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Assessment of the impact of local human activity on microplastic atmospheric deposition

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INTRODUCTION

The study of microplastic transfer in the atmospheric compartment is gaining traction as a scientific field [1], as it is likely to represent a major transport vector for microplastics into the environment. Several factors are expected to affect atmospheric microplastic contamination and deposition, human activity [2,3] and meteorological variations [4,5] being the leading ones. This work aims to assess the effect of human activity on atmospheric deposition of microplastics by comparing microplastic deposition rates in sites marked by different levels and types of human activity.

MATERIALS AND METHODS

This study focused on four sites of interest. Sites A (48.84227N, 2.58833E) and B (48.82406N, 3.13965E) are in proximity to Paris, 45 km from each other. Sites C (47.222209N, 1.537428W) and D (47.155701N, 1.637061W) are located near the regional metropolis of Nantes, France, and 11 km away from each other. Site A is in a suburban campus surrounding by traffic and urban activity, with a surrounding population density of $\sim 3,500$ inhab km⁻². Site C is located in a cemetery in Nantes urban centre. It is surrounded by traffic, transport, industrial activities and an average population density of $\sim 5,000$ inhab km⁻². Sites B and D are located in rural environments, and are largely surrounded by agricultural activities, with respective population densities of 300 and 500 inhab km⁻².

A monitoring campaign was conducted on each site using passive bulk atmospheric deposition samplers. The monitoring campaigns in site A and B were conducted partly simultaneously, using the same structure of passive sampler, and lasted 5 months. The campaigns in site C and D were conducted entirely simultaneously using the exact same form of sampler and lasted 12 months. New samples were collected every 4 to 11 days in site A, and samples were collected monthly in other sites.

After collection, all samples underwent a microplastics isolation treatment which consisted in a density-based separation of minerals using NaI, followed by an H₂O₂ oxidative treatment. After treatment, the microplastic content of all samples was characterized and quantified using an automated μ FTIR imaging analysis using a Nicolet iN10 by Thermo Scientific, equipped with a linear array of MCT imaging detectors, which allowed for the identification of microplastics down to 25 μ m. After acquisition, the maps obtained were analysed using the software for Systematic Identification of MicroPLastics in the Environment (siMPle) developed at the Aalborg university, Denmark and Alfred Wegener Institute in Helgoland, Germany [6].

RESULTS

In the Paris sampling campaign, median deposition rates of $29.2 \text{ MP m}^{-2} \text{ d}^{-1}$ were measured in site A and $14.3 \text{ MP m}^{-2} \text{ d}^{-1}$ in site B. Sampling campaigns in the Nantes region retrieved deposition rates of $60.2 \text{ MP m}^{-2} \text{ d}^{-1}$ in site C and $40.3 \text{ MP m}^{-2} \text{ d}^{-1}$ in site D. While Paris and Nantes campaigns cannot be directly compared, lower deposition rates were measured at rural sites than at urban sites.

The polymer types were similar between sites, dominated by polypropylene, polyethylene and polystyrene. Differences were however noted between sites. PE was the dominant polymer in rural sites, a higher diversity of polymers was observed in the urban sites. Similarly, differences were noted between the size distribution in urban and rural sites. The majority of plastics were centred around a modal class of 150 to 200 μm in rural sites, against a modal class of 100 to 150 μm in urban sites. PE particles in particular tended to be larger than other microplastics.

INSIGHTS AND DISCUSSIONS

In the light of the available dataset, it seems likely that the dominant factor affecting microplastic deposition is the surrounding human activity. Differences in polymer repartitions may be explained by different surrounding microplastic sources, while the differences in levels of activity may explain the relative difference in deposition rates.

While precipitation rates were measured throughout all campaigns, no clear effect of rainfall on microplastic deposition rates was identified. It is likely that the effect of precipitation and other meteorological events cannot be observed at the monitoring time scales of this study. In order to better assess the temporal variability of atmospheric microplastic deposition, future research should be conducted at a fine time scale. Separate sampling of dry atmospheric fallout and rainfall may also help to better understand the effects of hydrometeorological events.

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