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A first overview of textile fibers, including microplastics, in indoor and outdoor environments☆

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ABSTRACT

Studies about microplastics in various environments highlighted the ubiquity of anthropogenic fibers. As a follow-up of a recent study that emphasized the presence of man-made fibers in atmospheric fallout, this study is the first one to investigate fibers in indoor and outdoor air. Three different indoor sites were considered: two private apartments and one office. In parallel, the outdoor air was sampled in one site. The deposition rate of the fibers and their concentration in settled dust collected from vacuum cleaner bags were also estimated. Overall, indoor concentrations ranged between 1.0 and 60.0 fibers/m^3. Outdoor concentrations are significantly lower as they range between 0.3 and 1.5 fibers/m^3. The deposition rate of the fibers in indoor environments is between 1586 and 11,130 fibers/day/m^2 leading to an accumulation of fibers in settled dust (190–670 fibers/mg). Regarding fiber type, 67% of the analyzed fibers in indoor environments are made of natural material, primarily cellulosic, while the remaining 33% fibers contain petrochemicals with polypropylene being predominant. Such fibers are observed in marine and continental studies dealing with microplastics. The observed fibers are supposedly too large to be inhaled but the exposure may occur through dust ingestion, particularly for young children.

1. Introduction

There is a large amount of materials in our daily life that are made of fibers, either synthetic or natural (furniture, textile, etc.). A study detected the presence of these man-made fibers in the atmospheric fallout in the Parisian agglomeration (Dris et al., 2016). It suggests that the atmospheric phase contains fibers that lead to human exposure. This exposure raises concern. Pauly et al. (1998) observed human lungs with a microscope. It was showed that 87% of the studied lungs (n = 114) contained fibers. Cellulosic and plastic fibers were both observed. Moreover, the same study revealed that 97% of malignant lung specimens contained the fibers. The length of the fibers was mainly around 50 μm but could reach a length longer than 250 μm. It was recently pointed at the risk of inhalation of microplastic particles and fibers (House of Commons Environmental Audit Committee Oral evidence: Environmental impact of Microplastics, HC 925 Monday 9 May 2016).

The observed fibers in these studies are often textile fibers (Dris et al., 2016; Pauly et al., 1998). Those made of natural material are classified as either natural fibers (cotton, wool) or as artificial fibers (viscose, rayon, cellulose acetate). Fibers made of petrochemicals are considered as synthetic fibers and are included in the definition of microplastics (ISO/TR 11,827:2012 Textiles — Composition testing — Identification of fibers). Microplastics are particles smaller than 5 mm (Arthur et al., 2008). Many studies have highlighted the presence of these particles in the marine environment (Cole et al., 2013) and their impact on aquatic organisms (Wright et al., 2013). It is assumed that the main part of these plastics come from the continental environment (Jambeck et al., 2015). So far, only few freshwater bodies have been studied and only little information is provided regarding the inputs/sources and pathways of microplastics (Dris et al., 2015b; Wagner et al., 2014). Some studies showed relatively high concentrations of microplastics in rivers and gave first insight on the role of urban areas in this pollution (Dris et al., 2015a; Mani et al., 2015; McCormick et al.,

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2014). To date, few studies focused on the sources of microplastics in surface water and wastewater treatment plant discharges were mainly incriminated (Browne et al., 2011; McCormick et al., 2014).

This study was designed first, to extend the knowledge on fibers found in the air and to explore their occurrence in order to assess the potential exposure for people, and second, to estimate the proportion of microplastics among these fibers and estimate the role that could play indoor environments in the global dynamics of this new contaminant. In this context, this work studies fibers in indoor and outdoor environments. The indoor deposition rate of the fibers and their concentration in settled dust collected from vacuum cleaner bags were also investigated.

2. Materials and methods

Three different indoor sites were selected: two private apartments (apartments A and B, with an approximate ceiling height of 2.4 m) and one office (with an approximate height of 2.7 m). The apartments and the office (work place) were considered in order to have a complete overview of the contamination on the places where a regular person spends most of its day. In parallel, outdoor air was sampled on the roof of the office building. For each site, samplings were carried out on February, May, July and October of 2015. This choice was made in order to cover the four seasons and include any seasonal variation (due to a different air exchange between indoor and outdoor or a difference in the clothing).

All sampling sites were located at about 10 km from Paris city center (Fig. 1). Two adults and one child lived in each apartment (48°48′15.3″N 2°27′53.7″E apartment A, 48°48′20.2″N 2°24′48.9″E apartment B). The sampling was performed in the living room. The office and the outdoor sampling site were located at the University of Paris-Est-Creteil (48°47′17.8″N, 2°26′36.2″E). Three persons were working in the office during the sampling.

A pump (Stand-alone sampling pump GH300,Deltanova, France) allowed to sample 8 L/min of indoor air on quartz fiber GF/A Whatman filters (1.6 μm, 47 mm). Sampled volumes range between 2 and 5 m^3 depending on occupants presence. The samplings were carried out at a 1.2 m height because it is standardly used to correspond to the breathing height of an adult (Noguchi et al., 2016). Sampling periods ranged between 4 and 7 h. It was carried out discontinuously for both apartments, a part of the sampling in the morning before the inhabitants left home and the other half in the afternoon when they were back home, in order to sample the air only when the they were present. The sampling for the office site was carried out continuously during office hours. The same method was used for outdoor air but higher volumes (5–20 m^3) were sampled for a period between 10 and 40 h. A triplicate was carried out per season for each of the indoor and outdoor sites and the number of fibers per cubic meter was estimated.

A passive sampling of dust fall was carried out in order to estimate the deposition rate of fibers. Quartz fiber GF/A Whatman filters (1.6 μm, 47 mm) were exposed once per season at each of the apartments A and B and the office. Sampling was carried out in the living room at 1.2 cm height. The duration of the collection varied between 4 and 15 days. The deposition rate was normalized and expressed as a number of fibers per square meter per day.

Three samples of vacuum cleaner bags were taken, twice in apartment A (winter and autumn) and once in apartment B (winter). The samples were taken directly from the vacuum cleaners that the participants use in their daily life. In order to facilitate the following sample treatment steps, it was necessary to pass the vacuum cleaner's bag contents through a 2.5 mm mesh size sieve. The retained fraction (>2.5 mm) was visually inspected to verify if it contained plastics. As this was never the case, this fraction was systematically discarded. A mass of 5.5 mg was introduced in a separation funnel with 50 ml of Zinc chloride ($ZnCl_2$ - 1.6 g/cm^3) for density separation. Preliminary tests showed a very high number of fibers. In order to make the counting feasible, a subsample of a small volume had to be considered. The floating fraction was homogenized and a subsample of 1 ml taken and filtered on quartz fiber GF/A Whatman filters (1.6 μm, 47 mm).

All samples were observed with a stereomicroscope (Leica MZ12– Buffalo – United states). Previously used criteria were employed in order to identify man-made fibers (Dris et al., 2015a; Hidalgo-Ruz et al., 2012; Norén, 2007). The fibers have to be equally thick through their entire length and should not be entirely

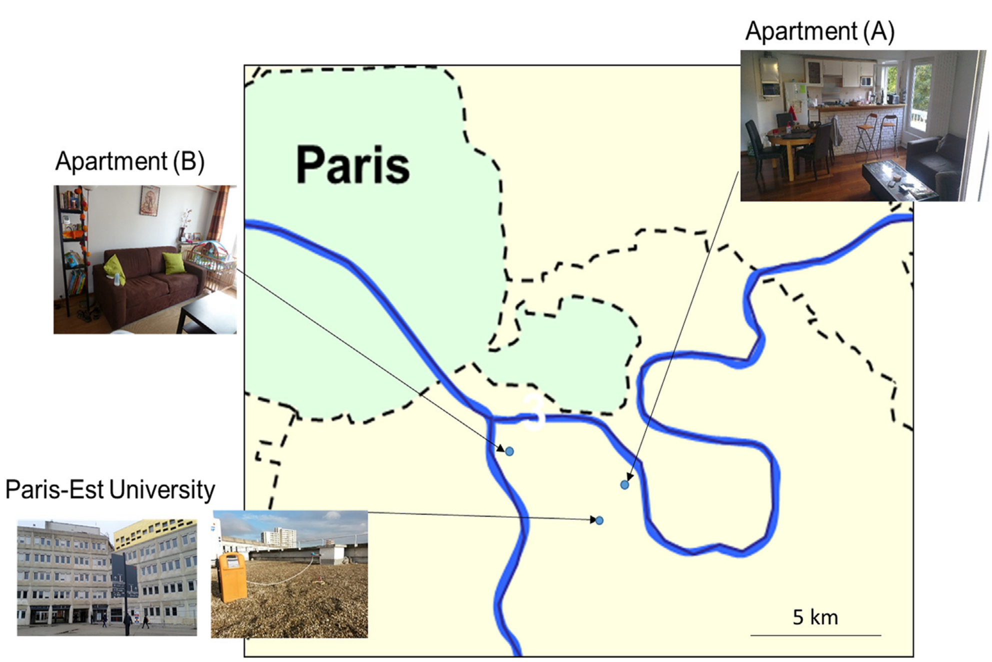

Fig. 1. Location of the monitored sites.