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Microplastic retention in urban tree canopies of Hamburg, Germany

Torben Brecht, Dr. Elke Kerstin Fischer
CEN, University of Hamburg

Introduction

Why perform this study?

Recent studies on atmospheric deposition of microplastic particles in the greater Hamburg area showed evidence of particle retention within the canopy of forests. That is what set us off to investigate the leaves of urban trees in parallel to further atmospheric investigations.

What is the aim of this study?

Our aim is to determine whether and to what extent leaves are collecting microplastics through the comb-out effect and whether those particles are washed off by rain events. Trees could act as kind of bio-collectors and could therefore be a relevant accumulation area of atmospheric microplastics.

Study Area

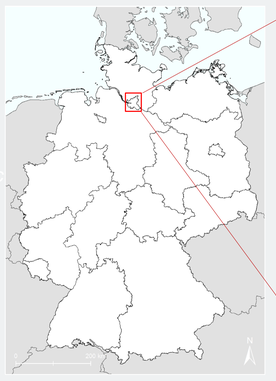

Fig. 1: Study area in Germany.

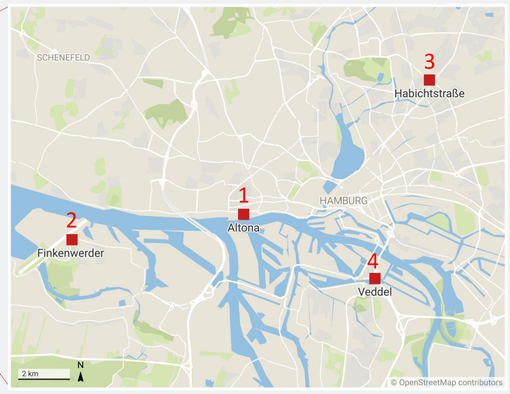

Fig. 2: Sampling sites in Hamburg

Fig. 3: Sampled species;
a) *Tilia × europaea*, b) *Tilia x europaea 'Pallida'*, c) *Tilia cordata*, d) *Quercus robur*

The study was conducted at 4 sites in the city of Hamburg in July and October 2020. At each site 2 trees were sampled by cutting 15 leaves from 3 expositions (=45 leaves per tree). Additionally, soil samples were taken from the surface layer in July.

Material & Methods

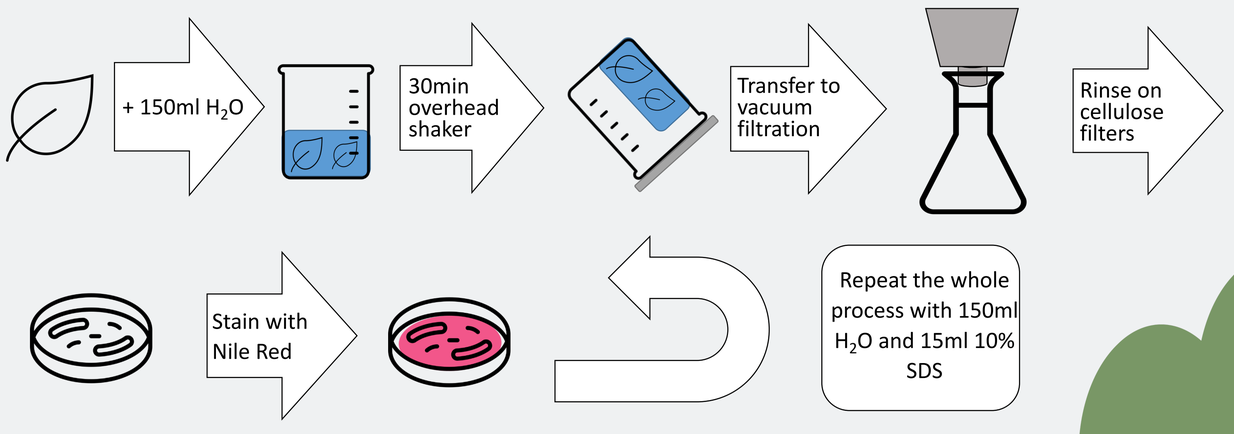

Fig. 4: Laboratory protocol fore the leaves

For the processing of leave samples, we developed a new laboratory protocol. Therefore, each sample is transferred into a pre-cleaned one-liter glass beaker. The aluminum box and the foil where the leaves were transported in are rinsed with filtered MilliQ water into the glass beaker and 150 ml of filtered MilliQ water are added. Samples are shaken for 30 minutes by 16 rounds per minute in an overhead shaker (Heidolph, Reax 20). The supernatant is transferred via vacuum filtration onto cellulose filter (VWR, qualitative filter paper 413, pore size 5-13 µm) including suspensions derived from leaf and glass beaker rinsing. This step is repeated adding 15 ml of sodium dodecyl sulfate (SDS-Solution 10% pure, AppliChem Panreac) prior to shaking. Dried filters are stained with Nile Red (1 mg/ml in chloroform) and analyzed via fluorescence microscopy (Zeiss, Axioscope 7) for particle numbers, morphology and size.

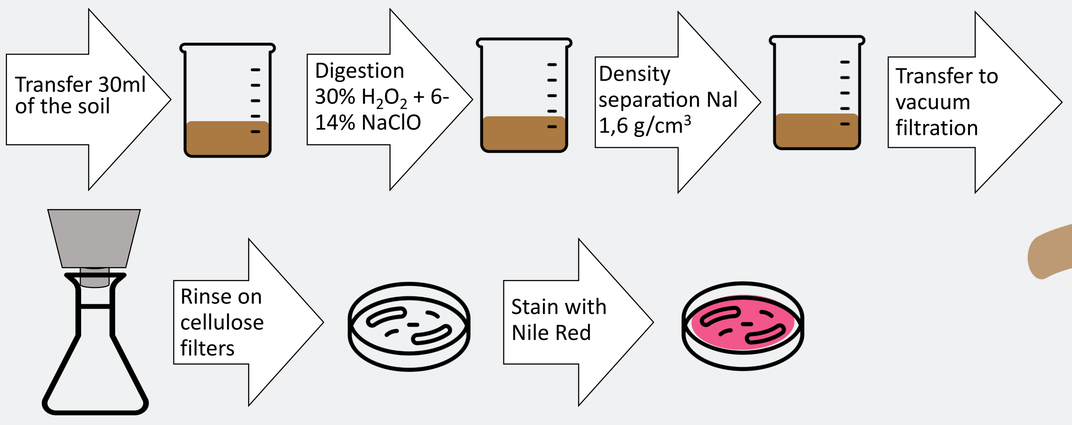

Fig. 5: Laboratory protocol fore the soli samples

30 ml of soil samples are transferred to a pre-cleaned glass beaker. Sample digestion consists of 1) 60 ml of hydrogen peroxide (H2O2, 10%), left to stand for 7 days at room temperature, 2) wet sieving (20 µm), 3) 30 ml of sodium hypochlorite (NaClO, 6-14%) for 24 hours at room temperature and 4) wet sieving (20 µm). For density separation the sieving residue is transferred to a pre-rinsed glass column. The column is levelled to 300 ml with sodium iodide (NaI 1.7 g/cm³) and homogenized via overhead shaking 12 times. After 10 minutes of sedimentation time, the sediment is drained off at the bottom of the column via a tap into a beaker. The supernatant is drained off in a clean beaker and transferred onto cellulose filters (VWR, 413, mean filtration rate, retention 5-13 µm) using a vacuum filtration system. This is repeated twice. Resulting filters are stained with Nile Red (1 mg/ml in chloroform) and analyzed via fluorescence microscopy (Zeiss, Axioscope 7). A subset of identified particles both from leaf and sediment samples is currently investigated for their polymer composition via Raman spectroscopy (DXR3xi, Thermofisher Scientific).

Results & Discussion

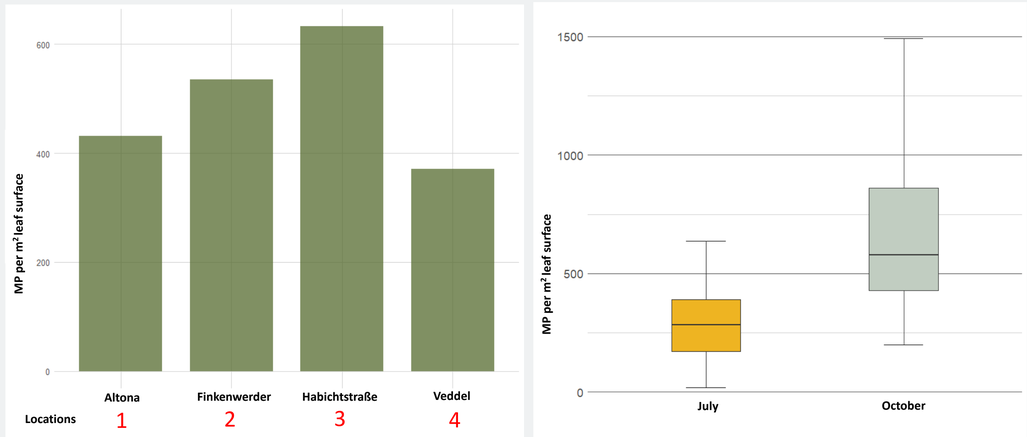

Fig. 6: Microplastics per m² leaf surface area according to locations and month

Microplastic mean concentrations in leaf samples are 493 ± 231 particles per m² of leaf surface. The lowest concentration was found at the "Veddel" site with a mean of 371 ± 168 microplastic particles per m² of leaf surface, highest concentrations at "Habichtstraße" site with a mean of 634 ± 213 microplastic particles per m² of leaf surface. Comparing the time of sampling, the values in July (mean 312 ± 101 microplastic particles per m² leaf surface) are significantly lower compared to October (674 ± 177 microplastic particles per m² leaf surface) (p-value < 0.01). It is assumed that both lower microplastic release rates and interdependencies to weather conditions do account here.

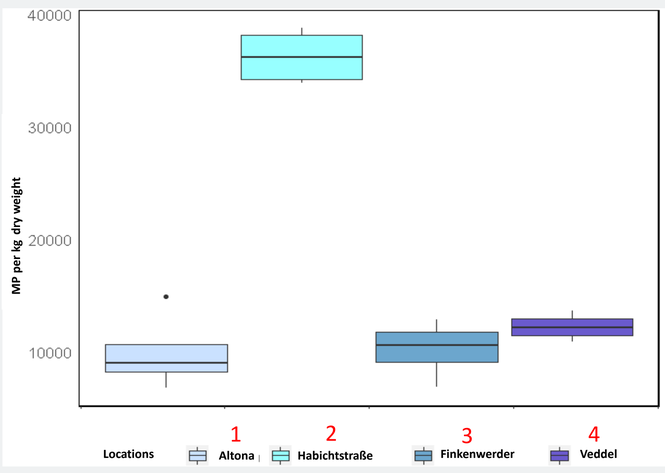

Fig. 7: Microplastics per kg dry weight of sediment according to locations

The sediment analyses result in microplastic concentrations from lowest median concentrations "Altona" (median 9,024.1, mean 9,935.2 ± 3,479.6 MP/kg dry weight), followed by "Finkenwerder" (median 10,617.3, mean 10,267.9 ± 2,563.3 MP/kg dry weight) and "Veddel" (median 12,166, mean 12,234.7 ± 1,193.3 MP/kg dry weight). These microplastic concentrations are significantly lower compared to those determined at "Habichtstraße" (median 36,160.2, mean 36,259.0 ± 2,461.9 MP/kg dry weight), a site of intense population density (10,944 people per km²) and high traffic frequencies ($p < 0.001$). Both for leaf and sediment samples fragments are clearly dominating compared to fibers and microbeads. No correlation between concentrations in leaf samples and referring sediment was detected, which is most likely due to low sample numbers.

Conclusion

The study is one of the first to show that microplastics adhere to leaf surfaces of deciduous trees due to the comb-out effect. The results indicate that leaf surfaces are an at least intermediate trap for microplastics. So far, no correlation to referring underlying sediments could be shown, however, both for leaves and sediments significantly highest concentrations occur at the station with dense population and large traffic frequencies.
Further investigations are necessary to show the correlation to atmospheric and related sediment in order to evaluate whether trees act as a representative bio-collector and thus, might be useful within biomonitoring.

References

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Contact: Torben Brecht, CEN, University of Hamburg, torben.brecht@uni-hamburg.de