AIRBORNE MICROPLASTICS: UNDERSTANDING OUR EXPOSURE

Global Concerns Surrounding Microplastics

In the past 60 years, worldwide plastic production has increased by over 200 percent.[1] This hasn't gone unnoticed, and the public has become increasingly aware of the emerging plastic-derived contaminants that pollute our environment and their various forms, such as microplastics (MPs).

Although they are ubiquitous in our environment today, MPs are so small that they can be invisible to the naked eye, measuring anywhere between 0.001-5 mm in length.[2] They are formed from a variety of sources and are broadly categorized into two types: primary and secondary MPs.[3] Primary MPs are originally manufactured at (<)5mm in size prior to entering the environment; an example of this is microbead synthesis for ingredient use in personal care products.[4] Whereas secondary MPs are typically smaller fragments degraded from larger plastics, such as plastic bags or bottles.[4] We often hear about MPs in our oceans, which is understandable given the majority of research undertaken on MPs today investigates their presence in marine and freshwater ecosystems. Less discussed, and typically overlooked however, are investigations into MPs in our air and atmosphere.

Airborne MPs – A Summary of What We Know

Airborne MPs have been detected across various geographies, from urban areas to remote mountain catchments.[5, 6] Collective evidence suggests that many of these airborne MPs are degraded from much larger materials based on sample identification; for example, natural cellulosic materials degraded from clothing garments.[5, 6]

Microplastics in the Air We Breathe

Some studies indicate that on average, human exposure to airborne microplastics probably outnumbers the exposure from other sources.[7] Despite this, there is currently insufficient data available to help us determine and better understand human exposure to MPs from the air we breathe.

Understandably, there are growing concerns over the potential health risks associated with MP ingestion and inhalation. These concerns are warranted as the presence of MP-associated micropollutants could pose adverse health implications, for example, airborne MPs are suspected of acting as vectors by desorbing micropollutants, such as Polycyclic Aromatic Hydrocarbons (PAH), dye pigments or plastic additives.[8] Potential carcinogenic or mutagenic risks cannot be excluded just yet, calling for more research into the issue.

Figure 1: Breathing Thermal Manikin in sitting position during the sampling (left) and its artificial lungs system (right)

At the Department of the Built Environment, Aalborg University, Denmark, we are focused on the development and improvement of analytical methods to quantify MPs in an array of environmental matrices. To further our understanding of the prevalence of microplastics, we recently conducted a novel experiment to investigate human exposure to indoor airborne MP particulates.[9] We also investigate their occurrence and fate in systems including wastewater treatment plants, stormwater management systems, soils, sediments, freshwaters, and seas.

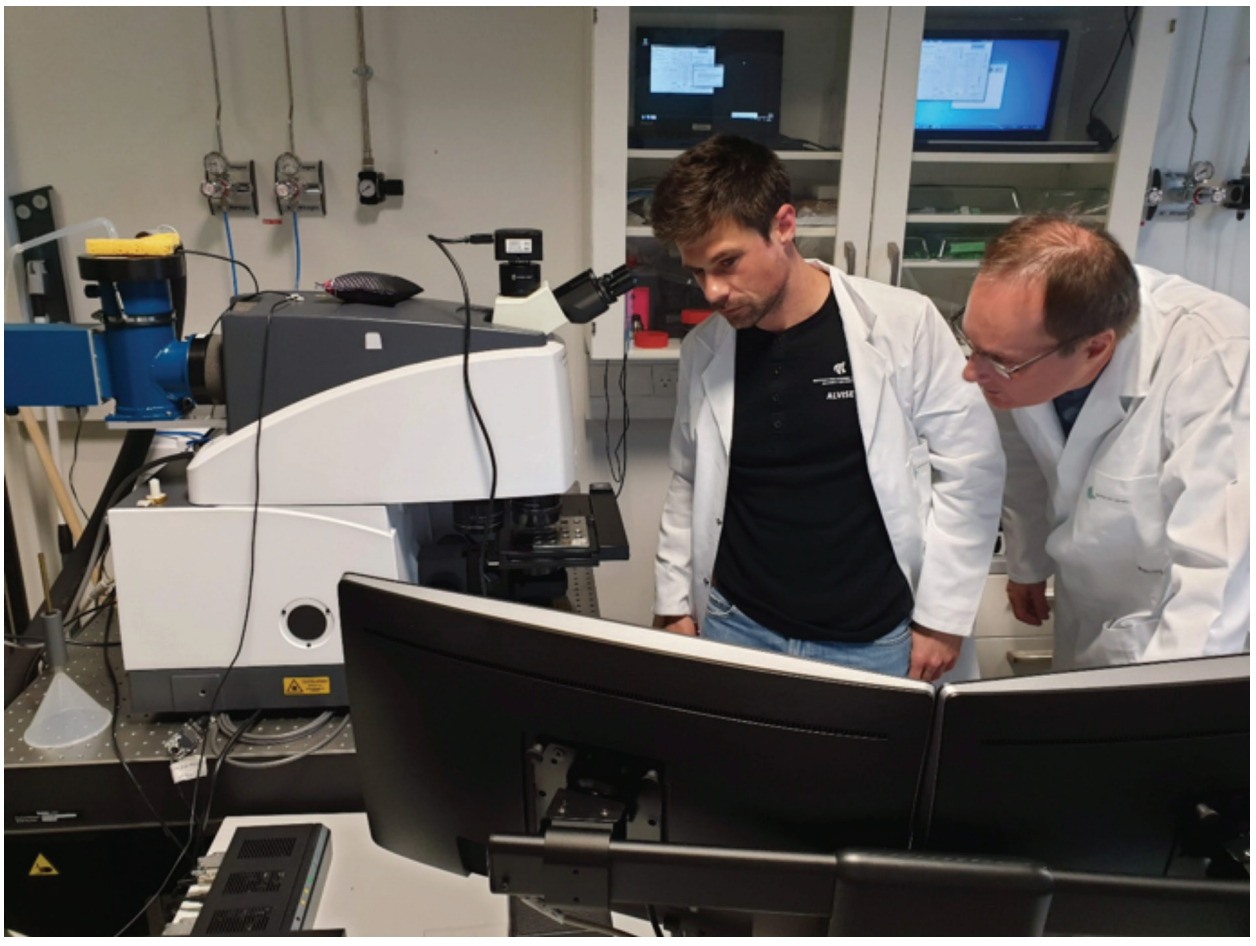

Figure 2: Image of Alvise Vianello (left) and Jes Vollertsen (right) analysing airborne MP samples in the FTIR lab, Alborg University, Denmark

Author Biographies

Alvise Vianello

Post doc, Department of the Built Environment, Aalborg University, Denmark

Alvise Vianello has a background in analytical chemistry – his expertise covers Infrared Spectroscopy (including FTIR) and Gas Chromatography Mass Spectrometry (GCMS) for analysis of microplastics. He works on the development and improvement of analytical methods to quantify microplastics in environmental matrices. Furthermore, he investigates microplastic occurrence and fate in different compartments, including wastewater treatment plants, stormwater management systems, soils, sediments, freshwaters, seas, and recently also airborne microplastics.

Professor Jes Vollertsen

Professor of Environmental Engineering, Department of the Built Environment, Aalborg University, Denmark

Professor Vollertsen's research involves the assessment and management of water systems at Aalborg University. A key focus area for his group at the institution is the development and improvement of analytical methods to quantify microplastics (MPs) in environmental matrices. His group also investigates the occurrence and fate in such systems – including wastewater treatment plants, stormwater management systems, soils, sediments, freshwaters, and seas. His group routinely use infrared (IR), Raman and gas chromatography (GC) technologies to perform quantitative analyses of microplastics.

The Study of Simulating Human Exposure to Indoor Airborne MPs

With this study, we set out to present novel data on simulated human exposure to airborne MPs in indoor environments. This was achieved by using a Breathing Thermal Manikin (a prototype model, shown in Figure 1) with comparative physical and biological structures to those of a real human, in terms of metabolic rate and breathing mechanisms only. [9]

During this experiment, air samples were collected from three separate family apartment buildings in Aarhus, Denmark. Sample analysis was performed using FPA-µFTIR-Imaging spectroscopy (Focal Plane Array-Fourier Transform-Imaging-Micro-Spectroscopy (Agilent Technologies 620 FTIR microscope coupled with a Cary 670 FTIR spectrometer)), followed by automated MP detection to provide unbiased qualitative and quantitative data. [9]

Results from this study highlight that indoor airborne samples contain significant fractions of MP particulates,[9] which are potentially ingestible and can be inhaled.

More specifically, polyester was identified as the predominant synthetic polymer in all samples (81%), followed by polyethylene (5%) and nylon (3%) in each of the three separate apartments. [9] MP sample sizes were identified as low as 11 µm (expanding the detectable size range in air samples than previously reported in other studies). [9] Based on these evaluations alone, we could not determine whether inhaled or ingested MP particles contribute to any adverse effects on human health – however, we also could not rule it out.

Call to Action for Expanding Airborne MP research

The discoveries from this pilot study were truly astonishing, especially to the families living inside the apartments where the experiments took place. Generally, most people are aware of environmental concerns with regards to plastic pollution but unaware of atmospheric MP contaminants. Given these results, the research group at Alborg University are performing consecutive studies to further investigate the occurrence of microplastics in indoor and outdoor air, in order to achieve a better understanding of human exposure to this contaminant.

Current research can show us that MPs are an emerging contaminant and more and more we are learning that MPs could act as vectors for other micropollutants.[8,10] However, at this stage, there is not enough scientific evidence to determine the overall fate, transport and health impacts of ingested MPs. A recent report published by The World Health Organization (WHO) stated that, *"a better understanding on the uptake and fate of microplastics and nanoplastics following ingestion is needed"*, and furthermore, *"a better understanding of overall exposure to microplastics from a broader environment is needed"*.[11]

Thus far, we can confirm that MP and even smaller plastic-derived fragments (nanoplastics) are ubiquitous throughout our environment. However, further research is critical to helping us understand human exposure and bioaccumulation levels which could potentially elicit harmful biochemical mechanisms inside human cavities. Once we have answers to the above concerns, we may see global progress across standardized safety measures and support management systems associated with emerging concerns around MP pollution.

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Author Contact Details

Alvise Vianello PhD • Department of Built Environment, Aalborg University, Denmark • Tel: +45 9940 3817 • Email: avia@build.aau.dk • **Web: www.en.build.aau.dk**

Jes Vollertsen, Professor of Environmental Engineering • Department of Built Environment, Aalborg University, Denmark • Tel: +456 9940 8504 • Email: jesvollertsen@build.aau.dk, • **Web: www.en.build.aau.dk**