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Do humans inhale microplastics in the air?

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Abstract: Over 6% more plastic is produced annually in the form of plastic textile fibres, reaching 60 million metric tonnes, or roughly 16% of global plastic production. Fibrous microplastics are created when these fibres break down (MPs). These MPs have been observed in indoor and outdoor environments, as well as in atmospheric fallouts. Certain fibrous MPs may be inhaled. However, some may persist in the lung causing localised biological responses, including inflammation, especially in individuals with compromised clearance mechanisms. The majority of the are likely to be susceptible to mucociliary clearance. Polycyclic Aromatic Hydrocarbons (PAHs) and other related contaminants may cause adverse effects on the nervous system, while the plastic and its additives (dyes, plasticizers) may cause reproductive toxicity, carcinogenicity, and mutation.

Keywords: Inhalation; Micropollutants; Fibres; Microplastics; Air pollution; Health risk.

I. INTRODUCTION

Globally, there is growing concern over plastic pollution, and most research has concentrated on microplastics (MPs; plastic particles with a longest length of less than 5 mm). settings that are maritime and, more lately, continental. With the exception of plastic fibre manufacture, global plastic production rises by about 3% yearly and reached 322 million metric tonnes in 2016 [1].

Although it has been established that microplastics (MPs) are ubiquitous in both freshwater and marine environments, particularly fibrous MPs, little is known about the dynamics of their sources, paths, and reservoirs. While the atmospheric behaviour is largely ignored, urban inputs such waste-water treatment plant effluents are being examined more and more as sources of microplastics.

The question of their inhalation and the related health concerns will be crucial if they are present in insufficient quantity.This paper, which focuses on fibrous MPs, tackles both concerns by going over research done on the presence of MPs in the atmospheric compartment and talking about human exposure and the possible health consequences that could follow.

II. IMICROPLASTICS' EXISTENCE IN THE ATMOSPHERE

Are Airborne MPs having a problem?

There are various types of fibres in air. Table 1 provides a generic classification of fibres. Fibres might be synthetic or natural. Additionally, man-made fibres might be categorised as organic or inorganic (carbon, ceramic, glass). Within the latter group, natural materials (artificial fibres) or synthetic polymers are transformed to produce organic fibres (Table 1).

In 2016, the global production of textile fibres exceeded 90 million metric tonnes. The production of plastic fibres, of which two thirds are synthetic, has increased annually at a pace of roughly 6.6% throughout the past ten years.6% of the fibres are cellulosic, and 27% are natural fibres, mostly cotton [2]. There has also been a rise in the commercial use of fine-diameter (1e5mm) plastic fibres, as seen in the sportswear sector[3].

These tiny fibres may shed and be discharged either directly or indirectly as the clothing is washed and dried [4,5].Moreover, fine particles may arise as a result of industrially cutting or grinding synthetic material. In addition to wind shear and/or abrasion from other ambient particulates, fibrous MPs may also undergo photo-oxidative degradation in the environment, which can lead to their eventual fragmentation into fine particles.The chance of breathing in fibrous MPs after

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Table 1: Classification of textile fibres in general

Textile fibers				Man-made fibers	
Natural fibers			From organic chemistry		From inorganic chemistry
Animal fibers	Vegetal fibers	Mineral fibers	Artificial fibers		Glass, ceramic, carbon, etc.
Wool, silk	Cotton, jute	Asbestos	Viscose/rayon, acetate, etc.	Polypropylene, acrylic, polyamide, polyester, polyethylene	

Is it possible to detect fibrous microplastics in the air? As of right now, as far as we are aware, only two investigations have shown that fibrous MPs exist in the atmospheric compartment [6,7], raising the possibility of human exposure. A previous study [8] did not distinguish between natural and synthetic materials, but it did highlight the presence of respirable organic fibres in both indoor and outdoor environments. Although other research has hypothesised the existence of atmospheric MPs, no concrete proof was offered [9,10].

In one urban site and one suburban site in the Paris Megacity, Dris et al. (2016) assessed the occurrence of fibrous MPs in total atmospheric fallout (TAF-including dry and wet deposition) [6]. TAF was regularly gathered from building rooftops. Nearly all of the material recovered (Fig. 1) was composed of fibrous material, with rare small plastic shards (less than 100 mm) making up the remaining material. Atmospheric fallout of between 2 and 355 fibers$m2$day was estimated based on a 1-year and a 6-month monitoring period, respectively, on two sites. TAF fluxes were systematically higher at the urban site than at the suburban one, probably linked to the density of the surrounding population. Rainfall also appears to be an important factor influencing the fallout flux. Despite no significant quantitative correlation between the concentrations of fibers and the characteristic of the rain events (rainfall depth, intensity, etc.), TAF during wet weather periods are always substantially larger that during dry weather periods.

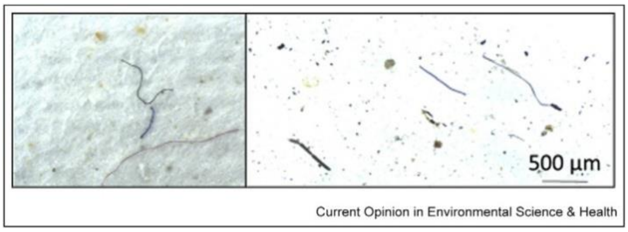

Figure 1: Fibrous microplastic observed in atmospheric fallout. Source: @LEESU.

What features distinguish fibrous microplastics in the atmosphere?

Following chemical evaluation, it was discovered that 29% of the fibres assessed in TAF were plastic, with cellulosic or natural origin fibres making up the majority [5]. It was determined what the length distribution of the fibres gathered greater than 50 mm was. Fibres in the bigger size categories were infrequent, while lower size classes [200e400 mm] and [400e600 mm] were predominate when measuring fibre length. There aren't many fibres that are longer than 200 mm or 50 mm (the observation limit). The fibres' diameter ranged primarily from 7 to 15 mm.

Are fibrous microplastics in the air something humans are exposed to?

Dris et al. (2017) looked at indoor settled dust and fibres in both outdoor and interior air [7]. Three inside locations in a Parisian neighbourhood with two residences and one office were chosen. In close proximity to the office site, where TAF monitoring was conducted, outside air was sampled. 8 L/min of indoor air was measured by a pump and placed into 1.6 mm quartz fibre filters. The sample volumes were different based on the number of inhabitants. The evaluation of outside air was conducted using the same methodology. In general, indoor concentrations varied between 1.0 and 60 fibers/m^3. The concentrations outside were much lower, ranging from 0.3 to 1.5 fibres $m—3. In the indoor settings, the fibre deposition rate varied from 1,586 to 11,130 fibers$m2$day. A traditional hoover cleaner was used to gather settled dust, and further research showed that the fibre content ranged from 190 to 670 fibers/mg.

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What traits do fibrous microplastics in interior settings have?
67% of indoor fibres were composed of natural material, mostly cellulose, according to chemical analysis, whereas 33% of the fibres comprised petrochemicals, with polypropylene predominating [6]. For indoor air, outdoor air, and TAF, comparable size distributions were found with minor variations. The size of the longest detected fibres in each compartment explains these differences: whereas dust fall has fibres ranging in length from 4,650 to 4,850 mm, indoor air does not include any fibres longer than 3,250 mm, which is over double the length of the longest fibres in outdoor air (1,650 mm). Because larger fibres settle and gather on the floor more quickly, larger fibres are seen in dust fall. Although the observation lower limit prevented fibres smaller than 50 mm from being counted, the size distribution pattern indicates that even smaller fibres may be present.
Effects on the health of people?

Are fibrous microplastics in the air breathable?

Size will determine how likely it is that airborne fibrous MPs will get into our respiratory system. First, it's critical to distinguish between the phrases respirable and inhalable. It is possible to inhale particles and fibres that can enter the mouth and nose and settle in the upper airway, but it is possible to breathe in those that can reach the deep lung and settle there. Aerodynamic diameter determines deposition in the airway, and at a 5 mm diameter, deposition in the respiratory zone decreases [11].

According to the World Health Organisation, a fibre is any particle that is longer than five millimetres, has a diameter less than three millimetres, and has an aspect ratio more than 3:1 [12]. Fibrous MPs exceeding these limits could be inhaled, but they will probably be cleared by mucociliary muscles in the upper respiratory tract, which could expose the gastrointestinal tract. However, some fibrous MPs may evade the lung's mucociliary clearance systems, particularly in those whose clearance mechanisms are impaired.

Does the human body accumulate fibrous microplastics?

The lung's ability to retain and expel fibrous MPs is correlated with their biopersistence [13]. Plastic fibres have proven to be remarkably resilient in physiological fluid, according to in vitro testing. After 180 days, polypropylene, polyethylene, and polycarbonate fibres in a synthetic extracellular lung fluid exhibited nearly no disintegration or changes in surface area and properties. This implies that plastic fibres are robust and probably will stay in the lungs [14]. Length and biopersistence are related; longer fibres have a higher chance of avoiding clearance [3].

The discovery of plastic fibres in pulmonary tissue [15] raises the possibility that human airways are big enough for plastic fibres to reach the deep lung. Lung biopsies from textile industry workers (polyamide, polyester, polyolefin, and acrylic) revealed histopathologically analysed granulomatous lesions containing foreign bodies, which were assumed to be dust from nylon, acrylic, and/or polyester [16]. These findings substantiate the notion that certain fibres evade elimination processes and endure.

Risks to one's health at work Research conducted on nylon flock (fibre) workers indicates that there is no proof of an elevated cancer risk; nonetheless, there was a greater incidence of respiratory irritation among them [3]. Workers who process nylon, polyester, or para-aramid fibres may experience dyspnea (breathlessness), coughing, and impaired lung capacity due to interstitial lung disease [17e19]. Additionally, workers exhibit clinical signs resembling allergic alveolilitis [16]. Given their absorption and persistence, these health consequences suggest that MPs may cause localised biological responses.

Although these consequences are different from those following asbestos exposure, the history of asbestos toxicity might help anticipate how fibrous MPs may affect a person's health. The properties of silicate-based fibres that control toxicity and the mechanisms underlying it are length and biopersistence in the lung and airway. It is unclear if fibrous MPs experience the same thing.

Which are the possible toxicity mechanisms? Effects of particles: secondary genotoxicity and inflammation
After repeated inhalation, all fibres appear to cause inflammation after a particular exposure level or dose [13]. Based on asbestos and synthetic vitreous fibres, the prevailing paradigm for fibrous particle toxicity holds that lung inflammation is caused by the release of cytotoxic agents and intracellular messengers upon cell contact. When reactive oxygen species (ROS) are produced in excess and continuously, this might result in secondary genotoxicity. Prolonged inflammation can lead to the manifestation of fibrosis and, in certain situations, malignancy [13]. Longer fibres are more toxic [13] because they are more difficult to phagocytose, which causes cells to generate inflammatory mediators [20] that worsen fibrosis.

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Rats have been shown to develop lung tumours and inflammation as a result of poorly soluble low-toxicity particles [21], but there is insufficient data to determine whether this also affects humans. Although plastic is often thought to be harmless, its biopersistence and the structure of fibrous MPs may cause inflammation.

Chemical reactions

Related pollutants

Because of their hydrophobic surface, airborne fibrous MPs may transport contaminants that have been absorbed from the surrounding environment [22]. They may contain transition metals and PAHs when they coexist with traffic pollutants in metropolitan settings. After related pollutants are desorbable, harmful pulmonary consequences may occur, which could result in primary genotoxicity among other consequences. For instance, following the metabolism of PAHs linked to fibrous MP, DNA lesions may become stable or unstable [13].

Persistent pollutants Unreacted monomers, additives, dyes, and pigments may be present in plastic; should these substances leach, volatilize, and accumulate, they may have detrimental effects on health, including mutagenicity, carcinogenicity, and reproductive toxicity [23]. For instance, it is well known across the world that home settling dust is contaminated with phthalates [26] or polybrominated diphenyl ethers [23–25]. This contamination may be caused by emissions from fibre MPs that are released when plastic household textiles are worn

III. RECOMMENDATIONS

Data on the effects of fibrous MPs on human health are desperately needed. It's crucial to more thoroughly determine whether and, if so, how we are exposed before this is determined. In order to do this, cooperation across the environmental, epidemiological, and air quality communities is needed to establish pertinent research projects with targeted monitoring plans.

When reporting on the presence of MPs, length and diameter should be taken into account since while diameter is vital to respirability, length is significant for persistence and toxicity. The entire range of fibres (both petrochemical-based and natural structures) needs to be taken into account. The studies that have been done up to this point have had a 50 mm observation limit, but smaller-scale detection (less than 10 mm) is important. The possibility of inhaling these fibres needs to be determined, and all possible effects need to be immediately identified.

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