Karlsruhe Institute of Technology

European Federation of Clean Air and Environmental Protection Associations (EFCA) International Symposium

Ultrafine Particles – Air Quality and Climate

Brussels, Belgium
July 3 and 4, 2024

BOOK OF ABSTRACTS AND PROGRAM

EFCA

Venue

Representation of the State of
Baden-Württemberg to the EU
Rue Belliard 60-62
B-1040 Brussels, Belgium

Baden-Württemberg
VERTRETUNG DES LANDES BEI DER EUROPÄISCHEN UNION

Registration and Fee

Please register online via **ufp.efca.net**
Participant fee: € 580,–
Reduced fee for authors: € 400,–
(one author per contribution)
Including book of abstracts, conference proceedings, conference buffets and refreshments

Information

Karlsruhe Institute of Technology (KIT)
Institute of Meteorology and Climate Research

Susanne Bolz
Kaiserstraße 12
76133 Karlsruhe, Germany

Email: ufp@imk-aaf.kit.edu
ufp.efca.net

European Federation of Clean Air and Environmental Protection Associations (EFCA) International Symposium

Ultrafine Particles – Air Quality and Climate

Brussels, Belgium
July 3 and 4, 2024

Ultrafine particles (UFP), the nano fraction of airborne particulate matter, are recognised as a major health risk factor in the WHO Guidance, considered to cause serious environmental effects and have a significant climate impact. The most important emission sector is transport of all kinds through direct particle emissions from vehicles, ships and aircraft engines but also by producing volatile organic pollutants which are converted in the atmosphere through photochemical reactions.

UFPs health effects are costantly demonstrated at all scales through indoor and ambient exposure. A further interest in UFP's results from their specific role in atmospheric processes such as cloud formation and precipitation and in climate. In particular, UfPs contribute to the Short-Lived Climate Pollutants (SLCPs), in particular black carbon (BC) and organic aerosols. The relation between UFP and human health and that of UFP and climate are both areas of active research and cross-links between these fields are more and more found nowadays.

EFCA is committed to promote a **"ONE-ATMOSPHERE"** approach to the framing of air/climate protection policies and to the standard/metric of UfPs in cooperation with international organizations. Therefore, the subtitle of the symposium series: **"air quality and climate"** reflects this constant development. However, the present policies to decrease exposure to particulate matter make use of the mass-based metrics PM10 and PM2.5, which do not properly represent all risks for human health. EFCA is therefore in favour of the development of a fraction-by-fraction approach on particulate matter, both with respect to size and chemical composition including Black Carbon particles as an additional metric in the Air Quality Directive.

The organizers trust that EFCA's 9th Ultrafine Particles Symposium 2024 will again feature the most recent scientific progress in the field and so contribute to policy-relevant developments which improve the dialogue with policymakers in Europe and in the UNECE region. EFCA and KIT, together with GUS and CEEES are pleased to organize this event again. We cordially invite all experts to contribute actively and hope to see you again at the State representation of Baden-Württemberg in Brussels in July, 2024.

Thomas Leisner | Chairman

Wednesday, 3 July

Opening

10:00 Greetings and Impulse Statement
by Jutta Paulus (MEP)

Keynote – Session

10:30 – 11:10 | Room Karlsruhe, Stuttgart, Mannheim

Session Chair: Thomas Leisner

10:30 **New particle formation in the upper troposphere and its role for climate**
Joachim Curtius
University of Frankfurt, Germany

Session A – UFP Sources I

11:10 – 12:30 | Room Karlsruhe, Stuttgart, Mannheim

Session Chair: Thomas Reichert

11:10 A.1
Particulate Filters for Combustion Engines to Mitigate Global Warming. Estimating the Effects of a Highly Efficient but Underutilized Tool
~~Andreas C.R. Mayer~~
VERT, Switzerland

11:30 A.2
Shortcomes in ultrafine particle measurement and source attribution, a review
Wolfgang Junkermann
Karlsruhe Institute of Technology, Germany

11:50 A.3
Development of a European-wide UFP map based on mobile monitoring
~~Youchen Shen~~
Utrecht University, Netherlands

12:10 A.4
Characterisation of Ultrafine Non-Exhaust Emissions
Manuel Löber
German Aerospace Center (DLR), Germany

12:30 Lunch

Session B – UFP Sources II

13:30 – 14:50 | Room Karlsruhe, Stuttgart, Mannheim

Session Chair: ~~Andreas Meyer~~

13:30 B.1

Nanoparticles in ambient air of residential areas: sources and mitigation potential

Peter Bächler
Karlsruhe Institute of Technology, Germany

13:50 B.2

Organic pollution bound to PM1 particle matter in indoor air

Ivana Jakovljević
Institute for Medical Research and Occupational Health, Croatia

14:10 B.3

Identification of aviation unique emission tracers by combining aerosol- and gas measurements

Sarah M.Tinorua
Paul Scherrer Institute, Switzerland

14:30 B.4

State of knowledge Importance of precursor substances for the formation of UFP

Nicola Toenges Schuller
AVISO Gmbh, Germany

Session C – Urban UFP & Methods

14:50 – 16:10 | Room Karlsruhe, Stuttgart, Mannheim

Session Chair: Harald Saathoff

14:50 C.1

Quantifying the contributions of NPF and traffic emissions on urban UFP concentrations

Pauli Paasonen
University of Helsinki, Finland

15:10 C.2

Numerical Simulation of Fibre Dose in an Air-Liquid-Interface Exposure System

Sonja Mülhopt
Karlsruhe Institute of Technology, Germany

15:30 C.3

Enhancing fine PM emissions assessment from urban traffic through bottom-up approach: case study for the city of Milan

Andrea Piccoli
Politecnico di Milano, Italy

15:50 C.4

Volatility, state of mixing and solid ultrafine aerosol particles in the urban atmosphere

Maria Gini
National Centre of Scientific Research "Demokritos", Greece

16:10 Coffee Break

Keynote – Session

16:30 – 17:10 | Room Karlsruhe, Stuttgart, Mannheim
Session Chair: Thomas Leisner

16:30 **Inhaled carbonaceous ultrafine particles (tbc)**
Tim Nawrot
University Hasselt, Belgium

Session D – Health I

17:10 – 18:30 | Room Karlsruhe, Stuttgart, Mannheim
Session Chair: Flemming Cassee

17:10 D.1
Particle number concentrations (PNC) and health effects in the Bavarian centres of the German National Cohort (NAKO): Augsburg and Regensburg
Josef Cyrys
Ludwig-Maximilians-Universität München & Helmholtz Munich, Germany

17:30 D.2
The toxicology and functional impact of ultrafine particles on the respiratory mucosa evaluated in a primary cell based air-liquid interface model
Till Meyer
University Hospital Würzburg, Germany

17:50 D.3
Long-term exposure to ultrafine particles and lung cancer mortality and incidence
Femke Bouma
Utrecht University, The Netherlands

18:10 D.4
Beyond the Runway: Respiratory health effects of ultrafine particles from aviation in children
Esther S. Lenssen
Utrecht University, The Netherlands

Poster Session E & Buffet

18:30 – 19:30 | Room Karlsruhe, Stuttgart, Mannheim

E.1
Environmental damage - Nicotine balance of cigarettes (tobacco burners) when smoking
Peter Eyerer
Fraunhofer Institute for Chemical Technology ICT, Germany

E.2
Understanding the drivers of differences in PAH compositions of PM1 and PM10 – a machine learning study in Zagreb, Croatia
Nikolina Račić
Institute for Medical Research and Occupational Health, Ksaverska cesta 2, Zagreb, Croatia

E.3
Source Identification Measurements of UFP Immission Next to an Italian Harbor
Volker Ziegler
Palas GmbH Germany

E.4
Relation between anhydrosugars and organic carbon in the PM1 particle fraction
Suzana Sopčić
Institute for Medical Research and Occupational Health, Zagreb, Croatia

E.5

Composition and sources of aerosol particles in three central European cities Karlsruhe, Stuttgart, and Munich

Harald Saathoff
Institute of Meteorology and Climate Research, KIT, Karlsruhe, Germany

E.6

Particulate Matter Emissions of the aeronautics manufacturing sector based on global market data and its potential derivation

Thomas Reichert
Fraunhofer Institute for Chemical Technology (ICT), Pfinztal, Germany

E.7

Meteoric Smoke Particles in the Mesopause – the only long-lived sub-nanometer particles in the atmosphere

Thomas Leisner
Institute of Meteorology and Climate Research, KIT, Karlsruhe, Germany

Thursday, 4 July

Keynote – Session

09:30 – 09:40 | Room Karlsruhe, Stuttgart, Mannheim
Session Chair: Thomas Leisner

09:30 **Short- and long-term effects of ultrafine particles**
Annette Peters
Helmholtz Munich, Germany

Session F – Health II

09:40 – 11:20 | Room Karlsruhe, Stuttgart, Mannheim
Session Chair: ~~Josef Cyrys~~

09:40 F.1
Early life exposure to ultrafine particles from air pollution affects proximal tubular epithelial cells development and resilience
Alessandra Tammaro
University of Amsterdam, The Netherlands

10:00 F.2
Neurodevelopmental impact of early-life ultrafine carbon nanoparticles exposure in mice
Kenneth Vanbrabant
Hasselt University, Belgium

10:20 F.3
Effects of inhaled carbon nanoparticles on the mouse lung
Roel Schins
IUF – Leibniz Research Institute for Environmental Medicine, Germany

10:40 F.4

Transgenerational susceptibility to asthma: Impact of maternal exposure to airborne ultrafine particles during pregnancy in mice

Djamal Achour
University Lille, CHU Lille, France

11:00 F.5

Air pollution-derived ultrafine particles induce neurological disorders in BALB/c mice and differentiated human dopaminergic neuronal LUHMES cells

Emma Theerens
University Lille, CHU Lille, France

11:20 Coffee Break

Session G – Policies

11:40 – 12:20 | Room Karlsruhe, Stuttgart, Mannheim
Session Chair: Karl-Friedrich Ziegahn

11:40 G.1

Will new legal regimei Integrate action for cleaner air and climate protection, including focus on ultrafine patricles (UFP)

Andrzej Jagusiewicz
European Federation of Clean Air and Environmental Protection Associations (EFCA), Poland

12:00 G.2

Expansion of UFP measuring capabilities in the Netherlands to improve models and emission inventories

Anneke Batenburg
National Institute for Public Health and the Environment (RIVM), The Netherlands

12:20 Lunch

Keynote – Session

13:20 – 14:00 | Room Karlsruhe, Stuttgart, Mannheim
Session Chair: Thomas Leisner

13:20 **Revision of EU Clean Air rules**

Lucia Bernal Saukkonen
EC Brussels, Belgium

~~14:00~~ Coffee

Panel Discussion

14:~~2~~0 – 15:~~5~~0 | Room Karlsruhe, Stuttgart, Mannheim
Session Chair: Flemming Cassee

14:~~2~~0 **The way forward: interactive session with audience and ~~panel~~**

Flemming Cassee

Symposium Chairman

Thomas Leisner
Institute for Meteorology and Climate Research,
Karlsruhe Institute of Technology, KIT, Germany

Organizing Committee

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Thomas Reichert
Fraunhofer ICT, EFCA and CEEES

Harald Saathoff
Karlsruhe Institute of Technology (KIT)

Proceedings

Presentations and Posters will be published electronically after the Symposium.

Jean Guy Bartaire, APPA, France

Abdurrahman Bayram, TUNCAP, Turkey

Giulio D'Emilia, CEEES, Italy

Giuseppe Fumarola, COSRIA/ATI, Italy

Ranka Godec, CAPPA, Croatia

Marie Haeger-Eugensson, SCAS, Sweden

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Britt-Ann Kåstad Høiskar, Norwegian Institute for Air Research, Norway

Anu Kousa, FAPPS, Finland

Richard Mills, IUAPPA, United Kingdom

John Murlis, EP-UK, United Kingdom

Marianne Popp, Institute for Ecology and Conservation Biology, BOKU,
Vienna, Austria

Jochen Theloke, VDI/DIN KRdL, Germany

Andrea von Känel, Cercl'Air, Switzerland

Karl-Friedrich Ziegahn, KIT and GUS, Germany

Presentation

Particulate Filters for Combustion Engines to Mitigate Global Warming. Estimating the Effects of a Highly Efficient but Underutilized Tool

Andreas C.R. Mayer[1], Joerg Mayer[2], Max Wyser[3], Fritz Legerer[4], an Czerwinski[5], Thomas W. Lutz[6], Timothy V. Johnson[7], Mark Z. Jacobson[8]

[1] TTM, Fohrhoelzlistr.14 b, CH 5443 Niederrohrdorf, Switzerland
[2] NCA, Niederlenz, Switzerland
[3] FOEN em., Bern, Switzerland
[4] VERT em., Vienna, Austria
[5] BFH em., Port, Switzerland
[6] ETH em., Egg, Switzerland
[7] CORNING em., New York, NY, USA
[8] Department of Civil and Environmental Engineering, Stanford University, Stanford, USA

Keywords: Global warming, Combustion soot particles, Diesel particulate filters, Retrofit of diesel and petrol engines CO2 equivalence of black carbon, Benefit/cost ratio of DPF-application

ABSTRACT

Particulate filters are state-of-the-art and are used in internal combustion engines worldwide to eliminate carcinogenic nanoparticles. Health studies estimate that this prevents about one million premature deaths annually. What is less known and often neglected is their equally powerful effect on mitigating global warming. This is because these ultrafine particles form stable aerosols in the atmosphere, absorb sunlight, and heat the atmosphere due to their jet-black color. In addition, once deposited on the ground, they reduce albedo especially when deposited on ice or snow. They also thin clouds and reduce their reflectivity. In this paper, we estimate for the first time the cumulative effect of more than 300 million particulate filters currently installed globally on vehicles, showing that, while they reduce ~ 0.5 Mt of soot per year, their effect on slowing global warming is equivalent to reducing 1 Bt of CO2 per year or about one-third of the CO2 emissions of all European Union Member States combined. Despite its strong potential, this highly efficient, proven, and low-cost technology is not yet regarded as a priority in curbing global warming, even though it is possibly the easiest and quickest to implement. If used in retrofitting more diesel and petrol engines worldwide, it could triple the aforementioned effect. While modern internal combustion engines are on track to be replaced with zero-emission vehicles, it is also crucial, and we strongly suggest that, in the interim, all remaining internal fossil fuel combusting engines be fitted with particulate filters. Evidence is presented in this paper that the potential benefits of such retrofit on climate and human health will be impactful and lasting.

Presentation

Shortcomes in ultrafine particle measurement and source attribution, a review

Wolfgang Junkermann[1], Jorg Hacker[2]

[1] Karlsruhe Institute of Technology, IMK-IFU, Garmisch-Partenkirchen
[2] Airborne Research Australia, Adelaide, SA

ABSTRACT

Ultrafine particles (UFP) in the atmosphere are the invisible, aerosol fraction, relevant for aerosol cloud interaction through cloud condensation nuclei (CCN). To understand their role in regional climate, especially their impact on hydrological cycle, it is essential to know their 3D number concentration, the UFP sources and budgets. Although measurements are available since 1890 and a few continuous long term background monitoring stations were already established 1975, further more sophisticated ones also including size information since about 1995, our knowledge of UFP and subsequent CCN numbers and distribution is still insufficient. This is due to the small particle size, which is not accessible for remote sensing applications. In situ measurements are the only tool for experimental investigations, monitoring, budget and emission rate estimates. Remote sensing of cloud properties like within ship tracks or temporal changes in rainfall rates may give some hints, where a distinct hydrological cycle disturbance might occur due to UFP/CCN. We present results from 25 years of aircraft studies focusing on both, source attribution and characterization and quantitative emission studies. Using highly mobile, flying research platforms were able to identify and even to quantify several typical dominating sources. Our results indicate a strong dependence on meteorological transport systems hampering the interpretation of ground based and / or mountain field site data. We will discuss the underlying meteorological processes, the benefits and limitations of field sites and monitoring networks and how they contribute to improve our understanding of the UFP budget, the role of primary and secondary production and the historical timelines.

Presentation

Development of a European-wide UFP map based on mobile monitoring

Youchen Shen, Jules Kerckhoffs, Gerard Hoek, Kees de Hoogh, Roel Vermeulen

ABSTRACT

Air quality has improved significantly over the past few decades but continues to have significant health impacts worldwide. Nevertheless, the WHO concluded in 2021 that the epidemiological evidence was insufficient to derive a guideline for UFP. This is mainly because in many places worldwide no hyperlocal maps of UFP exist to be linked to health effects. Mobile monitoring is therefore an efficient tool to map the spatial variation of UFP.

For the development of a European-wide UFP map we use mobile monitoring data from several campaigns, including a wall-to-wall driving campaign in Amsterdam and Copenhagen, with measurements on every street segment at least five times. The same cars were used in the EXPANSE project (www.expanseproject.eu). Here, we measured six urban areas (Basel, Barcelona, Munich, Rome, Athens, and Lodz) in different seasons for about six weeks each. Furthermore, within the RI-URBANS (www.riurbans.eu), we performed a similar campaign measuring the streets of Rotterdam. Since all data was collected with the same instruments, we combined all data and developed land use regression (LUR) models with predictor data that was available Europe-wide, including a new traffic intensity dataset. We evaluated the model with leave-one-area-out cross validation and by comparing the Europe-wide model with city-specific models.

We found significant differences in UFP concentrations between cities, with median concentrations ranging from 14.000 to 28.000 particles/cm3. These differences were best described by traffic intensity, the presence of major roads in a 50-meter buffer and a chemical transport model that was used for identifying the background concentration of UFP. The resulting maps with be very useful in European and local epidemiological studies.

Presentation

Characterisation of Ultrafine Non-Exhaust Emissions

M. Löber[1], L. Bondorf[1], T. Grein[1]

[1] Institute of Combustion Technology, German Aerospace Center (DLR), Stuttgart, Germany

ABSTRACT

Non-exhaust emissions are gaining attention for their significant impact on air quality and human health. Generated from road traffic sources such as tyre and brake wear, these emissions, with a high concentration of ultrafine particles (UFP), pose unique health risks due to their ability to penetrate deep into the respiratory system.[1] As the number of road vehicles continues to grow, pollution from tyre and brake wear is expected to increase. In particular, tyre wear from heavier battery electric vehicles is likely to rise. Addressing non-exhaust emissions is hence essential to protect air quality and public health.[2]

A comprehensive study of non-exhaust particulate emissions investigated the tyre and brake wear separately using two different passenger cars on a chassis dynamometer and in real-life driving scenarios. Additionally, emissions measurements of a novel hybrid brake were conducted on a brake dynamometer. The study included on-line characterisation of particle number concentration and size distribution. The results showed that the highest particle numbers were recorded below 100 nm for most of the investigated scenarios. On-line particle characterisation relies on specific particle shapes and sizes, which are based on optical, aerodynamic, or electromobility measurement principles. To gain a better understanding of particle shapes and potential formation mechanisms, a detailed off-line characterisation using scanning electron microscopy (SEM) and energy-dispersive X-ray spectroscopy (EDS) was conducted. The samples were collected using the Electrical Low Pressure Impactor (ELPI+), which covers a size range from 6 nm to 10 µm. The collected particles exhibit different morphologies and chemical compositions depending on their size. While tyre wear particles larger than 1 µm have highly elongated shapes with sharp edges, the UFP fraction consists of more spherical particles with soft edges and a distinct chemical composition Brake wear particles, on the other hand, tend to have a more flaky and plate-like morphology.

References

[1] Kwon, H.-S.; Ryu, M. H.; Carlsten, C. Ultrafine particles: unique physicochemical properties relevant to health and disease. Exp. Mol. Med. 2020, 52 (3), 318–328.
[2] Fussell, J. C.; Franklin, M.; Green, D. C.; Gustafsson, M.; Harrison, R. M.; Hicks, W.; Kelly, F. J.; Kishta, F.; Miller, M. R.; Mudway, I. S.; Oroumiyeh, F.; Selley, L.; Wang, M.; Zhu, Y. A Review of Road Traffic-Derived Non-Exhaust Particles: Emissions, Physicochemical Characteristics, Health Risks, and Mitigation Measures. Environ. Sci. Technol. 2022, 56 (11), 6813–6835.

Presentation

Nanoparticles in ambient air of residential areas: sources and mitigation potential

Peter Bächler, Jörg Meyer, Achim Dittler

Karlsruher Institut für Technologie, Institut für Mechanische Verfahrenstechnik und Mechanik, Straße am Forum 8, 76131 Karlsruhe

ABSTRACT

Monitoring of nanoparticles is gaining attention due to the classification under "new pollutants" in the context of the revision of the EU Ambient Air Quality Directive. The impact of nanoparticles on ambient air quality (immission) is linked to the release of nanoparticles from corresponding sources (emission). Two different perspectives of nanoparticle pollution (emission & immission) are discussed in this presentation. During field measurements applying a charge-based particle concentration monitor in a residential area ranging over approx. three months, increased nanoparticle concentrations significantly above typical background concentrations were measured during the evening hours on 52% of the time period of the measurements. The sources of the pollution could be linked to wood-stove combustion of biomass from the surrounding neighborhood. Due to a wide-spread lack of sufficient waste-gas cleaning technology for wood-stoves, air quality in residential areas is very much impacted by the particle emissions from the direct release of exhaust gas from biomass combustion. In the industrial application (e.g. incineration plants for district heating), dedicated waste-gas cleaning technology is required. During another field measurement campaign at a municipal biomass incineration plant equipped with pulse-jet cleaned filters, the nanoparticle emission through filter bags made from different filter media was measured. The transient particle emission behavior of the filters required a complex measurement setup, including aerosol conditioning (e.g. heating and drying) and a measurement system consisting of a condensation particle counter and a scanning mobility particle sizer in parallel for simultaneous monitoring of total and size resolved particle concentrations. The separation efficiency of a membrane filter bag enabled particle emission concentrations below the ambient level (approx. 13 #/cm³; separation efficiency > 99.999%; raw-gas concentration > 107 #/cm³). The results demonstrate the potential for mitigation of nanoparticle emissions by application of waste-gas cleaning technology to protect the environment and human health.

Presentation

Organic pollution bound to PM1 particle matter in indoor air

Ivana Jakovljević[1], Tajana Horvat[1], Mirna Labrović[2], Vesna Tomašić[2], Marija Jelena Lovrić Štefiček[1], Gordana Pehnec[1], Goran Gajski[1]

[1] Institute for Medical Research and Occupational Health, Ksaverska cesta 2, 10000 Zagreb, Croatia
[2] University of Zagreb, Faculty of Chemical Engineering and Technology, Marulićev trg 19, 10000 Zagreb, Croatia

ABSTRACT

People spend between 70 and 90% of their time indoors. Studies have found that exposure to air pollutants indoors can be significantly higher than outdoors, even in urban environments. Regardless of this, air quality standards currently apply only to outdoor, ambient air. For that reason, the main objective of research studies is to determine air quality in different types of indoor environments and, according to these data and corresponding health effects develop guidelines for indoor air quality.
The pollutants of interest in indoor air are atmospheric aerosols that results from the suspension of fine solid or liquid particles present in the atmosphere. Aerosols can originate from direct emissions or secondary formation from gaseous precursor species.
Polycyclic aromatic hydrocarbons (PAHs) are a huge group of organic compounds bound to airborne particulate matter (PM) ubiquitous in outdoor and indoor air. Due to their high toxicity and potential carcinogenic effects, they can have adverse effects on human health.
The aim of this study was to determine PAH mass concentration in the PM1 fraction of particulate matter in Croatian households. PM1 samples were collected over one week in 33 households from May to December 2023 on quartz filters from about 50 m^3 of air and were kept frozen in aluminium foil at -18 ° C until analysis. The following PAHs were analyzed: fluoranthene (Flu), pyrene (Pyr), benzo(a)anthracene (BaA), chrysene (Chry), benzo(j)fluoranthene (BjF), benzo(b)fluoranthene (BbF), benzo(k)fluoranthene (BkF), benzo(a)pyrene (BaP), dibenzo(a,h)anthracene (DahA), benzo(ghi)perylene (BghiP), and indeno(1,2,3-cd)pyrene (IP) by high-performance liquid chromatography (HPLC, Agilent Infinity 1260) using a fluorescence detector. PM_1 mass concentrations from Croatian households ranged from 2.3 to 23.7 μg m^{-3} with a median value of 12.8 μg m^{-3}. The median value of the sum of PAH mass concentration was 1.086 ng m^{-3}. The mass concentration of BaP, the most investigated PAH, ranged from 0.002 to 1.320 ng m^{-3}, and the median value was 0.076 ng m^{-3}.

Supported by the European Union's Horizon Europe research and innovation program under the grant agreement No. 101057497 (EDIAQI).

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#EnvironPollutHealth

Presentation

Identification of aviation unique emission tracers by combining aerosol- and gas measurements

S. M.Tinorua[1], B. T. Brem[1], Z. C. J. Decker[1],a, P. Alpert[1], J. G. Slowik[1], M. Ammann[1], A. S. H. Prevot[1], M. Bauer[1], M. Götsch[2], J. Sintermann[2] and M. Gysel-Beer[1]

[1] Laboratory of Atmospheric Chemistry, Paul Scherrer Institute, 5232 Villigen PSI, Switzerland
[2] AWEL, Amt für Abfall, Wasser, Energie und Luft, 8090 Zürich, Switzerland
[a] now at: NOAA CSL & Cooperative Institute for Research in Environmental Sciences (CIRES), Boulder, CO, USA
Associated key topics: Emission sources, Ultra-fine particles characterization, air quality.
Presenting author email: sarah.tinorua@psi.ch

ABSTRACT

Aircraft-engine emissions play a major role in the air quality near airports. A current technology civil aviation gas turbine emits 1010 to 1015 non-volatile particles per kg fuel (ICAO Aircraft Engine Emissions Databank, n.d.), in addition to gaseous precursors relevant for secondary aerosol formation. Aircraft particle emissions at the engine exit are largely composed of Ultra Fine Particles (UFPs, diameter of <100 nm) and significant concentrations of UFPs have been reported near the airports. Due to their small size, UFPs are transported deeper in the human body and can even reach the blood circulatory system, with significant adverse health effects (Bendtsen et al., 2021). Despite the predicted increase of passenger jets in the years to come, aircraft emission studies at the ground are very limited (Stacey, 2019).
During the Aviation Plume PROPeRtles AT point of Exposure (APPROPRIATE) research campaign, we performed laboratory, engine test cell, and ambient field measurements with a state-of-the-art set of gas- and aerosol-phase instrumentation to study aircraft UFPs and find a unique aviation emission tracer. This presentation focusses on sixweeks of in-situ PM concentration and size-distribution (1-560 nm) and optical detection of 10 trace gases measurements carried out 800 m from Zürich airport.
We identified several episodes of airport influence with UFP mean diameter of 11 nm, number concentrations above 106 cm-3 and an increase of other combustion gas markers (eg. sulfur dioxide and nitrogen oxides). We found different concentrations and size distributions of UFPs when comparing the landing with the taking off periods, which confirms the variability of UFPs characteristics with the engine thrust. Future work will further characterize UFPs for each aircraft regime (eg. take-off, landing and taxiing). A source apportionment using Positive Matrix Function method will provide key factors impacting the local air quality and further identify aviation source specific tracers.

Financial support:
This work was supported by the Swiss Federal Office of Civil Aviation (SFLV 2020-080). We acknowledge the support from SRTechnics, Frithjof Siegerist, and the City of Kloten.

References:

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ICAO Aircraft Engine Emissions Databank. (n.d.). EASA. https://www.easa.europa.eu/en/domains/environment/icaoaircraft-engine-emissions-databank, consulted on Feb. 27, 2024
Stacey, B. (2019). Measurement of ultrafine particles at airports: A review. Atm. Env., 198, 463 477.

Presentation

State of knowledge Importance of precursor substances for the formation of UFP

Nicola Toenges Schuller[1*], Christiane Schneider[1], Michael Elsasser[2], Bryan Hellack[2]

[1] AVISO GmbH, Am Hasselholz 15, D-52074 Aachen, Germany
[2] Umweltbundesamt (German Environment Agency), Paul-Ehrlich-Str. 29, 63225 Langen, Germany
[*] nicola.toenges schuller@avisogmbh.de

ABSTRACT

We will present the results of a literature survey on the formation of UFP ultrafine particles from precursor substances. The aims of the survey were

- identification of the most relevant sources,
- comparison of these group s regarding their contributions to particle number PN))/UFP concentrations at different sites the ir emissions of UFP precursors and the associated SOA formation potential
- compilation of reduction potentials

"Road traffic", "air traffic", "shipping", residential heating" heating", and "large combustion systems" were identified as particularly relevant regarding the anthropogenic emission of UFP and their precursor substances in Germany.
In the past, road traffic contributed the most to PN measured at ground level stations all year round. In winter, contributions to SOA from biomass burning in small combustion plants dominated. Near airports, ports and shipping lines, air and shipping traffic also made significant contributions to the PN concentration. PN emissions from large combustion plants generally do not contribute to the local pollution increment at measuring stations near the ground but are part of the background concentration after significant dilution and mixing.
For road traffic exhaust emissions, solid particles and volatile precursor substances can be reduced by aftertreatment systems, exhaust of vehicles of the Californian "SULEV" norm shows hardly any PN and SOA formation, even regarding increasing nucleation potential in cleaner air (lower cond ensational sink at lower PM2.5 concentrations, higher SOA formation potential at lower NOx concentrations 1. The other source groups are not limited w.r.t. volatile PN emissions or SOA precursors yet.
Future reduction potentials therefore include the monitoring of existing limits for road traffic and the introduction of corresponding limits for air traffic, shipping, and small combustion. For large combustion systems, the exit from coal combustion should be prioritized to further flue gas cleaning.

References

[1] Zhao et al. (2017), https://doi.org/10.1073/pnas.1620911114

Presentation

Quantifying the contributions of NPF and traffic emissions on urban UFP concentrations

P. Paasonen, V.-M. Kerminen, M. Kulmala and K. Lehtipalo

Institute for atmospheric and Earth system research (INAR/Physics), University of Helsinki, Finland

ABSTRACT

Urban particle number concentrations are dominated by particles originating from atmospheric new particle formation (NPF) process and traffic emitted particles with diameters DP < 25 nm. The growth of these particles contributes strongly to cloud condensation nuclei concentrations both in polluted urban and clean boreal terrestrial environments, and even to the accumulating aerosol mass (e.g., PM2.5) in polluted the environments. Distinguishing and quantifying the contributions of NPF and traffic sources in observed urban particle number size distributions is crucial for finding out effective ways to lessen adverse health impacts and understand the past and the future climate effects.

Here, we present our recent developments in approaches and methods for quantifying these sources based on atmospheric observations. The applicable methods include: i) determining continuous time series of the formation rate of nucleation mode particles from NPF [1], ii) associating the observed particle concentrations with traffic and NPF based on sulphuric acid and NOx concentrations [2], and iii) detailed classification of different types of increased nucleation mode particle concentration events [3] (Fig. 1). Finally, we describe how we will integrate these methods to determine the temporally varying contributions of NPF and traffic on UFP, CCN and PM2.5 concentrations.

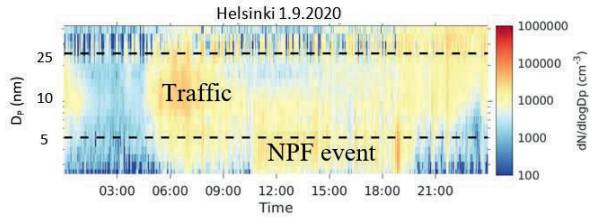

Figure 1: An example day with particle number size distribution measured with NAIS (Neutral cluster and Air Ion Spectrometer), where a traffic emission event is observed in the morning and NPF event with limited upwind area during the day.

References:

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Presentation

Numerical Simulation of Fibre Dose in an Air-Liquid-Interface Exposure System

S. Mülhopt[1], S. Klein[1], B. Gutmann[2], C. Schlager[2], T. Krebs[2] and D. Stapf[1]

[1] Institute for Technical Chemistry, Karlsruhe Institute of Technology, Karlsruhe, 76021, Germany
[2] Vitrocell Systems GmbH, Waldkirch, Germany

Keywords: aspect ratio, aerodynamic diameter, cell surface dose, exposure studies, deposition efficiency

Presenting author email: s.muelhopt@kit.edu

ABSTRACT

Investigating ultrafine particles and airborne nanomaterials regarding their lung toxic potential using Air Liquid Interface (ALI) exposure of lung cell cultures the knowledge of the exact relevant in-vitro dose (RID) is essential to determine the dose-response relationship of the inhalable aerosol.
Due to new materials as carbon fibre reinforced plastics, not only particles are of interest for ALI exposure testing but also inhalable objects of high aspect ratios, like fibres. The aspect ratio β describes the relationship of length l to diameter d of a cylindrical object like a fibre and can be used to calculate the form factor X of a non-spherical particle describing the relationship of the difference in particle behaviour in gas streams.
For ALI exposure studies carbon fibres were milled and dispersed in air by a segmented belt aerosol generator. The same experiments were performed to determine the deposited numbers of particles, fibres and fibres matching the criteria of the World Health Organisation (WHO) for being of concern regarding human health. These so-called WHO-fibres are fulfilling the fibre criterium of $\beta > 3$ and additionally their length $l > 5$ µm and thickness $d < 3$ µm. The carbon fibre aerosol generated was sampled and analysed by digital light microscopy. The observed objects of the aerosol were classified according to their dimensions and aspect ratio and their aerodynamic equivalent diameter was calculated.
The deposition behaviour of these three fractions of the carbon fibre aerosol was measured on the one hand and simulated by numerical methods on the other. All data sets were calculated to the aerodynamic equivalent diameter and classified. The comparison of experimental and simulated data will be shown and discussed.

Parts of this work were financed by the German Federal Ministry of Education and Research under project number FK03XP0195 which is greatly acknowledged.

Presentation

Enhancing fine PM emissions assessment from urban traffic through bottom-up approach: case study for the city of Milan

Andrea Piccoli[1,2], Valentina Agresti[1], Marco Bedogni[3], Giovanni Lonati[2], Guido Pirovano[1]

[1] Sustainable Development and Energy Sources, RSE Spa, Milan, Via R. Rubattino 54, 20134, Italy
[2] Department of Civil and Environmental Engineering, Politecnico di Milano, Milan, Piazza L. da Vinci 32, 20133, Italy
[3] AMAT, Milan, Via T. Pini 1, 20134, Italy

ABSTRACT

Exhaust and non-exhaust emissions from road traffic are the most relevant contributors to airborne particulate matter (PM) in urban areas, especially in the warm season when space heating sources are not active. Emission quantification, temporal modulation and spazialization are key points for developing accurate air quality modelling studies. Annual emissions data are usually available from emission inventories, mostly obtained through top-down (TD) approach and related to the whole urban area, thus lacking of detailed space and time resolution.

In this work, a bottom-up (BU) approach for assessing traffic emissions directly from traffic data is presented. This approach also includes the option to separately assess private and public transport emissions, and the potential to account for traffic-induced dust resuspension, generally not included in top-down inventories. Thanks to the direct link with traffic data, this approach is particularly suitable for the impact assessment on air quality of local interventions at the urban scale, such as Low and Zero Emission Zones and speed limit reduction.

BU approach was applied over the city of Milan based on the results of macroscopic traffic simulations and on HERMESv3_BU model, that follows EMEP/EEA methodologies for hot and cold exhaust emissions (Tier 3) and for non-exhaust (i.e. road, tire, and brake wear) PM emissions (Tier 2), also accounting PM resuspension based on vehicle-dependent emission factors.

The results of BU emission assessment were compared with the TD data from regional emission inventory for the traffic source in the city of Milan. While for gaseous pollutants the two approaches give close values, for PM10, PM2.5 and organic carbon higher values were obtained with BU approach, from 25% for PM2.5 up to almost 50% for PM10. The main reason for this discrepancy was the inclusion of PM resuspension due to vehicle transit in BU approach.

WEDNESDAY, 3 JULY | ROOM KARLSRUHE, STUTTGART, MANNHEIM

10:00 – 10:30
Opening

10:30 – 11:10
Keynote Session

11:10 – 12:30
Session A – UFP Sources I

Lunch
FOYER/PATIO

13:30 – 14:50
Session B – UFP Sources II

14:50 – 16:10
Session C – Urban UFP & Methods

Coffee Break
FOYER

16:30 – 17:10
Keynote Session

17:10 – 18:30
Session D – Health I

18:30 – 19:30
Poster Session E & Buffet
FOYER/PATIO

THURSDAY, 4 JULY | ROOM KARLSRUHE, STUTTGART, MANNHEIM

09:30 – 09:40
Keynote Session

09:40 – 11:20
Session F – Health II

Coffee Break
FOYER

11:40 – 12:20
Session G – Policies

Lunch
FOYER/PATIO

13:20 – 14:00
Keynote Session

Coffee Break
FOYER

14:20 – 15:50
Panel Discussion

Presentation

Volatility, state of mixing and solid ultrafine aerosol particles in the urban atmosphere

Maria Gini, Christina Spitieri, Luís Mendes[§], and Konstantinos Eleftheriadis[*]

Environmental Radioactivity & Aerosol technology for atmospheric & Climate impact Lab, N.C.S.R. "Demokritos", 15310 Athens, Greece

[§] presently at Sunset.lab

[*] Presenting author email: eleftheр@ipta.demokritos.gr

Keywords: atmospheric aerosol, solid particles, ultrafine particles, volatility

ABSTRACT

The ultrafine fraction of particulate matter (UFP) represents most of particle number, and has been associated with adverse health effects. Probing the properties of UFP in the atmosphere can be challenging due to their typical low mass concentration in ambient aerosol. The metrics and parameterization from the typical environmental monitoring networks and measurement systems are poorly representing the material initially emitted by the specifications of these engines certified by the manufacturers and the control legislation, especially for the solid particle fraction. Tandem Differential Mobility Analysers (TDMAs) have been used to infer UFP properties like volatility, hygroscopicity and organic content. Volatility can provide valuable real-time information on particle mixing state, and the solid particle number and volume fractions.

The present study aims to analyze the size distribution, volatility and solid particle fraction of urban atmospheric aerosol particles observed in the city of Athens at an urban background station, located at the N.C.S.R. "Demokritos" and at a Metro station located at a heavy traffic avenue.

Upon heating, particles may be sorted in 3 classes: volatile, semi-volatile, and non-volatile, depending on whether they disappear, shrink, or stay unaffected. The VTDMA was used to evaluate the volatility of particles with diameters of 30, 50, 80 and 120 nm, and temperatures of 25, 110, 200 and 300 °C. The mean number and volume fractions remaining after heating are mostly unchanged at the lowest temperatures and gradually a fraction of up to 80% appears as volatile at higher temperatures. The volatile number fraction displays a variability with season and location showing that the solid particle content is variable and depends on type of emissions and environmental conditions.

Presentation

Particle number concentrations (PNC) and health effects in the Bavarian centres of the German National Cohort (NAKO): Augsburg and Regensburg

Annette Peters[1,2], Kathrin Wolf[2], Marco Dallavalle[1,2], Alexandra Schneider[2], Regina Pickford[2], Susanne Sues[3], Jens Soentgen[3], Simonas Kecorius[2], Josef Cyrys[2], Susanne Breitner-Busch[1,2]

[1] IBE-Chair of Epidemiology, Ludwig-Maximilians-Universität München, 81377 Munich, Germany;
[2] Helmholtz Zentrum München–German Research Center for Environmental Health, Institute of Epidemiology, 86754 Neuherberg, Germany;
[3] University of Augsburg, Environmental Science Center, 86159 Augsburg, Germany;

ABSTRACT

Epidemiological studies on ultrafine particles (UFP) are challenging due to their short lifetime in the atmosphere and large spatial and temporal variability. Consequently, reliable data on chronic exposure to UFP is scarce, and air quality standards for UFP have not been developed yet.
The project "Ultrafine particles in Bavaria - UFP concentrations and health effects in the Bavarian centres of the German National Cohort (NAKO)" had two main objectives. Firstly, to model the long-term exposure to particle number concentrations (PNC) as an indicator for UFP in the Augsburg and Regensburg study regions. Secondly, to investigate the association between long-term PNC exposure and cardiometabolic risk markers as well as the prevalence of high blood pressure, heart attacks, strokes, and diabetes in NAKO participants.
The project developed Land Use Regression (LUR) models for both cities and adjacent districts to estimate the chronic exposure of the study participants at their home address. Specifically, based on PNC measurements from two earlier projects, an existing LUR model for Augsburg was updated and transferred to Regensburg. To validate this model, we compared our predictions for the Regensburg area with PNC measurements from a fixed network monitoring station and six satellite sites.
These unique and extensive datasets collected during three measurement campaigns (two in Augsburg and one in Regensburg) allowed us to assess and compare the spatial and temporal variability of the UFP concentrations within Augsburg and Regensburg. The developed PNC-LUR models performed very well. The validation of the models based on the measurements at the Regensburg measuring locations showed that the models mostly underestimated the measured concentrations. This should lead to an underestimation of the effect in the epidemiological analyses. The study observed an association between long-term PNC exposure and cardiovascular disease prevalence, also after adjustment for other air pollutants.

Acknowledgement:
This work was supported by the Bavarian State Ministry for the Environment and Consumer Protection under the umbrella of the project network "BayUFP - Measurement, Characterization and Evaluation of Ultrafine Particles". The authors thank Adam Mühlbauer and Mike Pitz (Bavarian Environment Agency) for providing exposure data from UFP monitoring station in Regensburg.
This project used data obtained in the ULTRA3 study (Environmental Nanoparticles and Health: Exposure, Modelling and Epidemiology of Nanoparticles and their Composition within KORA) and in the study "Influence of local sources on the spatial and temporal distribution of ultrafine particles". ULTRA3 was supported by intramural funding for Environmental Health projects of Helmholtz Zentrum München – German Research Center for Environmental Health. The project "Influence of local sources on the spatial and temporal distribution of ultrafine particles" was funded by the Bavarian Environment Agency on behalf of the Bavarian State Ministry for Environment and Consumer Protection.

Presentation

The toxicology and functional impact of ultrafine particles on the respiratory mucosa evaluated in a primary cell based air-liquid interface model

Totta Ehret Kasemo[1], Mathilde Delaval[2], Anusmita Das[2,3], Elias Zimmermann[2,3], Jana Panzke[2], Johannes Becker[2,3], Svenja Offer[2], Evelyn Kuhn[2], Seongho Jeong[2,3], Maria Steinke[1, 4], Helena Moratin[1], Martin Sklorz[2,3], Ralf Zimmermann[2], Agmal Scherzad[1], Stephan Hackenberg[1], Sebastiano Di Bucchianico[2,4], Till J. Meyer[1]

[1] University Hospital Würzburg, Department of Otorhinolaryngology, Plastic, Aesthetic and Reconstructive Head and Neck Surgery, Josef-Schneider-Strasse 11, 97080 Wuerzburg, Germany
[2] Joint Mass Spectrometry Center (JMSC) at Comprehensive Molecular Analytics (CMA), Helmholtz Zentrum München, Neuherberg, Germany
[3] Joint Mass Spectrometry Center (JMSC) at Analytical Chemistry, Institute of Chemistry, University of Rostock, Rostock, Germany
[4] Fraunhofer Institute for Silicate Research ISC, Wurzburg, Germany

ABSTRACT

The respiratory mucosa is the primary contact tissue to all airborne particles. The nature of interactions between ultrafine particles (UFP) and the human mucosa is unclear. Impairment of the respiratory mucosa integrity is observed in chronic disorders such as allergies, chronic rhinosinusitis or COPD and can predispose for acute and chronic diseases. According to the 3R principle (reduction, replacement and refinement of animal experiments), there is a high need for in vitro models of the respiratory mucosa with a high in-vivo-correlation. Aim of the study was the evaluation of toxicologically and functional impact of UFP on the human mucosa, evaluated in a primary cell-based model of the airways.

Primary fibroblasts for the basolateral and primary epithelial cells for the apical compartments of cell culture inserts were harvested from nasal sinus surgery biopsies and were cultivated for about 45 days under air-liquid-interface (ALI) conditions. After mucociliary differentiation, mucosa models were exposed to carbon black or online-combustion generated UFP. After exposure, toxicology testing by LDH- and comet assays were performed. Trans-epithelial-electrical resistance (TEER) was assessed for barrier integrity testing.

Mucociliary differentiation of the ALI-models was confirmed by different microscopically techniques, showing cilia movement, cilia ultrastructure, goblet cells and cell-cell contacts. Minor but significant changes in LDH release suggets membrane damage post exposure by both particle types. Neither particle species induced genotoxicity. Mild barrier disturbances – but still intact mucosa – were seen after 24h but not 2h post carbon black exposure. The TEER average after online-UFP exposure was reduced after 2h but due to high variance among the 9 human donors, interpretation must be done with care.

The used primary cell-based ALI-model of the respiratory mucosa shows a high in vitro/in vivo correlation. Compared to ALI-models based on cell lines there is a higher variance, reflecting donor differences. The observed minor changes, which do not cause cell detachment or cell death, suggest that long-term studies using the model are feasible. Such experiments may be informative to study mechanistic effects over time and investigate e.g. tissue regeneration or fibrosis after UFP exposure.

Presentation

Long-term exposure to ultrafine particles and lung cancer mortality and incidence

Femke Bouma, Nicole Janssen, Joost Wesseling, Sjoerd van Ratingen, Maciek Strak, Jules Kerckhoffs, Ulrike Gehring, Wouter Hendricx, Kees de Hoogh, Gerard Hoek, Roel Vermeulen

ABSTRACT

Background: Health implications of long-term exposure to ubiquitously present ultrafine particles (UFP) are uncertain. The aim of this study was to investigate the associations between long-term UFP exposure and lung cancer mortality and incidence in the Netherlands.

Methods: A Dutch national cohort of 10·8 million adults aged ≥30 years was followed from 2013 until 2019. Annual average UFP concentrations were estimated at the home address at baseline, using land-use regression models based on a nationwide mobile monitoring campaign performed at the midpoint of the follow-up period. Cox proportional hazard models were applied, adjusting for individual and area-level socio-economic status covariates. Twopollutant models with the major regulated pollutants nitrogen dioxide (NO_2) and fine particles ($PM_{2.5}$ and PM_{10}), and the health relevant combustion aerosol pollutant (elemental carbon (EC)) were assessed based on dispersion modelling.

Results: A total of 71,622 lung cancer deaths occurred during 71,008,209 person-years of follow-up. The correlation of UFP concentration with other pollutants ranged from moderate (0·59 ($PM_{2.5}$)) to high (0·81 (NO_2)). We found a significant association between annual average UFP exposure and lung cancer mortality [HR 1·038 (1·028 – 1·048), per interquartile range (IQR) (2723 particles/cm3) increment]. The associations of UFP with lung cancer mortality attenuated but remained significant in all two pollutant models.

Conclusion: Long-term UFP exposure was associated with lung cancer mortality among adults independently from other regulated air pollutants.

Presentation

Beyond the Runway: Respiratory health effects of ultrafine particles from aviation in children

Esther S. Lenssen[1], Nicole A.H. Janssen[2], Marieke Oldenwening[1], Kees Meliefste[1], Dave de Jonge[5], Regina J.M. Kamstra[3], Daniëlle van Dinther[3], Saskia van der Zee[4], Rinske H. Keuken[5], Gerard Hoek[1]

Institute for Risk Assessment Sciences (IRAS), Utrecht University, Utrecht, the Netherlands.

[2] National Institute for Public Health and the Environment (RIVM), Bilthoven, the Netherlands
[3] Netherlands Organization for Applied Scientific Research (TNO), Leiden, the Netherlands
[4] Public Health Service of Amsterdam, Amsterdam, the Netherlands
[5] Municipal Health Service (GGD) Haaglanden, Den Haag, the Netherlands

ABSTRACT

Aviation has been shown to cause high particle number concentrations (PNC) in areas surrounding major airports. Particle size distribution and composition differ from motorized traffic. Little is known about aviation-related health effects. The objective was to study short-term effects of aviation-related UFP on respiratory health in children.

In 2017-2018 a study was conducted in a school panel of 7-11 year old children (n=161) living in two towns North and South of Schiphol Airport. Weekly supervised spirometry and exhaled nitric oxide (eNO) measurements were executed. The school panel, and an additional group of asthmatic children (n=19), performed daily spirometry tests at home and recorded respiratory symptoms. Hourly concentrations of various size fractions of PNC and black carbon (BC) were measured at three school yards. Concentrations of aviation-related particles were estimated at the residential addresses using a dispersion model. Linear and logistic mixed models were used to investigate associations between daily air pollutant concentrations and respiratory health.

PNC20, a proxy for aviation-related UFP, was virtually uncorrelated with BC and PNC50-100 (reflecting primarily motorized traffic), supporting the feasibility of separating PNC from aviation and other combustion sources. No consistent associations were found between various pollutants and supervised spirometry and eNO. Measured PNC20, PNC100, PNC50-100 and BC and modeled aviation-related PNC were significantly associated with an increase in various respiratory symptoms. Odds Ratios for previous day PNC20 per 3598 pt/cm3 were 1.13 (95%CI 1.02; 1.24) for bronchodilator use and 1.14 (95%CI 1.03; 1.26) for wheeze. PNC20 was not associated with daily lung function, but PNC50-100 and BC were negatively associated with FEV1 (-10.9 (95%CI -17.6, -4.3) and -15.5 (95%CI -25.6; -5.4) ml change per previous day increase of 3598 pt/cm3 and 0.7 µg/m3 respectively.

PNC primarily from aviation and other combustion sources were independently associated with an increase of respiratory symptoms and bronchodilator use in children living near a major airport. No consistent associations between aviation-related UFP with lung function was observed.

Poster

Environmental damage - Nicotine balance of cigarettes (tobacco burners) when smoking

Peter Eyerer[1], Ulrike Gayh[2], Thomas Reichert[1], Claudia Seidel[1]

[1] Fraunhofer Institute for Chemical Technology ICT
[2] SRH Hochschule, Heidelberg

ABSTRACT

Illegally disposed cigarette butts cause enormous environmental damage [1,2,3]! Of the over 6 trillion cigarettes smoked worldwide each year, smokers throw around 4 trillion into the countryside. Toxicity [4,5] and microplastics [6] are of gigantic consequences for plants, animals, and humans, not including the personal damage [7] caused by active and passive smokers. The environmental hazard of passive smoking (UFP PM2.5) is very high [8, 9]. Of the approximately 12,000 different chemicals in a cigarette butt, only nicotine is considered in this poster [3, 5].

Our environment is polluted by cigarette smoking (disposal of cigarette butts)

- in surface water with 24,000 tons of nicotine
- in the air with 30,000 tons of nicotine during puff breaks and
- 1500 tons by exhaling the residual nicotine from the smoke a total of 55,500 tons of nicotine contaminated worldwide every year!

Environmental damage caused by nicotine from butts worldwide every year:
A as a result of the disposal of 2/3 of the filters in surface water and soil, approx. 6 mg of nicotine is released per butt; approx. 4x1012 discarded butts result in approx. 24,000 tons nicotine in water and soil worldwide every year.
B all smokers worldwide emit approx. 5 mg of nicotine from 6x1012 cigarettes into the ambient air every year; this results in approx. 30,000 t of nicotine being released into the atmosphere plus 1500 t of nicotine in exhaled air and 100,000 tons of other toxins from the butts.
The annual worldwide mass of cigarette butts is approx. 0.8 million tons. For comparison: tire abrasion from approx. 1.5 billion vehicles worldwide amounts to approx. 100,000 tons per year [10, 11]; or baby diapers account for approx. 40 million tons of waste [12]; the total annual waste on earth amounts to approx. 2.02 billion tons.
The environmental damage caused by cigarette butts is huge [13, 14]; and the tobacco industry neglects its global responsibility.

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Poster

Understanding the drivers of differences in PAH compositions of PM1 and PM10 – a machine learning study in Zagreb, Croatia

Nikolina Račić[1*], Mario Lovrić[2,3,4], Michael Forsmann[2], Ivana Jakovljević[1], Zdravka Sever Štrukil[1], Gordana Pehnec[1]

[1] Institute for Medical Research and Occupational Health, Ksaverska cesta 2, Zagreb, Croatia; nracic@imi.hr
[2] Copenhagen Prospective Studies on Asthma in Childhood, Herlev and Gentofte Hospital, University of Copenhagen, 2820 Gentofte, Denmark
[3] The Lisbon Council, Rue de la Loi 155, 1040 Brussels, Belgium
[4] Centre for Bioanthropology, Institute for Anthropological Research, Gajeva 32, HR-10000 Zagreb, Croatia

Keywords: air pollution, contributions, PAH_s, PM_1, PM_{10}

ABSTRACT

Polycyclic aromatic hydrocarbons (PAHs) are of significant interest due to their known association with health effects as constituents of particulate matter (PM). Understanding the differences in PAH composition between PM1 and PM10 is crucial, particularly because PM1 particles, given their size, can penetrate into the respiratory system.

This study presents an analysis of the seasonal variation and factors affecting the composition of PAHs in PM1 and PM10 particles in Zagreb, Croatia. Using machine learning techniques, including Principal Component Analysis (PCA) and Random Forest (RF) regression, alongside statistical methods such as t-tests and Cohen's d calculations, this study explores differences in the PAH-related composition of PM. To understand contributions in the models, techniques such as SHAP for post-hoc model interpretation were utilized. The results exhibited seasonal trends, with PM1 consistently showing a higher PAH contribution compared to PM10, suggesting a greater potential health risk. Seasonal boxplots revealed that PAH concentrations were notably higher in winter and autumn across both particulate sizes, reflecting the impact of temperature inversion and increased emissions from heating. In the analysis conducted using Random Forest regression models and permutation importance analysis, the temperature maximum emerged as the most significant variable impacting PAH concentrations across pollutants. This was likely due to its impact on the volatilization and atmospheric chemistry of these compounds, underscoring the importance of meteorological conditions in air pollution research. Our findings offer valuable insights into the seasonally affected distributions of PAHs in urban environments, thereby contributing to the understanding of pollution dynamics and public health implications.

Poster

Source Identification Measurements of UFP Immission Next to an Italian Harbor

Volker Ziegler[1]; Henrik Hof[1]; Michele Gianelli[2]; Dr. Stefan Hogekamp[1]

[1] Palas GmbH
[2] Labservice Analytica srl

Presentation by Volker Ziegler or Henrik Hof

ABSTRACT

Ultrafine particle studies are conducted for more than 50 years already and gained more and more attention in the last decades due to growing concerns about their health relevance and environmental impact. Numerous studies have been conducted across various fields, including atmospheric science, environmental health but as well on synthetic nanoparticles. The measurement of particle number concentrations and their size distribution with condensation particle counters and mobility particle size spectrometers are established since many decades. Alternative and cheaper technologies are developed and about to continuously verified. The upcoming European Air Quality Directive makes UFP measurements mandatory even though no limits are existing. Beside the proven nano technology with MPSS or CPC, the diffusion charge based method will be a pricewise cheaper method to determine hot spots and gradients.

Together with Labservice Analytics srl and their customer GRIMALDILINES (a Ferry operator), a campaign was started in Brindisi to determine the concentrations and mean diameters where regularly vessels enter and leave the port. For this campaign a new device AQ Guard Smart 2000, based on the technology of diffusion charging was used. The setup, results and some interesting conclusion will be presented.

Poster

Relation between anhydrosugars and organic carbon in the PM1 particle fraction

Suzana Sopčić, Ranka Godec, Gordana Pehnec

Institute for Medical Research and Occupational Health, Ksaverska cesta 2, 10000 Zagreb, Croatia

ABSTRACT

Levoglucosan is a very specific and unique biomass burning marker as it is formed only by cellulose decomposition, which is why it can unambiguously confirm the presence of biomass burning in air pollution contribution studies. Besides levoglucosan, mannosan and galactosan are also formed but are associated with hemicellulose degradation so generally their levels greatly depend on the type of biomass. Our previous studies in Zagreb, Croatia, showed more than 80 % of levoglucosan in the PM10 fraction is bound to the PM_1 fraction. This study aimed to determine the levels of anhydrosugars; levoglucosan, mannosan, and galactosan in the PM_1 fraction in different seasons, as well as the content of organic carbon to investigate the impact of biomass burning on organic carbon and PM1 levels. The ratio between different anhydrosugars was determined for biomass type identification.

The daily samples of the PM1 fraction were collected by a low-volume sampler onto quartz fiber filters at an urban background monitoring station. The analysis of anhydrosugars was performed by high-performance anion-exchange chromatography with pulsed amperometric detection, while organic carbon and water-soluble organic carbon were measured by thermal-optical transmittance. Results showed a domination of levoglucosan levels compared to mannosan, and galactosan levels. A pronounced seasonal cycle was observed for anhydrosugars, organic carbon, water-soluble organic carbon, and PM1 mass concentrations. Levoglucosan, organic carbon, water-soluble organic carbon, and PM1 reached the highest levels in the winter season, while the levels of mannosan, and galactosan were highest during the spring season. Depending on the season, the average contribution of anhydrosugars to the organic carbon ranged between 1.7 and 22.0 %, while the ratio of anhydrosugars in the PM1 fraction ranged from 0.3 to 7.1%

The strong correlation between anhydrosugars and organic carbon was observed in winter and autumn (r= 0.89 and 0.85, respectively) suggesting that biomass burning in the colder part of the year is an important source of organic carbon.

This study was performed using the facilities and equipment funded within the European Regional Development Fund project KK.01.1.1.02.0007 "Research and Education Centre of Environmental Health and Radiation Protection – Reconstruction and Expansion of the Institute for Medical Research and Occupational Health", and funded by the European Union – Next Generation EU (Program Contract of 8 December 2023, Class: 643-02/23-01/00016, Reg. no. 533-03-23-0006)-EnvironPollutHealth

Poster

Composition and sources of aerosol particles in three central European cities Karlsruhe, Stuttgart, and Munich

H. Saathoff[1], Y. Li[1], J. Fu[1], F. Jiang[1], H. Zhang[5], J. Song[4], L. Gao[4], W. Huang[2], X. Shen[3], T. Leisner[1]

[1] Institute of Meteorology and Climate Research, Karlsruhe Institute of Technology, 76344 Eggenstein-Leopoldshafen, Germany

[2] Institute for Atmospheric and Earth System Research (INAR) University of Helsinki, Helsinki, 0014, Finland

[3] Department of Earth, Atmospheric, and Planetary Sciences, Purdue University, West Lafayette, USA

[4] Université Claude Bernard Lyon 1, CNRS, IRCELYON, 69626 Villeurbanne, France

[5] Research Institute for Applied Mechanics, Kyushu University, Fukuoka, Japan

Keywords: Boundary layer dynamics, aerosol composition, urban air quality, mass spectrometry

ABSTRACT

Air quality in urban environments is not only influenced by emissions, e.g. from sources such as industrial processes, automobile traffic, and domestic heating, but also by meteorological conditions (e.g. solar radiation, wind, temperature, precipitation), atmospheric dispersion, chemical transformations, and topography (Linnarelli et al., 2022). Interaction of these different factors is of special importance for urban locations with a building structure or topography potentially limiting dispersion of pollutants. This is the case for the city of Stuttgart (635000 Pop.) which is located in a basin but less for the city of Karlsruhe (313000 Pop.) in a shallow river valley, while the city of Munich (1580000 Pop.) is significantly larger and on a relatively flat terrain. To understand the relative contributions of air quality controlling factors in these cities we measured air pollution parameters with special focus on aerosol composition as well as meteorological parameters and the spatial distribution of aerosol particles in and above the planetary boundary layer (PBL).

From June 28th to July 29th, 2019, we deployed an aerosol measurement container at a kerbside in downtown Karlsruhe (Song et al., 2022). From July 5th to August 17th 2017 it was in a park in downtown Stuttgart (Huang et al., 2019) and from August 2nd to 29th 2023 it was in a street canyon in downtown Munich. These observations were complemented by similar measurements in winter periods. Our container was equipped with a meteorology sensor (WS700, Lufft), trace gas monitors (O_3, NO_2, CO_2, SO_2), condensation particle counters, aethalometer, particle sizers (SMPS, OPC), a HR-ToF-AMS (Aerodyne), and a CHARON-PTR-MS (Ionicon).

On the roof of the container a scanning aerosol lidar (Raymetrics) performed zenith scanning measurements. The scanning lidar measurements provide information of the structure (height, residual layers) of the PBL and furthermore of the aerosol distribution also near ground level. This allows better comparison between the ground based and remote sensing measurements.

Despite the differences of the measurement locations in the three cities the main components of $PM_{2.5}$ compositions look quite similar with organic components dominating with 66-75% followed by sulphate with 21-13%. Please note, that the sum of the components measured by the AMS agreed well with independently measured $PM_{2.5}$ mass concentrations except for a few periods with significant dust levels. In this contribution we will compare the aerosol compositions, sources, seasonal changes, and ultrafine particle contributions for the three different cities.

This work was supported by the Helmholtz Association in the project MOSES.

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Poster

Particulate Matter Emissions of the aeronautics manufacturing sector based on global market data and its potential derivation

Thomas Reichert, Peter Brantsch

Fraunhofer ICT, 76327 Pfinztal, Germany

Presenting author email: thomas.reichert@ict.fraunhofer.de

ABSTRACT

The aeronautics sector has been regarded as an important contributor to environmental problems, due to fuel consumption and combustion emissions. Additional emissions are coming from aircraft manufacturing, aircraft End-of-Life and Recycling.

The complexity of aircraft systems and the lack of public data have prevented analysis of aggregated contributions of the value chain to key environmental problems - analysis that could provide valuable insight to reduce environmental impacts. In European funded projects with partner organisations Fraunhofer developed new mapping method to quantify the environmental burden of industrial areas, such as the aeronautics manufacturing sector.

The mapping performed by partners usually builds on environmental databases and available market data representing high percentage rates of the sector's sales (e.g. Aviation: 84% in 2017). The mapping results for aircraft production (EDES Project) show that material resources and aircraft manufacturing consumed 69.5 TWh energy (site specific energy consumption aggregated), emitted therefore 18.1 MtCO2e, and withdrew 475 million m³ water.

The largest contributions stemming from airframe manufacturers and aluminium alloy production. Carbon emissions predominantly occur in the manufacturing stage while water withdrawals mainly originate from the material production.

Based on the global manufacturing data collected by the partners, Fraunhofer ICT expand the System Boundaries for the Life Cycle Assessment (LCA) with the re-use and recycling quota developed in the ecoDESIGN transversal activity in Clean Sky 2. Applying the processes to the global amounts of materials in the system.

Due to the expected changes in the material mix in the aviation industry, there is as well a forecast derivative possible for future aircraft manufacturing scenarios, as well as different forecast scenarios for variation to the electricity and energy supply changes by using renewable energy. The poster will present the effect on the global particulate matter impact change.

Acknowledgements:

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Poster

Meteoric Smoke Particles in the Mesopause – the only long-lived sub-nanometer particles in the atmosphere.

Thomas Leisner, Thomas Dresch and Denis Duft,

Institute of Meteorology and Climate Change -Atmospheric Aerosol Research, Karlsruhe Institute of Technology, Karlsruhe, Germany

ABSTRACT

At the very low temperature and pressure of the mesopause in a height of ~85km, trace metal atoms originating from evaporated meteors co-nucleate with oxygen into very small (r<1nm) mineral particles called meteoric smoke particles (MSP). The main composition is $Mg_xFe_{2-x}(SiO_4)$. Due to the low pressure in the mesosphere and the low mixing ratio of the metals, these particles can be stable at this size over months.

During polar summer, water ice may nucleate on these particles to form polar stratospheric clouds. These most elusive clouds in the atmosphere have only been observed since 1885, but since then, their brightness and extension seem to be increasing. This has been brought into connection with climate change, but the evidence is not strong.

In this contribution, we will present laboratory experiments on the nucleation of water ice on synthetic MSP stored in a linear quadrupole trap under the conditions of the polar mesosphere. We study the nucleation of ice under these extreme conditions and find that very high supersaturation is necessary for its formation, which initially nucleates as amorphous ice and crystallizes into quasi-cubic ice only at higher temperatures.

Poster

Early life exposure to ultrafine particles from air pollution affects proximal tubular epithelial cells development and resilience

Peiqi Sun[1], Loes Butter[1], Nike Claessen[1], Kenneth Vanbrabant[2], Leen Rasking[2], Tim Nawrot[2], Michelle Plusquin[2], Flemming Cassee[3], Peter Boor[4], Joris Roelofs[1,5], Elena Levtchenko[6], Sandrine Florquin[1,5], Jesper Kers[1,5] and Alessandra Tammaro[1#]

[1] Amsterdam UMC location University of Amsterdam, Department of Pathology, Amsterdam Reproduction and development, Amsterdam, The Netherlands
[2] Center for environmental sciences, Hasselt University, Diepenbeek, Belgium
[3] National institute for public health and environment (RIVM), Bilthoven, The Netherlands
[4] Institute of Pathology, RWTH Aachen University Clinic, Aachen, Germany
[5] Department of Pathology, Leiden University Medical Center, Leiden, Netherlands
[6] Amsterdam UMC location University of Amsterdam, Department of Pediatric nephrology, Amsterdam, The Netherlands

Presenting author email: a.tammaro@amsterdamumc.nl

ABSTRACT

Background

Air pollution is a significant but uniquely overlooked factor in the development of chronic kidney disease (CKD). Limited epidemiological evidences suggest that early-life exposure to particulate matter, impairs organ growth resulting in prematurity, low birth weight and impaired nephrogenesis, leading to hypertension and higher risk to develop CKD in later life. Ultrafine particles (UFPs) derived primarily from transport, exert higher toxicity than larger particles based on mass. We know that UFPs cross the placenta and undergo high renal clearance, posing a significant risk for kidney development and function. We aimed to investigate the effect of UFPs on kidney development and resilience.

Methods

Pregnant mice and offspring were exposed to carbonaceous UFPs or filtered air, via inhalation. Animals were sacrificed at postnatal day-21 resulting in 4 groups (control, prenatal, postnatal and pre+postnatal exposure). Kidneys were processed for histopathology, immunofluorescence for proximal tubule (PT) markers, Transmission Electron Microscopy (TEM) and mitochondrial function assays. We also stimulated iPSCs-derived kidney organoids in vitro with Printex 90 (a proxy for UFPs), followed by hypoxia/re-oxygenation and performed gene expression analysis.

Results

Using a deep-learning algorithm able to detect subtle morphological changes in the kidney, we observed poor development of PT in the pre+postnatal group. Further examination via PT marker and TEM revealed a disorganized brush border and mitochondrial abnormalities within the PT. Metabolically, this resulted in reduced nicotinamide adenine dinucleotide (NAD+), and decreased mitochondrial DNA copy number. In vitro, kidney organoids exposed to UFPs and hypoxia/re-oxygenation injury, exhibited increased PT damage marker KIM1 and decreased NAD+ levels.

Conclusion

Prenatal exposure to rather clean UFPs triggers metabolic stress, starving PT at a critical time during development leading reduced resilience to stress, possibly enhancing the risk of CKD later in life. This suggests that the physical nature of UFPs may be a key driver for these responses.

Presentation

Neurodevelopmental impact of early-life ultrafine carbon nanoparticles exposure in mice

Kenneth Vanbrabant[1], Leen Rasking[1], Maartje Vangeneugden[1], Tina Wahle[2], Hannelore Bové[3], Marcel Ameloot[4], Tim S Nawrot[1], Evert Duistermaat[5], Paul Fokkens[5], John Boere[5], Tim Vanmierlo[6,7], Roel P. F. Schins[2], Flemming R. Cassee[5,8], Michelle Plusquin[1]

[1] Centre for Environmental Sciences, Hasselt University, Diepenbeek, Belgium;
[2] IUF – Leibniz Research Institute for Environmental Medicine, Düsseldorf, Germany;
[3] Hasselt University, Department of Sciences, Diepenbeek, Belgium;
[4] Hasselt University, Biophysics, Diepenbeek, Belgium;
[5] Centre for Sustainability, Environment and Health, National Institute for Public Health and the Environment (RIVM), Bilthoven, The Netherlands;
[6] Biomedical Research Institute, Hasselt University, Diepenbeek, Belgium;
[7] Department Psychiatry and Neuropsychology, School for Mental Health and Neuroscience, European Graduate School of Neuroscience, Maastricht University, Maastricht, The Netherlands;
[8] Institute for Risk Assessment Sciences (IRAS), Utrecht University, Utrecht, The Netherlands.

ABSTRACT

Exposure to airborne particulate matter is recognized as a major contributor to pulmonary and cardiovascular diseases, but also neurodegenerative impairment(s). However, the effects of particle inhalation on neurodevelopment, especially in early life, remain largely unexplored.

We conducted an experimental mouse study to investigate the neurodevelopmental effects of whole-body exposure to clean ultrafine carbonaceous particles (UFP^C) during early life. Pregnant wild type C57BL/6J mice were either sham-exposed (HEPA-filtered air) or exposed to UFPC (440 µg/m³) for four hours per day over four consecutive days per exposure period. The mice and their offspring were divided into four groups: i) sham, ii) only prenatal exposure, iii) only postnatal exposure, and iv) both prenatal and postnatal exposure. The mice of the only prenatally, only postnatally, and both pre- and postnatally exposed groups were re-exposed to UFPC in the adult phase to simulate chronic exposure.

The UFPC-exposed offspring displayed altered behaviour in the open field test, with postnatally exposed mice spending significantly more time exploring along the walls ($p = 0.01$) compared to the sham group. This change was not observed in mice with both prenatal and postnatal exposure, suggesting a potential compensatory mechanism following prenatal UFPC exposure. Further assessment using the object location task revealed impaired spatial memory in adult mice after re-exposed to UFP^C at the 5-hour interval examination (sham: $D2 = 0.31 \pm 0.20$, prenatal: $D2 = -0.01 \pm 0.28$, postnatal: $D2 = -0.05 \pm 0.20$, prenatal and postnatal: $D2 = -0.03 \pm 0.27$). Proteomic profiling of mice brain samples (Target 96 Mouse Exploratory panel, Olink® Proteomics) identified several differentially expressed proteins associated with UFPC exposure.

In conclusion, this study contributes to our understanding of the effect of UFP^C exposure on behavioural outcomes in mice and shed light on the brain proteomic landscape associated with cognitive impairment following exposure to UFPC.

Presentation

Effects of inhaled carbon nanoparticles on the mouse lung

Tim Spannbrucker[1], Tina Wahle[1], Kenneth Vanbrabant[2], Tamara Hornstein[1], Isabelle Masson[1], Andrea Rossnerova[3], Michal Sima[3], Pavel Rossner Jr[3], Evert Duistermaat[4], Paul Fokkens[4], John Boere[4], Flemming Cassee[4,5], Michelle Plusquin[2], Klaus Unfried[1], Roel P.F. Schins[1]

[1] IUF – Leibniz Research Institute for Environmental Medicine, Düsseldorf, Germany;
[2] Centre for Environmental Sciences, Hasselt University, Diepenbeek, Belgium;
[3] Department of Toxicology and Molecular Epidemiology, Institute of Experimental Medicine of the CAS, Prague, Czech Republic;
[4] National Institute for Public Health and the Environment (RIVM), Bilthoven, The Netherlands;
[5] Institute for Risk Assessment Sciences (IRAS), Faculty of Veterinary Medicine, Utrecht University, Utrecht, The Netherlands.

ABSTRACT

Traffic-related air pollution is typically characterized by high number concentrations of carbonaceous ultrafine particles (UFP) and has been associated with increased risks of respiratory diseases. However, the precise role of these UFP in the development of these disorders requires further clarification.

In the present study, we investigated the potential toxicity of clean ultrafine carbonaceous particles (UFP^C) in the absence of associated chemical constituents such as metals and organic species. Repeated inhalation exposure studies in C57BL/6JOlaHsdmice (4 h/day up to 16 days) were performed with UFP at an average mass concentration of 450 µg/m^3 and a median particle diameter of 55 nm. The potential priming effect of repeated low-dose UFP^C exposures was investigated. Therefore, adult male offspring that had already been (pre and/or postnatally) exposed to UFPC by inhalation, were challenged via pharyngeal aspiration to a single relatively high-dose of carbon black nanoparticles (Printex 90) to quantify the inflammatory response to this challenge.

Overall, UFPC inhalation did not cause any substantial lung inflammation, verified by bronchoalveolar lavage toxicity markers and in-depth analysis of changes in lung tissue mRNA and miRNA. However, the mice that were prenatally or both pre- and postnatally exposed to UFPC showed a significantly lower inflammatory response to the subsequent pro-inflammatory bolus dose of carbon black. Analysis of DNA methylation in the lung tissues yielded no clear indications for a potential underlying mechanism. The results of this experimental approach suggest that inhalation exposure to UFPC during pregnancy may reduce offspring's susceptibility to subsequent pulmonary inflammatory insults.

Acknowledgements:
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Presentation

Transgenerational susceptibility to asthma: Impact of maternal exposure to airborne ultrafine particles during pregnancy in mice

D. Achour1[#], C. Grare[1#], P. de Nadaï[2], A. Rekbi[1], J.-M. Lo Guidice[1]

[1] Univ. Lille, CHU Lille, Institut Pasteur de Lille, ULR4483-IMPECS, Lille, France
[2] Univ. Lille, CNRS, CHU Lille, Institut Pasteur de Lille, U1019-UMR9017-CILL- Centre d'Infection et d'Immunité de Lille, Lille, France
[#] DA and CG contribute equally to this work

Keywords: air pollution-derived ultrafine particles, Asthma, IL-33, prenatal exposure

Presenting author email: djamal.achour@univ-lille.fr / celine.grare@univ-lille.fr

ABSTRACT

Topic:
- Reproductive toxicity
- Environnement
- Respiratory diseases, asthma

INTRODUCTION:
While the direct impact of air pollution on asthma development or exacerbation is widely acknowledged, the transgenerational effects stemming from maternal exposure to airborne pollutants remain inadequately investigated. Inhaling ultrafine atmospheric particles (UFP) poses a significant concern due to their ability to evade phagocytosis by alveolar macrophages and traverse the alveolar-capillary barrier (ACB), entering the bloodstream. Despite the physiological separation of maternal and fetal circulations, continuous exchange facilitate the transmission of pollutants from gestating mothers to their offspring. Among these modifications is the transgenerational epigenetic inheritance in the fetus, which may impact the newborn's health, including the vulnerability to chronic respiratory diseases such as asthma.

METHODS:
Pregnant C57BL/6 wild-type mice were intranasal exposed to 30µg of UFP, twice weekly until childbirth, starting from the day after mating. To induce allergic asthma, the offspring is sensitized by exposure to an allergen, i.e. dermatophagoïdes farinae (Df). This leads to a provocation trigger of asthma, which is followed by a final exposer boost. Following sacrifice, epigenetic and immune-pathological mechanisms will be investigated in multiple organs (i.e., lungs, brain, and blood). Besides, a co-culture study of endothelial and epithelial cells cultivated in air-liquid interface was employed to assess the permeability of the ACB and its role in facilitating the systemic passage of UFP. This in vitro study focuses on interleuking-33 (IL-33), a pro-inflammatory cytokine strongly associated with asthma pathophysiology. This cell model aimed to enhance the understanding of airway remodelling, with as hypothesis that the major allergic asthma mediator IL-33 increases after UFP exposure in the maternal placenta tissue or fetal lungs. This released interleukin can play a key role in controlling inflammation as a signal transducer (e.g., NF-κB) and as epigenetic repressor.

CONCLUSION:
This ongoing in vivo and in vitro project will determine the underlying mechanisms of UFP exposure on the onset of allergic asthma.

Presentation

Air pollution-derived ultrafine particles induce neurological disorders in BALB/c mice and differentiated human dopaminergic neuronal LUHMES cells

E. Theerens[1,2], J. Carpentier[1], E. Barbier[1], K. Vanbrabant[3], O. Simonin[1], K. Timmerman[2], C. Laloux[2,4], A. Jonneaux[2], J.-M. Lo Guidice[1], D. Devos[2,], G. Garçon[1]

[1] Univ. Lille, CHU Lille, Institut Pasteur de Lille, ULR4483-IMPECS, Lille, France
[2] Univ. Lille, Inserm, CHU Lille, U1172 LilNCog, Lille, France
[3] Hasselt Univ., Centre for Environmental Sciences, Diepenbeek, Belgium
[4] Univ. Lille, CNRS, Inserm, CHU Lille, Institut Pasteur of Lille, US41-UAR2014 PLBS, In vivo imaging and functional exploration platform, Lille, France

Keywords: air pollution-derived ultrafine particles, LUHMES cells, BALB/c mice, oxidative stress, ferroptosis

Presenting author email: emma.theerens@univ-lille.fr

ABSTRACT

Topic:
- Neurosciences, Neurodegenerative diseases, Parkinson's disease
- Toxicology, environnement

INTRODUCTION:
Parkinson's disease (PD) is characterized by regulated cell death (RCD) of dopaminergic neurons of the Substantia Nigra pars compacta (SNpc), including ferroptosis. This work assessed whether ultrafine particles (UFP) from car-related air pollution could induce neuronal RCD, contributing to PD-ethiopathology.

METHODS:
Ten-week-old male BALB/c mice (n=12/group) were exposed to UFP-doses (0, 10 or 30 µg/I.N.), twice/week for 12 weeks, followed by open field, elevated plus-maze, passive avoidance, Y-maze, spontaneous alternation tests. UFP presence was searched in brains by transmission electron microscopy, femtosecond pulsed laser, and gene expression of aryl hydrocarbon receptor (AhR) and metallothionein. RCD hallmarks were assessed by WB in whole brains, completed by IHC on specific sections (prefrontal cortex, striatum, hippocampus, and SNpc). Besides, Lund human mesencephalic (LUHMES) cells (mature dopamine-like neurons) were exposed to 2 and 10µg/cm² UFP for 24h, and ferroptotic markers (ferritin, 4-hydroxynonenal: 4-HNE, glutathione status, glutathione peroxidase activity: GPx) were studied by immunological and biochemical assays.

RESULTS:
UFP reached the brain, but behavioral tests did not reveal any alterations. RCD markers (p-BAD/BAD, ATG5, MLKL, and 4-HNE) decreased after UFP exposure, while glutathione oxidation and GPx activity increased. LUHMES cells showed significant increases in 4-HNE, glutathione oxidation and GPx activity

DISCUSSION:
In vivo, UFP reached the brain and induced anti-RCD mechanisms. According to the in vitro study, UFP-acutely exposed dopaminergic neurons may die by ferroptosis. This hypothesis that UFP could contribute to the development of a PD phenotype. Overall, these results show the combativity to environmental air-pollution toxins of the brain, and suggests that long-term exposure to UFP could represent an additional environmental cause of PD.

Presentation

Will new legal regimei Integrate action for cleaner air and climate protection, including focus on ultrafine patricles (UFP)

Andrzej Jagusiewicz*, Thomas Reichert**

* Andrzej Jagusiewicz is the Outgoing President of European Federation of Clean Air and Environmental Protection Associations (EFCA)
** Thomas Reichert is the past President and Treasurer of European Federation of Clean Air and Environmental Protection Associations (EFCA)

ABSTRACT

Combustion of all kinds produces PM pollution, including its ultrafine fraction (UFP) of less than 1 micron. Carbonacerous particles in form of Black Carbon (BC) and Organic Aerosols (OA) are of particular concern. UFPs are also formed as secondary pollutants, including its precursors as Non-CO2 Greenhouse Gases (NCGG).

UFPs play an important role in policy to reduce the presence of toxic air pollutants and climate forcers in the atmoshere. Moreover, present policies to decrease exposure to particulate matter make use of the mass-balanced metrics for fractions PM 2,5 and PM 10, which do not properly represent all risks for human health. There are considerable differences in the toxic potency of UFPs from various sources when using mass as unifying metric. Therefore EFCA is in favour of developping fraction-by-fraction approach on PM both with respect to size and chemical composition and why not to take also into account the particulate concentration.

Also EFCA strongly supports the role of integrated policy as opposed to the current practice of separate sectoral policies in combatting air pollution and mitigating climate change. Of course reducing PM in general reduces also UfPs, that's why the current work on the revision of vthe Amended Gothenburg Protocol to Abate Acidification, Eutrophication and Ground-level Ozone as well as related legal initiative in the EU will be also given.

The review of the Amended Gothenburg Prorocol has been based on scietific and technical information involving all subsidiary bodies and task forces set under the Convention on Long-range Transboundary Air Pollution (the Air Convention). Its aim is to propose new set of obligations under the reviewed instrument, including new emission ceilings for NOx, NMVOCs, SOx, NH3, $PM_{2,5}$ and BC (black carbon), stricter emission limit values (ELVs) for stationary and mobile sources, timescales and facilitation mechanisms for ratification and implementation and a large set of guidance documents for sources emitting UfPs e.g. ships and shipping. Needless to add that the work under the Air Convention is fully harmozided with the updating of the relevant EU Directives (CAFE-Cleaner Air For Europe and NEC-National Emissin Ceilings) and take into account the WHO Guidance on Air Quality.

Presentation

Expansion of UFP measuring capabilities in the Netherlands to improve models and emission inventories

Anneke Batenburg, Joost Wesseling, Dirk Wever, Sjoerd van Ratingen, Ernie Weijers, Guus Stefess

National Institute for Public Health and the Environment (RIVM), Centre for Environmental Quality (MIL), Bilthoven, the Netherlands

Presenting author email: anneke.batenburg@rivm.nl

ABSTRACT

The health effects of ultrafine particles (UFP) have come under increased scrutiny. In 2021, the Health Council of the Netherlands published the advisory report "Risks of ultrafine particles in the outside air", which highlighted that our knowledge of UFP exposure and health effects is limited by a lack of structural measurements of UFP concentrations. The report therefore recommended measuring UFP concentrations structurally in the National Air Quality Monitoring Network (Landelijk Meetnet Luchtkwaliteit) and performing structural and validated model calculations to obtain a national overview of UFP concentrations. At the subsequent request of the Ministry of Infrastructure and Water Management, RIVM made an inventory of available data, knowledge and measurement equipment, and developed coupled strategies for incorporating UFP measurements into the national network and improving UFP models and the national emission inventory.

The National Air Quality Monitoring Network currently performs indicative UFP measurements with three TSI EPC 3783 instruments; diurnal and weekly cycles can already be observed in these data. More counting equipment will be purchased this year to perform both stationary measurements according to the latest technical standard as well as mobile measurements in the vicinity of large UFP sources. An indicative national UFP concentration map has been compiled by inter- and extrapolating existing empirical data. The locations where the new measurement equipment will be placed are selected with the specific aim to improve this map and obtain better estimates for the exposure of the Dutch population to UFP.

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NOTES

HOST ORGANIZATIONS

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www.kit.edu

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www.efca.net

GUS | Gesellschaft für Umweltsimulation e.V.
(Society for Environmental Engineering). It is the organization of people, institutions and companies who work in environmental engineering and testing. Since 1969, GUS supports the development of environmental engineering on a non profit basis.
www.gus-ev.de

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Karlsruhe Institute of Technology (KIT)

Prof. Dr. Oliver Kraft
Acting President of KIT
Kaiserstraße 12
76131 Karlsruhe, Germany
www.kit.edu