Airborne microplastic deposition across the Weser river basin

S. Kernchen*[1], M. G. J. Löder[2], C. Laforsch[2] and A. Held[3]

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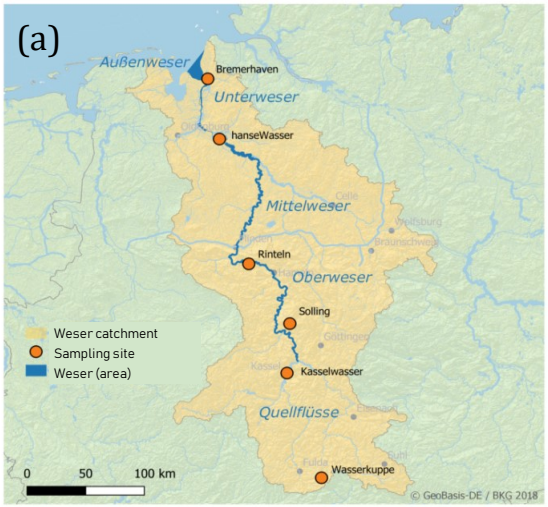
Introduction

Increasing plastic pollution is of growing environmental concern globally. Contrarily to aquatic, terrestrial and biological systems, microplastic (MP) contamination in the atmosphere has gained much less attention. In this work MP deposition fluxes (DFs) were studied across the Weser river basin, which connects urban, agricultural and rural areas in Germany with the North Sea.

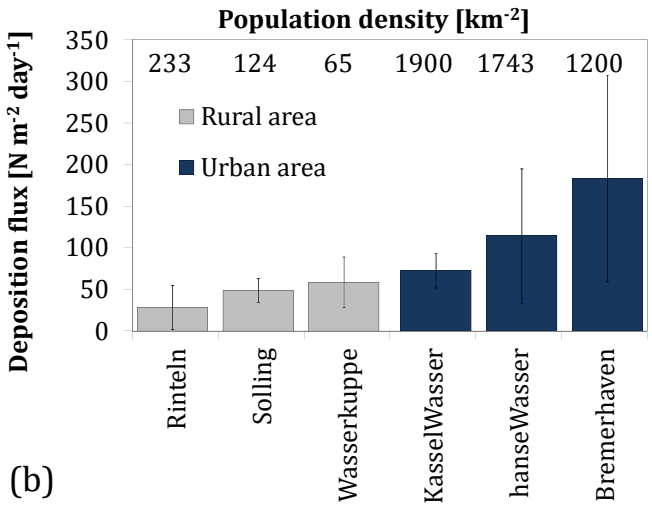


Experimental Work

Total atmospheric deposition was collected at six strategically different sites monthly from March to September/October (2018) at four sites (Wasserkuppe, KasselWasser, hanseWasser and Bremerhaven) and twice at two sites (Rinteln and Solling) in spring and autumn, while site KasselWasser was sampled monthly over one year from April 2019 to April 2020 for wet-only and dry-only atmospheric deposition. Samples were treated following a novel purification protocol based on oxidative-enzymatic digestion to remove organic and inorganic residues. The isolated MP fraction was analyzed with FTIR microscopy in a size range from 11 µm to > 500 µm.

Results

All sampled sites contained measurable amounts of MPs with deposition fluxes ranging from 10 to 367 particles (N) per m^2 per day (99±84, mean±SD), which corresponds to an average deposition of 0.05 kg ha^{-1} annually. MP fragments in different forms (96.9%) comprised most of the detected plastic particles, followed by fibres (2.9%) and spheres (0.2%). 92% out of all particles were in the smallest studied size range from 11 µm to 100 µm. In total, particles made of 17 different synthetic polymers were identified. The predominant MPs were made of PP, PE, PET, PVC, and PS accounting for 82% of all particles. Deposition fluxes at the site hanseWasser correlated significantly with precipitation (Pearson's r=0.8, $p<0.05$). Wet-only deposition fluxes of MPs were significantly higher than dry-only deposition. Dry deposition comprised only approximately 5% of the total deposition.



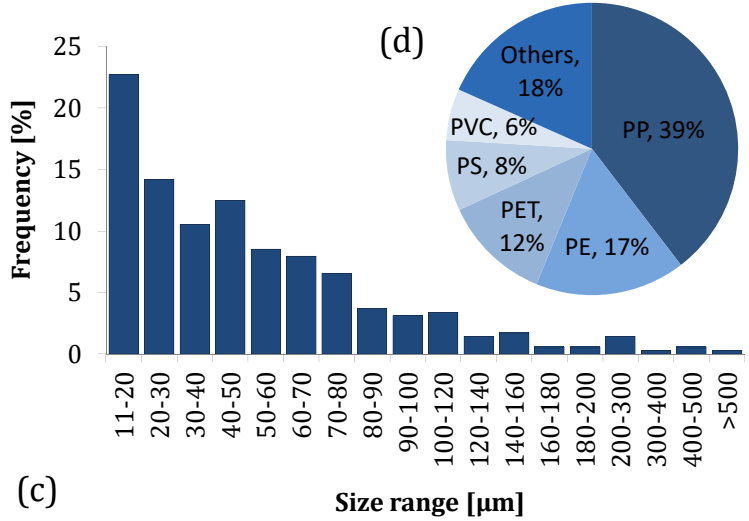
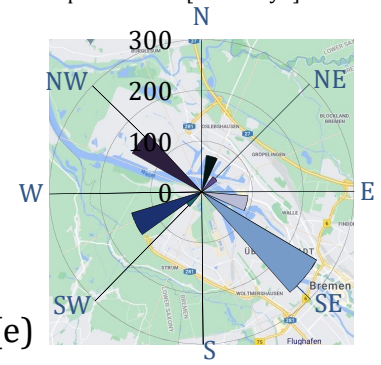


Fig. a-e. (a) Sampling sites; (b) total atmospheric deposition fluxes of MPs (mean±SD). Numbers above bars correspond to the population density (2019) at the site; (c) size distribution of deposited non-fibrous MPs; (d) plastic-type distribution in a set of 32 total deposition measurements; (e) wind rose plot of the relationship between total deposition flux [N m^{-2} day^{-1}] of MPs at the site hanseWasser and averaged wind direction. The highest deposition flux was observed downwind of the city Bremen.



Summary

- **MP total deposition fluxes were higher in urban areas than in rural areas.**
- **Deposition fluxes across the Weser river basin showed no clear seasonal characteristics.**
- **No tight correlation between population density and deposition fluxes was observed.**
- **We cannot confirm that wastewater treatment plants generate airborne MPs.**
- **Rainfall plays a major role in airborne MP scavenging from the atmosphere.**
- **Wind characteristics can be helpful to interpret MPs amounts in the air.**

***Presenting author** email: sarmite.kernchen@uni-bayreuth.de

[1]Department of Atmospheric Chemistry, University of Bayreuth, Bayreuth, 95440, Germany; [2]Department of Animal Ecology I, University of Bayreuth, Bayreuth, 95440, Germany; [3]Chair of Environmental Chemistry and Air Research, Technische Universität Berlin, Berlin, 10623, Germany

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