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Exposure routes of microplastics (MPs) to humans and possible risks of MPs to human health from food and the environment: a short review

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ABSTRACT

This review aims to document the exposure routes of microplastics (MPs) to humans from food and the environment and assess the possible effects of MPs and associated chemical pollutants on human health. MPs are small plastic particles that are less than five millimeters (<5 mm) in size. Humans can be exposed to MPs by ingesting contaminated water and food or inhaling contaminated air. MPs have been detected in human lungs, blood, placenta, and faeces. MPs may cause various effects on human health, including DNA damage, cellular damage, inflammation, oxidative stress, cancer, fetal growth, and inflammatory bowel disease. Both plastic additive chemicals and pollutants adsorbed onto MPs are harmful to humans. They are persistent (persists long in the environment), toxic (poisonous), and bioaccumulative (accumulate in tissues of food and human organs). These chemicals are also endocrine-disrupting (can alter functions of the endocrine system) and carcinogenic (can cause cancer). Exposure to these chemicals (additives and adsorbents) can have long-term effects on human health.

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1. Introduction

Plastic waste/plastic pollution is ubiquitous and is reported across the globe, from the Arctic to the Antarctic, from the surface to sediment. Plastic pollution in freshwater and marine environments has been identified as a global concern.

Plastics can enter or be transported to the environment through various pathways or sources that include intentional littering/open dumping, storm water run-off, floods, cyclones, wind-blown debris, sewage overflows, landfill waste, accidental spillage, the release of microfibers during washing of synthetic clothes/textiles, discharge of microbeads from personal care products, agricultural activities (residues

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of plastic mulch films), application of sewage sludge/ bio-fertilizers and atmospheric fallout (1-4).

The common types of plastics are polyethylene (PE), polyester (PS), polyethylene terephthalate (PET), polyvinyl chloride (PVC), polypropylene (PP), polystyrene, (PES), and polyamide/ nylon (PA). Smaller pieces of plastic that are less than five millimeters (1 μm to 5 mm) in size are called microplastics (MPs). MPs have been detected in soils, sediments, surface waters, drinking water, seafood, and agricultural food (1-4). Terrestrial food such as rice, salt, honey, and fruit have already been contaminated with MPs (1). Similarly, several seafood groups were reported to be contaminated across the globe (3). Both drinking and bottled water have also been found contaminated with MPs (1,4). In recent times, air samples (dust and atmospheric fallout) collected were found contaminated with MPs (5, 6). Humans can be exposed to MPs by ingesting contaminated food, water, and air. The objectives of this short review are to collect, collate, analyze, interpret, and synthesize information related to the possible exposure routes of MPs to humans and the effects of MPs and MPs associated with chemicals on human health.

2. Routes of exposure of microplastics (MPs) to humans

Most common food items like beer, chicken, fruit, honey, maize, milk, rice, salt, sugar, tea, vegetables, and wheat were contaminated with MPs (1, 4). Similarly, seafood such as finfish, sharks, crustaceans, molluscs and seaweeds have also been contaminated with MPs (1,3,4). In addition, drinking water (both bottled and tap water) was also reported to be contaminated with MPs (1,4). Several research studies have reported that bottled waters contain several times more MPs than tap water (1,4).

Nonetheless, air samples were also found contaminated with MPs; for example, MPs have been detected in roadside dust (5) and atmospheric fallout/ atmospheric deposition samples (6). Therefore, ingesting contaminated food and water and inhaling contaminated air are the likely routes of human exposure to MPs. For example, inhalation has been the primary route of exposure of MPs to human lungs (7). It is suspected that blood (8) and placenta (9) were contaminated via ingestion of contaminated food or inhalation of contaminated air (Fig. 1). In fact, mucosal contact (the moist lining of different organs) appears to be the main pathway of the entrance of MPs in human organs (8).

3. Effects of MPs and MPs associated chemicals on human health

The information related to MPs effects on humans is not readily available. Only very limited research has been carried out so far in recent times. Recent research demonstrates that once in contact with epithelial linings in the lung or intestine, MPs may cause various effects (Figure. 1). These effects include DNA damage, cellular damage, inflammation and immune reactions, oxidative stress (11), and bowel and lung cancer (from chronic exposure to synthetic plastic fibers) (12). The potential effects of MPs on fetuses (unborn-baby) include reduced fetal growth and alteration of immunity mechanisms during pregnancy. Eating MPs could cause inflammatory bowel disease (IBD) (10). The study of (10) confirms that people who suffer from IBD have more MPs in their feces than people who do not.

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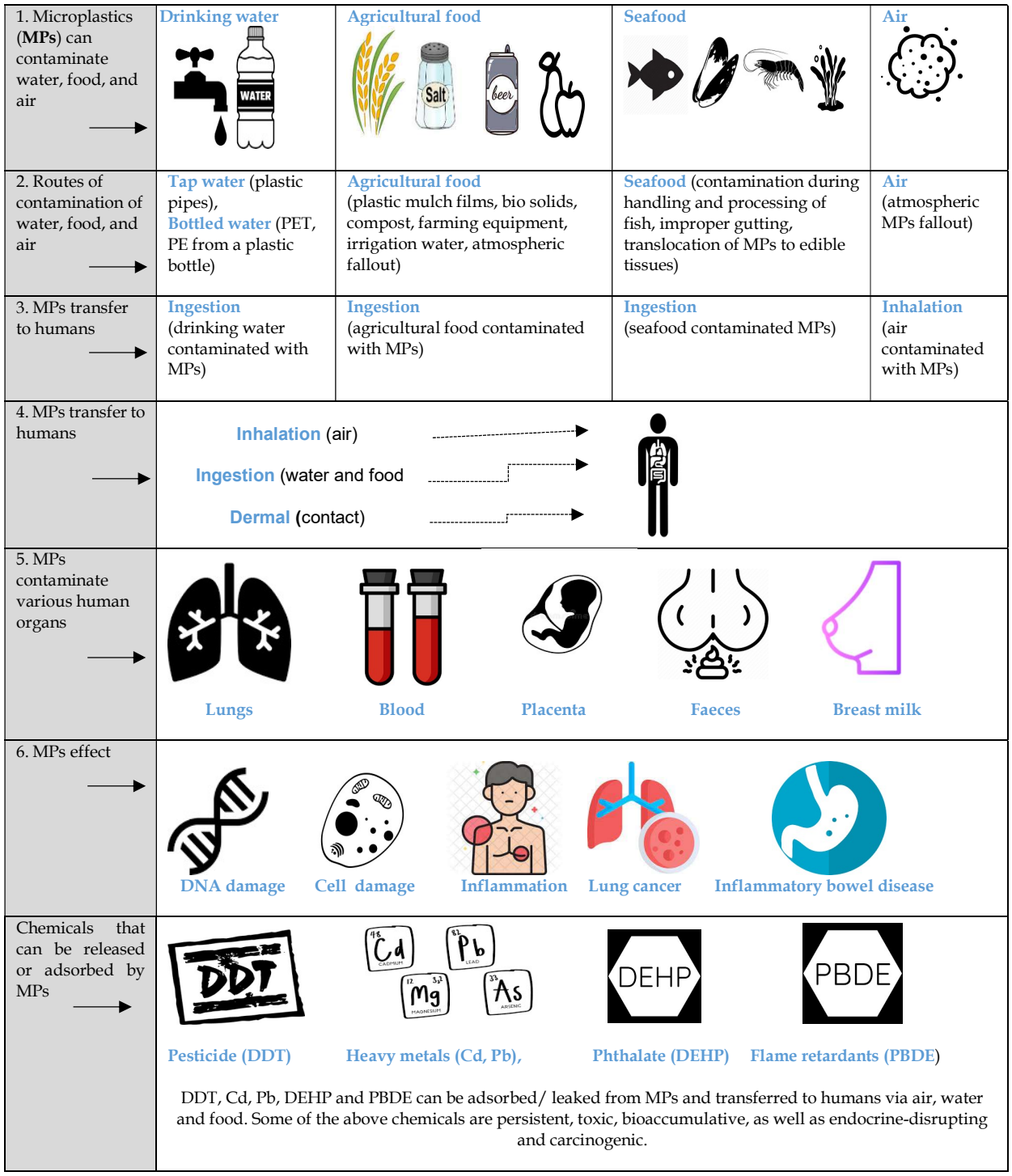

Figure 1. **Possible routes of microplastic exposure, transfer, and effects on humans**
DDT = Dichlorodiphenyltrichloroethane; DEHP = Diethylhexyl phthalate; DNA = Deoxyribonucleic acid; MPs = microplastics; PBDES =] .[polybrominated diphenyl ethers; Image source: freely available icons via https://www.google.com/search?q=icon

These people with IBD mostly drank MPs-contaminated bottled water or consumed plastic-packaged fast food. MPs can potentially reduce the defense mechanisms against pathogens and alter the utilization of energy stores (13). Furthermore, MP particles have also been linked to dermatitis and respiratory infections in specific oral pathways (12). Epidemiological studies have reported lung injuries among workers in the plastic and textile industries exposed to high amounts of plastic fibrous dust (13).

MPs can adsorb and concentrate chemical contaminants such as oil compounds/ polycyclic aromatic hydrocarbons (PAHs), DDT, polychlorinated biphenyls (PCBs), and pharmaceuticals (17α-ethinyl estradiol) and heavy metals (Cd, Cr, Ni, Pb) (1). MPs are thus a vector of priority pollutants/ chemicals (e.g., DDT, PAHs, PCBs, Cd, Pb). Several additives are incorporated into plastic materials to enhance polymer properties (1), which can leach out to the environment (13). Research carried out found that several potentially toxic substances were released from plastic products into water and food including phthalates (Di-2-ethylhexyl phthalate or DEHP), brominated flame retardants (polybrominated diphenyl ethers or PBDEs), bisphenol-A (BPA), heavy metals (lead, tin, cadmium), nonylphenol and many other volatile organic compounds (1,14). Priority pollutants/ chemicals adsorbed in contaminated food and water can be released from MPs upon ingestion and transfer to the surrounding tissue of humans. If MPs accumulate in human organs, they potentially present a source of chemicals to human tissues and fluids (13). Some of the plastic additives (DEHP, PBDEs, heavy metals), as well as adsorbed pollutants (DDT, PCBs, PAHs), are very harmful to humans as they are persistent, toxic/ poisonous, bioaccumulative, as well as endocrine-disrupting and carcinogenic (1). MPs-associated chemicals could cause long-term damage or effects on different organs, including upsetting the fetus's developing immune system (9).

4. Conclusion

Figure 1 shows the exposure and transfer pathways of MPs to humans. Of these, ingestion of contaminated water and food and or/ inhalation of contaminated air are the common pathways of exposure in humans. MPs have been detected in human lungs, blood, placenta, and feces. Inhalation has been the primary exposure route for MPs to human lungs, whereas the main exposure routes to blood and placenta are via ingestion of contaminated food (rice, seafood, seaweeds) and water. In fact, mucosal contact is the main pathway to the entrance of MPs into human organs. It was found that people with a higher abundance of fecal MPs usually drank bottled water or consumed plastic-packaged fast food. MPs may cause various effects on humans, including DNA damage, cellular damage, inflammation, oxidative stress, cancer, fetal growth, and inflammatory bowel disease. Both plastic additive chemicals and pollutants adsorbed onto MPs are harmful to humans as they are persistent, toxic, bio-accumulative, endocrine-disrupting, and carcinogenic. These chemicals (additives and adsorbed) could cause long-term effects on humans. Therefore, multidisciplinary research efforts are required involving scientists from the environmental, food, water, chemical, toxicological, medical sectors, and polymer scientists to reduce potential health hazards associated with MPs.

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Declaration of competing interest

The author declare that he has no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

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