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Concept and Transmission of Microplastics in Human Diet

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ABSTRACT: Use of plastics for different purposes which are non-biodegradable in nature has made a serious problem to nature. The hotspot areas of plastic pollution are confined to the ocean, landfills and open waste disposals. Plastics which fragments into small pieces in the size range of 0.001 - 5 mm are termed as microplastics. Microplastics can enter the environment through agricultural run-off, tyre and road-wear particles, wear and tear of clothes, plastic packages, industrial effluents, microbeads, etc. it can also transfer into the food chain through soil, seaweed, seasalt, drinking water, bottled water, processed food products, packaging, etc. The problems created by microplastics are of great concern for living beings.

KEYWORDS: Concept, microplastics, sources, transmission

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Plastics are synthetic organic polymers with durability, low production cost, versatility and light weight which makes it highly convenient for use in many applications. Although plastic is widely used for different purposes but its non-biodegradable nature has made it a serious pollution problem to nature. Increasing production of plastics has led to increase in plastic waste generation throughout the world (Wang *et al.*, 2016) and this problem is further increased by the use of single use plastics meant for immediate disposal usually in the form of plastic packaging, carry bags, food packaging, plastic bottles, straws, cutlery and containers (Singh and Mathur, 2019). It was estimated in 2017 that 348 million metric tons of plastic was produced globally, of which over 10% was intended for single use and disposed off as waste and only about 3% was recycled (Verla *et al.*, 2019). Globally, the hot spot areas of plastic pollution are confined to the oceans, landfills and open waste disposals.

Different reviews on plastics claim that environmental plastic litters are prone to undergoing aging processes such as degradation and disintegration which results from the action of physical, chemical and biological drivers. Small pieces of floating plastics on the surface of ocean were first reported in the scientific literature in the early 1970s. These plastics which fragments into small pieces are termed as microplastics.

Concept of microplastics

The term microplastic basically represents heterogeneous mixture of smaller plastic fragments in the size range of 0.001-5mm. The U.S. National Oceanic and Atmospheric Administration (NOAA) and the European Chemicals Agency defined microplastic as a type of small plastic piece or fragment, less than or equal to 5 millimeters (mm) in length. Microplastic pollution is one of the most widespread and long-lasting anthropogenic changes to the surface of our planet, and was identified to be among the most relevant topics for biodiversity conservation at global scale. The distribution and abundance of microplastics in the aquatic system, the terrestrial environment and in the atmosphere have significantly increased in recent decades (Sobhani *et al.*, 2020). These microplastics can induce adverse effects both in marine as well as in terrestrial organisms (Barboza *et al.*, 2018). Experiments show that microplastics damage aquatic creatures, including turtles and birds by blocking the digestive tracts, diminishing the urge to eat and altering feeding behavior which leads to reduction in growth and reproductive output. According to a report from the Centre for International Environmental Law about plastic and health in 2019, 'microplastics that accumulate in the body are a source of chemical contamination to tissues and fluids'. Although the exact toxicity of microplastics to human is not yet resolved but they have been detected in human faeces. It is not clear till now about how microplastics enter the human body but has been assumed that human exposure to microplastics could be through the food chain (ingestion) or due to air inhalation (Catarino *et al.*, 2018).

Types of microplastics

Syberg *et al.* (2015) categorized these sources of microplastics under two categories-

i. **Primary microplastics:** Primary microplastics are tiny particles purposefully manufactured in 5 millimeter (mm) size for use in different products such as for exfoliation in cosmetic products. These include microbeads used in personal care products, plastic pellets (nurdles) in industrial manufacturing, plastic fibres in synthetic textiles (nylon) etc.

ii. **Secondary microplastics:** Secondary microplastics are formed from the breakdown or degradation of larger plastics. This happens when larger plastics undergo weathering, through exposure to wave action, wind abrasion and ultraviolet radiation from sunlight. These include fragment of large plastics such as water and soda bottles, fishing nets, plastic bags etc.

Sources of microplastics

Microplastics can enter the environment through a variety of sources-

i. **Agricultural run-off:** Agricultural lands are likely to be the most plastic-contaminated places outside of landfill and urban spaces. Microplastics can contaminate the agricultural land through wastewater sludge used as a soil amendment, through fertilizers made from sewage sludge, through rain and airborne fallout (Corradini *et al.*, 2019).

ii. **Tyre and road-wear particles:** Roads are estimated to be the largest source of microplastic particles in the environment, through release of particles from tyres and road markings. Tyres consist of synthetic rubber, a plastic polymer, which erodes through heat and friction from contact with the road resulting in spread of these dusts by wind and rain leading to water bodies (Kole *et al.*, 2017). On the other hand, road markings are done using polymer tapes and paints which lead to loss of microplastics through weathering or abrasion by vehicles (Vogelsang *et al.*, 2018).

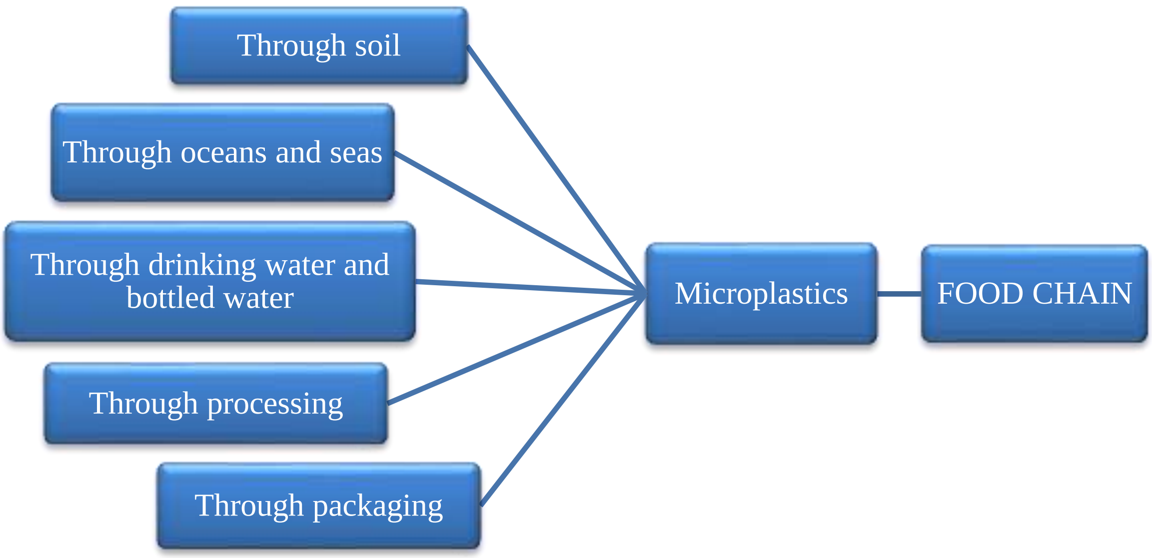
iii. **Wear and tear of clothes:** Clothes made of synthetic fibers like polyester, nylon, acrylic etc. frees engineered microplastics through abrasion and shedding of fibers from the fabrics during washing. Since these fibers are too small for the wastewater treatment plants to filter, so they are discharged with treated wastewater and eventually find its way to the oceans (Henry *et al.*, 2019).

iv. **Plastic packages:** Plastic packages such as polythene bags, plastic bottles and others are disposed off after use leading to accumulation of plastic debris in the environment. Since plastics are non-biodegradable so they break down into smaller fragments under the actions of ultra-violet rays and mechanical forces resulting in microplastic generation (Reimonn *et al.*, 2019).

v. **Industrial effluents:** Industrial and commercial sources of microplastics may include particles used in airblasting, pre-production pellets spilled during manufacturing, plastic dust from construction activities and fibers from synthetic textile fabrication.

vi. **Microbeads:** Discharge of plastic microbead wastes from cosmetic products following use has been identified as a potential important primary source of microplastics into the marine environment. Microbeads can be characterized as synthetic, non-biodegradable, water insoluble, solid materials comprising a range of polymers and additives which vary greatly in size (100µm to more than 1000µm), shape (from amorphic to spherical) and quantity used in different commercial products (Mohlenkamp *et al.*, 2018).

Transfer of microplastics in the food chain



i. **Through soil:** Microplastics have been found in soils of many terrestrial ecosystems, including agricultural fields (Piehl *et al.*, 2018), cities and industrialized areas (Fuller and Gautam, 2016). Once microplastics get deposited on the soil surface, they get accumulated in the soil and adversely affects the soil biota, such as earthworms (Huerta-Lwanga *et al.,* 2017), and can change soil biophysical properties, including soil aggregation, bulk density and water holding capacity. Humans consuming plants growing in plastic polluted areas may ingest microplastics since such plants have the tendency to accumulate more microplastics from the polluted soil (Li *et al.,* 2020).

ii. Through oceans and seas: The introduction of microplastics in the aquatic ecosystem is mainly because of the domestic runoff which contain microbeads and microplastic fragments (used in cosmetic and other consumer products) and also from the fragmentation of the large plastic trash (Claessens *et al.,* 2011). Once these microplastics enter the marine habitat, they are exposed to different processes such as biofouling and leaching or incorporation of secondary pollutants. Since these microplastics are persistent in the marine ecosystem and due to their small size, these fragments either settle down on the seabed or are mistaken as food and ingested by a range of marine biota which includes corals, phytoplanktons, zooplanktons, sea urchins, lobsters, fish etc. and ultimately get transferred to higher trophic level including humans (Chatterjee and Sharma, 2019). More than 690 marine species, including bivalves, crustaceans, fishes, sea mammals and seabirds have been testified to be contaminated by microplastics (Carbery *et al.,* 2018).

a) Seaweed: Apart from consuming marine fishes, microplastics can also get ingested through consumption of seaweeds (Gutow *et al.,* 2016). Seaweed refers to all the species of marine algae and plants that grow in water bodies such as rivers, seas and oceans. It has been reported that microplastics get attached to the seaweeds which are grown in highly polluted water environments and act as vectors for microplastic transfer in the marine food web (Li *et al.,* 2020).

b) Seasalt: Sea salts are typically produced in salinas (solar work ponds) by crystallisation due to the combined effects of evaporation and sunlight (Renzi and Blaskovic, 2018; Yang *et al.,* 2015). In solar saltwork ponds, prior to sea salt crystallisation, sea and freshwater circulates along a series of successive ponds, providing a gradient of environments with different salinity levels (35–240, Practical Salinity Scale). Consequently, commercial sea salts may contain microplastics that were present in the water during or after the crystallisation processes (Yang *et al.,* 2015).

iii. Through drinking water and bottled water:

a) Drinking water: Microplastics may enter drinking-water sources in a number of ways such as from surface run-off (e.g. after a rain event), wastewater effluent, industrial effluent, degraded plastic waste or litter, atmospheric deposition.

b) Bottled water: In case of bottled water, sources of microplastics may come from the plastic bottles and the caps used. An average of 325 plastic particles were detected for every litre of water on analysis of 259 bottles from 11 different brands (WHO, 2019). The most common type of plastic fragment found was polypropylene, the same type of plastic used to make bottle caps.

iv. Through processing: Processed food products are contaminated by microplastics during different steps of processing the product. Contamination may occur through water used, processing aids, air, machinery, equipments etc. (Diaz-Basantes *et al.,* 2020).

Microplastic contaminated products

A few references on microplastic contaminated processed products are given below (Table 1).

Table 1. Some processed products with microplastic contamination

Product	Level of microplastic contamination	References
Honey	32-108 coloured fibres/kg (mostly cellulose but a minor part being polyethylene terephthalate fibres).	Muhlschlegel *et al.* (2017)
Sugar	217 transparent and coloured fibres and 32 fragments per kg of sugar.	Liebezeit and Liebezeit (2013)
Beer	2-79 fibres/L, 12-109 fragments/L, 2-66 granules/L of beer.	Liebezeit and Liebezeit (2014)

v. Through packaging: Plastic packaging is most widely used in the food sector as it helps in the storage, transport, protection and preservation of products while reducing their waste (Mathlouthi, 2013). Although there is no evidence on the sources of microplastic contamination from packaging in food but the probable sources may come from manual cutting, tearing or twisting of the packaging, using already contaminated packaging material. A study was conducted by Kedzierski *et al.* (2020) on microplastic (MP) contamination of packaged meat by focussing on meat products (chicken) packed in extruded polystyrene trays (XPS). This study was the first study to draw attention to the microplastics found on the surface of meat products sealed in their packaging. The study revealed the presence of MP-XPS inside and outside the tray, as well as between the tray and the meat, and between the meat and the protective film.

CONCLUSION

Despite increased societal awareness and efforts at waste reduction, microplastics have pervaded the environment, and human's exposure and cumulative uptake of these plastics would only increase over time. Microplastics are tiny particles of 5 milimeter (mm) in size that results from the degradation of larger plastic debris or purposeful manufacturing of these particles for use in personal care products. These microplastics accumulate or get deposited in the terrestrial or aquatic environment leading to harmful effects both in terrestrial as well as aquatic organisms. Microplastics may be transferred into the food chain by means of soil, ocean and seas, drinking water as well as through processing and packaging, etc.

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