, which performed better than other available methods. The current sensor can be updated with further addition of chemo-selective dyes that would improve the sensitivity and broaden the range of detection. The versatility of the sniffer device allows a wider investigation involving other detection scenarios such as pesticides, bio-aerosols and environmental monitoring.

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(O-19)

Measurement methods and strategies for airborne biological agents at the workplace: Future challenges in a prevention context

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Occupational exposure to biological agents via the inhalation route has been identified in many sectors of professional activity. It has been associated to deleterious effects on workers' health, and appropriate preventive measures need to be implemented in problematic work situations. Although biological risk has never really been considered a priority risk, the COVID19 pandemic served as a reminder that exposure to biological agents could give rise to particularly problematic health situations for which mankind is not necessarily well prepared.

The keynote conference recalls the fundamentals of occupational risk prevention, addresses examples of sectors of activity where exposure to airborne biological agents has been identified and discusses the role of measurement in the prevention approach. It focuses on the methods and strategies used for the measurement of bioaerosols at the workplace and addresses the technical developments that are still needed to tackle future occupational health issues regarding biological risks.

Indeed, there are many reasons for organising a measurement campaign in a company or workshop. In all cases, the measurements taken should help to answer the occupational health question that was initially raised. To this end, the implementation of bioaerosol measurements is part of a broader structured methodology needed to provide an answer. This includes carrying out a preliminary survey, (aimed at gathering all the useful and available information and enables making an initial qualitative assessment of the work situations under study) as well as the design and the implementation of a suitable measurement strategy (aimed at providing concentration levels and composition of bioaerosols). Both are of crucial relevance in interpreting measurement results and implementing efficient and effective protection means for workers' health.
The presentation reviews efforts to develop, standardise and implement methods and instruments for measuring and characterising bioaerosols. This includes off-line methods, real-time ones, sensor networks and the promising technologies that are under developments. It also focuses on the issue of interpreting the results, which remains tricky in the absence of occupational exposure limit values, and reviews the alternatives currently available (guide values, for example).

The current state of knowledge underlines the need for a wide range of studies and research. In particular, poly-exposure can make it tricky to implement preventive measures that have to deal with both chemical and biological pollution without disrupting the smooth running of production. Similarly, the development of certain sectors, accompanied by the modernisation of facilities (waste sorting, for example), opens up a wide range of questions concerning occupational exposure and prevention methods. It also mentions subjects that are more difficult to grasp, but which should be addressed in order to anticipate tomorrow's issues. These include the emergence of infectious agents likely to cause epidemics or even pandemics, the development of antibiotic resistance in biological agents, and climate change. These issues will require appropriate measurement methods and strategies and, why not, exposome-type approaches.

(O-20)

Fluorescence-based suppression of water-induced noise in automated pollen monitoring

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Airflow cytometers are ideal for continuous pollen monitoring. They measure all particles in flight in real time and do not require impaction. Water droplets are measured and ejected again. This is not a problem for the hardware. It is different for classification.
False-positive detections caused by water droplets remain a significant challenge in automated airborne pollen monitoring, particularly for grass (*Poaceae)*, due to its similar size and morphology with water particles. This is especially relevant for real-time monitoring networks where off-season signals can directly impact human population. We demonstrate how the addition of fluorescence spectra data integrated into a multimodal deep learning classifier for SwisensPoleno instruments improves the differentiation of water droplets from biological particles.
The classifier combines digital holography with fluorescence spectra in a multimodal architecture, trained on a diverse dataset of more than 687,000 labelled aerosol particles. While existing holography-only classifiers often misclassify water as *Poaceae* during heavy rain and mist conditions, the new model incorporating fluorescence data effectively reduces these misclassifications. Water droplets exhibit no or extremely weak fluorescence emission, while *Poaceae* pollen have a strong, characteristic fluorescence response, enabling precise separation even under high-humidity conditions.
To enhance robustness further, a rule-based rain suppressor that monitors the *Poaceae*-to-water classification ratio in real time is applied. When this ratio exceeds an empirically determined threshold, the suppression of the *Poaceae* class is activated. In field testing, this system reduced false-positive *Poaceae* detections by 92.3% for the holography-only model and by 99.92% for the fluorescence-enhanced classifier.
Thus, the integration of fluorescence enables highly reliable real-time monitoring and improves trust in automatically acquired data, especially for operational networks.

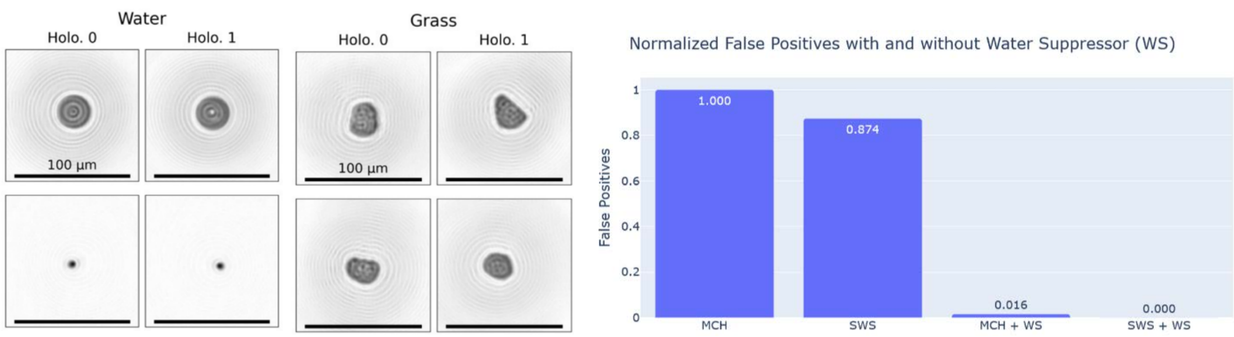

Figure above: Holographic images from Poleno of dry grass (Poaceae) pollen and water droplets. Below: Normalized false-positive rate without water suppression of the current operational classifier (MCH model, MeteoSwiss 2022) and the new classifier (SWS, Swisens 2025) and with water suppression system: (MCH+WS, SWS+WS). Smaller is better. Zero indicates no false positives. Data from SwisensPoleno Jupiter, Emmen, Switzerland, November 2024.

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(O-21)

Airborne fungi and bacteria in sorting plants for recycling plastic - occupational exposure over three years

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Large amounts of municipal waste are produced every year across the globe and this amount is projected to reach 3.4 billion tons annually by 2050. Goals from EU state that 60% of municipal waste should be recycled in 2030 and 65% in 2035. Municipal waste is sorted and recycled into different fractions, one of which is plastic waste. Over a three-year period (2021-2023), we conducted annual measurements of personal bioaerosol exposure in the air at a plastic recycling station.

Occupational exposure to airborne fungi and bacteria, measurements on staff members and in different stationary areas with an IOM sampler, flowrate of 2.0 L/min during full work shifts, when sorting plastic waste for recycling.

Bacteria and fungi from all IOM filters were extracted and plated in serial-dilutions at 25°C and 37°C aerobic or anaerobic, counted after 2, 4, and 7 days. Bacterial and fungal isolates were identified by matrix-assisted laser desorption-ionisation time-of-flight (MALDI-TOF) mass spectrometry (MS).

Very high concentrations of fungi in the air were found with several – such as *Aspergillus terreus* - classified in risk group 2, indicating potential for infection. In many areas of the waste plant, very high concentrations of *A. fumigatus, A. niger* and *Penicillium brevicompactum,* were measured. There was also high concentration of bacteria in the workplace measured both on personal and stationary samples. After the first measurement, the ventilation and work routines were changed,-resulting in lower levels of spores, although variability persisted.

The measurements showed that work with sorting waste for recycling plastic can generate a lot of fungal spores and bacteria in the work environment. *Penicillium* and *Aspergillus* species dominated the fungal exposure during the three-year study period, many of which are known producers of mycotoxins and allergens. After the first measurement in 2021, ventilation improved. For those operations with still high exposure to bioaerosols, workers must use personal protective equipment (PPE). At the plant, various zones of changing clothes were introduced to reduce the spread of spores. To minimize exposure, ventilation and logistics of the waste in the company must be improved.

The measurements showed that there was a high concentration of microorganisms in the workplace that can affect the health of employees.

(O-22)
Fungal contamination in schools: Key insights and assessment strategies

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Fungal contamination in schools poses significant risks to indoor air quality and student health [1,2,3], particularly from species like Aspergillus fumigatus and Fusarium sp., which are linked to respiratory illnesses [4,5]. This systematic review evaluates the influence of geographical location and seasonality on fungal presence in schools while assessing sampling methodologies, analytical approaches, and contextual factors affecting exposure.

This systematic review identified 47 studies selected for analysis, based on inclusion criteria such as "Indoor school environments" and "Fungi OR Mold". Data extraction focused on sampling practices (environments samples), sampling techniques (active/passive), analytical methods (culture-based/molecular), climatic conditions, and clinically relevant fungi.

Sampling occurred predominantly in classrooms (38/47 studies), with additional sites including canteens, corridors, and surfaces. Active sampling (32 studies) used impactors, filters, and pumps, while passive methods (15 studies) relied on settled dust and electrostatic cloths. Only 7 studies combined both approaches, limiting comprehensive exposure assessment. Culture-based methods (32 studies) dominated but risk underestimation, as only 11 studies used molecular assays (e.g., qPCR), and just 3 integrated both. Contextual data (building structure, ventilation, and cleaning practices) were reported in only 7% of studies, hindering meta-analysis. Moisture damage and carpeting correlated with elevated fungal levels and respiratory symptoms.

A comprehensive sampling approach, combining active and passive sampling with molecular and culture-based techniques, is critical for accurate fungal identification and resistance profiling [6]. Contextual factors (humidity, ventilation, seasonal changes) must be systematically reported to inform interventions. Regulatory frameworks should prioritize species-specific monitoring (e.g., Mucorales order, *Aspergillus fumigatus*) and school-specific guidelines for air quality. Future research must adopt interdisciplinary collaboration and centralized data repositories to advance risk mitigation. Addressing these gaps will safeguard student health and support evidence-based policies for healthier educational environments.

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(O-23)

Study of the airborne microbiome in buildings using air handling unit extraction filters as a sampling tool

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Indoor air quality can be affected by the presence of bioaerosols. This is a major concern for public health. For study or control purposes, various devices can be used to sample airborne microbial aerosols (i.e. impinger, agar plate impactor and filtration device). However, these techniques give a limited microbial quantity recovering during sampling because of the short sampling time and therefore the limited volume of air sampled. This may raise questions about the representativeness of microbial sampling at the scale of a building where the concentration is often very low with spatial and time variations. To overcome these limits, an innovative methodology consists in using extraction filters of air handling units (AHU) as sampling tools [1].

For low-energy buildings in particular, fresh air is blown into the rooms after a filtration stage, and return air is extracted from the rooms and often filtered to protect the air exchangers before being discharged into the atmosphere or recycled to the AHU. Thus, the extraction filters are exposed to the indoor contaminants over long periods, making them an interesting tool for microbial sampling. The methodology developed consists in using an AHU filter where filter pieces are carefully fixed on the surface prior the implementation in an operating AHU. The filter pieces are then removed periodically to characterize the airborne microorganisms using different analytical methods.

This technique was applied to the extraction filter of a low-energy building's AHU treating air from classrooms and offices. The samples were taken every month over one year and analyzed by culture on agar media specific to bacterial or fungal species, after extraction with a solution of $MgSO_4$ 10mM + Tween20 2mM. Samples were also analyzed by molecular biology tools. The PowerWater kit (QIAGEN) was used for DNA extraction, followed by Illumina sequencing to analyze the airborne microbiome. Specific detection of pathogenic microorganisms was done by PCR with lab-designed primers or detection kits (Respiratory Panel IV Viasure RT-PCR and *SARS-CoV-2* Viasure RT-qPCR (CerTest Biotec, Spain) to detect *SARS-CoV-2* more specifically).

The results of the study from culture method indicated that the quantity of bacteria and fungi extracted from the pieces of filter was similar (1.31×10^3 CFU/cm^2 on average for bacteria and 1.50×10^3 CFU/cm^2 for fungi). The sequencing analysis showed that most of the fungal species come from outdoor (*Agaricales, Polyporales*), while the bacterial species were mainly associated to human activity (*Acinetobacter, Micrococcus*). The use of PCR for specific detection led to the identification of several potential pathogens, including *Coronavirus OC43* and human *Adenoviruses*, as well as *Cladosporium* and *Aspergillus niger*, which have been linked to health disorders.

Both culture and molecular biology analysis did not show steady increase in the quantity of DNA or cultivable microorganisms recovered along the study as could be expected in the case of regular accumulation of particulate matter. This may be explained by the cell death on the filter surface, which can lead to DNA degradation over time by desiccation mainly. The results obtained would therefore highlight species resistant to physico-chemical conditions on the filter and those collected by the filter over the past month.

New campaigns are underway to gain a better understanding of these results, in particular in hospitals, to assess the ability of the methodology to detect specific biological risks.

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(O-24)

Preventing polyexposure in cheese dairies: A large-scale study to identify high-risk workstations in the workplace

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In France, there are over 500 cheese dairies, which employ around 22,000 people. In this sector, respiratory pathologies of the allergic type (rhinitis, asthma, hypersensitivity pneumonitis) linked to work activity have been reported. They are often attributed to the presence of moulds in the working atmosphere. However, limited data are available on occupational exposure levels to biological agents and the allergens they contain. A lack of data also applies to the impact of the concomitant presence of chemical agents emitted by cheeses on the sensitizing nature of these allergens. To gain further knowledge and understanding of these polyexposure situations, INRS has undertaken a large-scale study entitled "Preventing polyexposure in cheese dairies: study of bioallergens, chemical and biological agents".

The aims of the study are *i)* to investigate the potential biological and chemical occupational exposures in this sector, in the context of polyexposures ; *ii)* to characterize allergens present in the workplace atmosphere and in products handled, as well as their sensitizing potential ; and *iii)* to study exposure determinants and available prevention means (e.g. ventilation), to improve and reduce employee exposure to pollutants and allergens.

The measurements were carried out in various cheese dairies producing different types of cheese, to assess personal exposure levels and ambient concentrations for several airborne pollutants (carbon dioxide, ammonia, VOCs, bioaerosols, allergens). Stationary and personal measurements were performed. Both continuous monitoring with direct reading sensors and conventional sampling with pumped or passive devices were used. Cheese emissivity measurements were also performed, together with a ventilation study, to explain concentrations measured in ripening cellars.

The results obtained in several cheese factories will be presented. They show polyexposure to biological and chemical agents in a few cheese dairies and not only confirm the existence of a high allergic risk at the cheese rubbing/scraping station but also identify an unknown allergic risk at the packaging station.

(O-25)
Portuguese Primary Schools: Dust filter samples, a simple tool for assessing bacterial contamination indoors?

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This study aimed to assess seasonal variations in bacterial contamination across school settings (canteen, classroom, gymnasium, library, and toilet) with dust filter samples, to identify high-risk areas and inform targeted hygiene practices and public health strategies in educational environments.

Dust filter samples were collected in 10 schools within the Metropolitan Lisbon Area. Sterilized coffee filters were placed inside the disinfected vacuum tube for sampling. Samples were collected in the warm (N=33) and cold seasons (N=34), from canteens (N=14), classrooms (N=33), gymnasium (N=9), library (N=9), and toilets (N=2). Settled dust was collected from shelves, plinths, and floors around students' desks and near the door in all sampled rooms. After extraction with NaCl+Tween 80 solution, samples were inoculated onto Tryptic Soy Agar (TSA), Violet Red Bile Agar (VRBA), and MacConkey Agar (MAC).

Results from the cold season indicate that gymnasiums (TSA = 1.8×10^4 CFU/m²) and libraries (VRBA = 1.4×10^4 CFU/m²) were contamination hotspots, although libraries showed lower contamination on TSA (1.8×10^3 CFU/m²). Canteens (2.3×10^3 CFU/m²) exhibited elevated Gram-negative bacteria, while classrooms had the lowest contamination on VRBA (5.0×10^2 CFU/m²). For the warm season, canteens showed higher contamination on TSA (6.5×10^3 CFU/m²), while classrooms showed higher contamination on VRBA (4.5×10^3 CFU/m²), while for MAC results, gymnasiums showed higher contamination (2.0×10^3 CFU/m²).

Seasonal and spatial differences significantly influence microbial air contamination in schools. Gymnasiums and classrooms are potentially critical hotspots, particularly for MAC and TSA contamination results. TSA contamination results showed high variability (e.g., SD = 23,645 in canteens), suggesting fluctuating total bacterial contamination, likely tied to occupancy or cleaning schedules. These findings emphasize the need for seasonally adaptive hygiene protocols and focused monitoring in high-traffic areas to mitigate exposure risks.

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(O-26)

Aspergillus section *Nigri* in indoor environments: A silent public health sentinel for occupational and community exposure

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Aspergillus section *Nigri*, a filamentous fungus within the *Aspergillus* genus, proliferates in organic matter-rich environments and produces dark-pigmented spores (Klich, 2002). While recognized for its metabolic versatility and industrial applications, *Aspergillus* section *Nigri* also presents significant public health concerns, particularly in environmental and occupational settings. The fungus is known to produce mycotoxins (Ochratoxin A (OTA); Fumonisins), which pose risks to human health, including respiratory disorders and allergic reactions. Its prevalence is notably elevated in occupational environments such as industrial facilities and laboratories, where favorable conditions (e.g., elevated humidity and temperature) facilitate their growth (Pel et al., 2007).

This study aimed to assess the distribution of *Aspergillus* section *Nigri* across various indoor environments and evaluate its implications for public and occupational health.

The research was conducted in eight different indoor settings, including nursing homes (n = 15), archives (n = 25), municipal waste collection vehicles (n = 168), grocery stores (n = 101), gyms (n = 67), cemeteries (n = 72), fire stations (n = 360), and coffee industry facilities (n = 58). A total of 866 samples were collected using active (Coriolis µ air sampler, Millipore) and passive (electrostatic dust collectors, surface swabs, and settled dust) methods. Fungal growth was promoted through incubation at 25 ± 2°C, and identification was performed using lactophenol cotton blue staining and microscopic analysis.

The distribution of *Aspergillus* section *Nigri* will be analyzed across all sampled environments to determine prevalence and potential exposure risks.

This study highlights the need for enhanced surveillance of *Aspergillus s*ection *Nigri* in indoor environments to mitigate occupational and public health risks. Prolonged exposure may contribute to respiratory and allergic conditions, particularly in vulnerable populations. Preventive measures should be prioritized to reduce exposure in high-risk settings.

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(O-27)

Small is beautiful – progress of the bioaerosol-working group of CEN TC 137

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The Directive 2000/54/EC of the European Parliament and Council, dated 18 September 2000, describes rules to protect workers from risks related to exposure to biological agents at work. Biological agents include living microorganisms, their cell wall components, and metabolic products, which may present infectious, sensitizing, or toxic risks. Employers are required to conduct risk assessments of workplace activities. To meet this obligation, monitoring and measurement of biological agents can be valuable in assessing and understanding these potential risks.

Within CEN TC 137 (Workplace Atmosphere) working group 5 (WG 5) focuses on the standardization of biological agent measurement in the workplace. The group's objective is to develop guidelines that enable measurement institutions to conduct bioaerosol assessments, ensuring high-quality, meaningful, and comparable results.

Reactivated in 2016, the group revised the existing standards, including EN 13098, which provides general guidelines for assessing workplace exposure to airborne microorganisms (2019); EN 14031, focusing on the assessment of exposure to airborne bacterial endotoxins in the workplace (2021) and EN 14583, which outlines requirements for determining the performance of volumetric sampling devices used to assess bioaerosols in the workplace (2022). The group's ongoing project is a guideline designed to offer guidance on how to proceed with measurements of viruses in workplace air.

Further topics to be worked on in future are an evaluation of molecular tools for the analysis of microbial bioaerosols and the assessment of mycotoxins in workplaces.

Like the agents we study, our group is small but impactful. It actually comprises eight active members from seven European countries who are all dispatched by the standardization bodies of their countries. We are open for anybody interested in our work to join us!

(O-28)

Use of video exposure monitoring (VEM) for monitoring the activity of workers in charge of brushing cheese in a maturing cellar

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Workers in cheese ripening cellars can be exposed to biological agents (moulds, bacteria) and chemical substances (ammonia, carbon dioxide) by inhalation. Respiratory pathologies, such as allergies, have been reported in this sector. Following measurement campaigns carried out in a company ripening bloomy-crust cheese, which revealed such exposure, a detailed study of the most exposed workstation was further carried out. The workstation study took place in 2021 to provide a better understanding of the exposure factors of the involved workers and to identify the levers for preventive actions. It focused on the cheese brushing activity (two operators sharing the workstation).

The activity of the two workers was monitored over work as follows: *(i)* by means of video recordings (a fixed camera positioned in front of the brushing station and a mobile camera filming the gesture, localisation, and tasks of workers); *(ii)* by manually recording tasks and movements carried out by each operator, using a touch-sensitive tablet; *(iii)* by measuring operators' personal exposure to carbon dioxide (CO_2) and aerosols using real-time measuring instruments (ToxiRAE-ProCO_2® for CO_2 and LightHouse Handheld 3016 IAQ® for aerosols); *(iv)* by measuring heart rate using chest belts (Polar Team®) placed in direct contact with operators' skin under work equipment. Synchronisation of the real-time data with the videos, coding of the activities and analysis of the data were done afterwards to represent and interpret the results.

The results showed a link between cheese brushing and massive aerosol emissions in the work area. Emissions were accompanied by variable individual exposures, the variability of which can be linked precisely to well-identified tasks or gestures. For the brushing task, the exposure of operators to particles was substantially similar and of the order of 10^7 particles/m^3. The exposure profiles were significantly different for the two operators and showed sequences of peaks of exposure which were linked to the gestures and series of cheeses brushed. The work area in the cheese presses is also characterised by a high ambient concentration of CO_2 (3000-4000 ppm_v), a working temperature of around 12-13 °C and high relative air humidity (> 95%). Real-time measurements of individual operator exposure show that they are exposed to a high average CO_2 level of 3700 ppm_v, which is linked to the location of the operators in the cellar.

The ergotoxicological approach used enabled a detailed analysis of the work situation. The data obtained provides very precise evidence of the link between actions (work tasks and activity phases) and exposure to aerosols and CO_2, which improves our understanding of exposure mechanisms. The collected information will be used as a guide and teaching aid in the collective construction of prevention measures in the company.

(O-29)

Fungal degradation of historical pigments: Evidence from culture experiments and elemental analysis

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Microscopic fungi pose an often underestimated risk to historical artworks, especially in humid indoor environments. This study aimed to investigate whether fungi colonizing painting surfaces can chemically modify pigment composition through their metabolic activities. Nearly 60 paintings were surveyed across four museums, including locations previously affected by water damage. Surface samples were collected using sterile swabs and adhesive TapeLift methods, followed by cultivation on MY50G and MEACl media at 25 °C.
To investigate pigment degradation, five fungal strains (*Aspergillus halophilicus* TLiL-06-A, *Aspergillus halophilicus* TLiL-06-D, *Penicillium chrysogenum* TLiL-06-E, *Aspergillus niger* TLiL-05-B, and *Aspergillus niger* T810-T25) were selected and cultivated on agar media containing four original pigments: cobalt violet (cobalt phosphate), Prussian blue (iron hexacyanoferrate), verdigris (copper(II) acetate), and cadmium red (cadmium sulfoselenide). Cylinders measuring 5 mm in diameter and 5 mm in height were cut from the central area of the sporulating colonies, containing the fungal colonies on top and MY50G on the bottom. These cylinders were then placed onto cellophane discs on MY50G media that contained the original pigments; and colony growth was monitored over 16 days. The study observed significant differences in the fungi's tolerance to metal-rich environments. Some strains thrived in media with high heavy metal content and low water activity, exhibiting vigorous growth. In contrast, other strains struggled to grow, particularly on the substrate containing verdigris.

Visual documentation, including multispectral imaging and elemental analyses using x-ray fluorescence (XRF) mapping and inductively coupled plasma mass spectrometry (ICP-MS), confirmed the discoloration of certain pigments related to degradation and metal uptake by the fungi.
Our findings provide new insights into how fungi may compromise historical pigments. The observed degradation is not solely aesthetic; it indicates biochemical interactions that can threaten the physical and chemical stability of artworks. These effects may be especially noticeable on dust-covered surfaces or in environments with a relative humidity of approximately 60%, which is typical in modern climate-adapted buildings. In addition to implications for heritage conservation, the study highlights potential public health concerns, as some isolated fungi are recognized as airborne allergens. The simultaneous occurrence of mold growth and pigment deterioration emphasizes the need for integrated environmental monitoring and preventive conservation strategies.

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(O-30)

From IAQ monitoring to risk mitigation: Developing data-driven action plans for healthier buildings

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Buildings are fundamental to shield occupants from adverse external conditions while ensuring a healthy, safe and functional indoor environment suitable for their intended use. However, growing evidence points to the fact that certain building features or operational practices can inadvertently foster conditions that impair indoor air quality (IAQ), leading to detrimental effects on the health, well-being and performance of occupants. Despite the substantial body of evidence identifying risk factors, pollution sources, and potential areas for improvement, a major challenge remains in translating this scientific knowledge into effective, actionable measures. One key challenge is that the development of effective risk mitigation strategies for improving IAQ often requires a tailored approach, as no single solution is applicable to all buildings or occupant groups. Each building – whether residential, educational, commercial, or industrial – has unique characteristics, including architecture, construction, geographical context, usage patterns, equipment and systems, and environmental determinants. Therefore, the focus should be on creating targeted strategies that address not only the unique requirements of each space but also the specific exposure risks faced by the population groups occupying the target building(s).

To identify the need for mitigation measures, it is crucial to assess a representative panel of IAQ under realistic and representative exposure conditions. This requires a comprehensive understanding of the building, its occupants, and the key factors influencing IAQ, including ventilation systems, activities, and environmental elements such as indoor and outdoor pollution sources, as well as climate. By accurately characterizing these factors and critically interpreting them in light of the assessed indoor air pollutant levels, the most significant risks can be identified, allowing for the development of targeted solutions.

Source control strategies – removing or reducing pollutants emissions at their origin – and promoting desirable behavioural changes among occupants – guiding them on how to identify periods of peaks of exposure and take proper actions, limiting the use of high emission products or using it in rooms with improved ventilation – should be the primary focus. However, in environments with high occupancy rates or elevated pollution levels, where source control and behavioural interventions may have limited effectiveness, complementary technological solutions, such as appropriately sized ventilation systems, air purification devices, or even environmentally conscious building renovations, may be necessary. Equally important is the role of communicating the estimated risks and the effectiveness of mitigation strategies by promoting public awareness and engagement in the success of IAQ initiatives. In fact, educating building occupants on the importance of IAQ and involving them in mitigation actions is key to fostering long-term change and encouraging the adoption of sustainable policies.

This work investigates best practices through a literature review and real-world data from cross-sectional and longitudinal studies conducted over the past decade in diverse building typologies in Portugal, offering insights for the development of data-driven, customized action plans to foster healthier and more sustainable indoor environments.

(O-31)

New developments for the assessment of odours in indoor air

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The perception of unusual or unexpected odours can lead to complaints about odour annoyance and is often accompanied by concerns about possible health effects. Where indoor air measurement results are available, health-related guideline values or risk-related orientation values are used to check whether odours are associated with harmful indoor air pollutants. However, several standardised methods are now available to assess odours in indoor environments.

The German Committee on Indoor Air Guide Values (AIR) has developed a practical guidance on how to assess if complaints about odour annoyance are reasonable and how to reduce odour exposure using so-called Odour Guide Values (OGV).

The Indoor Air Quality questionnaire (IAQ questionnaire) can be used to investigate the perception of odours in indoor air and to record complaints about odour annoyance.
The method of polarity profiles and odour scores makes it possible to determine the hedonic tone (pleasant-unpleasant quality) of odours.

(O-32)

In vitro bioaccessibility method for endocrine disruptors pollutants in indoor dust

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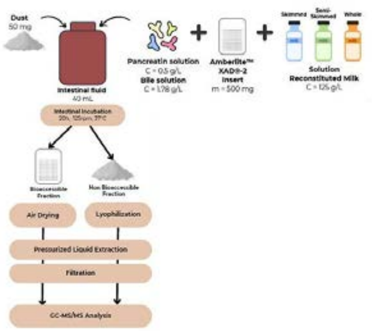
Indoor environments can be polluted with chemical compounds originating from indoor materials and objects, and from external soils and dust particles and aerosols. Recent indoor environmental quality measurement campaigns have revealed high concentrations of semi-volatile organic compounds (SVOCs), including endocrine disruptors (ED) like phthalates, organophosphate flame retardants (OPFRs) and pyrethroids. While indoor dust is contaminated, this matrix can be involuntarily ingested, particularly by young children through hand-to-mouth contact. Current risk assessments are based on the total concentration of pollutants in dust, which may lead to an overestimation of the actual exposure. Bioaccessibility could refine this exposure by taking into account the fraction that could cross the biological membrane in the gastrointestinal tract and be absorbed by the body to target organs.

We developed a simple fed-stated *in vitro* digestion method to study the impact of food on BA. This method uses reconstituted intestinal solution, Amberlite® XAD®-2 sink and reconstituted milks and was tested on the SRM®2585 material. Our results show that mean bioaccessibilities for dust only and dust with food, range between 17 and 100% for phthalates, 49 and 98% for OPFRs and 38 and 67% for pyrethroids. Significant augmentations of bioaccessibility were observed for TPP with skimmed milk, for DBP with semi-skimmed milk and for BBP with semi-skimmed and whole milk. We conclude that the addition of milk should be ruled out for our analysis method for EDs. To explore prediction between physico-chemical properties and bioaccessibility, descriptive analyses were carried out. Significant negative correlation between bioaccessibility and log P, Log Koc were found.

For next step, bioaccessibility data will be compared to bioavailability data to validate the bioaccessibility method, using *in vitro - in vivo* correlation. The final aim is to apply the method to several sample dust to obtain bioaccessibility values that can be used to refine health risk assessments for exposure to indoor environmental pollution.



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(O-33)

PM_{10} oxidative potential and chemical composition at an urban background and at an urban industrial site in Serbia during the heating period

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Oxidative potential (OP) of particulate matter (PM) is a crucial metric for assessing particles' ability to generate reactive oxygen species (ROS) and induce oxidative stress in biological systems. Measuring OP provides a more biologically relevant indicator of PM toxicity than traditional mass-based metrics, helping to evaluate potential health risks associated with air pollution. Recent studies suggest that OP varies significantly with PM sources and composition: particles originating from traffic and industrial sources often exhibiting higher values due to their metal and organic compounds content. To investigate these variations, PM_{10} samples were collected using low-volume reference pumps (Seven Leckel) at two locations: an urban background (UB) site in Belgrade (Ada Marina station) and an urban industrial site (UI) in Bor (Gradski Park station). 24-hour sampling was conducted every second day during the heating period from October 15, 2023, to the end of February 2024, resulting in 128 samples. Oxidative potential of PM_{10} was determined using the DTT assay (Dominuti et al., 2024). Comprehensive chemical analysis quantified organic (OC) and elemental carbon (EC), water-soluble ions (Cl^-, SO_4^{2-}, NO_3^-, NH_4^+), and 26 major and trace elements.

Average PM_{10} concentrations of the collected samples at the UB and UI sites were similar, 26.7±18.9 µg/m^3 and 24.5±17.3 µg/m^3, respectively. Average OP value at the UB site was significantly higher (1.775 nmol/min/m^3) than at the UI site (1.252 nmol/min/m^3). To examine the relationship between the availablechemical species and the increase in OP, Spearman correlation coefficients were determined. A strong correlation at the UB site was found between OP and PM_{10}, OC, EC, K, Rb, and Cd ($0.84<r<0.72$, $p<0.01$), while a moderate correlation was found with EC, Sn, SO_4^{2-}, NO_3^-, and several metals such as V, Cr, Ni, As and Pb ($0.69<r<0.72$, $p<0.01$). At the UI site, a moderate correlation was found between the measured OP values and PM_{10}, OC, EC, Cu and many detected metals such as Fe, Mn, V, Pb, and K.

The results indicate that the higher OP values at the UB site are primarily influenced by biomass burning and traffic emissions. In contrast, at the UI site, copper and other metals, continuously released from various processes in the nearby copper smelting facility, likely play a significant role, while the contribution to OP from individual combustion plants in Bor (a city relying on district heating) appears to be negligible. A comprehensive source apportionment study will be carried out a later stage of the project.

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(O-34)

Source apportionment of equivalent black carbon in Belgrade: Preliminary results from an urban background site

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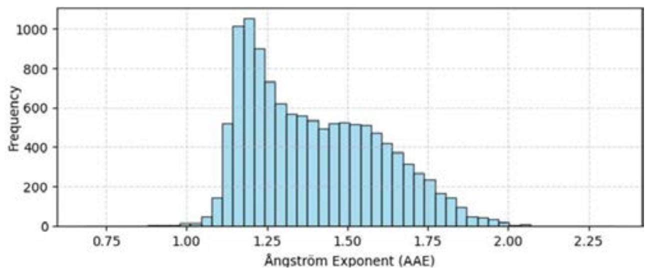
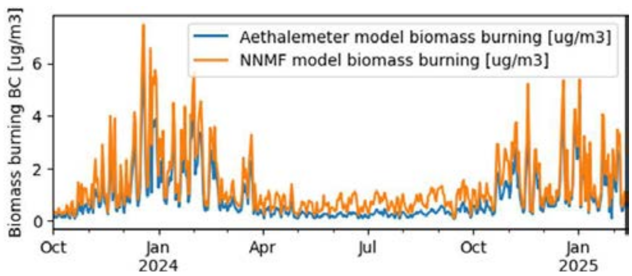
Black carbon (BC) is a primary pollutant produced by combustion processes, such as traffic emissions and residential heating, and is a key component of ambient particulate matter (PM). Equivalent BC (eBC), is typically measured using filter-based absorption photometers, which quantify light absorption by particles and estimate BC mass concentrations in real time. Within the framework of WeBaSOOP project, a monitoring supersite was established in 2023. at the Ada Marina, Belgrade, automatic monitoring station (AMS). In addition to the standard set of air quality parameters present at the AMS, supersite features instruments for more comprehensive characterization of PM with set off-line and on-line monitoring devices including the most relevant for this study filter absorption photometer (Magee AE33 aethalometer), capable of estimating real-time BC mass concentration, and Absorption Ångström Exponent (AAE). AAE is a critical parameter which can be used for categorization of aerosol samples, helping to distinguish contribution of BC from various sources. AAE values near 1.0 indicate BC-rich aerosols from liquid fuel burning, while higher values suggest aerosol sample containing products of solid fuel, biomass burning (BB). Fig. 1a shows distribution of AAE for the study period, with most values neatly fitting the 1.0 and 2.0 AAE range, and dominant mode, likely due to all season traffic influence, around AAE=1.2. To analyze portion of BC mass concentration attributable to BB, we utilize the classical aethalometer model [1] and novel non-negative matrix factorization model, NNMF [2], with results shown in Fig. 1b. Both models produced comparable results, with NNMF showing consistently higher estimates, with noticeable fact that during the heating season BB is several times higher compared to non heating season (April – October, Fig. 1b).



a



b

Figure: a) Value of AAE during the study period (Oct 2023 – Feb 2025) b) Biomass burning portion of equivalent black carbon, determined using aethalometer model and non-negative matrix factorization model.

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(O-35)

Snow DUMP-ing: Direct TD-GC-MS for the analysis of urban snow pollution

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Arctic cities experience long winters with heavy snowfalls. Every year, tons of urban snow contaminated with microplastics from tire wear and other traffic-related pollutants are dumped into the sea. Despite snow dumping being a yearly phenomenon, we have limited knowledge about the impacts of pollutants transported in this way from roadways to the sea.

Traditional laboratory methods require extraction with toxic solvents and extensive clean-up procedures to remove matrix components (e.g., lipids). The project, "DUMP—Direct analysis of Urban snow particulates for traffic-related Microplastic additives and Polycyclic aromatic hydrocarbons", aimed to develop a more environmentally friendly method that avoids the use of solvents, for analyzing traffic-related pollutants in urban snow. The method is based on thermal desorption (TD) technology, which uses rapid heat to directly desorb contaminants from the sample matrix to the gas phase for analysis with gas chromatography-mass spectrometry (GC-MS).

Snow samples were collected from locations with different traffic patterns (e.g., light residential, residential/industrial areas, and heavy arterial roads) in Tromsø during April 2024. Snow samples were melted and sieved to remove coarse gravel and debris. Fine particulate matter from the snowmelt was collected on glass fiber filters (GFFs) and packed into stainless-steel thermal desorption tubes. Method development and analyses were performed on a Thermo Scientific GC-Q Exactive Orbitrap.

The study successfully utilized polycyclic aromatic hydrocarbons (PAHs) for method development, demonstrating efficient desorption and low carryover in subsequent runs. The addition of analyte protectant (D-sorbitol) and thermal desorption aid (Tween20) improved peak area responses by 23%, on average, although their long-term effects on column longevity and degradation require further investigation. Concentrations of PAHs were highest at the more heavily trafficked locations and for larger PAHs (3-6 ringed) that preferentially bind to particles in snow. Reproducibility was ~25% for 3-4 ringed PAHs and ~40% for the 5-6 ringed PAHs.

While the benefits of TD-GC-MS are many (e.g., no sample clean-up, time/cost savings, wide range of sample matrices) and the potential for expanded applications across various disciplines is great, analytical challenges remain. Interference from sample matrix components requires more frequent maintenance and fine tuning of the sample mass and TD split flows. Higher detection limits suggest that direct TD-GC-MS methods are better-suited to industrial applications where higher contaminant concentrations are expected. Furthermore, the importance of matrix-matched TD calibration was not investigated in this study but is likely necessary to ensure fully quantitative results.

(O-36)

Indoor workplaces: Procedure for investigation of the working environment

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Indoor workplaces can be found in a wide range of environments, such as offices, shops, hospitals, schools and pre-school facilities, or libraries. By definition, such workplaces do not involve activities with hazardous substances and/or biological agents, such as those found in a hardware store or a bakery. They also do not include areas with high noise levels, such as workshops, or with special requirements in terms of room climate, such as cold-storage rooms.

Complaints from employees about indoor workplace conditions should be taken seriously. However, suspicion of possible causes can sometimes lead in the wrong direction. If there are unpleasant odours, for example, there is concern that the indoor air is polluted, and expensive air measurements are quickly commissioned. But factors such as work overload or problems with supervisors or colleagues can also play a role. If employees are dissatisfied with their work, their tolerance for unfavourable working conditions such as noise, poor lighting, odours, or an uncomfortable indoor climate is reduced.

The present report, “Indoor workplaces: procedure for investigating the working environment”, now in its fourth and fully revised edition, provides a step-by-step, modular investigation and assessment strategy for employee’s complaints about indoor workplace conditions. It was developed in interdisciplinary collaboration and takes into account all the major factors that current knowledge suggests should be considered as possible causes. These include not only ergonomic, physical and chemical factors, biological substances or allergens, but also mental stress factors.

(O-37)

Real-time VOCs measurements by PTR-MS in parallel with particles counting by SMPS and APS in Norwegian woodworking factories. A study on workroom air recirculation

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Wood dust is a classified IARC carcinogen. Wood-emitted volatile (VOCs) and semivolatile organic components (SVOCs) are potentially irritant for the airways. Therefore, wood dust and volatile organic compounds must be monitored in the workroom air, to grant a safe working environment. To save energy in winter, Norwegian woodworking companies are allowed with a legal exception to use air recirculation, by filtering warm air from the workroom and mixing it with a fraction of external air. Humidity is also added to the recirculated air to preserve the working characteristics of wood. It is therefore important to know whether the exemption and the technical solutions in air recirculation and humidification adequately protect occupational health in relation to the carcinogenic wood dust and respiratory irritants VOCs [1].

Over two-three workdays during autumn/winter 2021-2022 airborne particle concentrations and size distribution of indoor wood dust and of VOCs such as monoterpenes, acetaldehyde, acetic acid, ethanol and acetone, among others, were measured stationary and continuously in three Norwegian companies manufacturing respectively building elements, or stairs, door and windows frames, or cabinets and interior fixtures. Production used soft Nordic wood species (pine, spruce) as well as hard exotic wood species (teak, mahogany) and Nordic hard oak and beech. Two of these companies had air recirculation, but not the third. VOC concentrations were continuously monitored by a compact proton transfer reaction mass spectrometer (QMS300/c-PTR-MS, Ionicon Analytik Gmbh, A) operating in scan-mode between m/z 21 and 140, while particles were characterized instantaneously by a scanning mobility particle sizer (SMPS, mod. 3938, TSI Inc., USA) counting particles ranging from 0,015 to 0,637 µm electric mobility diameter, in parallel with an aerodynamic particle counter (APS, mod. 3321, TSI Inc., USA) operating from 0,5 to 20 µm aerodynamic diameter.

Indoors air levels and particle concentrations showed variations consistent with the effects of ventilation and humidification being present, active in working hours, or off after work. Working operations such as painting, glueing and impregnating increased the short-term levels of VOC, but not of monoterpenes, while particles diurnal patterns were mostly impacted by the different humidification solutions. Recirculation with filtration did not appear to up-concentrate VOCs and particles in worktime. Results from the study will be presented in the context of workroom air quality and discussed in the framework of odour, potential health effects and sick leave in the Norwegian woodworking industry [2].

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(O-38)

Modelling air pollution from industrial sources in "Chile's Sacrifice Zones": A fuzzy clustering approach

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Quintero and Puchuncaví are two coastal cities in Chile currently recognized as part of the country's "sacrifice zones" due to frequent air pollution episodes caused by industrial emissions from coal-fired power plants, an oil refinery, a copper smelter, and other industrial facilities. Despite steady population growth in nearby areas, these industrial sources have increased their activities. A key challenge in these areas is identifying the spatiotemporal distribution of Particulate Matter ($PM_{2.5}$) and Sulfur Dioxide (SO_2) at short distances from these industrial stack sources, influenced by meteorological conditions in the "gray zone" (<1 km).

We have developed a new methodology for source apportionment of industrial emissions, based on a fuzzy clustering technique to determine the contributions of $PM_{2.5}$ and SO_2 concentrations from the industrial complexes in Quintero and Puchuncaví. This approach allows us to isolate industrial impacts from other sources in the study areas, such as traffic and residential emissions. Additionally, we have evaluated several planetary boundary layer (PBL) schemes to assess their ability to model meteorological variables, including temperature and wind speed, in complex terrains.

To do this, we used the Weather Research and Forecasting (WRF) model, with domains as fine as 333 meters. We have tested classic schemes (YSU, MYJ, MYNN2.5, BouLac), incorporating the BEP scheme to account for urban canopy effects and the scale-aware Shin-Hong scheme. These WRF PBL configurations were evaluated to predict vertical wind speed and direction obtained from a SODAR campaign during the summer and winter seasons of 2022. The best configurations were used to model the dispersion of one of the major pollution sources: a coal-fired power plant.

The final goal was to validate the fuzzy clustering approach by comparing it to air pollution dispersion modeling, aiming to isolate the industrial spatiotemporal distribution from other air pollution sources in the area. Our results will provide valuable insights for more effective environmental policy-making and industrial regulation in Chile's coastal zones and could eventually be adapted for use in other coastal cities worldwide facing similar industrial pollution challenges.

*This paper is still in development, but its methodology is supported by a paper previously published by one of the authors.

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(O-39)

The pulmonary surfactant system as target and dealer of inhaled airborne materials

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The first biological material impacted by breathed air and their accompanying matters, once entering into the airspaces of any mammalian lung, is the pulmonary surfactant layer. This lipid/protein complex coats the whole respiratory air-liquid interface to reduce the surface tension at the thin aqueous layer of liquid that protects the epithelium. A very low surface tension, specially at minimal lung volume at the end of expiration, is strictly required to prevent alveolar collapse and atelectasis, therefore facilitating breathing mechanics. The particular lipid and protein composition of surfactant allows a very rapid and efficient adsorption and spreading at the interface to form the surface-active films. Furthermore, when type II pneumocytes assemble this surfactant material, they also produce and integrate other components that once secreted into the alveolar spaces contribute to their biological protection. Certain surfactant proteins can interact with different molecules at the surface of bacteria, virus, fungi, allergens or particles to facilitate their clearance via the mucocilliary scalator of the upper airways or by the alveolar macrophages in the deep lung. Thus, surfactant lipids and proteins also contribute to the innate defense system that acts as a barrier against the entrance of potentially noxious entities if reaching the highly vascularized alveolar spaces. Decades of research have established that both, the biophysical and the defense functions of surfactant have co-evolved from the earliest air-breathing animals, pulmonated fishes and amphibians, to the delicate structure of the alveolarized mammalian lung. Research in surfactant is also determining how the perturbation of surfactant composition and structure, especially as a consequence of lung injury and inflammation, is associated with severe respiratory pathologies, which can in some cases be treated by supplementation with exogenous therapeutic surfactants.

Recent investigation is resolving how the interaction of inhaled materials with the surfactant components defines their fate, linked to their chance to reach the deepest alveolar spaces. These interactions are therefore of high relevance to understand and predict possible deleterious actions as well as to optimize inhaled drug delivery. It is therefore of critical importance to include pulmonary surfactant-associated processes into the models that analyze the quality and safety of breathed air.

In this lecture, a summary will be offered on the critical structure-function determinants of the pulmonary surfactant system, its role to define the fate of inhaled entities and the models that can be used to integrate surfactant action into toxicological/biomedical respiratory studies.

(O-40)

Particle lung deposited surface area (LDSA) as an additional metric for fine particle pollution monitoring

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It has become clear that additional metrics along $PM_{2.5}$ mass concentration are needed to comprehensively understand the adverse health effects of fine particle pollution. For example, according to epidemiological studies, the per unit adverse health effects of $PM_{2.5}$ seem to increase as a function of decreasing concentration, indicating that $PM_{2.5}$ is relatively more harmful in low concentration regions. Also, $PM_{2.5}$ as a metric is not sensitive to ultrafine particles (< 100 nm particles) that are suggested to have various adverse health effects.

Particle lung deposited surface area (LDSA) is an interesting metric for ambient fine particle monitoring. LDSA measures the surface area of particles that deposit in the lung alveoli where the interaction between the pulmonary circulation and the respiration occurs. It has been suggested that surface area could be the most relevant metric for nanoparticle toxicity in the lung. By utilising electrical particle sensors, LDSA can be measured with reasonable accuracy, enabling an interesting option for air quality monitoring and particle health effect studies. In addition, LDSA can be measured with common particle size distribution devices.

In this presentation, LDSA concentrations and size distributions measured in different urban environments in different countries are compared. The studied countries were Finland, Germany, Czechia, India and Chile, which have significantly varying concentration of regional $PM_{2.5}$. The studied urban environments include road traffic sites, airports, detached housing areas, shipping and industrial sites. Overall, the characteristics of the lung-depositing particles varied significantly between the highly (India, Chile) and lowly polluted regions (Finland). In highly polluted regions, LDSA was dominated by larger particles (> 100 nm), and the ratio between LDSA and $PM_{2.5}$ was close to 1 $mm^2/\mu g$, whereas, in Finland, ultrafine particles dominated LDSA, and LDSA per $PM_{2.5}$ ratio varied between 2.0 and 5.8 $mm^2/\mu g$. The varying characteristics of lung-deposited particles indicates different health effects of particle exposure. Also, the varying LDSA per $PM_{2.5}$ -ratio could be one potential explanation for the relatively increased health effects of unit $PM_{2.5}$ in lowly polluted regions (see [1]).

In addition, the presentation discusses the differences and similarities of available LDSA measurement devices, including their strengths and weaknesses (see [2]).

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(O-41)

Occupational exposure to welding fumes is associated with changes in the lipid-profile- and increased inflammatory activity in the lining fluid of small airways, as well as small airway dysfunction

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Welding is associated with increased risk of asthma, chronic pulmonary diseases and lung cancer. Welding fumes deposit in small airways, where the first line of defense, the lining fluid, is composed of bioactive phospholipids and proteins. The aim of the study was to investigate alterations in phospholipid composition of small airway lining fluid and its association with pulmonary function among welding fume-exposed workers.

We collected small airway lining fluid from 134 subjects, of which 55 were exposed to welding fumes, using the Particles in Exhaled Air (PExA) method. Tandem mass spectrometry was used for analysis of the samples. Pulmonary function tests included: spirometry, diffusing capacity of carbon monoxide (DLCO), while small airway function was assessed using impulse oscillometry (IOS) and multiple breath washout (MBW). Univariate statics with Wilcoxon rank sum, Kendall tau and linear regression were employed, as well as multivariate analysis with OPLS and machine learning.

In multivariate models, the proportions of lipids belonging to the lipid-classes lysophosphatidyl-cholines (LPC) and plasmalogens (PE-O) were decreased among the welders. Moreover, the proportions of polyunsaturated fatty acids (PUFAs) among the welding fume exposed were significantly increased, whereas the levels of palmitic acid containing PC species were lower. In multiple regressions, the lipid PC (15:0_16:0) correlated with MBW-derived S_{acin} (τ -0.16, p <0.01) and the lipid (16:0_18:3) correlated with DLCO (τ -0.18, p <0.01). Both lipids correlated with resistance in small airways (R5-R20) measured by IOS (τ -0.18, p <0.05 and τ 0.22, p <0.01 respectively).

The results indicate a shift of the lipid composition towards pro-inflammatory pathways along with higher oxidative stress are also suggestive of changes in its biophysical properties. Two lipid-species, PC (15:0_16:0) and (16:0_18:3) were associated with two measures of small airway dysfunction, indicating their clinical relevance.

The phospholipid composition of the respiratory tract lining fluid is altered among welding fume exposed. These changes may both serve protective functions but also reflect inflammatory processes leading to chronic pulmonary diseases associated with welding fume exposure. These mechanisms need further investigations.

(O-42)
Inflammatory biomarkers in diesel exhaust exposed electricians

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Diesel exhaust is a complex mixture of many toxicants, and impaired pulmonary function, signs of inflammation, and increased ischemic heart disease mortality have been reported in diesel exhaust exposed populations. Many workers are exposed to diesel exhaust at work, including electricians working with maintenance and repair of road tunnels. The aim of this study was to assess biomarkers of systemic inflammation, endothelial activation and thrombogenicity in blood and pulmonary function in these workers.

Altogether 63 subjects engaged in repair and renewing of electrical infrastructure in nine road tunnels were compared to 66 referents working outside of tunnels at the same work sites. Full shift air samples were collected by personal sampling in the breathing zone of the exposed workers on the day of the clinical examinations for the determination of elemental (EC) and organic carbon (OC). Exposures to nitrogen dioxide (NO_2), particulate matter in the respirable aerosol fraction (PM) and respirable crystalline silica (RCS) were also assessed. Post-shift blood samples were collected from the exposed subjects for the determination of biomarkers.

The exposed subjects were younger and had body mass index (BMI) comparable to the referents. Night shift work was more prevalent in the exposed group. The geometric mean (GM) concentration of EC was 8.3 $\mu g/m^3$. The exposed workers had statistically significantly higher concentrations of interleukin (IL) 6 and P-selectin. The concentrations of club cell protein 16 (CC-16), myeloperoxidase (MPO) and tissue plasminogen activator (tPA) were significantly lower. The concentrations of CC-16, tPA, matrix metallo proteinase (MMP) 9 and tumor necrosis factor (TNF) were associated with exposure in multiple linear regression analyses. However, working during the night, BMI and blood sampling time were important determinants for many biomarker concentrations. Considering day or night work and adjusting for time of blood sampling, no significant differences were observed between the exposed subjects and referents. Time of blood sampling was important for the measured concentrations of CC-16 and tPA. Night work appeared to be important for the pro-inflammatory biomarkers IL-6 and TNF.

No effects of exposure to diesel exhaust on the biomarker concentrations were observed after considering other background variables. Several extraneous variables are important to consider in such studies, in particular BMI, but also blood sampling time and night work. A significant impact of diurnal variation was observed for CC-16 and tPA. The concentrations of the pro-inflammatory biomarkers IL-6 and TNF were significantly higher among participants working during the night compared to day-workers.

(O-43)

The impact of air pollution on DNA damage in humans: a comparative study of two cities in Slavonia, Croatia

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Based on the recent European Environment Agency's air quality status, the city of Slavonski Brod has one of the highest average annual $PM_{2.5}$ concentrations (26 µg/m^3) in the EU, which is 5-fold higher than the WHO guideline value. Given that air pollution is recognized as a major environmental health risk, it is plausible that it could impact public health in the designated area. We, therefore, conducted a human biomonitoring study during the colder season, when air pollution levels are higher, to evaluate genotoxicity biomarkers, comparing residents of Slavonski Brod, a city with higher air pollution levels, to residents of Vinkovci, a less polluted city in the Slavonia region.

The study included two similar groups: 55 non-smoking participants from Slavonski Brod (51% females, 162 min/day outdoor exposure, age 39±11 years, BMI 24.2±2.6 kg/m^2, living in the city for 19±13 years) and 54 non-smoking participants from Vinkovci (57% females, 126 min/day outdoor exposure, age 38±10 years, BMI 24.3±3.1 kg/m^2, living in the city for 16±12 years). Monitored air quality varied between the selected cities, with Slavonski Brod showing higher daily concentrations of PM_{10} (40.9±22.4 *vs* 33.6±16.1 µg/m^3), NO_2 (18.3±8.3 *vs* 13.1±6.1 µg/m^3), and benzo[a]pyrene (5.8±5.1 *vs* 2.9±2.5 ng/m^3) compared to Vinkovci.

These air quality differences, however, did not affect the biomarkers of baseline DNA damage in the study sample. We observed no significant differences between the two groups in micronuclei frequency (4.9±4.1 *vs* 3.8±2.9), nuclear buds (5.3±6.9 vs 4.8±4.7), and nucleoplasmic bridges (1.0±1.9 vs 1.1±1.8), while the groups exhibited a comet assay tail intensity of 1.0±0.4 %. We assessed exhaled NO as a marker of respiratory inflammation and found no significant differences between the two populations (21.3±13.9 vs 18.6±18.3 ppm).

These results suggest that exposure to measured air pollution levels did not affect monitored biomarkers, as seen in our previous studies. Future studies will evaluate additional biomarkers to better understand the mechanisms behind the observed results, along with the application of advanced statistical and modelling approaches to explore the relationship between air quality and health effects.

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(O-44)

Exploring the impact of air pollution on genomic instability and health: A study from Zagreb, Croatia

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Air pollution, characterised by the presence of harmful substances such as particulate matter (PM), nitrogen oxides, sulphur dioxide, and ozone in the Earth's atmosphere, primarily results from human activities like industrial processes, vehicle emissions, and deforestation. These pollutants are known to cause severe health effects, contribute to climate change, and harm ecosystems. This study aimed to explore the impact of air pollution on genomic instability and its subsequent effects on human health by examining potential associations between air pollutants and biomarkers of exposure and effect. In the first part of the study, we retrospectively assessed genomic instability in a cohort of 130 individuals from the general population residing in Zagreb, Croatia. We analysed blood samples using the comet and micronucleus assays and correlated the findings with air pollution levels recorded between 2011 and 2015. Our analysis did not reveal significant positive associations between the assayed parameters and air pollution levels, except for benzo(a)pyrene (B[a]P), which exhibited a significant negative association. Notably, most measured air pollution parameters were below regulatory limits during this period, except for B[a]P. In the second part, we investigated the potential effects of air pollution and exposure to BTEX compounds (benzene, toluene, ethylbenzene, and xylene isomers) on genomic instability. We conducted comet and micronucleus assays on blood and buccal cells from a cohort of 60 individuals living in Zagreb during colder and warmer periods from 2021 to 2022. The measured outdoor air pollutants were consistent with previously reported values and remained below regulatory limits, except for PM_{10} particles and B[a]P bound to PM_{10}, which exceeded those levels. Similar to the retrospective results, we did not observe a notable impact of air pollutants on the tested parameters. Given the transboundary nature of air pollution, our findings may have regional significance. Considering that air pollution is a major health concern and often site-specific, further studies utilizing various biomarkers of exposure and effect are warranted. Such research could facilitate the development of models to predict the effects of air pollution on human populations.

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(O-45)

Effect of occupational exposure to respirable crystalline silica dust on inflammatory lipid mediators

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Inhalation of respirable crystalline silica (RCS) dust is a well-known health hazard, and inflammation is a key mechanism in the development of diseases associated with exposure; however, the role of lipid inflammatory mediators in these settings is still largely unknown. Oxylipins is a large group of lipid mediators mainly derived from arachidonic acid or linoleic acid by enzymatic conversion by cycloogygenases, lipoxygenases or P450 enzymes. In this study, their use as biomarkers of exposure to RCS dust is explored in a cohort of foundry workers occupationally exposed to RCS dust.

Plasma levels of 79 lipid mediators were measured in 40 foundry workers by using solid-phase extraction and ultra high-pressure liquid chromatography coupled to unispray tandem mass spectrometry (SPE-UHPLC-USI-MS/MS). Lipids included oxylipins and un- mono- and polyunsaturated fatty acids. Lipids were correlated with exposure levels of respirable dust and RCS measured by personal sampling. For everyone, exposure measurements and blood were collected at two occasions, and the average levels for each worker were used in the analysis. In addition, correlation analysis between cytokines and lipid mediators were performed.

When adjusting for covariates (BMI, age, smoking), the morning levels of 7 lipids were significantly correlated with RCS exposure, mainly linoleic acid derived oxylipins with 9,10-DiHOME demonstrating the highest significance. For respirable dust, there was a significant correlation between exposure and 5 lipids, mainly eicosanoids, e.g., 8,9-DiHETrE. In general, there were no, or very few significant correlations between the lipid mediators and other inflammatory markers, such as interleukin-8, C-reactive protein and Serum amyloid A.

Linoleic acid-derived lipid mediators correlated with RCS exposure: data that could provide new insights into the inflammatory mechanisms triggered by occupational quartz dust exposure.

(O-46)

Response of DTT and FOX-based on-line systems for oxidative potential monitoring

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Exposure to particulate matter (PM) has been linked to adverse health effects, primarily associated with oxidative stress caused by reactive oxygen species (ROS), either present in the ambient air or generated endogenously through PM interactions (Albano *et al.* 2022, He & Zhang 2023). The oxidative potential (OP) of aerosols, which reflects their ability to produce ROS or oxidize target molecules, thus appears to be a relevant parameter for predicting their biological reactivity and potential toxicity. However, OP is usually measured off-line after sampling, limiting the representativeness of the measurements (loss of short-lived ROS or gas phase) (Fuller *et al.* 2014, Ghanem *et al.* 2024). A recent study reported a 60% to 99% loss of ROS and OP when comparing online measurements with offline filter-based methods (Campbell *et al.* 2025). To address these limitations, two on-line systems based on either dithiothreitol (OP^{DTT}) or Ferrous-Orange Xylenol (OP^{FOX}) assays were then developed and tested.

The performance assessment of the two systems was conducted in three main phases. The first phase focused on the response to selected model compounds: hydrogen peroxide (H_2O_2), copper ions (Cu^{2+}), 1,4-Naphthoquinone (1,4-NQ), and welding fumes. As expected, the FOX assay appeared to be more sensitive to H_2O_2, while the DTT assay exhibited higher sensitivity to Cu^{2+} and 1,4-NQ. The second phase compared the sampling efficiency of both systems and their on-line response to controlled concentrations of H_2O_2 and $CuSO_4$. These experiments corroborated the first phase findings and further validated the developed on-line methods and the differential sensitivity of the two assays to specific oxidative species. The third phase will assess the responses of both systems under more complex situations, including welding fumes, gaseous oxidants and secondary organic aerosols, also generated under controlled conditions.
These experiments are designed to refine the validation and comparison of the on-line OP measurement systems, ensuring their robustness and applicability in real environmental and occupational health monitoring.

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(O-47)

Planning and conducting HBM studies for exposure to chemicals

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The rate of chemical production is growing, and exposure of population is, consequently, also growing, raising awareness in public and policy-makers. Regulatory decisions on chemicals require more scientific information, including on exposure, as a priority. Biological monitoring can help to assess the health status in population groups or in occupational settings, complementary to the environmental monitoring, for the exposure assessment to chemical and other risk agents.

The human biological monitoring of exposure is the determination of biomarkers, which can be dose biomarkers, measuring internal exposure levels, effect biomarkers, which highlight early symptoms, and susceptibility biomarkers, which express individual differences of genetic or acquired origin.

This field has recently had a strong acceleration thanks to the progress of analytical techniques and to a greater sensitivity on environmental issues and on their impact on the health of the population.

Promoting the use of human biomonitoring and the establishment of HBM programmes is a recognized priority of chemical safety both globally and in the WHO European Region. Long having been on the EHP (European Environment and Health Process) agenda, HBM was reconfirmed as a priority in 2023 through the establishment of the EHP Partnership on Human Biomonitoring.

Planning HBM studies requires knowledge of HBM basic principles and how to perform laboratory analysis and data management. The type of study should be determined based on the objectives from the very beginning of the design process; the objectives have implications for each aspect of the study to be conducted and also on the scientific significance, especially if elucidating causality is the intention. Cross-sectional studies, for example, can answer policy questions related to the actual exposure levels of the target population but cannot be used to answer questions on causality. From the technical point of view the sample size should be determined, the sample collection procedure, the analytical technique and their performances. The laboratories of analysis should be selected on the basis of their reliability and QA/QC should cover all stages of HBM. Interpretation and evaluation of results, reporting and communication are also crucial for the effectiveness of the studies. Participants should be given access to their individual results, preferably accompanied by an explanation if their values raise concern. Other steps are statistical data analysis according to research questions, advice to the public and policy-makers, results dissemination and communication.

(O-48)

Biological guidance values and exposure mitigation. Where biomonitoring can make the difference to protect the health of workers

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The need to derive health-based biological guidance values (BGVs) for interpretation of human biomonitoring data is increasing. Currently most BGVs are often based on existing occupational or environmental exposure limits derived from animal data. In the future three data streams can be used to support derivation of BGVs: human, animal and mechanistic (Figure 1). For health-based BGVs, the use of human data is preferred. If such data are not available an OEL can also be based on animal toxicity studies (Figure 1).

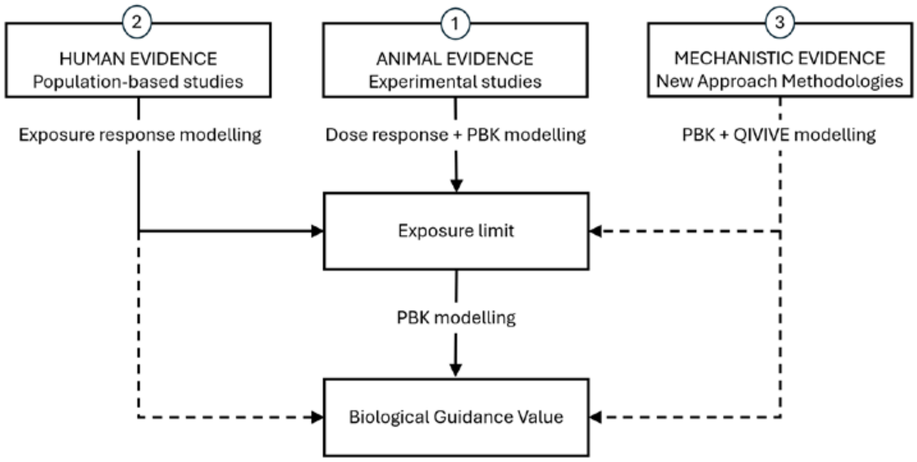

Figure 1. Perspective for derivation of health-based BGVs based on three streams of evidence: animal (1), human (2), and mechanistic (3). PBK, physiologically-based biokinetic; QIVIVE, quantitative *in vitro* to *in vivo* extrapolation.

A second option is to derive BGVs directly from epidemiological studies that have characterised exposure by use of biomonitoring to provide quantitative exposure-response function for a relevant health outcome. The third and currently least developed option uses PBK modelling-facilitated quantitative *in vitro* to *in vivo* (QIVIVE) extrapolation to predict dose-response relationships in humans based on *in vitro* concentration-response data. These are called New Approach Methodologies (NAMs) and developed in response to the need for alternatives to *in vivo* animal testing. For better policy uptake there is still work to do. For instance, harmonisation of the choice of biomarkers together with stakeholders would probably help.[1] If the requirement of causality is not sufficiently supported from a single stream of evidence, a weight of evidence approach could be used to support the derivation of health-based BGVs but without a predefined strict hierarchy of the use of the aforementioned streams of evidence. In this way establishing more BGVs will further increase the role for biomonitoring to support health-based exposure guidance to inform decisions in the interest of occupational and environmental health. As an example of a path forward for regulatory uptake of BGVs, recently the Health Council of the Netherlands recommended that BGVs be introduced and given the same weight as OELs in an existing legal framework the Netherlands.[2] With a robust set of BGVs, other countries may be willing to take similar steps.

1. Zare Jeddi et al. BASIC Guide: Biomonitoring and surveillance of chemical exposures in occupational settings (in preparation).
2. Health Council of the Netherlands (2025) Assessment framework for biological limit values. Report No. 2025/02e, The Hague, The Netherlands.

(O-49)

An overview over biomonitoring practices in EU member states and the making of EU guidance

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Biomonitoring is the measurement of exposure to substances (or biomarkers of exposure or effect) in tissues and fluids of the human body, e.g., in urine and blood. It is used to assess and control exposure to chemical substances in the workplace and detect early effects of exposure. Occupational biomonitoring has been part of the European tool-set through legislation since the evaluation of blood lead levels was introduced into it.

Following a request by the European Commission, the European Agency for Safety and Health at Work gathered information on the biomonitoring practices and policies in the EU. A detailed survey was conducted in 2022 and 23 EU Member States as well as Norway responded to the survey. The results were compiled into a report that provides insights into a diversity of approaches across the countries surveyed. The aspects covered include:

- The use of biomonitoring for assessing worker exposure, for specific substances;
- The national laws governing biomonitoring at work;
- Guidance developed in the Member States;
- Requirements on those who carry out biomonitoring;
- How biomonitoring is applied in the health surveillance of workers;
- What information is provided to workers;
- The relationship between biomonitoring and worker protection measures;
- Inspection practices that include biomonitoring results;
- The setting of biological limit values in the Member States.

Based on the results of the survey and national guides identified through the information-gathering exercise, a guidance document was developed. It gives practical advice on setting up a programme and how to protect workers’ rights, explains what EU legislation says and the role and use of biological monitoring guidance values and biological limit values, and provides information on how occupational biomonitoring is to be used to improve prevention at workplaces. Since biomonitoring involves measurements on biological samples collected from individuals, it is essential that the rights of the individual providing the sample are safeguarded. The guide explains how to set up an effective biomonitoring programme in the workplace context while protecting the rights of individual participants.

This presentation would cover the findings of the survey as well as how they supported the shaping of guidance and its contents.

(O-50)

Biomonitoring for respirable crystalline silica: The determination of Si-containing particles in exhaled breath condensate

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Biological monitoring is a useful way of determining overall exposures to chemical substances; however, in the case of respirable crystalline silica (RCS), this has not been possible in conventional biological matrices.

The work reported here describes the advances in methodology and the results reported from samples collected from three different UK workplaces known to use silica-containing materials. EBC samples were collected pre and post shift from thirty workers and eleven controls. To characterise exposures in the workplaces static air samples as well as bulk dust samples were collected and analysed. A range of real-time particle counting instruments was also employed.

The volume of EBC collected was standardised for exhaled air volume (50 L) and samples were measured for a range of elements as well as silicon (Si) containing particles using single particle inductively coupled plasma tandem mass spectrometry (spICPMSMS). To differentiate between the high backgrounds and the particles it was necessary to process the spICPMSMS data using an open-source Python-based SP/SC ICP-MS data processing platform ‘SPCal’. The bulk samples collected were characterised for particle size distribution, elemental and respirable crystalline silica (RCS) concentration.

Overall, the results show that EBC is a useful biological matrix for assessing exposure to RCS in workplaces. Exposures were seen to increase through the working day, and there were differences between workers and workplaces. Compared with the control EBC samples all workplace EBC samples had higher concentration of Si-containing particles and the particles were slightly bigger, they also exhibited higher background silicon levels. Realtime monitors also showed the potential to capture task specific exposures and offer additional information/exposure data not previously available.

(O-51)
Targeting human proteins in airborne particles twice – exhaled and indoors

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Human exhaled airborne particles are vehicles for viruses or bacteria, the causative agents for airborne infectious diseases like COVID-19 or tuberculosis. A lot of research has been conducted to proof the airborne transmission of different infective diseases, but comparatively little research has been done to elucidate the general contribution of human exhaled particles indoors and how it may change over time. Currently, a pragmatic approach is to analyse the concentration of carbon dioxide indoors, deduce the infection risk from this and suggest mitigation strategies.

However, the number of exhaled particles seems not to be perfectly correlating with exhaled carbon dioxide, which can be shown by our novel model of human particle emission that depends on the breathing volume and the flow rate during inspiration. Thus, another surrogate parameter may need to be employed to assess the human contribution on indoor airborne particles more reliably.

Our approach is to identity and quantify lung-specific proteins in exhaled and subsequently indoor air samples to compare these values and determine the contribution of human breathing. Metaproteomic methods have been used to analyse human lung-specific proteins in exhalate samples, including surfactant proteins. In addition to human proteins, microbial peptides originating from the described lung microbiome have also been identified in exhalate samples. Furthermore, the analysis of indoor air samples revealed a plethora of proteins whose presence is contingent on the indoor conditions. Further steps involve targeted analysis of selected lung-specific proteins to perform an absolute quantification.

(O-52)

Enhance real-time spores monitoring through advanced image feature extraction for classification of fibrous and elongated airborne particles

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Current concentrations of spores in the air allow the improvement of infection risk forecasts. This enables more targeted plant protection measures, for example in viticulture or potato growing. The risk forecast must be accurate for winegrowers and farmers to use this information. Robust classifiers are necessary. This publication shows how this can be achieved.
Measuring and classifying airborne fungal spores is a challenge for automatic monitoring instruments such as the flow cytometer SwisensPoleno due to the irregular shapes and tendency to form chains. Basic shape features extracted from holography images, such as area, solidity, eccentricity, perimeter and orientation are insufficient for description and thus classification of elongated particles, including fungal spores and particle chains.

We demonstrate how an advanced image feature extraction method leveraging particle skeletonization enhances classification of highly eccentric and fibrous airborne particles. By extracting a particle's skeleton from dual-angle holographic images (at a 90° offset), we accurately estimate particle length and width along the skeleton path. This method significantly improves measurement accuracy over traditional features such as major and minor axes, particularly for elongated or chained particles. Additionally, skeleton analysis reveals particle shape intricacies, such as indentations, indicative of chained structures.

Initially intended to improve dataset quality through enhanced filtering, the new skeleton-based features demonstrated robust direct classification capabilities. A lightweight Random Forest classifier trained on these enhanced features achieves classification performance comparable to or surpassing that of deep neural networks, particularly regarding resilience to outliers.

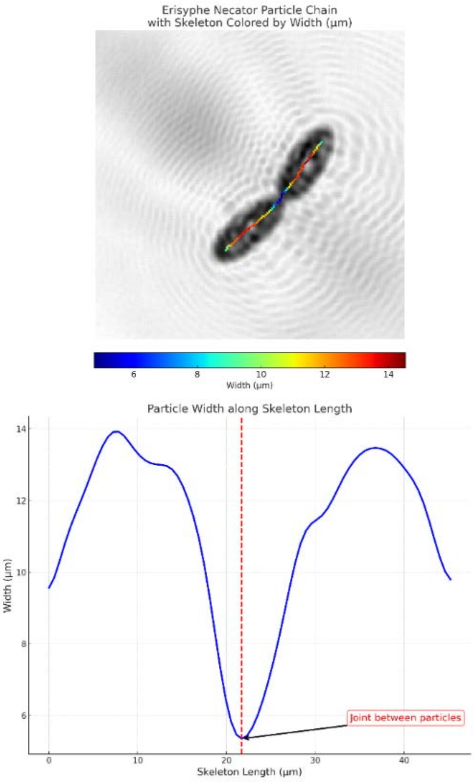

Figure: Analysis of fungal spores species **Erysiphe necator** particle chain using advanced skeleton-based feature extraction. (Top) Holographic image with particle skeleton overlay, color-coded by particle width in micrometers (µm). (Bottom) Particle width plotted along the skeleton.

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(O-53)
German firefighters' exposure to dioxin

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The term "dioxin(s)" indicates a group of substances which include polychlorinated dibenzo-para-dioxins (PCDDs), polychlorinated dibenzofurans (PCDFs), and a subgroup of polychlorinated biphenyls with dioxin-like properties (dioxin-like PCBs). PCDD/Fs are ubiquitous. Sources are mainly animal products such as meat, eggs or milk. But they are also generated as byproducts of combustion, whether burning synthetic materials or wood. Fire residues can contain up to 1100 ng/g PCDD/Fs in the ash, so firefighters are potentially highly exposed to them. Due to the persistent organic properties of dioxins, these accumulate in the fat of the human body and exposures are expected to be detectable over a long period.

Whole blood samples of 152 firefighters were collected in 2018 and 2019 during a human-biomonitoring study. Of them, 40 samples of professional firefighters were randomly selected and grouped into four age and duration of service categories. These samples were analyzed for 17 PCDD/F after a solid phase clean up by gas chromatography coupled with high resolution mass spectrometry (GC-HRMS). Evaluation of these data was done by calculating toxic equivalence (TEQ) values for PCDD/F according to the WHO-guideline from 2005. For values below the limit of quantification (LOQ), half of the individual LOQs were applied, and all results are presented as WHO (2005)-PCDD/F TEQ incl. 1/2 LOQ.

Detection rates for the PCDD/Fs ranged from 0 to 100 percent. For the carcinogenic 2,3,7,8-tetrachloro-dibenzopara-dioxin (2,3,7,8-TCDD) only four of the 40 samples were above the individual LOQ (LOQ range 0.04 – 2.69 pg/g lipid). The median exposure (WHO (2005)-PCCD-F-TEQ) of the firefighters was similar (6.3 pg/g lipid) to another general population study from southern Germany (4.5 pg/g lipid; Fromme et al. 2015) but lower than in Taiwanese firefighters (12 pg/g lipid; Hsu et al. 2011). An increase in the TEQs from age groups 20-29 and 30-39 (with 1-9 years on service) to the age groups 40-49 and 50-59 years (with 20-29 years on service) was observed. This increase showed statistically significant differences between the four groups. If stratified, no differences according to age or years of service were observed, using linear regression (β=0.15 vs. β=0.14).

The overall median PCDD/F WHO (2005)-TEQ for the firefighters in this study seem to be within the range observed in the general German population but lower than in Taiwanese firefighters, even for the oldest of our firefighter group (median: 7.76 pg/g lipid). Thus, for our firefighters we could not observe a significant influence on PCDD/F burden compared to the general population.

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(O-54)

Study of the exposure to pesticides using wristbands and biomonitoring. Preliminary results from the SPRINT project

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Simultaneous exposure to multiple pesticides residues occurs in the diet and in the environment. The aim of this study was to identify the real-world mixtures of pesticides by exposure biomonitoring in different crops grown in Europe.

In the field sampling campaign of the SPRINT project[1], blood, urine and faeces were collected from farmers (n=211), neighbours (n=203) and consumers (n=233) during the growth season of 10 different crops grown in distinct climate zones in Europe. Chemical analyses were done using multi-residue methods (LC-MS/MS, GC-MS/MS) and an additional method for glyphosate and AMPA, all together covering 198 residues in blood, 291 in faeces and 49 in urine. The participants received a silicon wristband to wear continuously for 7 days to study non-dietary routes. Contextual information was collected using a questionnaire. For acetamiprid and glyphosate physiologically based kinetic (PBK) models were developed using concentration-time data obtained human data from volunteer studies, conducted according to a study protocol approved by the ethics committee. Participants were exposed below the acceptable daily intake (ADI). These pesticides were studied for ingestion and skin absorption on separate occasions in the same person. The substance-specific PBK models were constructed to generate exposure estimates by back-calculation from available HBM data.

641 wristbands were analysed for 193 pesticide residues. 173 were detected. In 71% of the wristbands permethrin, chlorpyrifos, piperonyl butoxide (synergist) and DDE p,p' were detected as the four most frequently co-occurring components. The numbers of detected pesticides (and corresponding metabolites) were 92 in blood, 90 in faeces and 37 in urine. The back-calculated median values from the urine results indicated that exposures were below the current acceptable daily intake (ADI) and accepted operator exposure level (AOEL) by 2-4 orders of magnitude. Results are expressed as the median % of the (ADI), ranging from 5th to 95th percentile (P5-P95). For acetamiprid these values were 0.16% (0.02-1.8%) of the recently reduced ADI. For glyphosate these values were 0.06% (0.02-0.3%) of the ADI and 0.3% (0.1-1.6%) of the AOEL.

Of the substances measured, the number of detected pesticides was high (especially in wristbands and feces). Using biomonitoring and wristbands the most relevant pesticides and pesticides mixtures were identified. Co-occurrence of pesticides is the rule and confirms the need for mixture risk assessment.

The sustainable Plant Protection Transition (SPRINT) project is funded by EU Horizon under grant agreement no 862568. For further information see: https://sprint-h2020.eu/

Reference:

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(O-55)
Enhancing workplace exposure assessment and control with artificial intelligence

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Workplaces worldwide today are facing a rapidly changing landscape of hazards and an unprecedented volume of data generated through modern industrial processes and monitoring technologies. Simultaneously, artificial intelligence (AI) is transforming numerous fields by enabling advanced data analysis, automation, and decision support. This keynote speech examines how AI—encompassing foundational machine learning (ML) techniques to cutting-edge generative AI—can be leveraged to enhance occupational exposure assessment, hazard control, and overall workplace health protection.

The field of occupational hygiene has traditionally relied on expert-driven models and labor-intensive data collection methods to assess exposures to chemical, physical, biological, and psychosocial hazards. While effective, these traditional approaches struggle to scale to the complex and dynamic modern work environments that increasingly demand real-time or near-real-time decision-making. AI offers a new paradigm that can complement human expertise by analyzing large and complex datasets, revealing patterns not readily apparent to practitioners, and supporting proactive interventions.

One of the key enablers of AI in occupational hygiene is the increasing availability of data. Wearable sensors, stationary monitors, imagery, and other devices generate vast amounts of information about workplace conditions. However, this data must be carefully prepared to be useful for AI applications, which involve data cleaning, splitting, feature selection, and the application of AI techniques for handling incomplete or poor-quality data.

Different workplace scenarios present varying challenges for the adoption of AI. In data-rich environments—such as large manufacturing plants with automated monitoring systems—AI can integrate diverse data streams to identify hazard hotspots, predict exposure levels, and optimize control strategies. Conversely, data-limited environments—such as small businesses or settings with sparse historical records—require alternative approaches. The keynote will outline methods for developing robust AI models under constrained data conditions, including transfer learning, data augmentation, and leveraging domain knowledge to inform model development.

Evaluation of AI/ML models is critical to ensure their reliability and ethical use. The importance of transparency, interpretability, and human oversight in AI applications is emphasized, particularly given the high-stakes nature of occupational health decision-making. An up-and-coming area of AI applications is automated hazard identification. The emerging role of generative AI, particularly large language models (LLMs), in occupational hygiene. Generative AI can support a wide range of tasks, from generating training materials to assisting with documentation and regulatory compliance. Additionally, LLMs can serve as conversational interfaces for workers, enabling them to query safety information and receive context-aware guidance in real-time.

In conclusion, AI holds the potential to transform occupational hygiene by enabling more proactive, efficient, and personalized approaches to exposure assessment and hazard control. However, realizing this potential requires thoughtful integration of AI tools into existing workflows, careful attention to data quality and ethics, and continued collaboration between AI developers, occupational hygienists, and stakeholders.

(O-56)

One measurement is enough, isn't it? – A statistical point of view on small sample sizes and large variances

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Air and biomonitoring measurement values differ fundamentally from the everyday measurement experience. Measurement uncertainties are more than a magnitude larger. In addition, workplace factors influence the measurement values on an exponential scale. An initiative to draft an analogous standard to EN 689:2018 for biomonitoring is, therefore, reviewing statistical methods for compliance decisions in this respect.

Statistics assumes that the measurement values are described by a distribution function that attributes probabilities to certain ranges of measurement values. One can show by means of Galton's board, how a distribution function and experiments are connected.

Two steps are necessary to make a comparison with limit values: (1) derive the distribution function, and (2) show that this description is valid. Several statistical methods exist, e.g. in standards, to accomplish these two steps.

The concept of the "similar exposure group" includes pre-existing knowledge in the sampling strategy to achieve an independent and identically distributed sample. The distribution is tested, and the parameters of the distribution function are estimated. Compliance with limit values can be tested with a required probability. Depending on the situation, samples of the order of 20 are needed.

To reduce the number of sample values, one must include more pre-existing knowledge. For example, the "preliminary tests" of EN 689:2018 **assume** (1) a given variance of the distribution function, and (2) that this distribution function is valid. Only samples of 3-5 values are tested.

However, this reduction in sample size comes at the cost of a very low probability of detecting deviations from the underlying assumptions that could invalidate the entire analysis. This can be seen by calculating the operating characteristic for these tests.)

The information in samples too small for analysis can be made available by assumptions in the statistical process. However, standard writers need to inform about the risks associated with these assumptions.

(O-57)

Composition of occupational exposure to PAH differs between asphalt millers and asphalt pavers

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Asphalt paving and milling are open processes generating gas and dust particulate matter emissions. Asphalt consists of bitumen as binder and gravel as filler. Bitumen fumes during road paving have been classified as possibly carcinogenic. Bitumen consists of a complex mixture of compounds including polycyclic aromatic hydrocarbons (PAH). The carcinogenicity of PAH increases with increasing molecular weight, i.e. the PAH with high molecular weight (H-PAH) are the most carcinogenic. The H-PAH benzo[a]pyrene is considered one of the most carcinogenic PAH and is primarily present in dust particles. The aim of this study was to characterize occupational exposure to PAH during milling and road paving using air sampling, skin wiping, and biological monitoring of systemic exposure to PAH in urine.

25 nonsmoking male asphalt workers employed at a large Swedish asphalt paving company were included in the study. Of these, 7 were millers and 18 were pavers. The study was approved by the Swedish Ethical Review Authority. All participants gave informed written consent to participate. Air measurements of the 16 PAH prioritized by the US Environmental protection agency (16 US-EPA PAH) were performed using polyurethane foam (PUF) passive samplers placed in the breathing zone during the work shift. Skin wipe samples were collected by wiping the palm of the dominant hand of the workers before and after the work shift using a non-woven swab moistened with isopropanol. Spot urine samples were collected directly before and after the work shift. Analysis of the 16 US-EPA PAH in PUF and wipe samples and of metabolites of phenanthrene, fluorene and pyrene in urine was performed using GC-MS/MS and LC-MS/MS, respectively.

Air levels of 16 US-EPA PAHs were higher for pavers compared to millers, with geometric mean (GM) levels of 290 ng/m^3 and 53 ng/m^3, respectively. However, levels of H-PAH were higher for millers compared to pavers, GM 4.1 ng/m^3 and 2.9 ng/m^3, respectively. Asphalt pavers showed significantly higher levels of PAH on the palm after the work shift compared to asphalt millers, but asphalt millers showed higher levels of benzo[a]pyrene on the palm after the work shift compared to pavers. Statistical analysis showed that the urinary levels of PAH metabolites were significantly increased in asphalt pavers after the work shift.

Thus, air- and skin exposure measurements of PAHs were vital to detect exposure to carcinogenic particulate PAH, as biomonitoring generally is performed by measurements of metabolites of gaseous and intermediate PAH.

(O-58)

Occupational exposure to carcinogen metals and particles in additive manufacturing processes

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Metal additive manufacturing (metal 3D printing) experienced a growth of nearly 25% in 2023 due to the advantages it offers like speed, economy, personalisation, waste reduce, etc. These processes can be a source of potential emissions of hazardous substances, such as carcinogen metals and therefore, they must be studied to protect workers´ health.
Although for some technologies like Selective Laser Melting (SLM-PBLF) the process occurs in a closed chamber, the activities related to the process can release high concentrations of metal dust.

The objective of this study was to characterize airborne particle emissions of metal dust and related occupational exposure levels during SLM-PBLF, Wire Arc Additive Manufacturing (WAAM) and Binder Jetting (BJ). The materials used with each technique was Iron Alloy 1.2709 and Ancor 316L for the first technology, stainless steel ER308LSi and Aimtek-SDS-MARM247 respectively. Measurements of airborne particles emitted were carried out simultaneously at the source/ near field, in the far field and on the operator, during the printing and pre- and post-processed operations. Real-time instruments (CPC3007, OPS 3030, ELPI+ and DISC-Mini) were used to characterize particle emissions (10 nm - 10 µm). Static and personal inhalable and respirable samplers (PGP-GSP 3,5 and GK 2,69) were used to measure the concentration of metals and open cassettes were used for electronic microscopy (SEM and TEM) analysis.

The highest number of particles in the near field was for SLM-PBLF (40.000 particles/m^3) while in the other two processes were around 15.000 particles/m^3. The mean size of particles ranged from 10-70 nm (SLM-PBLF) to 7 µm (BJ).

Exposure concentrations of carcinogen metals for the three processes were: Cr (VI) 0,0006 mg/m^3 and Co 0,073 mg/m^3 (SLM-PBLF); Cr (VI) 0,0004 mg/m^3 and Ni 0,0085 mg/m^3 (WAAM); and Co 0,011 mg/m^3 (BJ). About the rest of the metals, the more significant concentrations were in SLM-PFLF, Fe 5,0090 mg/m^3 and WAAM 0,0163 mg/m^3 of respirable Mn.

Concentrations in SLM-PFLF and BJ were mainly due to the necessary manipulation of metallic powder. In the first case in post-processing, since pieces are completely covered with metal dust that has to be removed; and in the second in pre-processing tasks due to the operation of hopper filling with raw material.

The three techniques had a collective protective measure but according to the results, a more efficient exposure control measure should be implemented to ensure that the level of exposure is reduced to as low a level as is technically possible (Directive 2004/37).

(O-59)
Assessment of waste isoflurane gas exposure during the surgery on rats

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In recent years, biomedical research is closely associated with the implementation of inhalational anesthetics in the practice. The use of isoflurane or other volatile anesthetics may lead to potential professional exposures to the waste anesthetic gases (WAG). Possible health effects from the chronic exposure to isoflurane comprise hepatotoxic, genotoxic as well as some teratogenic and reproductive effects. A significant number of research results prove that professional exposures to the WAG at the hospitals has largely improved while the exposures at veterinary hospitals or veterinary biomedical laboratories remain uncertain.

Following a purchase of a new anesthesia module within a toxicology research laboratory at INRS (The French National Research and Safety Institute for the Prevention of Occupational accidents and Diseases), an initial sampling campaign has revealed a significant exposure of operators to isoflurane. Consequently, a study was performed to identify the sources of emissions and provide solutions to reduce the isoflurane emissions during the routine surgical operations on rats. The study aimed to assess the atmospheric concentration of isoflurane in the surgery laboratory as well as personal exposures of operators. Results of the first sampling campaign over three days has revealed a progressive increase of atmospheric isoflurane concentration from 0,36 to 2,69 ppm and from 0,72 to 32,52 ppm at two different monitored workstations. The individual exposure levels have also increased progressively over three days from 0,40 to 4,40 ppm. Moreover, the results of the measurements have demonstrated the important concentrations of the isoflurane at the outlet of the filter cartridge. Installation of the external gas evacuation system allowed a significant decrease of the isoflurane concentration. Moreover, no increase in atmospheric concentration and in individual exposure levels over the 3 days was observed. Obtained results indicate that installation of the external gas scavenging system makes it possible to reduce WAG levels and to respect the recommended concentration values of isoflurane. Moreover, at these conditions, it was possible to identify the sources of isoflurane emission and relate operators' individual exposures with the performed tasks. The evolution of isoflurane concentrations with and without installed external gas scavenging system is demonstrated in the figure. Concerning the potential risks for health from the chronic exposures to WAG such as those observed in this study when no external gas scavenging system was installed, additional research is required to provide more definitive information.

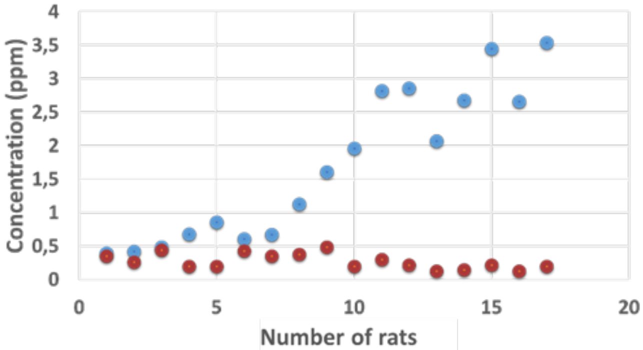

Figure: Evolution of isoflurane concentrations as function of the number of sequentially operated rats with (red) and without (blue) external gas scavenging system.

(O-60)

Formaldehyde exposure in pathology laboratories – A best practice approach

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Controlling occupational exposure to carcinogenic formaldehyde in pathology laboratories remains challenging, since even small deviations from standard operating procedures may lead to high exposures exceeding occupational exposure levels. In a joint effort, several partners from the German social accident insurance and state measurement authorities, used precise air exposure assessments and modelling methodologies to define best practice procedures for the safe handling of formaldehyde in pathology laboratories.

We employed a multi-parametric exposure assessment strategy including air sampling, systematically accounting for variables such as task type, exposure duration, frequency, and laboratory-specific conditions such as air suction speed. Key activities, including specimen processing, staining, and tissue fixation, were analysed to determine exposure levels. Prior to field measurement we conducted measurements on a test bench with adjustable ventilation to determine minimum requirements regarding the safety equipment installed in the pathology laboratories.

Our results showed that occupational exposure limits can be maintained if specific technical and organizational measures are in place. Key factors included, among others, a necessary minimum air suction speed at vacuum tables, a perforated surface that employs negative pressure during pathological processing to vacuum volatile hazardous substances, and defined handling procedures that effectively minimize formaldehyde exposure during critical tasks.

Further efforts will focus on developing sector-wide safe handling guidelines for formaldehyde in pathology laboratories. These guidelines will provide clear recommendations on technical, organizational, and personal protective measures to ensure long-term occupational safety.

(O-61)

Assessment of nitrous oxide exposure in health care activities and prevention means

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The ready-to-use equimolecular mixture of oxygen and nitrous oxide (Emono) is widely used in hospitals as an analgesic during short clinical procedures, delivered through a face mask. Healthcare workers are regularly exposed to this gas mixture, and therefore to nitrous oxide, which is toxic to humans. Exposures are mainly caused by the leaks at patient/mask interface as well as during the mask removing from the patient's face to communicate with them. Existing technical prevention solutions to reduce these exposures rely on the scavenging of accidental nitrous oxide emissions at the source using localized extraction devices: double-masks. The use of a demand valve can also reduce nitrous oxide emissions during sedation.

The aim of this study was to assess the effectiveness of these two types of exposure reduction means both through laboratory experiments by reproducing healthcare procedures on a mannequin in standard conditions and through field measurements during real treatments. The field measurements were also coupled with an ergotoxicological approach combining video and real-time measurements in order to find out and understand the link between practices and exposures. Twenty-five interventions in six different hospitals monitored 270 treatments in several care units. Nearly 800 sampling were performed, both personal and ambient. The results confirm the high occupational exposure levels during treatments performed with conventional masks and reveal that occupational exposure levels strongly vary as function of the healthcare type. Laboratory and field results also revealed the effectiveness of the double mask and demand valve in significantly reducing exposure to nitrous oxide. However, while technical solutions are necessary to comply with French Exposure limit values (25 ppm for 8h and 125ppm for 15 minutes), they are not sufficient. Indeed, laboratory experiments revealed that the pressure drop of the gas exhaust system strongly influence the ambient concentration and consequently the occupational exposure. They have also revealed that some kind of leaks cannot be avoided, even with double masks. Furthermore, the ercotoxicological study underlines the lack of information and insufficient training of healthcare staff, as well as the paucity of shared practices and indicators.
The results will provide a useful source of information for future INRS recommendations for the safe use of Enomo during healthcare by proposing an appropriate prevention method adapted for the specific healthcare type.

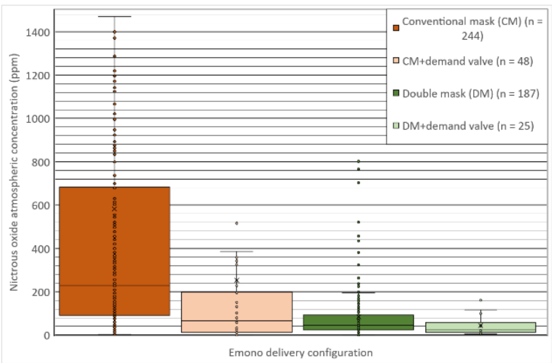

Figure 2 : Exposure levels as function of the delivery configurtion

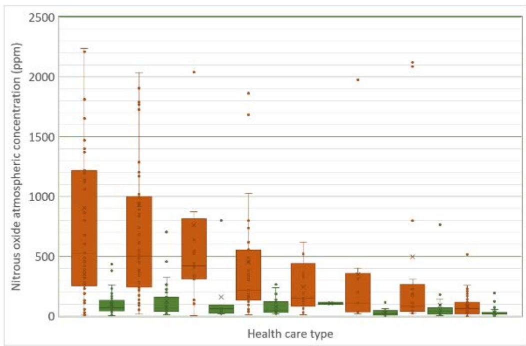

Figure 2 : Exposure levels as function of healthcare type

(O-62)
Inhalative heroin exposure of workers at supervised drug consumption facilities in Germany

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In supervised drug consumption facilities, illicit drugs, such as heroin, cocaine, and amphetamine can be consumed under the supervision of trained staff. The main aim of these facilities is the reduction of the disease transmission risk by offering hygienic conditions and supplies, the prevention of deaths by drug overdoses, and the connection of drug users to health and social services. The consumed substances themselves are typically supplied by the drug users, whereas clean equipment for the injection or inhalation of the drugs can be obtained in the facilities. Initially, most of the drug consumption rooms only targeted users injecting substances like heroin. Adapting to a general change in the use patterns towards increased inhalation of illicit drugs, many facilities now offer additional areas for the supervised smoking of cocaine (crack) and heroin.

With rising numbers of drug consumption by smoking, the risk of inhalative passive exposure of employees is increasing. In a cooperation with the Institute for Forensic Medicine in Düsseldorf, a method for the monitoring of heroin concentrations in air has been developed. Field measurements have been carried out in cooperation with the German social accident insurance provider for non-state institutions within the health and welfare service sectors (BGW) in multiple drug consumption facilities. Depending on the actual conditions on-site, worst-case measurements in the room used for smoking, separate areas for the injection of drugs, as well as adjacent first aid or office areas were performed. Personal air samplers were used for employees with direct contact to drug users, whereas stationary measurements were performed in the remaining locations.

Trace levels of heroin could be detected in air samples from many areas of the drug consumption facilities. Highest heroin concentrations of up to 30 µg/m³ were determined directly in the rooms or compartments used for the smoking of drugs. Depending on the number of consumption processes, the layout of the facilities, and the installed ventilation system, major local differences in the heroin concentration could be observed. The concentrations determined by personal air sampling of employees, varied between values of below 0,1 µg/m³ and up to 3,1 µg/m³ under unfavourable conditions. Based on the measurement results obtained from different facilities, suggestions for the reduction of passive smoke exposure of employees could be made to the operators of the drug consumption rooms. In addition to heroin, cocaine and various opium related alkaloids were identified in the air samples. With increasing numbers of crack users observed in many drug consumption facilities, an extension of the existing air monitoring method could be performed in a follow-up project.

(O-63)

Striking a balance: Establishing effective occupational exposure limit values for nickel in Norway

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In April 2024, the Norwegian Labour Inspection Authority announced its decision to adopt occupational exposure limit values (OELVs) for nickel-containing substances that correspond to the limit values proposed at the European Union level and the DNELs (Derived No-Effect Levels) established by NiPERA (Nickel Producers Environmental Research Association). (Derived No-Effect Levels) established by NiPERA (Nickel Producers Environmental Research Association). The adopted OELVs, which have been set at 0.05 mg/m³ for the inhalable and 0.01 mg/m³ for the respirable nickel fractions, represent an important step forward in protecting the health of workers, especially after previous proposals for stricter OELVs that would not provide additional protection against the risks of nickel exposure but could make compliance more difficult and would involve the mandatory introduction of respiratory protection, which is an additional burden on workers. From a business perspective, it is therefore logical to prioritise measures that do have an effect on the well-being of employees.

The joint plea of the Nickel Institute and the robust scientific input have shown that the binding EU OELVs offer sufficient protection for health and at the same time are practically applicable in all industrial environments. This positions the adopted values as a scientifically sound approach, emphasising the need for a defined exposure threshold that critically reduces the health risks, particularly the carcinogenicity, of nickel compounds.

Through a joint effort, including consultations with experts and technical discussions, stakeholders successfully emphasised that the adapted OELVs, which are protective of health, guarantee that no additional health benefits would result from adopting lower, more onerous limit values. This groundbreaking decision underlines the importance of using scientifically based threshold values to protect the health of workers while enabling realistic compliance for industries involved in nickel production and use.

While Norway implements these science-based OELVs, the Nickel Institute will continue to advocate for health-based regulatory practices across Europe to ensure that future occupational health frameworks are both protective and achievable. This result is an important step forward in improving safety standards for workers in the nickel industry and beyond.

(O-64)

The GESTIS Biologic Agents Database – compact information for occupational safety and health protection

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Numerous biological agents are used in laboratories, in biotechnology and in animal experiments. Employees may also be exposed to biological agents during other activities (e.g. in the healthcare sector, during cleaning and rehabilitation work, in veterinary medicine, in agriculture and forestry and in wastewater and waste management). Therefore, biological agents occurring in workplaces must be included in the risk assessment. Risk assessment is the central element of occupational health and safety and the basis for systematic and effective health and safety protection in the daily working environment.

The GESTIS Biological Agents Database is a part of GESTIS (Information system on hazardous substances of the German Social Accident Insurance) and provides reliable information on biological agents and measures to maintain the safety and health of employees. It supports employers in risk assessment in connection with the implementation of the Biological Agents Ordinance when working with biological agents. Therefore, the GESTIS Biological Agents Database is particularly useful for people who are responsible for occupational health and safety but is also available to the interested public. The database is accessible for everyone in German and English language and free of charge.

The Database contains information on occupational safety and health measures for over 18,000 micro-organisms. In addition, the database provides data sheets with occupational safety and health information for non-specific activities involving possible contact with various potentially occurring micro-organisms.

For selected biological agents of medical relevance or of relevance to occupational safety and health, datasheets are available containing extended information. These data sheets with further information include, among others, details on medical significance, the relevant areas and activities, morphology and physiology, pathogenicity, epidemiology, resistance and legal principles.

The information is continuously updated and expanded. In collaboration with experts from various national reference centres for microorganisms, among others, we ensure a high-quality standard of information in the database.

The GESTIS Biological Agents Database is a cooperation project of the German Social Accident Insurance Institution for the raw materials and chemical industry (BG RCI), the German Social Accident Insurance (DGUV) and the Federal Ministry for Labour and Social Affairs (BMAS).

Access to the Database: https://www.dguv.de/ifa/gestis/gestis-biostoffdatenbank/index-2.jsp

(O-65)
Occupational lead exposure among lead handlers in a copper mining company, Zambia

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Enlisted among the World Health Organisation's 10 chemicals of major public health concern and causing 0.6% of the global disease burden, lead exposure occurs through multiple routes. Zambian literature is scanty. This study characterised exposure among lead handlers at a Zambian copper mine by comparing external occupational exposure with the internal lead body burden.

The study was University of the Witwatersrand Medical - Human Research Ethics Committee, Tropical Diseases Research Centre Committee, and Zambian National Health Research Authority approved. Historical (n=51) and current (n=39) blood lead values, versus multi-route current external occupational exposure assessment was conducted. Palmar wipes (n=53), surface wipes (n=27), breathing zone air (n=37), and room air (n=5) samples determined external lead contamination. Convenience sampling was done. South African National Accreditation System - accredited laboratories performed chemical analyses. JASP software was used with 5% Alpha level of significance.

The data was log normal with some normal distributions. International reference standards were adopted since Zambia has none known to us. Mean age of participants, all male, was 41 years with median exposure duration 10 years. Mean blood lead was 1.61 units higher than the Occupational Health and Safety Administration's (OSHA) recommended value (10µg/dL). Personal and room air time weighted averages were below the OSHA recommended value (0.05mg/m^3), National Institute for Occupational Safety and Health recommended value (0.1mg/m^3), and American Conference of Governmental Industrial Hygienists recommended value (0.05mg/m^3). Dermal and ingestion reference standards were unavailable. Dermal chronic daily intake (CDI=6.76×10^{-11}mg/kg/day), Oral (CDI=5.97×10^{-3}mg/kg/day), whereas Inhalation was (CDI=4.20×10^{-2}mg/kg/day). All pathways showed low risk for adverse health effects with hazard quotient less than one. The highest contributing pathway was inhalation. Fifty-nine percent of blood samples collected exceeded 10 µg/dL.

The study contributes to exposure science by considering exposure pathways of lead in an occupational setting. These findings could guide development of intervention strategies to mitigate exposure thus preventing negative health impacts.

(O-66)

Development of field-portable real-time instrumentation for aerosol chemical speciation

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Real-time aerosol monitoring is crucial for improving ambient air quality and for advancing exposure science in indoor and workplace atmospheres. Real-time instruments enable the detection of transient exposures, task-specific exposure profiling, immediate feedback for protective measures, and integration with innovative engineering control systems, such as hazard warnings and adaptive ventilation.

Traditional filter-based methods provide delayed, time-averaged results that miss short-term peak exposures and limit timely interventions. The talk will summarize our recent studies on the development of near-real-time methods for measuring aerosol chemical composition. Our efforts focused on developing new aerosol sampling methods to obtain spot samples, followed by semi-continuous atomic and molecular speciation of particulate analyte therein.

We initially explored several micro plasma techniques to evaluate their suitability for elemental detection, which led to the development of a pulsed high-voltage spark-based technique. Molecular speciation was obtained using Raman spectroscopy. We also developed new spot collection methods that enabled sample collection at rates of up to 10 L/min.

The design, development, and characterization of two prototype hand-portable near-real-time instruments will be presented: the Aerosol Spark Emission Spectrometer (ASES) for measuring particulate metal and the Tandem Raman Elemental Aerosol Spectrometer (TREAS) for high-specificity measurement of inorganic and organic aerosol components. These instruments provide near real-time measurement at a time resolution of a few minutes with a detection limit in the range of 0.01-10 $\mu g/m^3$. Laboratory and field evaluation of the prototype instruments will be presented, and applications to various workplace aerosol monitoring scenarios will be discussed.

(O-67)

Proton-transfer-reaction mass spectrometry (PTR-MS): From fundamentals of VOC monitoring to pilot studies on tire wear particle detection

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Proton-transfer reaction mass spectrometry (PTR-MS) is a powerful analytical technique for real-time monitoring of volatile organic compounds (VOCs), offering second-scale time resolution and sensitivity across a wide dynamic range - from parts per trillion (ppt) to parts per million (ppm). Although PTR-MS has become a cornerstone in atmospheric chemistry and air composition research over the past two decades, its adoption in workplace exposure assessment remains limited, partly due to its perceived complexity and the specialized expertise required for operation and data interpretation.

In the first half of my presentation, I will provide a primer on PTR-MS, outlining the fundamental principles of the technique, including its soft ionization mechanism and high temporal resolution. I will highlight key advantages such as online, near-instantaneous VOC detection and ppt-level sensitivity. In addition, I will discuss current limitations, particularly related to compound specificity, and how these challenges are being addressed using alternative reagent ions and advancements in analytical methodology.

The second half will focus on our group's recent efforts to adapt PTR-MS for the detection of tire wear particles (TWPs) in air -an emerging, non-exhaust source of urban particulate matter with growing significance for both environmental and occupational exposure. Two complementary studies will be presented:

1. Thermal desorption/pyrolysis screening: Controlled heating of representative tire polymers was used to produce diagnostic VOC fingerprints, providing a basis for future thermal desorption/pyrolysis-based analyses of ambient particulate matter.

2. Additive-marker survey: We targeted specific organic additives uniquely associated with tire materials to identify potential chemical markers for TWP in ambient air.

Our findings highlight the potential of PTR-MS to bridge the gap between real-time gas-phase analysis and particulate pollution research, supporting its broader application in occupational hygiene, regulatory air monitoring, and urban air quality assessment.

(O-68)

Automatic and real-time airborne microplastic detection based on UV-LIF measurements

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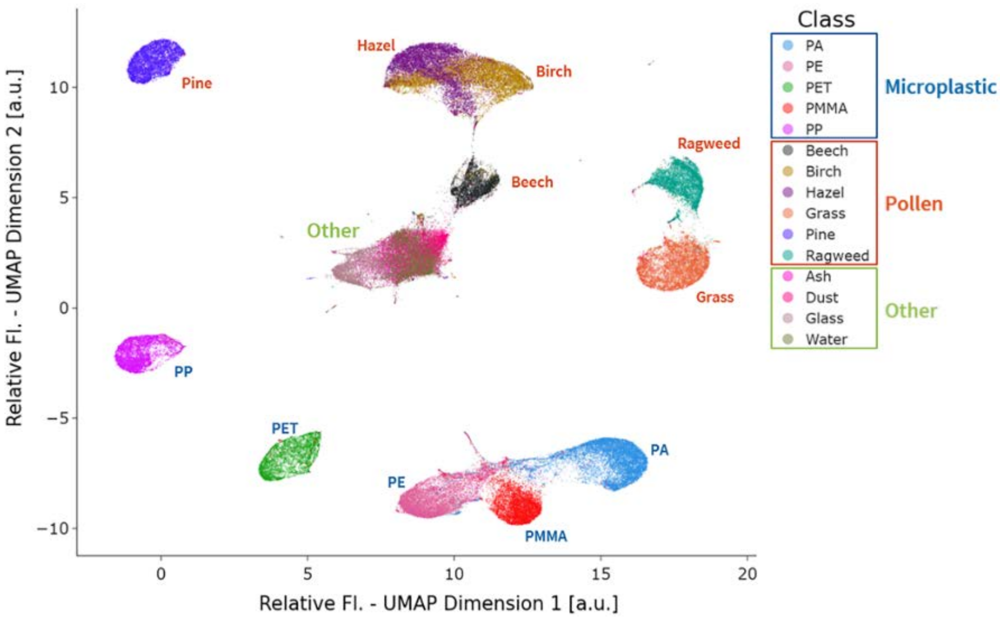
Measuring microplastics in the air is crucial due to their potential impacts on human health and the environment. Atmospheric transport facilitates their global distribution, contaminating remote ecosystems. Understanding concentrations, sources, and pathways of airborne microplastics is essential for developing effective mitigation strategies.
The detection and analysis of MPs once airborne, however, remains a challenge because most observational methods are offline and resource-intensive, and, therefore, are not capable of providing continuous quantitative information (Primpke et al., 2020).
We present laboratory measurement-based results using an online, in situ airflow cytometer (SwisensPoleno Jupiter; Swisens AG; Emmen, Switzerland) – coupled with machine learning – to detect, analyze, and classify airborne, single-particle MPs in near real time (Beres et al., 2024). The performance of Poleno's ultraviolet-light induced fluorescence measurement setup (UV-LIF) using the relative fluorescence spectra (relative Fl) is shown in the figure. It shows a UMAP plot based on the relative Fl spectra for every event in the study. The UMAP analysis depicts the high-dimensional relative FL spectra in a low-dimensional (2D) representation, where each dot represents one measured particle (event) in the study. This 2D representation also provides insight into the relative similarity and difference between the relative Fl spectra: the closer each event is, the more similar their relative Fl spectra are. Each dot is colored according to its class name in the legend; the text for each class is colored according to the category of particle types. The events from the particle classes in the "other"
categories are clustered and overlap near the center of the UMAP plot, indicating the underlying similarity of relative Fl in this study.
The tested MPs exhibit a measurable fluorescence signal that not only allows them to be distinguished from the other fluorescent particles, such as pollen, but can also be differentiated from each other.

Beres, N. D. et al. (2024) AMT, 17(23), 6945–6964.
Primpke, S. et al. (2020) Appl. Spectrosc. 74(9), 1012–1047.



(O-69)

Improvements in the determination of diisocyanates using a new gradient elution HPLC methodology

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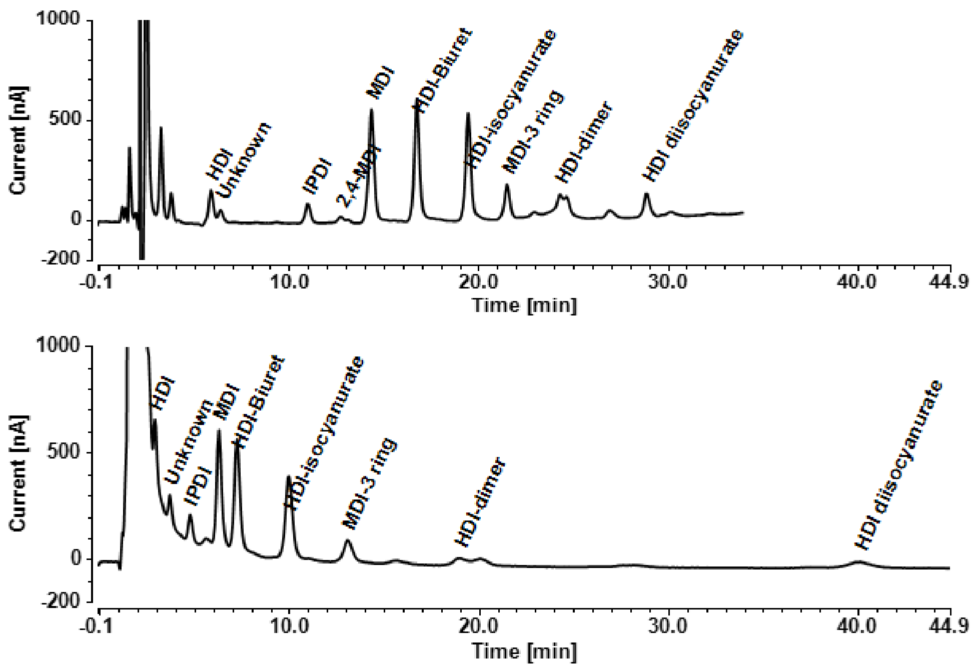
Exposure to airborne diisocyanates remains a leading cause of occupational asthma and sensitization. Occupational exposure limits, based upon measuring the total reactive isocyanate groups (TRIG) within such agents, are enforced in the United Kingdom and elsewhere. The measurement of TRIG has advantages over the measurement of individual monomer and oligomer isocyanate species because the exposure metric is explicit, thus facilitating easier comparability of exposure data sets. The European Chemical Agency's Risk Assessment Committee supports this approach because in their view diisocyanates share a common mechanism of inducing hypersensitivity reactions and also because there is insufficient data to assess differences in potency for different diisocyanates.
In the UK, HSE MDHS25/4 is the recommended analytical method for determining TRIG as it is the only method capable of measuring oligomeric diisocyanate compounds where calibrants are not available. This procedure employs high-performance liquid chromatography with concurrent use of ultraviolet spectrophotometric and electrochemical (EC) detectors to facilitate the identification of oligomer species and to enable quantification using a readily available monomeric calibrant.
Historically, using gradient elution resulted in instabilities in EC detector responses. However, with improved instrumentation, a new gradient elution method (bottom chromatogram) now offers improvements to; peak shape (especially for later eluting oligomers); response ratios; resolution of monomers from the 1,2-MP reagent peak and better sensitivity, over the original isocratic method (top chromatogram).

The presentation will describe the analytical validation work undertaken that included the analysis of bulk diisocyanate formulations and air samples derived from workplaces.



(O-70)

Method development for the speciation of organotin compounds in workplace air samples via HPLC-ICP-MS

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Organotin compounds (OTCs) are widely regulated due to their recognised human and environmental toxicity. However, due to their excellent physicochemical properties, they remain among the most used organometallic-compounds in various branches of industry, which makes occupational exposure to OTCs a substantial concern. At workplaces OTCs can be released as particles, vapours or mixed phases and absorbed through inhalation or by skin contact. The toxicity of OTCs is highly variable due to the many different types of organic substituents and bonding forms. The harmful effects can range from skin and respiratory tract irritation to immunosuppression, and even severe neurotoxicity. Due to their lipophilicity, OTCs tend to bioaccumulate in organisms and can therefore accumulate in tissues over a longer period.

In Germany, the 'Technical Rules for Hazardous Substances' (TRGS) specify occupational exposure limits (OELs) for 23 individual OTCs. However, there are currently no substance-specific analytical methods for monitoring exposure to multiple OTCs in workplace air. In other areas, for example environmental and product analysis, gas (GC) and liquid chromatography (HPLC) applications can be found for various matrices. While GC methods offer a higher peak resolution for more compounds, HPLC methods excel due to minimal sample preparation without the need of an error-prone derivatization. The coupling to mass spectrometry with inductively coupled plasma (ICP-MS) stands out due to its particularly high sensitivity but also poses challenges considering the complex method development. Previously published HPLC-ICP-MS methods describe a separation of a maximum of seven compounds using a simple binary gradient.

This work presents the successful development of a method for the determination of eleven regulated OTCs in workplace air via HPLC-ICP-MS. The method allows the separation of monomethyltin (MMT), monobutyltin (MBT), monooctyltin (MOT), monophenyltin (MPhT), dimethyltin (DMT), dibutyltin (DBT), diphenyltin (DPhT), trimethyltin (TMT), tributyltin (TBT), triphenyltin (TPhT) and tetramethyltin (TTMT) within 22 minutes by means of a C18 reversed phase column and a ternary solvent and flow rate gradient using methanol, acetonitrile, and ultrapure water + acetic acid + α-tropolone.

One of the primary challenges in the method developing process was the high reactivity and thermal instability of OTCs, which required careful optimization of sampling and preparation conditions to preserve the organotin species throughout the entire process.

(O-71)

Determination of nanomaterials in air samples by means single particle inductively coupled plasma mass spectrometry

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Nanomaterials (NMs) are considered one of the game-changing technologies of this century, offering unique physicochemical properties for a wide range of industrial applications. However, our current understanding of the impact of NMs on human health and the environment is still limited. Further research efforts are necessary to fully comprehend their effects on human health, as well as their environmental fate and behaviour. To this end, the development of novel analytical methodologies for the accurate and precise characterization of NMs is crucial. Inductively coupled plasma mass spectrometry has traditionally been employed as the reference technique to determine the elemental content in airborne particulate matter following an appropriate acid digestion treatment. Nevertheless, because samples are completely decomposed, information regarding the specific distribution of metals across particulate fractions is lost. Single particle inductively coupled plasma mass spectrometry (spICP-MS) has recently emerged as a powerful analytical tool for the detection, characterization, and quantification of NMs in complex samples. In this technique, a diluted NM suspension is directly introduced into the plasma, and for each atomized and ionized NM, a signal peak is generated above a continuous baseline. The intensity of this signal peak correlates with the elemental mass within the NM, and thus, its size, provided information on its composition, shape, and density is available. The event frequency, however, is directly proportional to the particle number concentration in the suspension.

Our research group has recently explored the adaptation of existing air sampling strategies, utilizing air filters for both indoor and outdoor monitoring, to enable the characterization of NMs and ultrafine particles via spICP-MS. Our studies show that, when operating microquartz filters, particulate was quantitatively resuspended in liquid media by means a basic MW-assisted extraction treatment within 10 minutes. If mixed cellulose ester filters were used instead, the procedure was more advantageous since this material is fully dissolved allowing direct sample analysis, minimizing sample manipulation. The proposed methods were successfully applied to metallic and metal oxides nanoparticles (AgNPs, AuNPs, PtNPs, TiO_2NPs, ZrO_2NPs, etc.) determination in indoor air for assessing occupational exposure where these materials are handled [1,2]. Similarly, these methodologies were also tested for outdoor air sample analysis, demonstrating their ability to identify variations in metal composition and their fraction in NM form (e.g., Cr, Cu, Pb, etc.).

References:
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[2] C. Gómez-Pertusa, M. Carmen García-Poyo, G. Grindlay, R. Pedraza, M. Adela Yañez, L. Gras, *Microchim Acta*, 2025, Accepted.

(O-72)

Detection and identification of plastic nanoparticles in a PET recycling facility

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There has been an increasing focus on exposure to and health effects of micro- and nanoplastic (MNP) particles. Airborne MNP particles can be inhaled, and due to their small size, some of them might deposit deep down in the respiratory tract. There is a concern that nanoplastic particles might enter the bloodstream from the alveoli and translocate to other organs, causing adverse health effects. However, few studies have so far been able to identify airborne nanoplastic particles. In this study, we show the presence of polyethylene terephthalate (PET) nanoparticles in a PET recycling plant.

Airborne particles were measured with a Scanning mobility Particle Sizer (SMPS) covering the range from 20 - 600 nm. In addition, airborne particles were collected with Sioutas Impactors. The Sioutas Impactors collect size fractionated samples in five different size fractions: 10-2.5 µm, 2.5-1.0 µm, 1.0-0.5 µm, 0.5-0.25 µm, and particles below 0.25 µm collected on an end filter. This impactor was used with both quartz and PVC filters, where the PVC filters was used for gravimetric determination of the collected mass and quarts filters were used for pyro GC-MS.

The SMPS measurements showed a higher number of ultrafine particles in the production area compared to the background measurements. The pyro GC-MS analysis identified the presence of PET in all size fractions of the Sioutas Impactors, indicating the presence of both micro- and nanosized PET particles in the workplace air.

(O-73)

Modifications to the phase-contrast microscopy (PCM) method for fibre-counting to support a new occupational exposure limit value

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The current detection limit for phase-contrast microscopy (PCM) for counting airborne fibres, including asbestos fibres, is typically given as 0.1 f.cm^{-3}. This value is the same as the occupational exposure limit value (OELV) currently in force for airborne asbestos in most of the world. However, there is an initiative to lower the OELV in the EU to 0.01 f.cm^{-3}. In the EU, OELVs are established with specific requirements for the expanded uncertainty around the limit value, and to meet those requirements the OELV should not be a simple limit of detection.

There are several options which can be added to published methods to allow the PCM method to meet an OELV of 0.01 f.cm^{-3}. Measurement of low levels requires precision in counting low numbers, which is a function of the filter background, the number counted above background, and their distribution across the filter. The number of fibres available to count is a function of the volume of air sampled and the area of filter examined. Counting few fibres requires a lower background than that currently required. It also requires assurance of adequate counting precision, which can be obtained through participation by the microscopist in a proficiency test program tailored to this purpose, provided a passing score is obtained. The volume of air sampled can be increased with modern, high-volume personal sampling pumps. The area of filter examined can be increased, as necessary.

These modifications, taken together, ensure accurate measurement of 0.005 f.cm^{-3}, thus demonstrating compliance with an OELV of 0.01 f.cm^{-3} for a 4-hour or 8-hour TWA sample. Although there would be some additional cost in sampling and analysis, the PCM method can be retained, with its advantages of low cost and capability for on-site analysis, and, most importantly, traceability to risk assessments based on prior PCM data.

(O-74)

Occupational exposure assessment criteria for metal compounds in airborne dusts differentiated by ‚solubility‘ - an analytical perspective

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In Germany, assessment criteria for certain metal compounds in airborne dusts at the workplace are referred to their ‘solubility’. Consequently, there may exist different assessment criteria for distinct classes of compounds. For instance, the permanent senate commission for the investigation of health hazards of chemical compounds in the work area (MAK commission) recently recommended novel maximum workplace concentrations (MAK values) for ‘soluble, irritating’ (e.g., aluminium chloride) and ‘soluble, non-irritating’ aluminium compounds (e.g., aluminium chlorohydrate) as well as for aluminium and its ‘poorly soluble’ compounds (e.g., gamma aluminium oxide, but not alpha aluminium oxide which is considered ‘insoluble’) based on the substances’ effects. However, a fundamental problem arises from the fact that precise definitions of the ‘degrees of solubility’ are lacking. The aim of the present investigation was to demonstrate analytical challenges resulting from assessment criteria for metal compounds differentiated by ‘solubility’ or other substances’ characteristics.

Regarding the classification of aluminium compounds (differentiation between ‘soluble, irritating’, ‘soluble, non-irritating’, ‘poorly soluble’, ‘insoluble’ aluminium compounds), standardized sample preparation procedures for the determination of ‘soluble metal compounds’ (digestion using 0.1 M hydrochloric acid) as well as for the determination of the total metal content (open hot-block digestion with a mixture of nitric and hydrochloric acid or microwave-assisted digestion with nitric acid) were examined in terms of their selectivity. Analysis of aluminium (determination of recovery) was performed by means of inductively coupled plasma mass spectrometry (ICP-MS).

Digestion using 0.1 M hydrochloric acid is suitable for the determination of ‘soluble’ aluminium compounds such as aluminium chloride and aluminium sulfate. However, aluminium powder (metals basis) can also be dissolved using this digestion procedure. Open hot-block digestion with mixtures of nitric acid and hydrochloric acid provides sufficient recovery for aluminium powder but not for ‘poorly soluble’ aluminium oxide. Using a powerful microwave-assisted digestion process, satisfying recoveries were obtained for both aluminium powder and aluminium oxide (including alpha-phase which is considered ‘insoluble’).

The results of the investigations show that a selective determination of aluminium compounds in line with the classification of the recently published assessment criteria is not entirely possible by the choice of a commonly used digestion method. This analytical limitation also affects the evaluation of workplaces based on the measured aluminium concentrations in airborne dust.
Although a differentiated assessment of compounds based on their toxicity appears reasonable, practical challenges arise due to a limited capability for a selective determination of distinct classes of metal compounds. To overcome these challenges, precise and standardized definitions of the substances’ properties (e.g., ‘degree of solubility’) might be expedient.

(O-75)

Evaluation of the passive air samplers PUF and SPMD to mimic firefighters' skin uptake of polycyclic aromatic compounds

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High exposure to toxic and carcinogenic substances in the work environment occurs in many occupations, e.g. steelworkers, chimney sweeps, asphalt workers, sailors and firefighters. One important group of such substances are polycyclic aromatic compounds (PACs): polycyclic aromatic hydrocarbons (PAH), and their alkyl-, oxy- and nitro-derivatives with even higher carcinogenic potency and mutagenicity compared to the parent PAHs. The most common exposure pathways are inhalation and skin uptake from contaminated air and direct skin contact. The main route of exposure for firefighters to PAHs appears to be via skin absorption. It is important to develop and evaluate simple sampling techniques for this profession, preferably based on passive sampling, where traditional sampling techniques are not practically applicable.

We have recently demonstrated that polyurethane foam (PUF) can be effective both as personal passive air samplers for PACs during firefighting exercises and as passive samplers to mimic skin exposure under the firefighters' protective clothing. We are now working on testing semi-permeable membrane devices (SPMDs) as passive air samplers with the aim to simulate skin uptake of PACs during firefighting. SPMDs consists of a polyethylene membrane filled with a film of the lipid triolein. The thickness of the film is 0.1 mm, which roughly corresponds to the thickness of the upper skin layers. The triolein fat at the inside of the SPMD corresponds to systemic uptake into the body.

This study aimed to compare the protection factors for PACs for two different firefighters' protective clothing configurations, a standard type and an innovative adsorptive undergarment. It further aimed to investigate SPMD as a proxy of skin uptake of PACs.

The results showed that the innovative undergarment had a protection factor about 100 times better than the standard type. After a firefighting exercise (smoke diving) of about 1h, the SPMD surface was wiped with a cotton swab, and the membrane and the triolein separated at different times after the firefighting exercise. For the PAH phenanthrene, about 40% penetrated the membrane immediately after the smoke dive and after 8 hours, almost 80% had penetrated. Thus, absorption through the skin can be very rapid.

The project will lead to improvements and safety measures to monitor exposure of toxic substances like PACs through the skin for firefighters as well as other occupational groups with a risk of increased exposure.

(O-76)

Comparative analysis of air sampling strategies for VOC monitoring

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Human exposure to VOCs, such as benzene, is a major public health concern. Many VOCs have been associated with wide range of adverse health effects and exposure can occur anywhere: outside, the workplace and in the home. In this study we compare different sorbent based methodologies for sampling VOCs in air and assess which techniques provide the most comprehensive overview of the air quality and determine how advanced software tools can more easily help analysts process the large amounts of information generated in studies like this.

Four separate sampling sites in India which may have unique VOC profiles (roadside, next to a gas station, industrial area, residential area) were chosen for the sampling study and a range of diffusive and active samplers were installed at each site. Diffusive sampling has the advantage of not requiring any external equipment or power to take the sample and can easily be applied to remote locations or used for extended time periods. Active sampling using a pump is often a more sensitive technique where large air volumes can be collected to enhance sensitivity of the analysis allowing for pg/L concentrations of compounds in air to be quantified.

Once the samples were collected, they were returned to the lab for analysis by Thermal Desorption (TD) - Gas Chromatography (GC) - Mass Spectrometry (MS). TD is a solvent free technique which preconcentrates analytes prior to automated injection into the GC-MS. Samples were analysed in scan mode to enable qualification of unknowns whilst still being able to quantitate target species. The data files were then run through Unknowns Analysis. This presentation will discuss the respective benefits of each sampler and whether there were any distinct benefits when applied to the different locations.

(O-77)

Comparison of passive and active sampling of benzene, toluene, ethylbenzene, and xylenes in the oil and gas industry

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Exposure to benzene is still an occupational hazard in the oil and gas industry. The Norwegian occupational exposure limit (OEL) for benzene has recently been reduced to 0.1 ppm – which, according to the Norwegian legislation gives an OEL of 0.06 ppm for 12h shifts used in the oil and gas industry. Thus, raising the need to more up to date exposure assessment and to measure exposure on tasks which previously might have been overlooked due to presumed low exposure.

The aim of this study was to compare the measured concentrations of benzene, toluene, ethylbenzene, and xylenes (BTEX) in active and passive personal air samples using thermal desorption tubes with Carbopack X adsorbent. During 10 sampling campaigns on onshore and offshore facilities a total of 386 pairs of active and passive air samples were collected. All samples were collected as full shift samples; a full shift is mostly 12 h for employees in the petroleum industries, including eventual overtime. Median sampling time was 670 min and the sampling time varied from 285 to 979 min.

A slightly higher benzene concentration was measured using passive air sampling compared to active air sampling, however, no statistically significant difference between active and passive air sampling was found.

(O-78)

Validation of diffusive sampling methods for nitrogen dioxide concentration measurements in ambient air and at the workplace

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The research project was aimed at validating a diffusive monitoring technique for nitrogen dioxide ambient air measurements and personal exposure monitoring at workplaces, with reference to the EU air quality standard set by Directive 2008/50/EC and the Occupational Exposure Limit Value issued by the Directive 2017/164/EU. The experiments have been conducted following the EN 13528:2003 standard in the range of 15 to 80 µg/m³ for ambient air measurements and following the EN ISO 23320:2022 standard in the range from 95 to 1900 µg/m³ for workplace monitoring. Exposure duration and estimation of the effect of environmental parameters have been tailored to the different applications.

For nitrogen dioxide concentration measurements in ambient air, the diffusive sampler might be regarded as a candidate method for the demonstration of equivalence of ambient air monitoring methods, as described by the EC Working Group report "Guidance to Demonstration of Equivalence" (EC Joint Research Centre, Ispra, Italy, January 2010). The cited document states that "*an Equivalent Method to the Standard Method for the measurement of a specified air pollutant, is a method meeting the Data Quality Objectives for continuous or fixed measurements specified in the relevant air quality directive*", and the currently applied data quality objective corresponds to method expanded uncertainty within ±15% for NO_2 measurements aimed at evaluation of conformity to the limit value of 40 µg/m³.

Workplace monitoring of exposure to NO_2 is recommended in consideration of its properties of severe respiratory irritant, with delayed symptoms surge which may cause less warning and increase the potential for physiological damage when exposures occur. Workers may be exposed to NO_2 in the mining and agricultural sector (silo filler disease, nitrogen fertilizer production), during gas or arc welding, electroplating, or in the food and textile bleaching processes. A simple but accurate device for personal exposure measurements will ensure better workers' health protection by ensuring effective monitoring at actual working conditions and during the entire workday.

(O-79)

Measurement uncertainty? You MUST do it

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The true measurement value is always unknown – no matter whether a distance is measured, or an analytical concentration is determined. Therefore, the measured value is only an estimate which is influenced by various factors. Due to these influences the measured results vary with a specific variance around the measured value. The variation of the results is calculated by the expanded measurement uncertainty (U).

Firstly, national and international regulations for measurement methods controlling limit values at workplaces in industry require the calculation of U. Secondly, the knowledge of U is necessary to compare the performance and quality of the measurement method with other laboratories. Finally, it provides a thorough insight into the measurement process and the quantitative evaluation of the influencing factors. Thus, the calculation of U is a huge benefit: one can show compliance, improve the methods and rely on results based on quantitative data.

The calculation of the expanded measurement uncertainty rests on all available information on the measurement process, especially those gained from the validation. International standards (ISO/IEC guide 98-1:2009) provide methods to quantify this information by means of a mathematical model. The models for several validated standard methods at the IFA laboratories are implemented in a software application: the Measurement Uncertainty Service Tool (MUST). This software can compute U for every measurement, as long as the standard methods are followed.

In this presentation, a measurement method for the determination of manganese in workplace air is described, including the sampling and the analytical procedure (microwave-assisted digestion for sample preparation and mass spectrometry with inductively coupled plasma). In association to the different steps of the method, all influencing factors on the measured concentration are described as well as how their standard deviations are derived by using the method validation, calibration protocols, and standards. With the help of these standard deviations, the mathematical model and the calculation of U is presented step by step. In addition, it is shown how the same calculations can be done by using the MUST application in a convenient, user-friendly way.

The MUST application calculates U and takes the mathematical burden away from the user of standard analytical methods. This facilitates access to the benefits of an uncertainty calculation. It is also constantly extended to include further measurement methods and improved for better quality. To promote the use of software applications for the calculation of U, the IFA provides the MUST application free of charge on their website.

(O-80)

Characterization of occupational air exposure during different metal enrichment processes

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With the increasing demand for new materials, metal mining and enrichment is important processes, together with recycling, to meet current and future needs. But with intensifying extraction processes comes a growing concern for occupational exposure to different airborne particles, which can pose serious health risks to the workers. The mining processes, from either open pit mining or underground mining, are often well characterized in relation to personal exposure, but less so for the enrichment processes.

A field study was therefore performed at a metal enrichment plant in Europe where rock milling, metal separation (through a froth flotation process) as well as dewatering/filtration processes were included. At this mining and enrichment site, the main metal extracted is copper, but gold and silver are also important byproducts. Personal exposure monitoring was conducted on eight workers at the plant over three days (16 measurements in total). Five measurements were performed for the rock milling process, six for the froth flotation process, three for the dewatering/filtration process and two measurements were performed for personnel handling oil lubrication in the whole enrichment plant. Both time-integrated filter sampling of inhalable and respirable dust fractions, and time-resolved instruments including Partector2 (Naneos) and SidePak AM520/AM520i (TSI Inc.), were used to measure the exposure in the personal breathing zone of the workers. The filters were analyzed both gravimetrically and for metal content, and the time-resolved instruments were used to identify specific work tasks generating high particle concentrations. Complementary to the personal exposure monitoring, stationary measurements were performed with an XACT 625i X-ray fluorescence (XRF) analyzer, providing time-resoled elemental analysis, together with several other time-resolved instruments as well as a 12-stage impactor for offline size resolved metal measurements.

The gravimetrical results from the personal filters showed that the geometric mean (GM) of the inhalable dust was 2.60, 1.71 and 0.51 mg/m^3 for personnel working at the rock milling, froth flotation and dewatering/filtration processes respectively. From the metal measurements, copper was shown to be remarkably high in relation to the EU occupational exposure limit (OEL) for the respirable fraction (10 µg/m^3) in the whole enrichment plant, with all 16 samples showing values of 11-97 % of the OEL. The GM of copper was 2.78, 5.39 and 2.11 µg/m^3 for rock milling, froth flotation and dewatering/filtration processes respectively. Worth noting is that all personnel in the enrichment plant worked without any breathing protection, except for short periods when they walked into the rock crusher or the reagent mixing room, but not during the rest of their time in the plant. Other metals present in high abundance were aluminium, iron, and zinc. Lead was detected in all samples, in both inhalable and respirable fraction, but in relatively low concentrations compared to the EU OEL of 100 µg/m^3 for the inhalable fraction. Silver was also detected in 15 inhalable samples, but in low concentrations. Gold was not measured.

These results provide important input for the company to assess the working environment and implement active measures to improve and minimize airborne metal exposure for the workers. Suggestions include installing process ventilation and incapsulate the processes where possible.

(O-81)

Evaluation of size and composition of particulate matter generated at multiple copper processing operations in Europe

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Although mined for centuries, copper (Cu) has now been deemed one of many critical minerals due to its important application in transitioning to greener energy sources. With this heightened demand for Cu and the objective to contribute to a circular economy, Cu production is rapidly growing, and operations now process a variety of Cu materials from ore (primary sources) to recycled products (secondary sources). During mining and concentrate production, operations are required to monitor Occupational Exposure Limit Values (OELVs) from dust emissions to ensure the health and safety of workers and to limit contamination to the environment. The European Commission's Scientific Committee on Occupational Exposure Limits (SCOEL) has recently proposed to reduce the OELV several fold more stringent than existing limits; however, a recent longitudinal health surveillance study of workers at Cu smelters suggest no adverse health effects on lung function with exposure at operating conditions over the last 20 to 30 years. Given the variety of materials that are processed across Europe, exposure to workers will differ between operations.

To understand the relevance of the proposed limit on a multi-operational scale, a characterization study was performed on dust exposed to workers at multiple facilities (smelters and refineries) that process different types of Cu materials (Cu ore and secondary sources of Cu powders containing Cu oxides and hydroxide minerals). Respirable and inhalable dust was sampled from workers performing key dust-generating activities around the operations. The dust was characterized using a combination of automated mineralogical analysis and chemical assay. An apportionment of Cu by species was determined for respirable and inhalable fractions. The results show significant differences in the composition of dust generated from feed materials entering the operations, but similar characteristics in composition and particle size around furnace and refining activities. At each operation, only minimal total Cu is present in the respirable dust, however, the ratio of respirable Cu to inhalable Cu differs widely between operation and activity.

During high-temperature furnace and smelting activities, more fugitive dust emissions are created, and the amount of respirable dust increased with the presence of elements that have a lower vapor pressure such as Zn. Where Cu was present in respirable fraction, Cu oxides were the dominant species.

These findings suggest that the interpretation of toxicology and health surveillance studies that focus on exposure to Cu oxides are relevant for setting occupational health limits and will be conservative given that the oxides are considered the most toxic Cu species in respiratory health. However, the nominal OELV derived for the respirable fraction should account for the variable ratio of respirable to inhalable Cu observed across multiple operations and processing activities.

(O-82)

Determination of quartz in bulk samples by X-ray diffraction with internal standard method

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Respirable crystalline silica has been known to cause silicosis and lung cancer. This is the reason enough to test materials used in the workplace for their quartz content. Analysis using X-ray diffraction has become an established analytical method.
X-ray diffraction analysis is influenced by several factors. In addition to instrumental factors, the specific properties of the sample come into play.
For quantitative analysis by X-ray diffraction, the desired grain size of the material should be between 1 and 10 µm (less can lead to a widening of the reflections, greater influence distribution of the intensity of the reflections (see figure 1)).
Additionally, accompanying components in the materials can have an attenuating or amplifying effect on the detected quartz signals due to their mass attenuation coefficient. The quantification with an internal standard is one method to compensate this effect. Different evaluation methods can be used (calibration graph and reference intensity ratio approach).
Various aspects should be considered when selecting the internal standard. Although the mass attenuation coefficient can also have a relevant influence here, it has been shown that peak overlaps (see figure 2) are much more problematic. For this reason, various internal standards should be used for quantification purposes (e. g. anatase, corundum).
Furthermore, it is important to note that the peak deconvolution have a significant impact on the quantification.
For analyzing bulk samples mainly infinite thickness specimens are used. In the prevention sector in Germany, however, only thin-layer preparation is currently used. For this reason, the various influencing variables for both preparation techniques were examined and the effects that occurred were compared with each other.

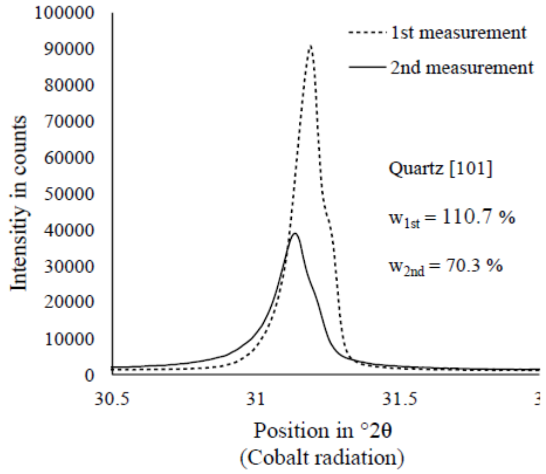

Figure 1: Detail view of two diffractograms at the position of the main reflection of quartz with insufficient comminution (dotted line) and with optimum particle size distribution (solid line) attained by additional comminution.

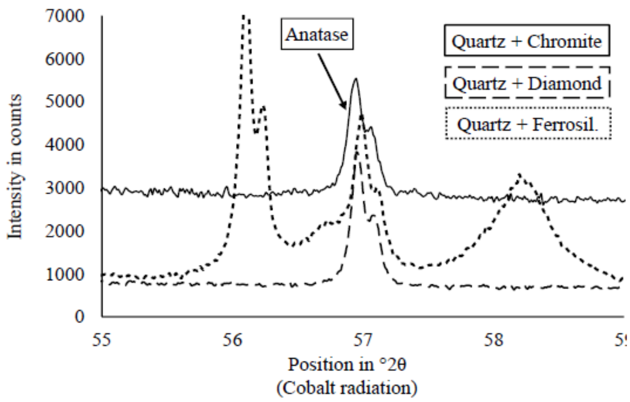

Figure 2: Detail view of three diffractograms of bulk samples (chromite, diamond and ferrosilicon) mixed with anatase as internal standard. The clearly visible peak overlap of anatase and ferrosilicon results in a significant underestimation of quartz.

(O-83)

An evaluation of validation schemes for the direct-on-filter X-ray diffraction method for analysis of respirable crystalline silica

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Silicosis is an occupational lung disease caused by exposure to respirable crystalline silica (RCS). Silicosis has no cure, so preventing it is essential. Recent increases of the incidence of silicosis have led some jurisdictions to reassess the occupational exposure limit values (OELV) for RCS. Lower OELV require better performance of analytical methods, i.e. lower limits of detection (LOD) and quantification (LOQ) and analytical uncertainty. Currently, several different schemes are being used for the validation of RCS analysis methods, because the international method standards do not impose a specific validation protocol. Analytical laboratories have a commercial incentive to publish the lowest possible LOD and LOQ for their methods. Yet not all validation schemes are equivalent, and some give unrealistically low limits. This fosters a false perception of confidence in the capabilities of RCS analysis, which may ultimately lead to OELV that are beyond analytical feasibility at the performance requirements for compliance testing.

Because XRD analysis gives no measurable signal at zero analyte content, LOD and LOQ from repeated measurements of blank substrates, which is the most used validation method, are highly subjective and generally substantial underestimations. Therefore, a validation protocol based on repeated measurements of samples with the lowest possible spike of analyte is recommended. This contribution will demonstrate using data from systematic validation measurements that this lowest-spike protocol yields reliable and reproducible LOD and LOQ values. Another major advantage of the lowest spike protocol is that it allows for determining the validation parameters in the presence of a mineral matrix that interferes with the determination of RCS. It will be shown that some common interferences can dramatically raise the limits of detection and quantification.

(O-84)

Mineral composition as a function of particle size in airborne dust samples from indoor demolition

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Exposure to respirable crystalline silica (RSC) is known for adverse health effect. An increase in renovation and repurposing of buildings are changing the potential occupational exposure in the construction industry. Workers are exposed to a mix of inorganic dust and other components from demolition and rebuilding. More knowledge on the specific distribution of silica in airborne dust may offer a better understanding of RCS exposure.

Sioutas cascade impactor was used to collect airborne dust from five different construction sites with indoor demolition of brick and concrete structures. The collected dust was analysed for quartz with X-ray diffraction using the NIOSH 7500 method. The crystalline composition was further determined by Rietveld refinement. The measured silica content at each impactor stage was compared with personal respirable samples from the same location and material samples collected from the demolished materials. An aerodynamic particle sizer (APS) was used as a reference method for size distribution in the size range 0.54 µm – 17 µm.

The silica percentage of the dust was found to increase with increasing particle size. The dust from Sioutas samples and personal samples all contained less crystalline silica than the source material.

(O-85)

Consensus recommendations for aerosol sampler selection

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Measurements are the basis of exposure assessments used to determine risks to workers. Samplers for measurement of aerosolized substances have been developed over more than 120 years. Each new design has been intended to address flaws perceived in earlier designs, but, once marketed commercially, samplers have only rarely been withdrawn. Users, therefore, are faced with a varied array of samplers from which to choose the most appropriate one(s). Sampler testing in the laboratory and comparisons in the field has been carried out, and, in some cases, there is more than 50 years of experience with certain sampler types, but standardized testing of sampler performance has not been widely adopted.

Therefore, published test results are difficult to compare, most especially between the laboratory and the field. However, such a large body of work does allow some conclusions to be drawn regarding performance, and these are reported in the commentary. In addition to performance characteristics, environmental influences, and even the design of a sampler and how it must be handled in the field and laboratory can have an enormous influence on the results obtained. Cost, ease of use and ease of setting flow rates also have an impact in selecting between different samplers with similar performance. In this commentary, common inhalable and respirable aerosol samplers are, considered with regard to these issues and recommendations, made for their best use in the field. However, there is not one aerosol sampler, either for the assessment of the inhalable fraction or the respirable fraction that can be used for all situations. The range of available samplers constitutes a toolkit from which the most appropriate sampler can be selected for a given specific situation.

(O-86)

Validation results of a multi-fraction sampler for recovering inhalable and respirable dust mass, and metals in workplace air

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A 2019 Worksafe BC-funded study of sampler performance for adequate collection of workplace metals to meet occupational exposure limits (OELVs) evaluated the performance of the disposable inhalable sampler with foam (DIS C+F) in measuring inhalable and respirable dust mass, and workplace air metals, through a combination of laboratory and field evaluations. The DIS C+F was tested alongside other commonly used samplers, including the IOM sampler and closed-face cassette sampler for the inhalable fraction and the PPI and Cassella cyclone for the respirable fraction, to determine its efficiency and accuracy in collecting metals and metalloids in occupational exposure assessment surveys.

The results indicate that the DIS C+F performed comparably to other inhalable samplers, particularly the IOM sampler, in both laboratory and field settings. In field studies, the DIS C+F yielded higher concentration results compared to the IOM sampler, potentially due to improved retention of wall deposits and reduced sample loss. In addition, the foam insert provided an effective means of separating respirable particles in line with established size-selective criteria for workplace exposure monitoring, although it always gave the highest results, which may indicate that respirable samplers also suffer from internal wall deposition and sample losses.

The ability of the DIS C+F to measure both inhalable and respirable fractions in a single device suggests its potential for streamlined workplace air monitoring applications, reducing the need for multiple sampling devices. Overall, the DIS C+F demonstrates a high degree of utility in occupational exposure assessment for metals and metalloids with occupational exposure limit values in both inhalable and respirable fractions. Further research into the stability of foam inserts, their size separation efficiency and their impact on gravimetric and elemental analysis is ongoing. This includes testing at higher sample flow rates to reduce the method's limit of detection and quantification.

(O-87)
Sampler selection tool

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Previous work of the ISGC has shown that many industrial hygiene (IH) professionals do not read sampler validation studies in scientific literature. Their perception is that all samplers on the market must have been validated, and that workplace specific sampler validation is not required. Sampler selection is therefore all too often based on availability and tradition. Many IH professionals also rely on the laboratories they work with for sampler selection advice. Yet, analytical experts in labs are not always sampling experts. Hence, there is a need for a 'quick and easy' sampler selection guide.

This contribution will explain the concept of the 'Sampler Selection Tool' that is currently being developed within the framework of ISCG. The Sampler Selection Tool is web based, so that it is always and everywhere accessible available to hygienists, without charge. It is being designed to provide the user information on sampler performance at different levels: from very basic level (e.g. "I don't care, just tell me what to use") to specialist level (e.g. "I need the references for the bias map of sampler X"). The general concept of the tool is that a user enters a number of characteristics and parameters of the workplace he/she intends to sample to get a ranked list of suitable samplers. The ranking is based on a metric for suitability (fitness for purpose) of the sampler, and on the availability of performance characteristics for the sampler (level of validation). The double metrics enables the user to identify suitable but poorly characterised samplers and those that were extensively studied. The metrics are based on weighted scores for each sampler on a broad list of characteristics, covering for example performance parameters like 'bias from the sampling conventions' but also convenience indicators like 'ease of use on site' or 'local availability (distributor network)'. The parameter database of the tool is populated with data from the scientific literature and by scores and weights given by a panel of objective experts in aerosol sampling. All data, sources and criteria used for weighing and scoring will be made available to the user.

The ISCG Sampler Selection Tool will be a dynamic source of information, meaning that it should always reflect the most recent insights and not be a snapshot of the state-of-the-art, like a review paper. It is intended to help users make a more informed choice of samplers for specific purposes and will thus help generating the awareness that not all samplers perform equally at all workplaces. Anonymous usage statistics of the Sampler Selection Tool will also help the ISCG in its prioritization of future research on sampler performance.

(O-88)

The Western Australian sampler comparison project

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Whilst there is an increasing number real time and near real time particulate monitoring devices on the market, and most people involved in aerosol exposure assessments have access to these devices, there is limited impartial information describing their performance.

In this study a variety of real time and near real time devices have been mounted on the Workplace Aerosol Multi-sampler (‘WAM’), a previously validated device which rotates up to 12 devices per run, allowing comparison of results. The WAM has been located at iron ore mines sites in Western Australia.

In this presentation, the results of approximately 30 runs of the WAM, which included several (near) real time devices, compared to the appropriate conventional sample device (i.e. cyclone for respirable, and IOM sample head for inhalable) will be reported.

The results of the research indicate a series of strengths and limitations of the real time devices which should be considered when planning their use, and interpreting the results.

(O-89)

Aerosol sampler performance - laboratory protocol development and related field studies

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Previous work by ISCG members and our partners included the development of sampler performance laboratory testing protocols for inhalable and respirable aerosol samplers. After preliminary testing and follow-up workshops, there are important questions that remain regarding how to best harmonize such protocols.

Further work is still needed to optimize such protocols, which will require careful prioritization of which studies should be conducted to that aim. Relatedly, recent field-based sampling work by ISCG members has also highlighted issues related to how best to relate laboratory sampler performance to field-based sampling results.

Therefore, the overall objective of this ongoing work is to continue to optimize laboratory testing protocols while making more direct connections between the lab and field work.

13 Short Course Abstracts

(SC-1)

Human biomonitoring basic

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Human biomonitoring (HBM) is a method of assessing human exposure to chemicals by measuring the concentrations of chemical substances in human body fluids or tissues. It is an effective instrument to support policies and actions on chemical safety.

Everyone is exposed to hazardous chemicals as they are present in the air, in water and in the soil, in consumer products and at the workplace. Hazardous chemicals can cause a variety of health disorders that affect reproductive, nervous, respiratory, cardiovascular and immune systems, and can cause cancer, diabetes and other metabolic problems. Young children are especially vulnerable to the harmful effects of chemicals.

HBM helps to evaluate whether and to what extent a group of population is exposed to harmful substances, to identify risks and to recommend risk-reduction measures as needed.
A course explaining the fundamentals of HBM can be used for training public-health and health-care professionals, students of medical, biological and other allied sciences, and decision-makers in the health, environment and occupational sectors.

The course will start form the basics of toxicokinetics and toxicodynamics and explore the types of possible biomarkers. Then how to plan and conduct HBM studies will be examined starting from the prioritization of chemicals, followed by the selection of target population and biomarkers, HBM ethics, Sampling size, Laboratory analysis and Data management and analysis.
The last part will focus on the interpretation and evaluation of results.
The course is based on the WHO educational course on human biomonitoring prepared in collaboration with several leading HBM experts (1), as promoting the use of HBM is a recognized priority of chemical safety globally and in the WHO European Region.

References:

1- Human biomonitoring. Basics: educational course, World Health Organization. Regional Office for Europe. **ISBN:** 9789289060097. **WHO Reference Number:** 9789289060097

(SC-2)
Behaviour of particles in the human respiratory tract and in sampling instruments

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Dust sampling at workplaces has been started in the 1950- and 1960-ies. The aim was sampling dust fractions, which cause occupational diseases. The first occupational disease was silicosis (acknowledged in the year 1929 in Germany), other occupational diseases have been detected and acknowledged. Medical research has identified areas in the human respiratory tract as starting areas (total respiratory tract, bronchial tree, alveoli) for several occupational diseases. Consequently, the first conventions for dust sampling have been developed.

Studies on total deposition of particles in the human respiratory tract have been started by C. N. Davies in the late 1960-ies and afterwards by several working groups worldwide. In the same time M. Lippmann et al. began studies on the regional deposition of particles in the human respiratory tract. W. Stahlhofen et al. started additional studies on regional deposition some years later.

The new conventions on particle fractions contained in the standards EN 481 and ISO 7708 are based on all data on inhalability, total and regional deposition available in the late 1980-ies. These standards have been published in 1993.

The conventions for dust fractions beyond the inhalable fraction include the exhalable fraction.
In practice “old” samplers for “total dust” can be used for sampling the inhalable fractions, but limited to air speeds below 3m/s. Meanwhile new personal samplers and static point samplers have been developed for sampling the inhalable fraction of airborne dust.

“Old” samplers for sampling the respirable dust are also in use for sampling the alveolar fraction, the differences to ideal samplers for the alveolar fraction have been regarded as acceptable.
It is necessary, that instruments for sampling all fractions simultaneously are equipped with an inlet sampling the inhalable fraction in order to separate the subfractions correctly
.
If the airborne dust contains “soft” agglomerates, for sampling the alveolar fraction, samplers operating with low separation forces may be preferred.

(SC-3)
Low-cost sensors for air quality monitoring

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This short course introduces the use of novel low-cost sensor (LCS) technologies for air quality monitoring and exposure assessment. As air pollution remains a critical global health and environmental challenge, advancements in sensor technology have enabled cost-effective, high-resolution monitoring solutions that complement traditional regulatory networks.

The course will cover key aspects of LCS technology, including sensor principles, deployment strategies, calibration techniques, data quality control, and integration with reference-grade monitoring. Participants will gain practical insights into sensor performance evaluation, bias correction methods, and the role of machine learning in enhancing data reliability. Additionally, the course will explore real-world applications in urban air quality management, citizen science, and personal exposure assessment. The course will use the guidance from the CitiObs tools and toolkits.

At the end of the session, attendees will have a better understanding of LCS capabilities and limitations, as well as hands-on knowledge of best practices for handling air quality sensor network data. The course is suitable for researchers, policymakers, environmental professionals, and community stakeholders interested in innovative approaches to air pollution monitoring.

We acknowledge funding for CitiObs project from the European Union's Horizon Europe research and innovation programme under grant agreement No.101086421.

(SC-4)
Measurement strategies for airborne biological agents at the workplace

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The exposure of workers to airborne microorganisms and related compounds (*i.e.* bioaerosols) has been shown for a wide range of occupational activities and associated with health disorders among exposed workers. For some work situations, the measurement of personal exposure to bioaerosols may significantly contribute to prevent biological risks. The design of the measurement strategy is of crucial relevance in the context of occupational risk prevention, as it enables the implementation of efficient and effective protection means for workers' health.

The aim of the short course is to share expertise and knowledge, both practical and theoretical, about the strategies used for measuring airborne biological agents in the workplace. The implementation of measurements is considered above all in the general context of the management of biological risk at occupational settings. The measurement strategy of bioaerosols is part of a broader structured approach that aims to answer an initial question, itself linked to an occupational risk prevention issue. The final objective is to answer this prevention question, in particular by providing information on risk assessment and proposing an action plan to reduce risks.

The short course recalls the absence of OELvs for bioaerosols and reviews published reference documents dealing with measurement strategies. Measurement is placed in the context of a broader structured approach. Firstly, a look is given at the ins and outs of the preliminary survey, which gathers all the useful and available information and enables making an initial qualitative assessment of the work situations under study. This initial work may be sufficient to answer the initial question without the need to carry out measurements. If not, measurements should be considered. The short course then focuses on the measurement strategies themselves, detailing their different components. The first concerns the measurement objectives, which have to be specified. These objectives can vary considerably from one study to another, and the measurement strategy itself must be designed to be consistent with them. The second relates to the design of a measurement strategy and details all the components of measurement campaigns including those for the measurement plan (*e.g.* biological agents and substances to be measured, categories and number of workers, at which location, when, for how long, how many samples to be taken, sampling and analytical methods, stationary *vs* personal, measurement, etc.) and those for the collection of contextual information (information to be collected on site, the method and medium for their collection, the exposure determinants, etc.). The benefits of deploying other tools (real-time measurement devices; video monitoring, biodiversity studies, etc.) are also discussed. The third deals with the deployment of the strategy on site and details the practical and material aspects. The last component of strategy deals with the interpretation of measurement results, a crucial and often tricky stage in the absence of OELvs for biological agents.

The one-and-a-half-hour course is punctuated by both statements of the theoretical aspects and role-playing exercises. Priority is given to providing the audience with the opportunity to participate actively in the theoretical and practical aspects of defining and implementing measurement strategies as well as to express their views on the issue.

(SC-5)
Biological monitoring is more than the analysis of biomarkers

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In Europe biomonitoring research was done to study worker's exposure and develop strategies for occupational health and safety. More recently, biomonitoring has gone through an accelerated development due to the Human Biomonitoring Initiative (HBM4EU) as a partnership between the European Commission and the member states (1). In the United States biomonitoring activities were upscaled in the NHANES programme that started in the 1990's (2). Both programmes aimed at capacity building to support and infrastructure of prospective monitoring in general population. In this short course we will try to show how these developments in occupational and environmental applications of biomonitoring are interconnected can lead to synergies.

In the tradition of the Airmon conferences we will discuss to what extent biological monitoring complements environmental monitoring and can provide added value. For this we will start to describe how biomonitoring can support the interpretation of bioavailability and bio(de)activation of hazardous substances. In many cases measurement of different types of biomarkers can support a link between external exposure and internal dose as an indicator of an early effect, supporting a link between exposure and predicted health outcome. Some examples will be provided to show how biomonitoring can have added value in an occupational or environmental setting. E.g. worker's exposures biomonitoring can be applied to study dermal absorption or more in general how indirect uptake can be prevented by improved personal hygiene. In the general population biomonitoring can contribute to a better understanding of aggregate exposure, defined as the study of uptake of xenobiotics from different sources by different routes of exposure (3).

The aforementioned research efforts have resulted in improvements of analytical capability to detect and quantify very low concentrations of xenobiotics in human matrices using harmonized methods and further improving analytical performance. However, the analysis of random or 'convenience' sampling may lead to difficulties because the laboratory results themselves do not provide the contextual information for a meaningful interpretation. For that we need a well-prepared study design with well-justified decisions on the choice of biomarkers, preferably in a prospective monitoring programme that may require involvement of controls to support interpretation. So, we will not focus too much on the technicalities of sample collection and analysis but more on the study designs needed to support meaningful interpretations of our biomarker findings to answer our research questions.

References:

1. Ganzleben C et al. Human biomonitoring as a tool to support chemicals regulation in the European Union. Int J Hyg Environ Health. 2017 Mar;220(2 Pt A):94-97. doi: 10.1016/j.ijheh.2017.01.007. Epub 2017 Feb 22. PMID: 28284775.

2. Calafat AM. The U.S. National Health and Nutrition Examination Survey and human exposure to environmental chemicals. Int J Hyg Environ Health. 2012 Feb;215(2):99-101. doi: 10.1016/j.ijheh.2011.08.014.

3. Hopf et al. A harmonized occupational biomonitoring approach. Environ Int. 2024 Sep;191:108990. doi: 10.1016/j.envint.2024.108990.

(SC-6)
Occupational exposure monitoring: Samplers and monitors for particles

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The determination of exposure to hazardous substances is often related to sampling particles in air besides gases. Occupational exposure limit values for particulate matter are linked to a health-related dust fraction: inhalable, thoracic or respirable dust (EN 481, ISO 7708). A collection of worldwide OELVs can be accessed at https://ilv.ifa.dguv.de/substances. Aerosol samplers shall follow these conventions. An inhalable dust sampler usually has one orifice or a ring slot where the dust enters, thoracic or respirable dust samplers need a more effective separation mechanism. This can be achieved by a cyclone effect, impaction, sedimentation or by open cell foams. Dimensions of such samplers depend on the applied air flow. Applications are for static and personal sampling, sampling pumps usually need to be added. The measurement strategy defines the place, sampling duration and repetition to allow a representative assessment of worker's exposure. Determination of fibres in workplace air require a slightly differing measurement setup. A suitable filter with sufficient retention is mounted into the sampler, either in a transportable cassette or directly without holder.

For more information on time dependence of the exposure concentration, direct reading instruments can find helpful application. For particulate aerosol detection different physical principles are used. Some allow the direct determination of the particles' mass like oscillating elements or beta-ray attenuation. An acceleration of particles and measuring the resulting velocities makes a measurement of the aerodynamic diameter possible and gives particle size distributions. The main applied principle is scattering and attenuation of light, e.g. used in photometers and optical particle counters. These methods need to have a calibration for each different dust when mass concentrations are derived. This principle makes cheap and small devices be manufactured for a large market. Looking for ultrafine particles, other principles need to be used. Condensation particle counters condense alcohol or water vapour onto the particles and get them counted by optics, while diffusion chargers and differential mobility analysers use electrical charges on the particles to determine size and number.

The use of such direct-reading instruments gives additional information directly on site but is usually not suited for compliance measurements against mass concentration limit values as the physical properties of the particles are highly varying. Questions for the efficiency of control measures, discovering sources of particles and on the distribution of concentrations in a larger working hall can be answered with the use of such sensors (see also CEN/TR 16013), especially when they have low prices. Such solutions can open the field of big data for a broad exposure assessment in relation to chemical and physical hazards.

EN 481: Workplace atmospheres; size fraction definitions for measurement of airborne particles. CEN 1993
CEN/TR 16013-1: Workplace exposure. Guide for the use of direct-reading instruments for aerosol monitoring. Choice of monitor for specific applications. CEN 2010

(SC-7)

Building knowledge to guide industry in planning, conducting, and interpreting occupational exposure assessments

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This short course is designed to inform researchers and laboratory staff on how to assist industries in selecting the most appropriate assays for evaluating occupational exposure to chemicals, identifying critical workplaces, and interpreting the resulting reports. The course will draw on the experience of INEGI in providing services to industrial companies in the assessment of occupational exposure to airborne chemicals.

Main Course Objectives:

- Address the most frequently asked questions raised by companies to INEGI regarding occupational exposure assessments.

- Introduce and discuss strategies for guiding companies that wish to conduct an exposure assessment but do not yet have a risk management plan in place, and are uncertain about what to measure, how to assess, where to focus, and the duration of the assessment.

- Provide guidance on how to assist companies in accurately interpreting exposure data. This includes understanding the outcomes of assessing combined exposure to chemicals with similar toxicological effects, as well as recommendations on necessary or advised biomonitoring based on the environmental data collected.

- Conduct practical exercises: Case studies, safety data sheet analysis, and real report evaluations.

(SC-8)

Pulmonary surfactants and the fate of inhaled particulate matter

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In this course, we will summarize some of the most useful models, materials, methodologies and parameters that are being used to characterize pulmonary surfactant activity in the absence and presence of potential toxic molecules and/or particles. We will go from simple biophysical measurements to the last generation of sophisticated lung-on-chip setups. Particular focus will be made to approaches that could be used to replace a large fraction of animal experimentation. A last group of experimental methods will be selected to illustrate how to evaluate the interfacial delivery capabilities of surfactant towards different drugs, toxics and particulate matters, a major contribution of surfactant towards air quality assessment.

(SC-9)
Sampling, analysis, and monitoring emerging air pollutants in workplace

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Workplace air quality is facing new challenges as the industrial landscape evolves. Alongside traditional airborne hazards such as welding fume, lead, and mold, a growing array of emerging air pollutants, including engineered nanoparticles, respirable crystalline silica (RCS), micro- and nano-plastics, and infectious bioaerosols are becoming increasingly prevalent in occupational settings. These pollutants originate from various industries, including advanced manufacturing, construction, recycling, additive manufacturing, and biotechnology, among others. Due to their unique properties, such as ultrafine particle size, complex chemical composition, or biological activity, these emerging pollutants pose distinct challenges for exposure assessment, health risk characterization, and regulatory control.

For airborne particulate hazards, traditional gravimetric methods using filters with cyclones or impactors remain a cornerstone for mass-based sampling. Such methods are especially effective for RCS and microplastics when size-selective sampling is required. However, these methods often lack time resolution and cannot capture dynamic changes in exposure environments. Complementing gravimetric sampling, a wide range of real-time direct-reading instruments (DRIs) and low-cost sensors have emerged. They can provide high-resolution data on particle number, size distribution, and trends.

Rapid chemical and physical characterization of emerging pollutants is crucial for understanding their composition and potential toxicity. Infrared spectroscopy, particularly Fourier-transform infrared (FTIR) spectroscopy, provides a rapid and non-destructive method for directly identifying RCS and polymer-based microplastics on filters. Laser-based Raman spectroscopy is increasingly used for the identification of nano- and microplastics, providing both chemical specificity and size information. Raman spectroscopy also supports the analysis of nanoparticles and engineered nanomaterials, especially metal oxides and carbon-based materials.

Continuous real-time monitoring is crucial for dynamic work environments, such as construction sites, additive manufacturing facilities, and laboratories. Optical particle monitors, which utilize light scattering techniques, are widely deployed to monitor the particle number concentration and size distribution of fine and ultrafine particles.

The increasing volume, complexity, and multidimensionality of data generated by modern instruments necessitate advanced data processing tools. Machine learning (ML) approaches are becoming increasingly vital for interpreting sensor signals, correcting for environmental interferences, identifying patterns, and predicting exposure trends. For example, ML algorithms can enhance source apportionment, differentiate between process-generated particles and background aerosols, identify episodic emission events, and help remedy the deficiencies of low-cost instruments.

As workplaces continue to adopt novel materials and advanced manufacturing processes, the need for robust methods to sample, monitor, and analyze emerging air pollutants is critical. Integrating traditional sampling methods with advanced analytical tools and real-time monitoring, provides a powerful framework for comprehensive exposure assessment. Such approaches are crucial for developing evidence-based regulations, informing engineering controls, and ultimately safeguarding worker health.

14 Poster abstracts

(P-1)
OMEGAone: A digitalization benchmark for workplace exposure assessment

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The OMEGAone project represents a transformative step in modernizing workplace exposure assessment and stands as a model for digital innovation in occupational health. As part of the German Social Accident Insurance (DGUV) strategy, OMEGAone replaces fragmented, paper-based workflows with a fully integrated, mobile, and networked digital platform. This innovative system is designed for collection, documentation, and analysis of workplace exposure data, enabling a more precise and efficient evaluation of hazardous substances in the air of workplaces. By doing so, it strengthens the ability of accident insurance institutions to fulfill their prevention mandates while supporting regulatory compliance and advancing occupational health practices. At its core, OMEGAone consolidates diverse tools and processes into a unified platform, fostering seamless collaboration among over 300 professionals, including measurement technicians, laboratory staff, and quality assurance employees. Its modular, service-oriented architecture ensures scalability and adaptability to evolving technological and regulatory demands. By enabling real-time data entry and analysis, OMEGAone improves data quality, reduces manual errors, and provides actionable insights through structured and scalable analytics. The platform's design also supports mobile devices, empowering users to enter data directly from on-site measurements, enhancing both usability and operational efficiency. Preliminary evaluations underline the system's measurable benefits, including significant reductions in workflow times and enhanced user satisfaction, as evidenced by an impressive Net Promoter Score (NPS). These results confirm that OMEGAone not only meets but exceeds the needs of its diverse user base. Additionally, its integration with complementary tools such as MEGAinnovativ for advanced analytics and MEGApublic for public transparency initiatives illustrates its potential to serve as a foundational element in a broader ecosystem for occupational health innovation. OMEGAone's development reflects the combination of scientific data collection and practical applicability. The project incorporates cutting-edge methodologies, drawing on decades of expertise within the DGUV and its partners. By setting new benchmarks for the digitalization of workplace safety, OMEGAone highlights the DGUV's ambitions in addressing the challenges of a rapidly evolving work environment. The system has already garnered significant international interest and was recently showcased at the Partnership for European Research in Occupational Safety and Health (PEROSH) as a pioneering example of digital transformation in occupational health systems. This poster will provide an in-depth overview of the system's architecture, development process, and evaluation metrics while exploring its implications as a scalable, adaptable, and internationally applicable model for occupational health systems. OMEGAone is more than a technological upgrade; it is a transformative approach to managing workplace safety in the digital age. Through its innovative design and measurable impact, the project sets new standards for efficiency, data quality, and stakeholder engagement, paving the way for future advancements in exposure assessment and prevention strategies.

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https://perosh.eu/wp-content/uploads/2024/09/OMEGAone-Accuracy-Development-of-Ergonomic-Work-Equipment.pdf

(P-2)
Determination of quartz by direct-on-filter analysis of FSP-10 samples

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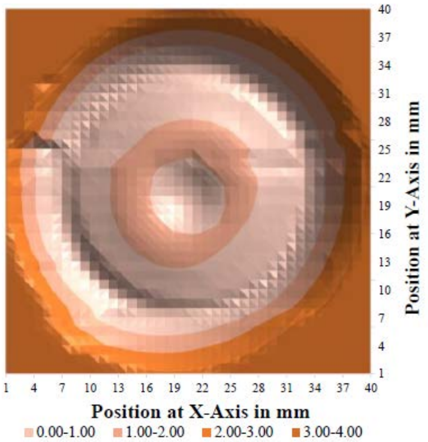
Respirable crystalline silica has been known to cause silicosis and lung cancer. Therefore, it is necessary to analyse dusts from workplaces for their quartz content. In Germany two methods for measure quartz are established using X-ray diffraction or FTIR. Both methods need an extensive sample preparation (dust transfer to silver filter or KBr-pellet) which causes a time gap of several weeks before results are available. In some cases, a rapid determination of results is required. Therefore, an alternative determination using direct-on-filter method (DoF) should be developed for use with FSP-10 sampling.
As the sample holders available on the market were not suitable for the DoF method, a system was developed to enable inhomogeneous filter loading to be characterised. It was designed so that the clamped filter could be moved along the X and Y axes perpendicular to the IR beam.
Also, a suitable filter medium for analysis by FTIR had to be found. In addition to the CN filter used in Germany, PVC and PTFE filters have been studied to see how they affect the quartz double band region. The PVC filter was found to be suitable, as has been confirmed by previous studies. If PVC filters are used, due to the large variability in filter weight per unit area, the need for different reference filters for background correction must be considered.
Different filters were loaded with quartz (SF800 material from Quarzwerke GmbH, Frechen) in a dust channel of the IGF (Institute for Research on Hazardous Substances of the BG RCI in Dortmund) with use of FSP-10 sampling systems. It was expected that selection of different points of measurement on the filter would lead to different quartz contents being measured. To describe this relationship and enable it to be evaluated for use in practice, the entire loaded area of one PVC filter was analysed at intervals of 1 mm along the X and Y axis (see figure 1). In practice, it is not possible to determine the absorption over the entire loaded filter area. To enable low quartz contents to be quantified, a measuring point on the filter with the highest possible dust loading was to be used for the analysis. This maximum loading is located at one point
The quantification is based on the creation of a calibration curve in which the evaluated signal (e.g., the integral) is plotted against the known quantity of the substance being measured. The masses determined by the KBr-pellet method were used because the gravimetric determination of the quartz mass is subject to greater uncertainty. From the data obtained it was possible to deduce that at least 25 µg of quartz must be present on the filter for quantification by DoF. In comparison, a minimum of 5 µg is sufficient for the KBr-pellet method. In the first experiment, quantification was tested on samples from a well-defined working area. Signal overlap and the use of different evaluation methods proved to be important factors. Further extensive testing is required before DoF can be used in practice.

Figure: Distribution profile of ring deposition by FSP-10 sampling on a PVC filter.



(P-3)
Uptake rates of VVOCs on passive sampling systems in the indoor air – GerES

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The identity and concentration of volatile contaminants are important factors in ensuring a healthy indoor environment. Volatile organic compounds (VOCs) in indoor air can be determined by using passive samplers that are exposed to the air for a well-defined period of time. This sampling method is often used in environmental surveys, e.g. the German Environmental Survey (GerES). [1] Conclusions about indoor air concentrations can be drawn from substance and adsorption material specific uptake rates. For the assessment of indoor air quality, highly volatile organic compounds may also be substantial, but for many of these substances realistic uptake rates and suitable analytical methods are lacking. A small chamber is used to generate gas atmospheres with constant concentrations of the analytes at 23 °C and 50 % relative humidity. For a large number of compounds, a very small flow of pure liquid VVOCs is introduced into the chamber via a syringe pump and mixed with a constant flow of clean and humidified air. A gas mixture from cylinders is also used for this purpose. Carbograph 5TD has already been proven as a suitable sorption material for active sampling for most of VVOCs. [2] With this procedure up to 55 different VVOCs should be tested in this study.

Table. Average values of the determined effective uptake rates U_{eff} and experimental diffusion coefficients D_{exp} on Carbograph 5TD tubes and an exposure duration of 7 days.

acetone		**2-butanone**		**methyl acrylate**	
U_{eff} [mL*min^{-1}]	D_{exp}	U_{eff} [mL*min^{-1}]	D_{exp}	U_{eff} [mL*min^{-1}]	D_{exp}
0,274	2,149	0,462	3,345	0,471	3,698
± 4,9%		± 4,7%		± 4,9%	

Stable concentrations of gas phase atmospheres of the first group of VVOCs (acetone, 2-butanone, methyl acrylate) were produced for exposure of passive samplers. Comparison of different adsorbent materials showed that Carbograph 5TD was the most suitable for passive sampling of these substances, with higher uptake than Carbopack X and Tenax® TA. Very strong adsorbents are not suitable for this experimental design as it adsorbs larger amounts of water. The effective uptake rates were calculated for the first three VVOCs on Carbograph 5TD tubes and an exposure time of 7 days. The same experiment will be performed for all VVOCs and ideally one material should be the best option for all of them.

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2. Even et al. 2023 *https://doi.org/10.1016/j.aca.2022.340561*

The project is funded by the UBA REFOPLAN programme under FKZ3724377070

(P-4)

Development and validation of a method for measuring toluene diisocyanate in accordance with the ACGIH® inhalable fraction and vapor (IFV) notation

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Isocyanates are widely recognized as irritants and sensitizers, and their occupational exposure must be controlled to reduce risks to worker health. The American Conference of Governmental Industrial Hygienists (ACGIH®) threshold limit value (TLV) for toluene diisocyanate (TDI) is 1 ppb (7 µg/m³) (8 hours) and 5 ppb (36 µg/m³) (15 minutes), with the notation inhalable fraction and vapor (IFV). [1] This notation means that exposure to TDI must be assessed for both the inhalable fraction (particles) and the vapor. Currently, there are very few sampling methods available in Canada and the United States that have demonstrated their ability to measure TDI levels according to the IFV notation.

This presentation will describe a newly developed method for evaluating airborne TDI concentrations comparable to the ACGIH® TLV and its IFV notation. The new sampling method uses an IOM sampler (stainless steel cassette) with a glass fiber filter coated with 1,2-(methoxyphenyl)piperazine (MP) and diethyl phthalate. The sample is extracted using acetonitrile and analyzed by UPLC-MS. This application of the IOM sampler for such a reactive chemical was characterized and tested in laboratory to ensure efficient TDI recovery from both spiked samples and air samples. Based on a sampling time of 2 hours, the method has a measuring range of 0.08 to 15 µg/m³. At its limit of quantification, the method is capable of measuring 2% of the 15 min short-term TLV. Method comparisons were performed under laboratory-controlled conditions and in the workplace atmosphere with two reference methods: OSHA 5002 and ISO 17334-1.

1. ACGIH. 2021 TLVs and BEIs : based on the documentation of the threshold limit values for chemical substances and physical agents and biological exposure indices. Cincinnati, Ohio: American Conference on Government Industrial Hygienists (ACGIH®); 2025. 279 p.

(P-5)

Qualitative and quantitative analysis of crystalline silica by differential scanning calorimetry (DSC)

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Polymorphic transformations during heating will cause the silica to pass from one form to another, leading to changes in density or specific crystallographic properties. The objective of this study is to evaluate the feasibility of the identification and quantification of crystalline silica by measuring the heat fluxes related to the phase transitions between the different polymorphs.
First tests have been carried out using either pure standard minerals or in a mineral matrix, heated between 20 and 1600°C. For crystalline silica, endothermic peaks are observed around 250°C for cristobalite and around 570°C for quartz. These peaks correspond to the transition of the α-β forms of cristobalite and quartz respectively (Figure 1). These transitions are reversible (β-α transition during cooling).

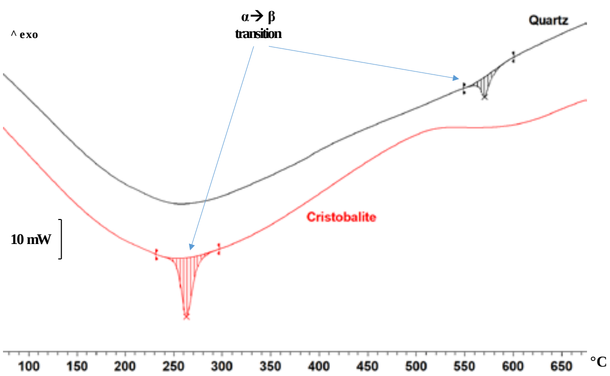

Figure 1. *α to β phase transition for cristobalite (red curve) and quartz (black curve).*

Occurrence of this transition thus makes it easy to distinguish the presence of crystalline silica and the type of polymorph present in the sample. The heat flux related to the α-β transitions calculated by integrating the surface of the endothermic peak is shown to proportional to the amount of crystalline silica and can therefore be used for a quantitative approach (Figure 2). The performance of this method in terms of selectivity and sensitivity has yet to be compared to reference methods such as XRD analysis.

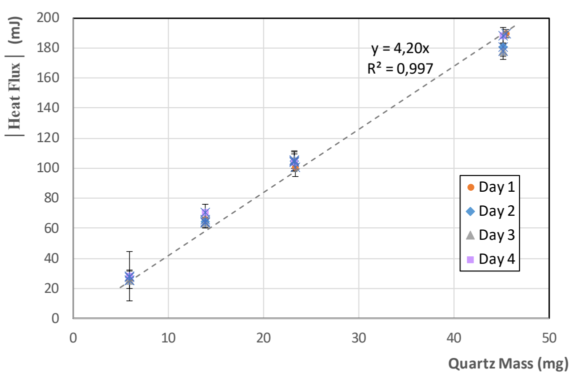

Figure 2. *Relationship between quartz mass and α-β transition heat flux (errors bars = 1 SD)*

(P-6)

Evaluation of the performance of Raman spectroscopy for the determination of different forms of silica. Comparison with French regulatory techniques

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The first aim of this study was to review the literature to assess the feasibility of qualitative and quantitative analysis of different forms of silica using Raman spectroscopy. It was found that this method could effectively be used to identify and distinguish between different polymorphs of crystalline silica as well as amorphous silica. However, in the case of natural samples or mixtures, the interpretation of the results obtained quickly becomes difficult.

After this review, the second phase of this study was to determine experimentally the performances of crystalline silica analysis by Raman spectroscopy. The performances observed in terms of sensitivity are very encouraging. Limits, such as fluorescence or presence of interferences, have however been highlighted. Other influential parameters have also been identified and characterized (particle size, choice of sampling medium, diameter of the deposit, etc.). A semi-quantitative method based on cartography rather than averaging data is also proposed. More data are expected to upgrade this method to obtain quantitative results.

Compared to French regulatory methods, namely XRD and FTIR, laboratory Raman spectroscopy allows reaching a limit of detection up to 10 times lower. The use of mapping would also likely improve these results. This would then permit us to anticipate a potential reduction of an OEL and enable a reduction of sampling times.

We also show in this study that Raman spectroscopy allows analyzing samples encapsulated in a thin film of prolene, which permits to eliminate the risk of contamination for operators and instruments during handling, analysis and storage.

Handheld Raman spectrometers also seem to be efficient enough to perform direct on-site analysis, at least for semi-quantitative analysis, this would allow us to assess the risk directly on-site, enabling the constant protection of the operator while saving significant time for the company.

(P-7)

High-volume sampling of simultaneously occurring aerosols and vapour – is that possible?

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A variety of substances with a higher vapour pressure can occur simultaneously as aerosols and vapours. To ensure adequate collection, special samplers are required to capture the particles as well as the gaseous phase. Various sampling systems have been developed for this purpose, which unfortunately lack suitability for high flow rates in combination with an inlet for the inhalable fraction.

To determine chemical substances consisting of a mixture of airborne particles and vapours, a new high-performance sampling device with a flow rate of up to 10 litres per minute is presented here. This sampling device consists of a filter and a downstream sorbent bed and fulfils the requirements according to DIN EN ISO 23861:2022:

- an inlet for inhalable aerosols according to the EN 481
- a flow resistance shown to be acceptable for the appropriate pumps
- a minimum of dead volume and accessible surfaces ensured by a linear orientation and direct connection of the collection substrates
- a minimized loss of the analyte by proper handling of the substrates after sampling.

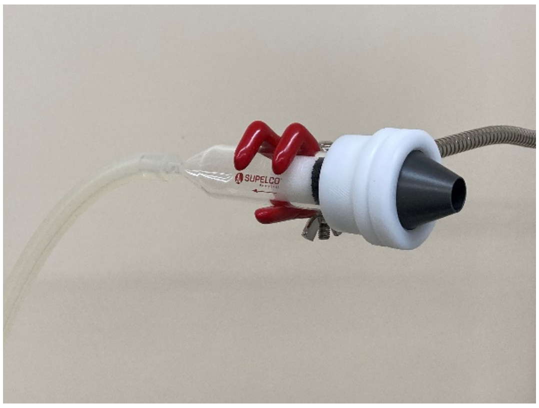
This so-called "GGP-Maxi" sampler is an advancement of the "GGP-Mini", a miniaturised and fully validated sampler, developed by the Institute for Occupational Safety and Health of the German Social Accident Insurance (IFA) to collect airborne particles as well as vapour. In contrast to the GGP-Maxi, the capacity of the GGP-Mini is per definition rather low and the flow rate is limited to a maximum of 0.5 litres per minute.

As basic component we chose a commercially available sampler, which is designed to collect PCBs or polychlorinated pesticides by ASTM or EPA methods. It consists of a glass tube, typically containing a polyurethane foam and an upstream attached cartridge bearing a glass fibre filter. To ensure the collection of the inhalable aerosols, the cartridge was modified by attaching a different front element enabling the use of special orifices, provided by IFA. The orifices differ in inner diameter and therefore allow for the use of different flow rates. The glass tube itself can be filled with one or two sections of a suitable type and amount of sorbent, each secured by a foam plug.

We have validated this sampler according to our scopes, e.g., quantifying aerosols of a glycol compound used as cleaning fluid or aerosols occurring as exhalates of waterpipe smokers.

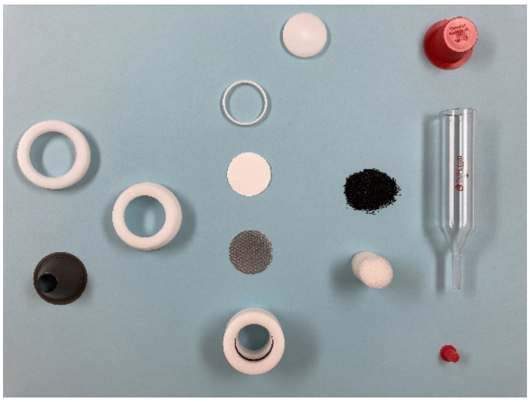
We demonstrate that the GGP-Maxi is a very versatile tool that can be used especially when short-term sampling is necessary or large quantities of a hazardous substance are occurring.

Figure 1



Sampler, equipped with a 10 L/min orifice

Figure 2



Sampler components, blind plugs included

(P-8)

Design and investigation of a high flow personal sampler for respirable fraction

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Sampling for the purpose of determining dust exposure in the workplace is always conducted actively by means of samplers. For the respirable dust fraction, the most common are cyclone samplers and nowadays there is a variety of personal cyclone samplers, which operate at flow rates from 1 l/min up to 10 l/min. The main objective of this work is to develop a cyclone sampler operating at a flow rate of 20 l/min that meets the sampling efficiency curve, determined by respirable convention EN481. This is realized using experimental measurements and Computational Fluid Dynamics (CFD).

First, three different cyclone designs were computationally investigated. For aerosol flow modelling the Euler-Lagrange method was applied where the continuous air phase is treated with Large Eddy Simulations (LES), whereas the dispersed phase is treated in a Lagrangian approach. Numerical simulations have been validated based on experimental data on penetration.

The cyclone design which showed the lowest deviation in the sampling efficiency curve compared to the respirable convention was manufactured and experimentally tested. The measurements of the particle penetration were performed at two institutes using different experimental setups and particle measuring devices, aerodynamic particle sizer APS 3321 and optical particle counter (OPC) Welas 3000. The measured sampling efficiency curves at a flow rate of 20 l/min are shown in the Figure.

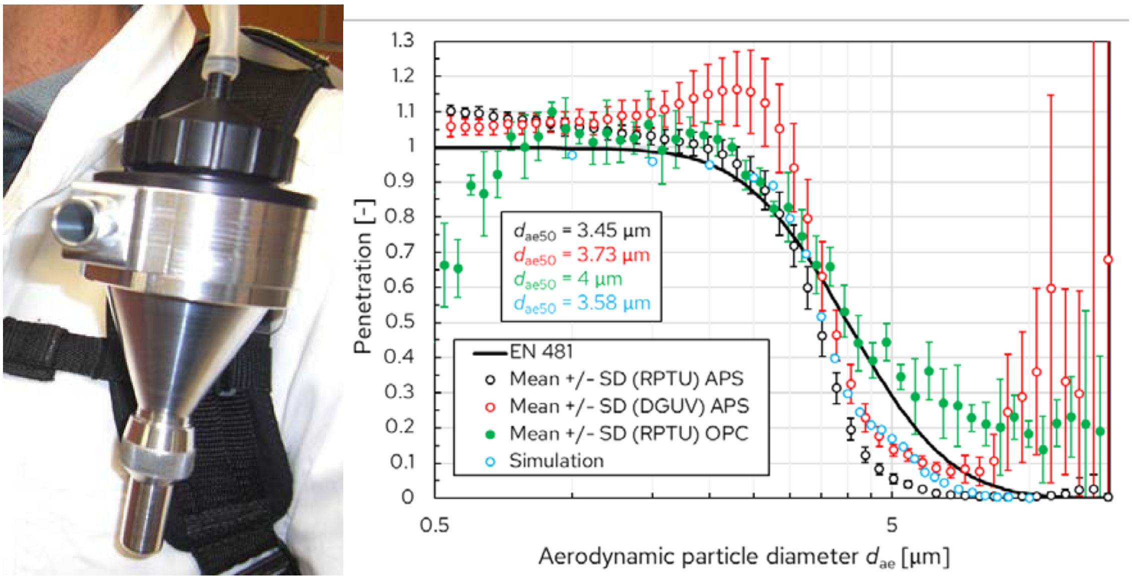

Figure. The GK sampler for a flow rate of 20 l/min and its sampling efficiency measured with APS and OPC at two institutes, RPTU and DGUV, and determined from simulations.

This work was supported by the German Social Accident Insurance (DGUV) under project FP-0484.

(P-9)

Study of OPC-N3 low-cost sensors: Suitability for occupational exposure assessment

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Low-Cost particles Sensors (LCS) initially developed for environmental applications, are booming due to their low cost (< €500), miniaturization, low energy consumption and non-existent maintenance (because they are “disposable”). These light-scattering based devices provide real-time information on mass concentration and in some cases the size distribution, making them theoretically promising tools for measurements in workplaces. However, many questions remain regarding their performance, and their inability to measure mass concentrations based on occupational health metrics (respirable, thoracic and inhalable), which limits their adoption by users.

A growing number of LCS are available on the market, but many of them are unable to detect and/or classify particles in the 2.5-10 µm size range[1-4]. Performances are also limited in the 1-2.5 µm size range. LCS have a “particle counter” behaviour[1], so correct particle classification is the foundation of reliable mass concentration measurement. To our knowledge, only the OPC-N3 produced by Alphasense appears to be able to classify particles correctly[4] and to perform measurements in high concentration environments (PM_{10} up to 10000 µg.m^{-3} according to the manufacturer), making it an interesting LCS for occupational exposure assessment.

In this study, the performances of OPC-N3 were evaluated in laboratory and field campaigns for real-time workers’ exposure assessment. Concentration linearity, size selectivity and the ability to report aerosol particle size distribution were assessed. The ability to estimate mass concentrations according to occupational health metrics were also studied.

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(P-10)

Towards metagenomic approaches to the molecular characterization of indoor air

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Conventional diagnostic microbiology is increasingly complemented by sequencing-based methods, such as second or third generation sequencing. The former relies heavily on microbial cultivation and isolation for identification, and is hence limited. The latter lacks standardization with respect to indoor air measurements.

The different sequencing technologies, and applied experimental methodologies, i.e., amplicon based or whole genome sequencing approaches, all come with their respective strengths and weaknesses, affecting downstream data processing and analyses. Short reads obtained by second generation sequencing are of high accuracy, but data processing is computationally intensive. Long reads generated by third generation sequencers are beneficial in the *de novo* assembly and metagenomics, despite their lower raw read accuracy. Sequencing data of environmental samples itself is difficult in analysis and interpretation, due to e.g., technically introduced bias, compositionality, and available databases, especially with respect to quantitative assessments. However, these are required for a thorough assessment of bioaerosols in indoor environments, including the assessment of microbial load with potentially adverse effects on human health.

Despite a vast portion of microbial diversity eluding cultivation-based approaches, relevant known human pathogens are culturable. Hence, the combination of molecular identification by DNA sequencing and established quantitation using cultivation-based approaches may bridge the gap towards the application of true metagenomics, i.e., whole genome sequencing approaches for a comprehensive description of indoor bioaerosols.

(P-11)
LIBS – An advanced spectroscopic method for microplastic identification

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Microplastics are an escalating environmental threat due to the widespread use and durability of plastics. These particles, which are byproducts of various industries, pose risks to ecosystems and human health. Effective biomonitoring is crucial to mitigate their impact [1].

In this study, we explore the potential of Laser-Induced Breakdown Spectroscopy (LIBS) for microplastic biomonitoring and its advantages. LIBS shows promise for direct microplastic analysis, as highlighted by Pořízka et al. [2], who highlighted its ability to differentiate polymer types based on signal response. This technique also enables classification through variations in CN and C_2 band intensities. Moreover, it shows potential for classifying microplastics according to different stages of aging [2]. One of the key objectives of our research is to optimize the parameters for LIBS analysis of microplastic and apply LIBS for detecting microplastics in biological tissues.

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(P-12)

Speciation of organotin compounds in workplace air samples via HPLC-ICP-MS

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Organotin compounds (OTCs) rank among the most used organometallic compounds and have been utilized in various industrial sectors for several decades. Although they are widely regulated due to their severe effects on human and ecosystem health, there is still a risk of exposure to OTCs at some industrial workplaces. Therefore, in Germany occupational exposure limits are specified for 23 OTCs. The degree of toxicity of OTCs varies considerably depending on the number and type of organic substituents. As a result, the speciation of different OTCs is of great interest in the fields of consumer protection, environmental and occupational health.

In terms of available analytical methods mostly gas (GC) or liquid chromatography (LC) coupled to mass spectrometry are employed. While GC methods offer a higher peak resolution of more compounds, HPLC methods excel due to minimal sample preparation without the need of an error-prone derivatization. The coupling to mass spectrometry with inductively coupled plasma (ICP-MS) stands out due to its particularly high sensitivity. Previously published HPLC-ICP-MS methods describe a separation of maximum seven compounds using a simple binary gradient.

Tropolone is an organic compound combining aromatic, ketonic and hydroxylic functionalities which is soluble in both water and organic solvents. Due to its electronic structure, it forms mono- and bidentate complexes with various mono-, bi- and trivalent metal cations. This makes it a suitable complexing agent for liquid chromatography in metal speciation to selectively manipulate the retention of specific compounds.

This work shows the influence of varying α-tropolone concentrations on the chromatographic separation of OTCs in a ternary eluent and flow rate gradient consisting of methanol, acetonitrile, and acetic acid (6 % v/v) in ultrapure water. This newly developed HPLC-ICP-MS method achieves a separation of the eleven OTCs monomethyltin (MMT), monobutyltin (MBT), monooctyltin (MOT), monophenyltin (MPhT), dimethyltin (DMT), dibutyltin (DBT), diphenyltin (DPhT), trimethyltin (TMT), tributyltin (TBT), triphenyltin (TPhT) and tetramethyltin (TTMT) within 22 minutes using a C18 reversed phase column.

(P-13)

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 about their local sources and temporal trends. Most 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 samplers for bulk 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 the Norwegian capital, Oslo. Samples were collected in 2023, 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. Tire wear particles (TWP) dominated the samples from Oslo, suggesting that car traffic is the predominant source of airborne microplastic contamination in urban areas. While TWP and Nylon dominated the samples from Birkenes, nearly all 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. In general, Arctic samples exhibited lower MP deposition fluxes than samples from the Norwegian mainland.

(P-14)

HBM4EU – E-Waste study: Occupational assessment to chromium, cadmium, mercury and lead during e-waste recycling

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Recycling of electronic waste (e-waste) can release harmful substances such as chromium, cadmium, mercury and lead, causing occupational exposure to workers involved in these processes. The aim of this study was to gather new information and exposure data by investigating the internal and external exposures of workers processing e-waste.

Institutes from eight countries collected samples from 195 workers involved in the recycling of i) lead batteries, ii) white goods, iii) brown goods, iv) metals and plastics and v) miscellaneous worker roles. In addition, 73 unexposed workers also provided samples (control group). Urine, blood and hair samples were collected, alongside industrial hygiene data consisting of personal air samples, hand wipes and contextual information.
Workers from all five types of e-waste processing showed evidence of exposure to lead (primarily lead battery workers followed by metals and plastic workers). The lead results were elevated in all matrices, and high ($r = > 0.7 - \leq 1$) positive correlations between both internal and external markers were found.

Some work-related exposure to cadmium and mercury was observed, however, correlations between markers were low. Low-level cadmium exposure was found in workers across all five categories of e-waste processing when compared against the control group. Exposure to mercury, although low-level, was found mainly in brown goods workers. The results show that chromium had the lowest work-related exposure.

This study has highlighted exposure concerns when processing e-waste, particularly for lead across all waste categories, indicating a need for improved control measures in this sector.

(P-15)

MRSA environmental surveillance: The need for standardized protocols

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Methicillin-resistant Staphylococcus aureus (MRSA) is a major cause of infections, with airborne transmission playing a crucial role in its environmental spread. While healthcare settings remain high-risk areas, the increasing presence of community-associated MRSA (CA-MRSA) and livestock-associated MRSA (LA-MRSA) in diverse environments raises new public health concerns. This systematic review assessed MRSA contamination in different environmental reservoirs, focusing on transmission pathways and sampling methodologies.

A literature search was conducted using databases such as PubMed, Scopus, and Web of Science, identifying 95 studies that reported MRSA detection through environmental sampling.

MRSA was detected in healthcare settings (N=19), aquatic environments (N=13), wastewater treatment plants (N=5), public and occupational settings (N=11), and farms/veterinary hospitals (N=27). The growing presence in public and agricultural environments highlights the need for broader surveillance beyond hospitals.
A review of sampling methods showed substantial variability. Active air sampling (27 studies, 28%) included impaction, filtration, and impinger techniques with diverse culture media and filter types. Passive sampling (84 studies, 88%) was more common, using settled dust, electrostatic dust cloths, settle plates, dust wipes, and swabs. The lack of standardized protocols complicates data comparability and limits risk assessment accuracy.

The widespread detection of MRSA across environments underscores the importance of airborne transmission. While healthcare settings remain hotspots, increasing contamination in public and agricultural areas demands harmonized surveillance protocols. Standardizing air sampling techniques, culture media, and resistance profiling is essential for effective monitoring. A One Health approach integrating human, animal, and environmental interactions is crucial to mitigating airborne MRSA transmission and antimicrobial resistance risks. Future research should prioritize standardized methodologies to enhance global monitoring and control efforts.

(P-16)

Occupational exposure to respirable dust and quartz during tunnel excavation with tunnel boring machines

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Tunnel boring machines (TBMs) are large underground factories which are used to excavate tunnels. During excavation of the tunnels, several procedures are carried out simultaneously, including lining of the walls with concrete segments and injection of concrete and/or pea gravel fill in the spaces between the rock and the segments. When TBMs excavate the bedrock, fine mineral dust is generated. Depending on petrology, the mineral dust that the TBM workers are exposed to may contain respirable quartz particles. Respirable particles can be inhaled into the alveolar region of the lung and long-term exposure to respirable quartz particles may lead to lung diseases.

Respirable dust and quartz exposure measurements were performed for workers on two TBMs drilling from either side of a 20-kilometer water supply tunnel in the Oslo area. Rhomb-porphyry, basalt, shale, and limestone are among the rocks that predominate in this region. Stationary equipment, including an aerodynamic particle sizer (APS), was used to measure particle concentrations in the tunnel. To date, 209 personal respirable dust samples were collected during 6 sampling campaigns (autumn 2023 - winter 2025). In addition, samples from the bedrock were collected. The dust collected with respirable samplers and the rock samples were analyzed for their quartz content using X-ray diffraction (XRD).

The geometric mean (GM) of the respirable dust concentration was 0.47 mg/m^3, and the GM concentration for quartz 0.013 mg/m^3. There are, however, large variations, which may be caused by different duration of drilling throughout the shift, varying work tasks, and differences in quartz content in the bedrock as the TBM advances. Preliminary analysis shows that drilling time during the shift is a significant factor determining the dust and quartz concentration on the TBMs. The APS measures also clearly demonstrated that TBM drilling activities influenced the particle concentrations in the tunnels. Shift bosses, erectors and pea gravel operators are the workers with the highest exposure to respirable quartz. The respirable dust contained an average of 3.1 wt. % quartz. The quartz content of the rock samples varied from <LOD up to 13 wt. %. The pea gravel contained much higher levels of quartz, close to 40 wt. %.

It is important to note that even relatively low quartz contents in the rock may lead to significant exposure to respirable quartz. Effective dust suppression measures are necessary to control the dust levels on the TBM.

(P-17)

The influence of diet on biological monitoring in the arsenic occupational exposure assessment

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Arsenic (As) is a ubiquitous element found in soil, rocks, water, and food. Occupational exposure to As and its compounds can occur in a variety of work settings. In the general population, the major source of As is the diet through the consumption of fish, seafood, seaweed, and rice where it is primarily present as organic forms such as arsenobetaine, arsenocholine or arsenosugars and, to a lesser extent, as monomethylarsonic acid (MMA) and dimethylarsinic acid (DMA). In the occupational exposure assessment by biological monitoring, the total arsenic in urine does not allow the differentiation of As derived from diet and occupational exposure components.

This study aimed to evaluate the potential exposure to As for a group of workers where high urinary total As levels were found by the determination of As species to differentiate potential occupational exposure from extra-occupational factors.

The study involved a cohort of 34 exposed workers and 32 controls. For each subject, urine samples were collected at three time points: Monday morning before work, Friday after work, and the following Monday morning. In addition to total As concentration, the species AsIII, AsV, MMA, DMA, and arsenobetaine were measured using HPLC-ICP-MS. Urinary creatinine was measured spectrophotometrically for result normalization. Participants completed a questionnaire on their dietary habits in the 48 hours preceding sample collection.

Elevated levels of total urinary As were found in samples from both groups (exposed: 2.4-592 µg/L; controls: 2.2 - 575 µg/L). Arsenobetaine was the predominant As species (exposed <0.5 - 454 µg/L; controls: <0.5-500 µg/L). The sum of the toxic As species (AsIII, AsV, MMA, DMA) was below the ACGIH BEI of 15 µg/g creatinine (95th percentile of levels found in the non-occupationally exposed general population) in 98% of exposed workers (range 0.6-26.9), and in 97% of controls (range <0.5-34,0 µg/g creatinine). Notably, on Friday after potential occupational exposure, the sum of the toxic As species was below the BEI (range <0.05 – 8.30 µg/g creatinine) in all exposed workers. No statistically significant differences were observed between the sum of these species measured in exposed and controls during the three days and nor considering all data collectively. A strong correlation was observed between urinary total As and arsenobetaine in both exposed workers and controls. The study highlights the importance of selecting appropriate biomarkers and gathering information on non-occupational exposure sources when assessing occupational exposure to As through biological monitoring. The determination of total As can lead to false occupational exposure assessment conclusions, especially after consuming fish or other seafood, resulting in a significant overestimation of health risk. The determination of the different As species and the evaluation of the sum of inorganic As (AsIII and AsV) and methylated species (MMA and DMA) represents a better method for assessing occupational exposure.

(P-18)

Assessment of personal $PM_{2.5}$ exposure of children living in Bandung, Indonesia and Kathmandu, Nepal

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$PM_{2.5}$ (particulate matter with an aerodynamic diameter of 2.5 micrometers or smaller) air pollution is recognized as a significant contributor to the global burden of disease. $PM_{2.5}$ air pollution is particularly important to children's health due to its significant impacts on respiratory health and overall well-being.

Children’s exposure to $PM_{2.5}$ in two highly polluted cities (Bandung, Indonesia and Kathmandu, Nepal) was investigated over a week-long period. The exposure monitoring campaigns were focussed to address the following research questions: 1) What are the $PM_{2.5}$ exposure levels for children living in Bandung, Indonesia and Kathmandu, Nepal?; 2) What environments/activities lead to their highest $PM_{2.5}$ exposures?; 3) What similarities or differences in $PM_{2.5}$ exposure are there between the two study populations?

Low-cost $PM_{2.5}$ sensors (PurpleAir) and GPS devices were carried by the children in custom designed backpacks. Questionnaires were deployed to the children’s carers and teachers to gather information about the household and school environment, as well as the child’s routine. Sixty-one children were recruited from four schools and PurpleAir sensors were also installed outdoors at each school to measure ambient $PM_{2.5}$ concentrations.

Comparison with WHO guidelines suggests these children are regularly exceeding recommended levels of $PM_{2.5}$. Personal exposure levels in the home were found to be high but no specific source driving these elevated concentrations was identified. In terms of commuting, travelling by scooter or walking exposes children to the highest $PM_{2.5}$ levels. Car or bus commutes expose children to lower concentrations, but the longer duration of these commutes might offset this benefit. The air quality in school classrooms was found to be better than the other microenvironments but $PM_{2.5}$ concentrations were still high compared to WHO guidelines.

The results of our study emphasise the urgent need for effective interventions to protect children from high pollution levels.

(P-19)
Characterization of selected elements and element species in size resolved urban aerosol samples by (HPLC-)ICP-MS/MS

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The health effects resulting from the deposition of PM in the respiratory tract depend on the dose received, the site of deposition, and the body's response to the deposited particles. Particle deposition models indicate that respiratory tract deposition is highly dependent on the size of aerosol particles (Bartley and Vincent, 2011). Among the components of urban PM, metallic compounds – especially their different species - are less investigated compared to other compounds.

In the presented study, size-resolved urban aerosol samples were analyzed using state-of-the-art analytical techniques, including high-performance liquid chromatography (HPLC) coupled to inductively coupled plasma mass spectrometry (ICP-MS). To gain useful information on concentration levels of different elements (primarily metals) and some of their species in urban aerosol size fractions; elements: such as lithium (Li), sodium (Na), magnesium (Mg), aluminium (Al), potassium (K), calcium (Ca), phosphorus (P), sulphur (S), vanadium (V), chromium (Cr), manganese (Mn), iron (Fe), cobalt (Co), nickel (Ni), copper (Cu), zinc (Zn), rubidium (Rb), strontium (Sr), arsenic (As), molybdenum (Mo), selenium (Se), cadmium (Cd), tin (Sn), antimony (Sb), tungsten (W), thallium (Tl), lead (Pb), bismuth (Bi) and uranium (U), as well as some arsenic species were determined in the PM size fractions.

Urban aerosol samples were collected in winter and summer periods in two European capitals. For the PM sample collection, a Model 125R NanoMOUDI-II™ (Microorifice Uniform Deposit Impactor; MSP corporation, TSI, Shoreview, MN, USA) and DLPI (Dekati® Low Pressure Impactor; Dekati Ltd., Kangasala, Finland) were used in Oslo and Budapest, respectively. Both impactors were equipped with 5 µm pore size polycarbonate (PC) foils (Merck Millipore, Burlington, MA, USA). The PC foils were greased (either with Apiezon-L grease or DS-515 Collection Substrate Spray) to prevent the bouncing of the particles during collection.

PM-loaded foils were cut into two halves. 50% of each PC foil was used to determine the total elemental content. The other half of each filter was used to quantify As species. For total element determination, foils were digested in an ultraCLAVE III microwave digestion system (MLS GmbH Mikrowellen-Labor-Systeme). Furthermore, Standard Reference Material (SRM) 1648a Urban Particulate Matter (National Institute of Standards & Technology), a set of digestion blanks and a set of foil blanks were digested with each set of samples. For the determination of organoarsenicals, namely trimethylarsine oxide (TMAO), dimethylarsinate (DMA), methylarsonate (MA), and total inorganic arsenic as arsenate a combined extraction and oxidation technique was used. An Agilent 8900 triple quadrupole ICP-MS/MS (Agilent Technologies, Santa Clara, CA, USA) was used for determining total element concentrations. An HPLC system was coupled to the ICP-MS/MS for the arsenic speciation analysis (Tanda *et al.*, 2019).

Information on elemental concentration levels and the distribution of these elements between different urban aerosol size fractions are presented at the conference. The information on the distribution of elements (and element species) allows us to have a better estimate of the dose of elements that may deposit in the human airways after exposure to urban air. Furthermore, regarding arsenic speciation analysis, the data obtained from both locations, particularly from Oslo, may provide new insights into the topic of arsenic biovolatilization.

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(P-20)

Reprogramming of the GESTIS-ILV and GESTIS-AMCAW databases: optimisation and modernisation of the IFA's information systems

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In the past, finding suitable measurement methods was difficult due to the large number of method descriptions from different institutions and organisations. The Council Directive 98/24/EC on the protection of the health and safety of workers from the risks related to chemical agents at work therefore requires standardised methods for the measurement and assessment of airborne concentrations of hazardous substances in the workplace. Under the leadership of the IFA, the database **GESTIS** - **A**nalytical **M**ethods for **C**hemical **A**gents at **W**orkplaces (GESTIS-AMCAW) was developed in 2005, listing suitable, validated measurement methods from various international institutions and organisations. For each substance, a list of methods has been compiled, in which the most important characteristics of the methods are listed. These include the principle of the method, i.e. the sampling conditions and sample preparation, the analytical method, the limits of quantification and detection (LOQ and LOD), the working range of the method and the associated expanded measurement uncertainties.

In 2022, the database was relaunched using a modern programming language and its content was updated. The change of programming language is reflected not only in a more modern interface and a more appealing web design, but also in improved maintenance. It is now possible to correct errors in real time.
The database currently (as of January 2025) contains over 600 different measurement methods for 141 hazardous substances. These methods are evaluated for suitability and quality based on European norms and standards.

The **GESTIS** - **I**nternational **L**imit **V**alues (GESTIS-ILV) database allows a quick comparison of occupational exposure limit values for inhalation exposure in Europe and overseas in a clear tabular form. In accordance with national regulations in Germany, the database is an important tool for assessing inhalation exposure to hazardous substances at workplaces without a national assessment standard. As GESTIS-ILV addresses an international user group and is maintained in cooperation with many partners worldwide, the database content is only available in English.
The reprogramming made the web application responsive, allowing the database content to be used offline regardless of the mobile device, eliminating the need for mobile native applications. This will also allow content revision cycles to be reduced. Up to four content updates per year will be offered to ensure that hazardous substance entries are up-to-date and of high quality. Another significant functional improvement is that errors in the content of the database can now be corrected in real time.

The current valid version (as of January 2025) contains a compilation of 34 limit value lists from 28 countries for a total of 2,319 hazardous substances. In addition to the assessment criteria published in Germany, it contains the indicative occupational exposure limit values and the binding limit values of the European Commission, as well as the national lists of 17 other European countries and ten countries from Africa, Asia, Oceania and North America.

(P-21)
Monitoring of exposure to polyamide powders used for additive manufacturing processes: laboratory emission and toxicity testing

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Additive manufacturing (AM) is a rapidly evolving technology that has transformed the design and fabrication of components across a wide range of industries. AM enables the production of complex geometries with a high degree of customization by building objects layer-by-layer directly from digital models. AM technologies have evolved in the last years with the emergence of new processes, novel materials, and increasing demand for different applications. Among these, advanced materials are specifically designed to allow superior properties than traditional materials, to be utilized in high-technology applications. High-performance polymers like polyamide 12 (PA12) have significantly impacted on the capabilities of AM, particularly on those techniques that employes it in powder form to produce complex and robust parts.
Despite the increasing adoption of these novel manufacturing techniques, comprehensive studies on airborne emissions monitoring and related exposure remain limited. The nature and quantity of these emissions are highly dependent on material, processing conditions, and technique employed. This is particularly relevant in occupational settings, where workers may be exposed to airborne particulate by-products, raising concerns about air quality in manufacturing spaces and related health effects, making workplace monitoring essential for risk assessment and mitigation.
This study investigates airborne emissions associated with the handling of PA12 powders used in 3D printing applications, combining laboratory simulations in controlled environments and real-time measurements.
Commercial PA12 powders were characterized using scanning electron microscopy (SEM) and Dynamic Light Scattering (DLS) analysis to determine their morphology and size distribution. Particle emissions were monitored by simulation of handling activities of PA12 powders in an isolated and controlled laboratory environment (Figure 1a). Real-time instruments were used to quantify total particle number concentration (PNC) and size distribution resulting from powder dispersion.
PNC (Dp < 1 micron) level during the powder dispersion resulted doubled compared to the background (Figure 1b). No significant contribution of particles in the nanometric size range (1-100 nm) has been highlighted in the controlled environment.
To evaluate the potential health risks associated with inhalation exposure, an in vitro toxicological assessment was also conducted. The cytotoxicity of PA12 powder was tested using HBEC-3KT bronchial epithelial cells, chosen for their relevance to the respiratory exposure pathway in occupational settings.
Additional real-time measurements conducted during a desktop 3D printing session by using PA12, could be useful to assess potential emissions of airborne particles during the different stages of the process in a realistic work environment.

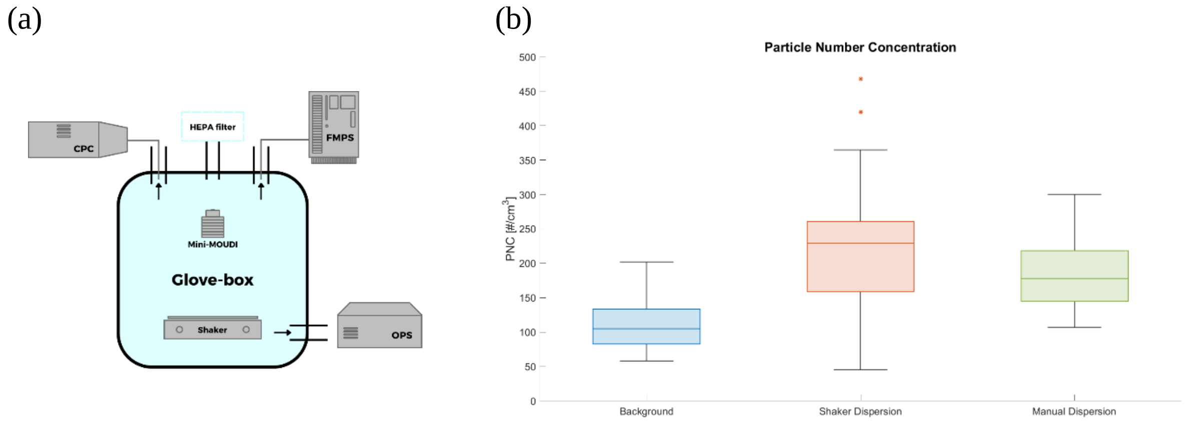

Figure 1. Schematic of glove box chamber used for laboratory testing (a) and box plots of PNC (part/cm^3) measured by the Condensation Particle Counter (Dp < 1μm) during the dispersion session (b).

(P-22)

Monitoring of indoor air quality in Cyprus

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The quality of the indoor environment is a major health concern due to the fact that most of the indoor air is merely outdoor air with additional pollutants emitted from building materials and consumer products. The indoor environment forms the basic breathing and dermal exposure background for 90% of the lifetime of the European population. For this reason, two field studies were conducted in Nicosia. The first study aims in assessing the exposure for emitted compounds in indoor air while the second investigates the exposure in indoor air quality in school buildings since children are more vulnerable to the adverse health effects of indoor air pollution.

The first campaign covered a weekly winter and summer concentration measurements, in two public buildings and two private houses. BTEX, terpenes (a – pinene, d - limonene) were determined using GC/FID and GC-MS after desorption with carbon disulfide (CS_2) while carbonyls were determined using HPLC/UV after desorption with acetonitrile. The sampling was carried out using passive samplers in two sites inside the building and one outside. Formaldehyde, benzene, trichloroethylene, tetrachloroethylene, a-pinene, d-limonene, naphthalene, NO_2, O_3, CO and CO_2 were determined using GC/FID, HPLC/UV, ion chromatography and UV VIS spectrophotometry in the second study. These air pollutants were monitored in classrooms of 5 schools, 4 elementary and a kindergarten.

In the first study, formaldehyde (9.0 - 41.9 μg/m^3), acetaldehyde (2.7 - 14.3 μg/m^3), toluene (2.2 - 86.9 μg/m^3), xylenes (0.2 - 135.9 μg/m^3) and acetone (9.4 - 192.2 μg/m^3) have shown diversity and relatively significant indoor sources depending on the ventilation rates, building type and age and outdoor environment. In the second study the concentrations of chemical parameters and CO_2 ranged from 0.5 μg/m^3 to 31.1 μg/m^3 and 337 ppm to 2712 ppm, respectively. Trichoroethylene, tetrachloroethylene and naphthalene were not detected.

In general, indoor air quality in buildings is shown to be a complex function of outdoor air pollution, building characteristics, operation and management practices, cleaning and ventilation strategies. There is a need to integrate exposures occurring in school's environment with home pollution, as children spend more than 60% of their time at home, and also to elaborate and implement holistic and cost-effective approaches concerning prevention, control and communication strategies for achieving healthy indoor air quality in Europe. The expertise from previous projects will be combined in the future with air quality measurements in citizens homes within the framework of PARC (European Partnership for the Assessment of the Risk from Chemicals, Horizon 2022-2029).

(P-23)

Spatio-temporal mapping of occupational exposures to airborne chemical using a physics-informed neural network method with sparse observations

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The deployment of low-cost Wireless Sensor Networks (WSN) in occupational environments provides useful information regarding spatial and temporal variation in concentration of airborne chemical pollutants. Such information were successfully used to identify sources, working areas with the highest concentration levels and emissive processes as well as to produce spatio-temporal pollution maps. The central issue with hazard mapping is to what extent the estimated map is complete and representative of the reality of ambient concentration and personal exposures. Indeed, spatiotemporal mapping is the result of both real-time measurement of concentrations at a limited number of points spread across a working area and mathematical interpolation, which enables concentrations at other points in the area to be estimated. Therefore, the reliability of maps as well as their interpretation are based on both the quality of the measurements and the interpolation methods used to process the data.

The presentation reports results from laboratory experiments, which were aimed at investigating the accuracy of spatiotemporal mapping as well as the possibility to estimate personal exposure from created maps and the trajectory of workers in space. The experiments were carried out under laboratory conditions in an experimental chamber and a room installed at the INRS. They consisted in the generation of carbon dioxide (CO_2) in the air of the chamber/rom and the real time monitoring of the evolution of CO_2 over time, simultaneously at different points in space. The WSN used in the study consisted of 20 sensor modules connected to the Base Station and positioned at predefined locations in space. Source of carbon dioxide pollution de CO_2 consist of carbon dioxide gas cylinder tank. Ten ToxiRAE Pro CO_2 portable detectors were used as reference detectors. A mobile robot, equipped with measuring devices, moving between the modules was used to simulate an exposed worker. Several interpolation methods (kriging, spatiotemporal regularization, etc.) were used for estimating the spatiotemporal CO_2 maps.

The results confirmed the crucial role of calibration of sensors modules and reference detectors for the deployment of WSN for occupational purposes. The root-mean-square error (RMSE) which quantifies the mean difference between measured and estimated concentration, was shown useful to assess the accuracy of maps. The series of experiments also showed that it was possible to estimate individual exposure from the map and the robot's position. However, further work is still needed to refine the concept. The used interpolation method significantly influenced the interpretation of the resulting pollution maps. Kriging is limited by its high dependency on the accuracy of the variogram model used in the interpolation procedure. Further methods using physics-informed neural network model using sparse observations are under study.

(P-24)

Low-odour and low-emission indoor products - Nose vers. odour threshold values

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To achieve good air quality in buildings, it is necessary to remove, avoid or reduce cleaning loads through ventilation. To reduce the cleaning loads and their effect on the odour perception of the occupants, a sensory test in indoor spaces and on building products is necessary in addition to VOC emission measurements of the contaminants. ISO 16000-28 provides the basis for odour assessment of products using a human olfactory panel.

Through many years of experience and testing of these methods, it can now be assumed that reproducible odour ratings are available for many products used indoors. An odour measurement is mandatory for the Blue Angel for carpets and is being tested for environmentally friendly resilient floor coverings. Based on the results of an earlier project and new results of the upcoming study, the ISO should be revised and completed.

The project investigates the odour and VOC emissions of building products based on natural raw materials. The data generated is used to address several issues, which are briefly explained below. Floor coverings based on linoleum and rubber are included in the Blue Angel eco-label with an odour assessment. The aim of the project is to clarify whether other assessment methods in addition to intensity can provide better information. Positive hedonics have an influence on the intensity assessment. Typically, building products show high intensity with low hedonic values.

Results for wood-based products often show high intensity and positive hedonics. Based on these examples, an appropriate odour assessment of wood-based products for the Blue Angel, supported by research results, should be possible. The concept of the odour guide value which is based on odour threshold values was renewed in 2023. This approach will now be compared with the standardised odour measurement (16000-28). This assessment is based on GC/MS measurements and uses odour thresholds analytically when panel-based odour assessment is not possible. For this procedure well defined odour thresholds are necessary

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(P-25)
Determinants of indoor ventilation rates in South African clothing and textile factory workspaces using low-cost CO2 sensors

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Higher ventilation rates of workspaces are generally associated with reduced presence of airborne pathogens and improved health outcomes. The spread of respiratory pathogens such as SARS-CoV-2 and tuberculosis, as well as building-related illness are associated with poor air quality in specific workspaces. The clothing and textile industry is a large employer and important contributor to the economy in South Africa. This study investigated the environmental and workplace factors associated with poor ventilation in workspaces in South African textile factories.

Workplace health risk inspections and assessment of indoor air quality were conducted in the production areas, canteens, offices and boardrooms of 20 clothing and textile factories from May to December 2024. All factories, employing an average of 136 workers per factory, were in the Western Cape province. Parameters measured in all areas included room depth (m), width (m), ceiling height (m), area (m^2), ceiling height/depth, occupation density (person/m^2), and the number of windows and doors in each space. Low-cost cloud-connected Airwits CO_2 plus sensors (Connected Inventions Oy) were placed for two continuous days in the four workspaces of each factory to measure carbon dioxide (ppm), temperature (◦C), and relative humidity (%). In total, 56 measurements were obtained from all work areas. Data analysis, including simple and multiple linear regression modelling used STATA 17.0 statistical computer software (StataCorp, College Station, Texas, USA). The end of shift (16h00) CO_2, temperature, and relative humidity data collected on day 1 of monitoring was included in the analysis.

A total of 20 clothing and textile factories underwent inspections and CO_2 monitoring. Almost all factories were naturally ventilated (n=19). While all factories had a common production area (n=20), fewer factories had a separate or demarcated canteen (n=17), office (n=14) or boardroom (n=5). In general, the lowest CO_2 levels were measured in the canteen (median: 506ppm, IQR: 465 - 595) while the highest measured CO_2 levels were in the boardroom (median: 1560 ppm, IQR: 648 - 1631). There were 2 (10%) production areas, 2 (11%) canteens, 4 (29%) offices, and 3 (60%) boardrooms that exceeded the recommended 700ppm CO_2 concentration limit value. On the other hand, per person ventilation rates ranged between 0.234 L/s per person and 0.697 L/s/person and were classified as being very low (< 5 L/s/per person) in 95% of work areas evaluated (n=53).

Simple linear regression analysis revealed that person ventilation rates were positively associated with the number of windows and doors (β= 0.1323, $p<0.001$) and negatively associated with occupation density (β=-1.1507, p=0.045). Working in the canteen relative to the production area was also negatively associated with person ventilation rates. In the final multivariate model, which adjusted for outdoor CO_2, temperature and humidity, the major determinants of per person ventilation rates were working in the canteen (β=-0.6301, p=0.002), and the number of windows and doors (β=0.12961, $p<0.001$). This model explained 73% of the variability in the per person ventilation rates (Adj_R^2=0.73, $p<0.001$), but the occupation density in the factory was not statistically significant and therefore did not appear to be a major determinant.

Conclusion: This study has demonstrated that the poor design of workspaces such as canteens can significantly impact on indoor air quality in clothing and textile factories. Simple administrative measures such as increasing the number of windows and doors have the potential to significantly improve ventilation rates in different areas of the factory. The use of low-cost CO2 sensors provides an important adjunct tool for assessing the adequacy of ventilation in these workspaces.

(P-26)

Toxicological implications of nanoparticle inhalation: The pulmonary surfactant perspective

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Pulmonary surfactant (PS) is a lipoprotein complex secreted by type II pneumocytes in the alveoli. This complex coats the entire respiratory surface and plays a crucial role in optimizing respiratory mechanics by reducing surface tension to facilitate alveolar expansion and preventing alveolar collapse at the lowest lung volumes at expiration. PS exhibits low viscosity, enabling rapid spreading along the air-liquid interface. Its high fluidity and the presence of specific surfactant proteins (particularly the hydrophobic proteins SP-B and SP-C) allow PS to adapt to changes in surface area while regulating its stability and distribution, a key behavior to ensure breathing efficiency. Nanoparticles (NPs) of different types are typically inhaled, while suspended in air, during breathing and impact as a first target into the PS layer coating the airways. The nature and extent of NP/PS interactions define both the fate of the NPs and their impact on PS function and on breathing mechanics. Some NPs are being designed and produced nowadays to serve as vehicles for drug delivery, being key materials in the so-called nanomedicine. In this line, PEGylation of NPs using polyethylene glycol as part of their coating is a widely used approach to increase the stability and circulation time of these NPs intended for drug delivery.

The aim of this study was to evaluate the impact of PEGylated (PEG-NPs) and non-PEGylated NPs on the functional determinants of PS, as well as the role of PS in facilitating the spreading of NPs along the respiratory air-liquid interface. To this end, we assessed the transport of NPs across a three-dimensional air-liquid interface using a double surface balance setup that mimics the travel from upper to distal respiratory airways. The impact of the interaction of the different NPs with PS was analyzed by an adsorption Wilhelmy balance. Additionally, the effect of the NPs on surfactant performance was evaluated using a captive bubble surfactometer operated under quasi-static and dynamic cycling conditions that simulate breathing dynamics.

(P-27)
Lung surfactant in respiratory pathologies: Alterations, assessments, and implications for airway health

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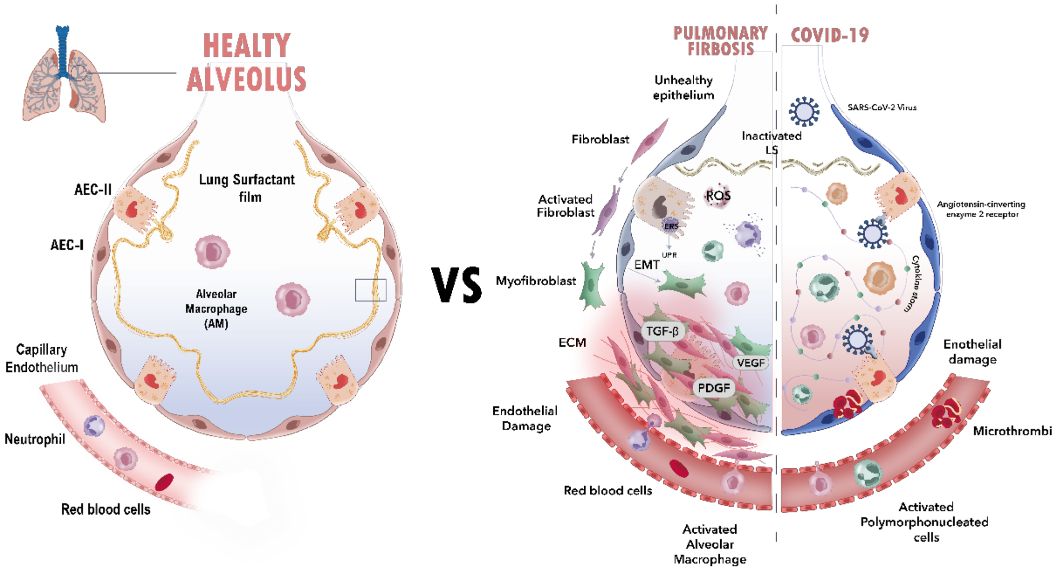
Pulmonary surfactant is a lipid-protein complex that reduces alveolar surface tension, preventing lung collapse and enabling efficient gas exchange. Beyond its critical role in breathing, surfactant also serves as a first-line defense in pulmonary immunity, interacting with and facilitating the clearance of inhaled particles, pathogens, and pollutants. Its proper function is essential for lung health. Yet, it is highly vulnerable to damage in respiratory pathologies associated with lung injury and acute or chronic inflammation, such as bronchopulmonary dysplasia (BPD), COVID-19-induced lung injury, and lung fibrosis. Environmental pollutants and airborne toxins can further exacerbate surfactant dysfunction, leading to increased surface tension, impaired lung compliance, and compromised oxygenation. In conditions like lung fibrosis, changes in surfactant composition and function contribute to alveolar instability and progressive respiratory decline.

Assessing surfactant dysfunction requires a combination of biophysical, biochemical, and molecular techniques. Biophysical methods, such as Captive Bubble Surfactometry (CBS) and the Surfactant Absorption Test (SAT), provide insights into surfactant adsorption, re-spreading, and surface tension regulation under physiological conditions. Biochemical analyses, including Western Blot, electrophoresis, and lipidomics, enable the evaluation and quantification of surfactant proteins and lipid composition.

Given the increasing concerns about air pollution and respiratory diseases, understanding surfactant alterations is more relevant than ever. A comprehensive approach that integrates these diverse methodologies can provide deeper insights into surfactant pathophysiology and its interaction with environmental factors. This knowledge is crucial for improving respiratory health, optimizing ventilation strategies, and developing new therapeutic approaches to mitigate the impact of lung injury and inflammation. In this work, we will summarize data from a few studies that illustrate these challenges, including surfactant alterations in COVID-19 patients, the effects of mechanical ventilation strategies, lung fibrosis, and other relevant pathological models.



(P-28)

Efficiency of traditional low-pressure mercury lamps and modern light-emitting diodes in inactivation of bacterial, viral, and fungal aerosols

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Ultraviolet germicidal irradiation (UVGI) in the UV-C band (especially within the range of 250–280nm) is known to be effective in inactivation of microorganisms. Numerous UVGI systems are available today for the control of microbial pollution of the air in buildings and ventilation systems. This study aimed to assess the effectiveness of low-pressure mercury lamp (LPML) and light-emitting diodes (LEDs) in inactivation of microorganisms suspended in the air considering distance of the UV-C light source from the bioaerosol emitter.

Five microbial strains (bacteria: *Staphylococcus aureus* ATCC 6538, *Bacillus subtilis* ATCC 6633, *Pseudomonas aeruginosa* ATCC 260; fungus: *Aspergillus versicolor* ATCC 9577; virus: bacteriophage PhiX174 ATCC 13706-B1, which serves as a surrogate for the SARS-CoV-2 coronavirus) dispersed in the air (using Collison nebulizer) as bioaerosols were irradiated with LPML as well as LEDs at the distances of 0.5m, 1m, and 1.5m from the nebulizer (which translate into UV-C doses of 762J/m^2, 218J/m^2, and 118J/m^2 as well as 823J/m^2, 269J/m^2, and 125J/m^2, respectively). After irradiation, microbial particles were sampled from the air using Button Aerosol Sampler with polycarbonate filter and their survivability was checked using cultivation method.

UV-C radiation emitted by LPML and LEDs effectively inactivated the tested microorganisms dispersed in the air (Fig. 1). However, the efficiency of this process depends to a significant extent on the dose of radiation (fluence) to which the microbial particles suspended in the air are exposed.

Effective cleaning of the air from microbial particles cannot be limited to their exposure to UV-C radiation but should be supplemented with other techniques enabling elimination and/or neutralization of microorganisms, which need to be subsequently applied after such exposure.

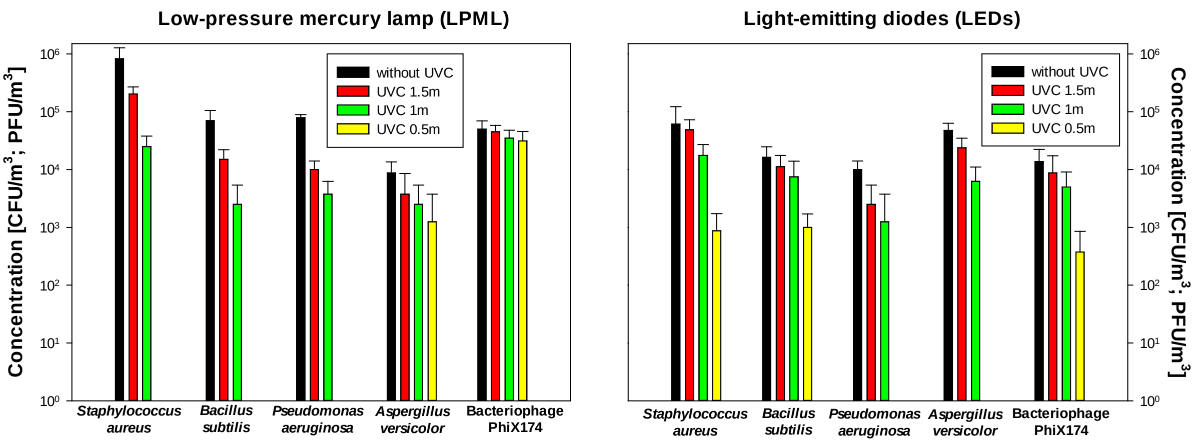

Figure: Survivability of microorganisms dispersed in the air after exposure to UV-C radiation emitted by LPML and LEDs at distances of 0.5m, 1m, and 1.5m from bioaerosol emission source.

(P-29)
The wind speed and direction dependence of personal aerosol sampler aspiration efficiency

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Personal aerosol samplers are typically used in indoor environments where airflow speeds are low. These personal aerosol samplers are often not designed to be used in outdoor environments where wind speeds can be much higher and wind direction can vary rapidly. The aspiration efficiency of personal aerosol samplers tends to be strongly dependent on wind conditions. Data on a free-standing Institute of Occupational Medicine (IOM) sampler demonstrates the impact of wind direction, as it was 140% efficient at collecting particles with an aerodynamic diameter of 21 µm when facing the wind but was only 10% efficient when oriented 90 degrees to the wind [1]. Consequently, the quantity of particles collected may be heavily biased due to variations in prevailing wind direction during the sampling period.

The Defence Science and Technology Laboratory (Dstl), in partnership with the University of Southampton, undertook a design study using Ansys Fluent, a Computational Fluid Dynamics (CFD) code, to develop a personal aerosol sampler inlet with reduced wind direction dependence for outdoor applications. First, a CFD methodology was developed for accurate modelling flow and particle dispersion around an aerosol sampler. This was validated against wind tunnel data for the free-standing IOM sampler [1].

This methodology was applied to a sampler inlet design proposed by Dstl that was developed to be worn by soldiers on patrol. The effect of sampler location (chest or head mounted), wind direction, wind speed, and particle size on the aspiration efficiency was evaluated. The validation and sampler location studies will be presented at the conference.

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(P-30) Occupational exposure and health effects in offshore drilling waste treatment plants

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The aim of this study was to describe occupational exposure to microorganisms and endotoxin and investigate potential health effects, for workers employed in the recycling of offshore drilling waste plants.

The study included 7 different plants across Norway, thus encompassing most of the industry. 384 personal full-shift samples, 26 bulk samples and 123 stationary short-time samples of microorganisms were collected. Viable bacterial and fungal species were identified with MALDI-TOF.
Venous blood and self-reported health data were collected from respectively 56 and 73 drilling waste workers. Plasma levels of various inflammatory markers related to the exposure were analysed using a LUMINEX analysis kit. The inflammatory potential (TLR2 and TLR4 activation) of airborne dust, collected with personal sampling at the plants, were assessed *in vivo* in HEK293 cells.

Even though mean exposure was low, some workers were exposed to high levels of endotoxin (207 EU/m^3), bacteria (3.8×10^4 CFU/m^3 and 9.8×10^4 DNA copies/m^3) or fungi (1.4×10^7 CFU/m^3 and 3600 DNA copies/m^3).

Airborne dust collected at workplaces, induced an *in vitro* inflammatory response in 90% of all samples. The *in vivo* response correlated with measured air levels of microbiological components. Significant differences in biomarker expression and symptom prevalence were identified among exposed workers compared to unexposed.

Despite moderate exposure levels, certain work tasks and techniques were associated with elevated levels of microorganisms and endotoxin. These exposures were also found to be a potential occupational health concern among workers in offshore drilling waste treatment.

(P-31)

In-animal performance testing of surgical smoke management technologies for laparoscopic surgery

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Electrically-powered instruments are used nowadays for fast and precise transection of organic tissues during surgical interventions. The use of such instruments is accompanied by the formation of surgical smoke that poses a potential health risk to medical staff. Especially for laparoscopic interventions, various smoke management technologies exist. Most of them based on evacuation by continuous carbon dioxide exchange, more rarely on electrostatic particle deposition. Although numerous guidelines recommend the strict use of smoke management technologies, only limited performance data for single technologies exist (Buggisch et al. 2020).
To start with filling this gap, the performance of five smoke management technologies was analysed in-vivo on the example of three laparoscopic interventions performed at twenty anesthetised pigs. Various aerosol-analytical instruments with different principles of operation were operated in a two-sectional setup (see Fig. 1) to characterise contemporaneously smoke formation and elimination intra-abdominally and extra-abdominally.

It was found that the half-life of the particle concentration is a suitable parameter to describe the smoke elimination efficacy. Moreover, it could be shown that the efficacy of smoke management technologies based on evacuation by continuous carbon dioxide exchange can be predicted by simple equations as used in the area of occupational hygiene to describe the concentration decrease in ventilated rooms (Hewett & Ganser 2017). Electrostatic precipitation was found to be most efficient for smoke management with minimal carbon dioxide consumption (Göhler et al. 2024).

The presentation will give details on the setup, the performed analyses and the results.

Figure: Photographic image of the two-sectional aerosol-analytical setup for the characterisation of surgical smoke formation and elimination.

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Ethical approval
The study was approved by the French Ministry of Higher Education and Research (Ministère de l'enseignement supérieur et de la recherche). Animals were cared for and handled according to all guidelines by authorized researchers.

(P-32)

Tackling fungal contamination for safer farming

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Biosafety measures are essential for maintaining animal health and workplace safety in poultry production. Poultry farm environments favor fungal growth, yet information on fungal contamination and associated health risks remains scarce [1]. This study aimed to assess fungal and mycotoxins contamination in poultry pavilions (PP) during poultries growth cycle. Sampling was conducted during winter in 14 PP, Portugal, using electrostatic dust cloths (EDC) and conventional microbiological methods to quantify fungal densities (CFU/m²) [2]. Isolation, identification, and determination of major mycotoxins (aflatoxins; ochratoxin A, fumonisins and zearalenone) were performed using HPLC. Results showed higher fungal loads during the 3rd week (5.32 x101 CFU.m-2.day—1) aligning with existing literature [3].

Regarding fungal diversity, clinically and toxicologically relevant species belonging to *Aspergillus* sp. and *Penicillium* sp. were frequently identified. Regarding mycotoxins, fumonisins (B1 and B2) classified as possibly carcinogenic (IARC, group 2B) were the most detected in EDC samples (27 out 47). This study evidence that PP are contaminated with mycotoxigenic fungi and mycotoxins. The identification of clinically relevant fungal species and mycotoxins even after sanitary measures, highlight gaps in biosafety protocols [4]. Given the presence of at least two mycotoxins in 18 EDC samples, further studies are needed to determine their cumulative effects and develop mitigation strategies. Integrating a One Health approach is critical for reducing fungal exposure and promoting a safer farming.

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(P-33)

Non-invasive breath sampling for occupational hygiene biomonitoring

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The analysis of volatile organic compounds (VOCs) in exhaled breath offers a powerful approach to indicate the presence of volatiles absorbed into the bloodstream in a non-invasive and inexpensive fashion.

Monitoring of VOCs in workplace air has become standard practice, especially in industries using hazardous materials such as solvents, fuels and resins. However, air monitoring does not always accurately reflect an individual's true exposure, VOCs can enter the body not only through inhalation but also via skin absorption. Additionally, the use of respiratory protective equipment (RPE) means that room air monitoring does not always give a true picture of the exposure as workplace concentrations may be high, but use of RPE can significantly reduce the exposure potential.

For this reason, biological monitoring is used to identify any VOC exposure resulting from poor working practice or unsuitable protective equipment. Biological monitoring allows the actual body burden of VOCs to be measured, whatever the route of exposure, facilitating assessment of short term (acute) exposure and providing an indication of chronic exposure. Biological monitoring methods have generally involved the study of urine or blood samples. However, these methods are often invasive, costly and complex leading to low worker compliance and limiting their widespread adoption in routine occupational health assessment.

Breath sampling offers a compelling alternative, it enables simple, non-invasive biological monitoring for screening workers for exposure to potentially toxic VOCs. By capturing and concentrating VOCs from only the alveolar portion of an exhaled breath, which is in direct contact with circulating blood, followed by analysis by thermal desorption GC-MS breath samples provide a picture of toxic VOCs in the bloodstream. In this poster we present case studies assessing occupational exposure of workers in dry cleaning and manufacturing industries.

(P-34)

From data to decision: Wearable sensors transforming workplace health

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The HealthTech project by Aker Solutions AS has investigated the feasibility and effectiveness of using wearable sensor technology to monitor and mitigate occupational hygiene risks in industrial environments. The primary objective of the project was to mitigate work-related illnesses by providing enhanced insights into personal and environmental exposures. Through systematic data collection and analysis, we addressed critical issues such as vibration, dust, and noise exposure, and got more insights into the implications, consequences, costs and benefits of an eventual implementation of wearable sensors. We investigated commercially available wearables to identify sensors that align with the project objective and found several key challenges: restrictive IP and data-ownership policies; high costs and advanced technologies tailored to occupational-hygiene experts; reliance on manual data logging with no real-time measurements; and display-only functionality without any cloud infrastructure.

We conducted test campaigns with selected sensors to gather comprehensive worker feedback on comfort, ease of use, and seamless integration into daily tasks—identifying any ergonomic issues during prolonged wear—with several occupational groups contributing to the data collection. Each occupational group tested the sensors for one full working week (5 consecutive days), with data collecting during their regular shifts each day. Each participant group was equipped with three sensors: earplug-based noise monitors, jacket-mounted dust detectors, and wrist-worn vibration sensors. To enhance employee engagement and awareness, on the first day of each week, an introductory workshop was organized by medical professionals to explain the purpose, benefits, functionality and proper usage of the sensors. At the end of each shift, a brief daily questionnaire was completed, capturing technical issues (e.g., sensor malfunctions, battery problems), comfort and ease of use, and any notable challenges or environmental factors. At the end of the week, participants answered the System Usability Scale (SUS) questionnaire, which focused on comfort, acceptance, alignment with PPE, usability, and perceived usefulness of the sensors after a full week of use.

Results suggest that wearable sensors technology is positively received by employees, with a particularly high appreciation for the company’s initiative in adopting health-preserving solutions. While most participants believe the technology will enhance safety, reduce health uncertainties, and encourage PPE use, the variability in responses highlights the need for additional awareness or training to maximize engagement. Furthermore, one key takeaway from test campaigns was the value of providing adequate training and orientation for participants before introducing them to the sensors. By offering a detailed explanation of how each sensor works, its purpose, and the data it collects, participants are more likely to feel comfortable and engaged with the testing process. In conclusion, utilizing wearable sensors technology and continuous monitoring, rather than spot checks, makes it feasible to gain a comprehensive overview of the environment, identify faulty devices, and understand the reasons behind pollution increases.