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Editorial: Fine particulate matter pathways—Monitoring and modelling

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Editorial on the Research Topic
Fine particulate matter pathways—Monitoring and modelling

Improving air quality in urban areas is one of the top environmental global challenges. Among several, one major concern is the high concentration of fine particulate matter (PM or PM_X, where x is the particle diameter in μm) and the potentially toxic metals within these particles. Fine PM is a heterogeneous mixture of particles that make up the urban PM and stem from several different sources, and hence particles' toxicity varies considerably on a spatial and temporal scale. The most important problem for tackling air pollution is therefore precise source apportionment, the attribution of different pollution sources to the PM mix at the site of exposure. Therefore, good monitoring and modelling approaches for source apportionment (either source or receptor-based models) are needed to understand the PM pollution sources in cities and to evaluate or predict the success of targeted abatement measures. This Research Topic provides exciting insights into novel approaches to trace fine PM, its sources, pathways, and health effects in different settings worldwide.

Isotope fingerprints have been successfully applied for source tracing of pollutants in rivers, oceans, and soils, but only more recently for atmospheric PM (Schleicher et al., 2020). They have the advantage to work independently of concentrations and are often unique for individual sources. The so-called multi-isotope fingerprint (MIF) approach, which uses more than one isotope system, has been successfully applied to trace sources of atmospheric PM in cities, such as London and Barcelona (Ochoa Gonzalez et al., 2016), or São Paulo (Souto-Oliveira et al., 2018). Souto-Oliveira et al. combined positive matrix factorization (PMF), a statistical method widely used for aerosol source apportionment, and MIF to enhance source identification/discrimination and its quantification in urban areas. Their results show that cross-validation of PMF source identification by MIFs improves the accuracy of source apportionment. The authors recommend more such studies to improve the isotope fingerprints database of sources based on diverse elements in order to advance MIF model applications in atmospheric sciences.

The period of the Olympic Games in Beijing 2008 is an example of a successful reduction of PM mass and metal concentrations due to the large-scale emission control measures taken by the Chinese government (Schleicher et al., 2012). Breitner et al. studied the health benefits of short-term PM mass reductions using the Olympic Games period as an excellent case study. They observed associations between different particle metrics and respiratory and pneumonia mortality. Their findings suggest that even a short-term reduction in pollution concentrations may lead to health benefits. The authors recommend focussing on smaller particles in the ultrafine size range as they seem to be particularly important for respiratory health. Such ultra-fine particles (UFP, with a diameter smaller than 100 nm) have been investigated in a German city by Giemsa et al.. The authors observed a pronounced temporal and spatial variability of the urban UFP concentrations. They observed peak concentrations next to a street canyon with a high traffic volume, especially during rush hour times. However, their results highlight that not only the different local source contributions are of importance for the urban load of UFP, but also the influence of meteorological conditions. This study shows the importance to include UFP in future monitoring campaigns in urban areas.

Kaushik et al. investigated the water-soluble species of PM_{10} and $PM_{2.5}$ samples collected over a complete year at a coastal location in the northeastern Arabian Sea. The dominant ions in their samples were sulphate anions and ammonium cations showing a contribution from anthropogenic emissions and significant secondary inorganic species formation. They also found water-soluble potassium cations during the winter months and attributed them to biomass-burning emissions. Regional scale characterization of atmospheric aerosols like in this study are of importance to enhance parameterization in chemical transport models and to better estimate radiative forcing.

Recently, machine learning tools have been applied to improve aerosol source apportionment (e.g., Zhang et al., 2022). Rajput and Gupta applied instrumental variable analysis (IVA) for inferring causality in atmospheric and aerosol chemistry observations. IVA is a quasi-experimental design that can control for measured as well as unmeasured confounders. The authors applied and validated IVA with data collected during a festive Diwali and Post-Diwali period in India. The study showed that ozone had a causal effect on the formation of SOA (secondary organic aerosols) during daytime when biomass burning emissions influenced the receptor site.

In the last article of this Research Topic, Norra et al. focus on local inhomogeneities of PM concentrations within a medium-sized city in Germany. The authors used a mobile sensor platform on a trailer pulled by a bicycle to investigate the spatial distribution of $PM_{2.5}$ and PM_{10} concentrations. Their work highlights how difficult it is to determine the so-called urban background concentrations by a single or few reference measurement stations due to the high spatial variations.

The studies included in this Research Topic highlight that very different approaches are needed to tackle the complex problem of air pollution in urban areas. The articles apply various methods to advance the monitoring and modelling of fine particulate matter pathways. This includes focusing on fine (PM_1) or ultra-fine (UFP) particles, using mobile measuring platforms, or applying machine learning methods. In addition, the combination of two very different methods, such as the combination of a traditional tool like PMF with a very novel tool such as MIF, resulted in significantly improved source apportionment. Generally, it can be concluded that the best approach to improve urban air quality is to include and combine a variety of tools from a broad range of disciplines.

Author contributions

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Conflict of interest

Author SS was employed by Hensoldt Optronics GmbH.

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Publisher's note

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