

Exposure Routes of Micro and Nanoplastics to Human

Subjects: **Others**

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Microplastics (MPs) are plastic particles that range from 1 μm to less than 5 mm, while nanoplastics (NPs) are plastic particles smaller than 1 μm . MNPLs are mainly classified in two ways—primary or secondary—taking into account their origin. Primary MNPLs are plastic particles intentionally manufactured to have a small size (1 μm to less than 5 mm), e.g., pellet beads, which are used as raw material for the production of cosmetics, such as toothpastes, exfoliating treatments, body wash, and other personal care products.

microplastics

ecosystem

human health

1. Introduction

Nowadays, a wide variety and large quantity of plastic is being produced and consumed on a large scale by human beings. Plastics are synthetic polymers mainly derived from the petrochemical industry. Although some sources of biodegradable plastics are produced by natural sources (cellulose, cornstarch, soybeans and so on), those coming from the oil industry are the most commonly manufactured and can cause a greater impact on nature since they remain longer in the environment ^[1].

Since it is mostly a synthetic polymerized product, plastic has desirable characteristics when considering durability, resistance, inertia, and its low cost. These properties, while beneficial to industry, have created a significant problem for the environment and human health. The pollution of the environment and the oceans with large amounts of plastic, in all its varieties, has become a global issue in environmental pollution ^[2].

As previously mentioned, synthetic plastic has incredible characteristics for use in industry, but these same characteristics make these products virtually indestructible due to their composition and material hardness. When in contact with air, soil, and fresh or saltwater, plastic deteriorates into smaller particles called micro and nanoplastics (MNPLs). Consequently, long and short fragments are released from the chains of polymerized organic molecules which can remain in the environment for hundreds of years ^[3].

Secondary MNPLs are products derived from the degradation and fragmentation of larger plastics, such as bottles, tire and road wear particles (TRWPs), or caps which generate plastic microparticles. This fragmentation occurs due to mechanical actions, UV radiation, temperature, humidity and so on, producing both micro and nanoplastics ^[4]. In addition to these two types of MNPLs, synthetic microfibers used in the manufacture of clothing and fabrics are

also found in the environment [5]. These filaments are released during processes such as washing, reaching urban sewers, and consequently, the environment, and affecting human health [6].

Despite the well-established concept of microplastics and nanoplastics (MNPLs) and their characteristics and presence in the environment, little is known about their real effects on human health. Here, it considers the scientific evidence of their harmful effects on the environment and human health.

2. Routes of Exposure

Micro and nanoplastics (MNPLs) have become ubiquitous since they can be found in many ecosystem components. Plastic particles can be found in soil, water, and air. There are many routes of human exposure to microplastics. These can include oral exposure through contaminated water and food (mainly of marine origin); via the dermal route through the use of soaps, scrubs, or via contact with soil; and via inhalation through the precipitation of particles in the air [7], which was found in pulmonary tissue samples from the first one to identify MNPLs in lung tissues [8].

2.1. Respiratory Exposure to Micro and Nanoplastics

MNPL particles, derived from the degradation of plastic in the environment, have been observed in atmospheric precipitations. Depending on the sizes of these particles, they can be inhaled. It must clarify that particles capable of entering through the nose and mouth and being deposited in the upper respiratory tract are classified as inhalables, and particles that are deposited in the lungs are classified as breathable [9]. These particles may be subject to non-specific host defense mechanisms that remove mucus through the mucociliary process. Alveolar macrophages may capture these particles and transport them to the intestine to be removed [10].

It has been reported that exposure to MNPLs can cause damage to human health, creating problems such as bronchitis, asthma, fibrosis, and pneumothorax. In an experimental one with rats, in which the toxicological potential of MNPLs inhaled for 14 days was investigated, it was observed that levels of transforming growth factor beta (TGF-beta), factors related to fibrosis, and tumor necrosis factor alpha (TNF-alpha) were altered [11].

Polystyrene nanoplastics using alveolar basal epithelial cells (A549) have shown that they are able to disturb gene expression, resulting in inflammatory responses and the launch of apoptosis pathways, particularly when smaller PS-NPs are used. The results was suggested that nanoplastics can cause definite damage and functional disturbance to human and mammalian respiratory systems [12].

Regarding the involvement of MNPLs in the respiratory tract of humans, for the first time, a recent one was identified that plastic particles ranging in size from 1.60 to 5.58 μm in the bronchoalveolar region in more than 50% of analyzed lung samples, confirming that the respiratory system is an important route of exposure and that the lungs act as a site of accumulation of MNPLs in human beings [8]. Environmental exposure to MNPLs through the air occurs through several sources, such as synthetic textiles, tire erosion, synthetic rubber, and urban dust [13].

Other sources of airborne MNPLs include plastics from clothes and household furniture. Of note are synthetic textiles, which may be responsible for human exposure in both internal and external environments [14].

The persistence of these particles in the atmosphere is determined by atmospheric precipitation, which is influenced by rain, wind, local conditions, and particle size. Particles with lower densities can be easily carried by the wind, which causes the contamination of terrestrial and aquatic environments [15][16].

Plastic nanoparticles have diameters smaller than 1 μm . These nanoparticles can generate distinct toxicities due to their smaller dimensions [17][18]. The inhalation of MPs and NPs is related to some pathologies and a higher incidence of cancer. Those carried out using animal models indicate that exposure can induce granulomatous lesions [19][20][21]. MNPLs can have the same toxicity as other atmospheric nanoparticles, which makes it difficult to compare them. Therefore, it is necessary to carry out regarding the toxicity of different sizes of polymers and their surface properties [22].

With the arrival of the new coronavirus, the use of masks has become essential for the population, with N95 surgical masks being the most effective at reducing the risk of virus transmission. However, due to the scarcity of masks, people have chosen to use masks made of other materials, such as cotton, nylon, clothing cloth, and textile mixed with polypropylene. During the process of disinfecting masks, the fabric may suffer wear and tear [23][24], causing distress in the material, leading to the risk of inhalation through respiration [25][26].

Li and colleagues [27] carried out one using seven types of masks—N95, cotton, sky surgery, ply surgery, fashion, activated carbon, and non-woven—for the detection of MNPLs using Raman spectroscopy and infrared spectrometry. The N95 mask performed well and reduced particle inhalation even after disinfection. In addition, fashionable cotton masks and those made of non-woven fabrics and activated carbon were shown to reduce the risk of MNPL inhalation. When compared to not wearing a mask, it was concluded that using the above-mentioned masks for at least two hours could reduce the inhalation of plastic particles [27].

2.2. Oral Exposure to Micro and Nanoplastics

The presence of MNPLs in food and beverages has evidently increased. Recently it has been reported that the detection of plastic particles in common food products, such as salt, milk, honey, fruits, vegetables, mineral water, and marine foods. Thus, human exposure through ingestion is quite likely and needs to be focused while taking into account the entire food production chain, from cultivation to consumption [28][29][30].

Despite being a subject of interest, there are still many obstacles in relation to the methodologies used to detect MNPLs in foods and beverages and characterization parameters, such as exposure dose. A first issue is the diversity of these particles, which can have different chemical compositions, in addition to different densities, sizes, and formats, which makes it difficult to standardize techniques. In addition, there is an absence of reference values and precise definitions [30]. Such obstacles make research on oral exposure to MNPLs challenging. However, advances have been reported. Recently it was estimated that each person ingests an amount of MNPLs ranging

from 39,000 to 52,000 particles annually [29]. Such findings highlight the importance of and the need for further investigation on this subject [31][32].

Some of the most targeted foods are those of aquatic origin [33]. Generally, fish accumulate MNPLs in their gills, liver, and intestine, parts that are generally not eaten by humans [34]. However, in some filtering animals, such as shrimps, a relatively large amount of MNPLs was observed. It is estimated that consumers of these animals ingest about 11,000 particles annually [35]. In addition to food of aquatic origin, commercial mineral water showed traces of plastic particles, even in bottled water in glass containers [36], while polypropylene particles have been identified in various brands of table salt [37]. Plastic particles have also been found in fruits, such as apples and pears, and vegetables, such as potatoes, broccoli, carrots, and lettuce [38]. The presence of microplastics in fecal samples from humans reinforces the idea that particles are ingested by humans [39]. However, the effects of this kind of oral exposure are still unclear.

Once ingested, particles can interact with the gastrointestinal tract and digestive fluids. Despite being considered chemically inert particles, plastics can adsorb substances, such as additives, heavy metals, proteins, or even microorganisms, on their surface, which can cause greater toxicity. In this situation, MNPLs work like a Trojan horse, bringing a series of environmental contaminants with them. When ingested, the particles can interact with the mucus that lines the gastrointestinal tract, with the epithelial cells themselves, and even with intestinal microbiota, causing cellular responses and diverse physiological changes [40][41][42][43].

Recent research suggests that, depending on the size, particles can be internalized by intestinal epithelial cells (endocytosis) or they can pass between intestinal cells (paracellular transport) [44]. It has been shown that the distribution and deposition of MNPLs in organs such as the kidneys, liver, and lymph nodes [45][46][47]. However, this systemic distribution remains controversial, and further studies are needed to corroborate this hypothesis.

2.3. Dermal Exposure to Micro and Nanoplastics

Although oral exposure is the most notable type of exposure, there are also other types of exposure—one of these is dermal exposure. Even though it is a less efficient route, it was showed that micro and nanoplastics can cross the dermal barrier [48]. These nanoparticles are applied, for example, in cosmetics and in the continuous reduction of textile microfibers. In addition, microplastic microspheres (less than 1 mm in diameter) are widely used in dermal exfoliation products, such as toothpastes and denture restorations [49].

Another area in which dermal exposure is discussed is in medicine. In suturing, for example, plastics are known to induce low inflammatory reactions and a foreign body reaction with fibrous encapsulation. For mice, the effects of polyethylene and polyvinyl chloride (PVC) were evaluated, showing that polyethylene was associated with lower inflammation compared to PVC. However, micro and nanoplastics can also induce inflammation and foreign body reactions, with differences in surface properties leading to different results. Human epithelial cells undergo

oxidative stress from exposure to micro and nanoplastics, confirming the need for the ones that evaluate the effects of exposure to MNPLs [48].

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