Tracing Airborne Microplastics in Modena: results from the MicroTRACES project

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Introduction and study objectives

Microplastics (MPs) are plastic particles smaller than 5 mm [1], resulting from the mismanagement of plastic products and waste as well as from the fragmentation of larger plastic products. They are ubiquitous in all environmental compartments, from the deepest ocean depths to the highest mountain peaks [2]. Due to their diverse nature, small size, and hydrophobic properties, MPs can easily adsorb contaminants, release harmful chemicals, and enter the food chain, posing significant environmental threats to human health. Recent studies have shown that MPs can accumulate in human tissues and organs, potentially leading to oxidative stress and inflammation [3]. Moreover, some MPs contain toxic chemicals that can be released into the body, raising concerns about their potential long-term health effects [4]. Despite this, little research has been conducted on the presence of MPs in the atmosphere, and data on airborne MP levels in urban outdoor environments are limited to reports from few megalopolises worldwide [5-6].

The latest studies indicate that densely populated areas largely contribute to MP contamination, with tire wear abrasion being an abundant source of emission in these environments. Within this framework, the MicroTRACES project ("Microplastics: Tracing souRces of Airborne Contamination and Ecotoxicity on Soil), started on November 2022, aims at investigating the occurrence, small-scale transport and environmental impacts of airborne MPs in Modena, a mid-sized city located in the Po Valley (Italy). To reach this goal, MicroTRACES adopts a multidisciplinary approach covering different aspects of MP contamination, from field monitoring, analytical detection and physico-chemical characterization to atmospheric dispersion modeling and ecotoxicity testing. Alongside its scientific activities, the project incorporates a dissemination program that seeks to engage stakeholders and increase public awareness about MP contamination, its sources and impacts, and potential mitigation actions.

Materials and methods

To evaluate the airborne MP contamination in Modena, samples were collected at two distinct air quality monitoring stations, one located in close proximity to a busy street with heavy traffic, and the other situated within a public park representing urban background conditions. Daily measurements were taken during wintertime, from January 13th to 19th, 2023, using low volume active pumped samplers featured with quartz fiber filters and an inlet size cut-off of 10 µm. Passive deposition samples were also collected at both

locations using aluminum funnels with glass bottles. After 7-14 days, upon collection, the funnels were extensively washed in filtered ultrapure water and samples were concentrated onto membrane filters through vacuum filtration. If needed, passive samples underwent an oxidative treatment and MPs were collected by density separation to minimize matrix effects. Finally, samples were concentrated onto membrane filters. Both active and passive filter samples were examined under an optical fluorescent microscope to determine the number, shape and size of the MP candidates, which were stained with Nile Red, a lipophilic dye that facilitates MP identification. Sub-samples were further analyzed by Raman microscopy (μRaman) to identify their polymeric composition.

Concurrent with the MP identification analysis, atmospheric dispersion simulations of tire, brake and surface wear were conducted at the city scale to estimate the spatial distribution of MP concentrations and deposition. Emissions were estimated using firm technical vehicle characteristics (i.e., speed-dependent emission factors), activity data (measured and modeled traffic fluxes of light and duty vehicles), and local fleet composition. On the other hand, dispersion simulations were conducted during the same periods of the sampling campaigns, using the Lagrangian modeling suite GRAMM-GRAL [7], which offers a spatial resolution of 4 x 4 m^2 and is able to account for the presence of buildings in the flow-field reconstruction.

As outreach activity, citizens from Modena area were engaged in MicroTRACES through an online survey released during November-December 2022. The questionnaire was developed to characterize public perception of MP pollution and individuals' actions that may enhance their exposure to MPs. A variety of respondents from public and private ethical organizations and local companies was involved, aiming at investigating people attitude, risk perception and willingness to address environmental issues effectively. Besides, a hundred of students from a scientific high school took part to the educational project "Taking MPs into the class". Their early level of knowledge about plastic pollution was assessed through a first brief cognitive questionnaire related to the project topics, followed by a formative meeting held in the high school. Then, their potential raising of awareness was verified with a second questionnaire. A class was also directly involved in a hands-on laboratory activity focused on the classification of litter items.

Results and Discussion

Preliminary analyses of active and passive filter samples showed that MPs were present in all the processed samples, and petro-chemical-based polymers associated to together with textile natural-based and synthetic fibers represented the great majority of MPs (Figure 1).

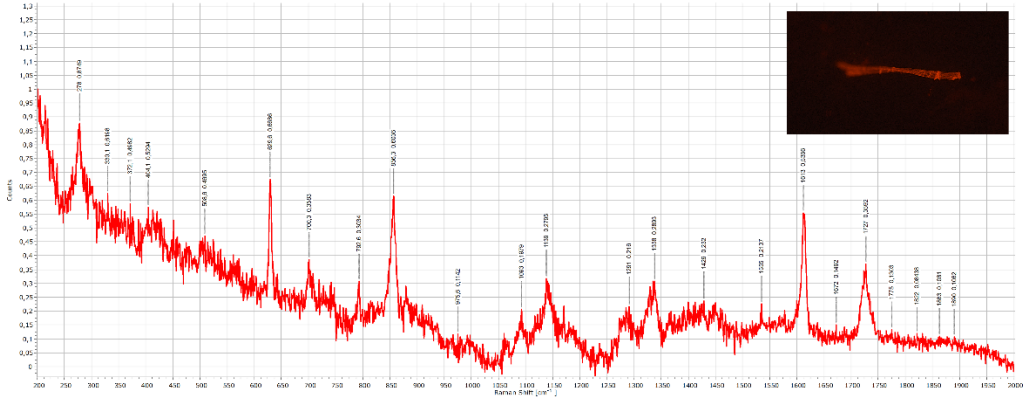

Figure 1: µRaman spectrum of a polyester (match rating: 77%) microfiber from passive deposition samples in Modena. Corner image: Nile Red-stained microfiber under optical fluorescent microscope

Further analyses are ongoing to estimate MP deposition rates and abundances at the two sites characterize the physico-chemical properties of polymers and assess their toxicity on soil fauna through bench-scale chronic toxicity tests.

The feedbacks of the questionnaire survey shared with Modena citizens are under elaboration. At an initial assessment of the responses collected, people's perception of plastic pollution emerged as a public issue of concern. Indeed, most of the respondents (93.9%) would support initiatives to raise awareness and monitor plastic contamination in their city. Citizens were concerned or very concerned (92.8%) about the impacts of plastic pollution on the environment and human health. The 96% of the participants had already heard of MP, mainly through social media channels and television, but the questionnaire showed a general lack of knowledge about the main sources of MP in urban environments, their dispersion in the atmosphere and pathways of human exposure. Likewise, almost all high school students (95.2%) stated they will pay more attention to how their habits can affect the environment and human health. After the formative meeting, at least 70% of them were properly informed about MP classification, sources, impacts and routes of exposure.

Conclusions

Plastic pollution is emerging as an enhanced concern topic among citizens. Although massive campaigns have provided a general education about MP widespread distribution and threat for biological communities, public awareness on people's exposure from urban areas is still limited. The preliminary results achieved within the MicroTRACES project support that tyre and road wear may constitute a potentially important source of MP in urban ecosystems. Considering citizens' high interest and awareness towards this topic, the participation of the public in citizen science and student-driven projects could result effective in monitoring MP pollution in indoor and outdoor environments and pursuing a greater understanding of their impacts on the environment and human health.

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