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Microplastics Pollution in the Environment: Challenges and Future Prospectives: A Mini-Review

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Plastic pollution becomes an emerging global concern because of the increasing usage and rapid distribution in the environment. Plastics defragment into small particles, of which the particles that are smaller than 5 mm is defined as microplastics. Microplastic in found even in the water bottles and different ecosystems. It reaches to the environment from many sources because of human activities. It has many negative impacts on the environments and organisms including accumulation in the food chain and collecting the contamination (either organic or inorganic) from the surroundings. However, there is a gap of knowledge in this hot topic especially regarding the effect of microplastics on the terrestrial ecosystem. Therefore, this mini review highlights this issue and addressing some challenges and future prospective in this regard.

Keywords: Microplastic; Pollution; Environment; Soil; Aquatic ecosystems**.**

1. Introduction

Recently, environmental pollution is one of the major issuesthat threatenthe human health andsustainable development (Elbasiouny and Elbehiry, 2019).. Microplastics (MPs) pollution is pervasive and has emerged as a major worldwide environmental concern. Recent research on MPs contamination has mostly concentrated on aquatic ecosystems, with significant knowledge gaps about MPs in terrestrial ecosystems still present (Chai et al., 2020). Between 1955 and 2015, the global population grew at an annual pace of 1.68 percent on average. At the conclusion of the Great Famine of 1315–1317 and the Black Death in 1350, the world population was approximately 370 million; currently, the population has surpassed 7.7 billion people as of April 2019, indicating a huge growth. This massive rise has resulted in an increase in the quantity of garbage created by individuals (Verla et al., 2019).

Anthropogenic activities have been identified as the primary causes of biodiversity loss and ecosystem function degradation in recent years (Abbas et al., 2021). The enormous number of plastics created and utilized is a typical indicator of human activity. Plastics' demand and utilization have increased steadily over the previous decades due to its low cost, efficient malleability, and durability (Kumar et al., 2020). Glasses, metals, and papers are being phased out in favor of more cost-effective plastic packaging with equal or greater design. As a result, over one-third of all plastic resin manufacturing is turned into consumable plastic packaging, which includes throw-away single-use products often seen in beach litter. It is not known how much of the approximately 80 million tons of packaging plastic utilized worldwide yearly winds up in the oceans (Andrady et al., 2011). Thus, the presence of plastic wastes in the environment, including MPs, have become a global concern (Khoironi et al., 2020; Jiang et al. 2022). Currently,

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the MPs presence has been recognized even in drinking water and bottled water (Wei et al., 2021).

Due to the recognized negative impacts of MPs on the environment as a result of its rapid distribution in the environment, in addition to the gap of knowledge in this field, this mini review highlights the MPs sources, negative impacts on the environment, the brief challenges and future prospective.

2. Microplastics definition

Plastic (drived from the Greek "plastikos," which means "moldable") is a class of synthetic or semi-synthetic organic polymers with a high molecular weight that are usually produced by polymerization process of monomers derived from coal, gas, or oil. Polystyrene (PS), polyethylene terephthalate (PET), polycarbonate (PC), polypropylene (PP), polyester (PES), polyamides (PA), and polyethylene are all examples of plastics (PE). The chemical composition of plastics in polymers influences the difference in possible hazards between plastics (Du and Wang, 2021). Plastics are generally classified according to their size. Primary plastics are less than 5 mm in diameter (Fig. 1) and are generally derived from microbeads used in cosmetics, bathroom items including soap and body washes, and laundry detergents (Kumar et al., 2020). Secondary plastics include those bigger than 5 mm in diameter, like as plastic bags, caps, and plastic rings. Microplastics (MPs) are often defined as particles that are smaller than 5 mm (Du and Wang et al., 2021). Polyethylene (PE), polypropylene (PP), polystyrene (PS), polyvinylchloride (PVC), polyethylene terephthalate, and other polymers are commonly used to make MPs (Mohajerani and Karabatak, 2020). Since there is no universal agreement on MP size, the reported size vary in the literature differed greatly. The sieve opening, mesh size, or membrane pore size that used in laboratory testing procedures can define the minimum size on MPs. This observed minimum size varied and ranged from 0.01 - 1 mm. The size distribution properties of MPs were evaluated by classifying them as a large (3–5 mm), a medium (1–3 mm), and a small (1 mm) (Zhou et al., 2020).

3. Sources of microplastic in the environment

The sources of MPs will differ from ecosystem to other (Fig. 2). The defragmentation of larger plastics on coasts owing to oxidation, heating, and radiation is the primary source of MPs in the aquatic environment (Palmer and Herat, 2020).

Fig. 1. Microplastic particles Source: https://www. innovationnewsnetwork.com/plastic-pollution-new-study-reveals-how-microplastic-particles-travel/7836/ and https://www.eco-business.com/opinion/microplastics-small-plastics-big-problem/.

Pollution by MPs in the marine environment can be related to humans direct or indirect dumping plastic into the seas, via activities such as oil rigs, fishery, sailing shipping, and the activities on land, especially in densely populated areas where plastic is reached to the sea by water runoff, wind, or if it is directly discharged into it (Khoironi et al., 2020). Dumpsites, inorganic fertilizers, and organic waste applications (such as compost and sewage sludge) that contain plastics, agricultural use of plastic films (e.g., plastic mulch that broadly used to enhance water use efficiency and growth of plants), greenhouse covering), plastic coated fertilizers, road dusts, and diffused atmospheric depositions are all sources of MPs in soil ((Blöcker et al., 2020; Qi et al., 2020, Xu et al., 2020, Zang et al., 2020, Cheng et al., 2021, Duan et al., 2021, Yang et al., 2021). As well, e-waste is an important source of MPs that can then throw randomly into the soil, causing local ecosystems to deteriorate (Chai et al., 2020).

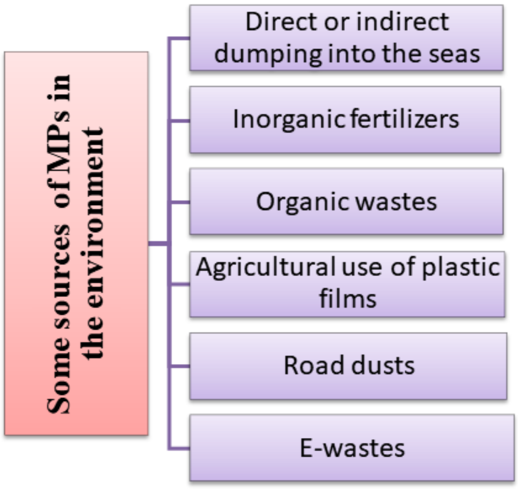

Fig. 2. Some sources of MPs in the environment.

4. The fate of microplastic in the environment

Rapidly increasing evidence indicates that MPs are also found in the terrestrial ecosystems, and also that landfills contain 79 % of worldwide plastic trash; consequently, soil is likely a significant MPs sink. According to recent estimations, farmlands' annual MPs input varies from 63000 to 430000 tons in Europe and 44000–300000 tons in North America, which both exceeded the estimated annual MPS discharges to the surface water of oceans (Guo et al., 2020). Single-use packaging items, including shopping bags, account for about 40% of worldwide plastic manufacturing (120 million tons). For a many reasons, such as the difficulty of sorting plastic items from mixed garbage, the high expense of separate collection, and so on, < 30% of post-consumer plastics is recovered for reusing. Single-use plastic packaging, particularly lightweight (LW; plastic bags less than 50 lm thick) and ultra-thin (UT; thickness less than 15 lm) plastic bags, always has lower rates of recovery, with the majority of these products being burned or dumped in landfills. These plastic bags, however, are accidentally dispersed through the environment because of their low weight and parachute-shaped shape. Because LW and UT plastic bags are usually made of high-density polyethylene, their persistence as litter in the environment (e.g., soil, sea) is a serious environmental concern. Furthermore, following prolonged exposure to sunlight and air pollutants, they become brittle and easily break into small-sized, persistent particles (i.e., MPs) (Accinelli et al. 2020). Guo et al. (2020) reported also that current level of plastic production, using/disposal patterns, limited recovery rates, and demographic statistics all indicate to an increase in plastic trash accumulation. Although plastics are both durable and reusable, less than 5% is recycled, and 4.8 to 12.7 million tons of plastic wastes reached the oceans in 2010. The degradation cycle of plastic waste projected more than one hundred years, predicts severe environmental problems as surface embrittled plastics are microcracked by microbiota and weathering circumstances and processes, such as ultra-violet (UV) light and hydrolysis, and are gradually fragmented into small pieces (Guo et al., 2020). Khoironi, et al. (2020) added that plastic degradation in the aquatic ecosystem has been widely investigated, particularly with regard to MPs impacting the food supply chain. Plastics fragment in the marine ecosystem, where MPs break into smaller micro- and nano-plastics. This plastic breakages are caused by a mix of physical forces, such as waves, and/or photochemical reactions driven by sunshine. Thus, plastic degradation in aquatic systems is triggered by two factors: abiotic (moisture, temperature, pH, UV exposure) and biotic (hydrophobicity, extracellular enzymes, biosurfactants), which are endorsed by polymer properties such as flexibility, morphology, crystallinity functional groups, in addition to molecular weight (Khoironi, et al., 2020). Thus, negative impacts will vary based on their properties.

5. Negative impacts on microplastic in the environment

There are many negative impacts of MPs stated in the literatures. Microplastics are abundant in marine and coastal ecosystems. Microplastics have a tendency to absorb and collect contaminants from their surroundings. Many different types of marine organisms may consume MPs. As a result, MPs may not only cause physical harm to species, but may also transfer pollution to marine organisms and food chain. As more lab research and environmental monitoring researches have been conducted to examine MP sorption behaviors and its effects of MPs on marine organisms, it is essential to evaluate the interactions between MPs and contaminants (Guo and Wang 2019).

Table 1. A survey on the plastic pollution of some terrestrial compartments

Item	Main topic of the study	Reference
Agricultural ecosystems		
	Agricultural plastic resulted from mulching wastes as a source of microplastic pollution in the terrestrial ecosystems	Qadeer et al. (2021)
	Impacts of microplastics in agroecosystems on different ecosystem-functions and food chain	Okeke et al. (2022)
Agricultural soil		
	Ecotoxicological effects of micro- and nano-plastics in terrestrial and aquatic environments	Gomes et al. (2022)
	Microplastics pollution in the soils based on various land-use types in China, which depend on migration and degradation of aging MPs associating with soil C and N turnover	Liu et al. (2022)
	Impacts of microplastics on soil microbiomes, where film, fiber, and foam microplastics may cause greater dissimilarity on bacterial communities in soils	Sun et al. (2022)
	Microplastics as serious environmental pollutants based on their key interaction and toxicology in soil and aquatic environments	Xiang et al. (2022)
	Impacts of microplastics on the emissions of soil CO_2 and the microbial genes involved in soil organic carbon decomposition	Zhang et al. (2022)
	The fate of micro-nano plastics in soil/plant system may pose hazards by reacting with soil potentially toxic elements and bioplastics should be used	Allouzi et al. (2021)
	Impacts of microplastic pollution on the soil environment and its key nexus linking to all spheres	Mbachu et al. (2021)
	Effects, and monitoring the soil pollution with microplastics in dumping site soils in six Asian countries	Tun et al. (2021)
	The relationship between pollution of plastic debris and e-waste recycling in soil	Zhang et al. (2021a)
	The response of soil microbial metabolism to MPs pollution for better understanding and estimation of the eco-behavior and eco-risk of MPs in agricultural soils	Zhang et al. (2021b)
	Plastic pollution in soil could be detected using transferable model like transfer learning strategy	Zhao et al. (2021)
	Soil micro- and nano-plastic pollution and its impacts on soil-plant system and soil microbial activity	Iqbal et al. (2020)
Agricultural drainage water		
	A strong relation between the agricultural drainage water and microplastics, which may transport into the soil and aquatic environments	Bigalke et al. (2021)
Groundwater		
	Microplastic pollutants fate and transport in groundwater aquifer in Victoria, Australia	Samandra et al. (2022)
	Microplastic pollution in groundwater, soil and their remediation methods and impacts on human health	Chia et al. (2021)
	Risks and impacts of micro-plastic pollution on soils and groundwater, plants, animals, and antibiotic resistance and human health	Huang et al. (2021a)
Cultivated plants		
	Microplastics pollution in the terrestrial environments including the sources and nutritive values of some edible vegetables	Campanale et al. (2022)
	Field study on microplastics impacts on rice quality by interfering metabolite accumulation and energy expenditure pathways	Wu et al. (2022)
	Abundance and distribution of microplastic in cultivated soils in China, and their pollution status in these soils	Huang et al. (2021b)
	Micro(nano)plastic pollutions from soils to plants and their risks for human foods	He et al. (2021)
	Negative impacts of plastic particles on germination and growth of soybean under field condition	Li et al. (2021)
	The uptake and toxicity of micro- and nano-plastics as well as their impacts on aquatic macrophytes and terrestrial plants	Mateos-Cardenas et al. (2021)

Plastic degradation in the aquatic ecosystem has been widely investigated, particularly with regard to MPs impacting the food supply chain. Plastics fragment in the marine ecosystem, where MPs break into smaller micro- and nano-plastics. This plastic breakages are caused by a mix of physical forces, such as waves, and/or photochemical reactions driven by sunshine.

Terrestrial environments, such as soils, are more vulnerable to plastic pollution than aquatic environments (**Table 1**). Because of the use of sewage sludge for fertilizing and the breakdown of plastic mulches, agricultural soil may be a major MPs sink. Because of inadequate management techniques, a substantial quantity of plastic mulching residue remains in the soil. Once MP particles accumulate in soil, they have a direct or indirect impact on the functions of soil ecosystem. MPs have the ability to greatly increase water holding capacity while decreasing bulk density as well as water-stable aggregation. MPs also can change the soil physical characteristics and accumulate in the soil, increasing at a rate that can have an impact on soil functions and biodiversity. However, the impact of MPs on soil aggregates weren't well investigated (Hou et al., 2021). As well, the MPs' hydrophobic nature and its high surface area-to-volume ratio promotes the accumulation of organic pollutants, such as polyaromatic hydrocarbons, polychlorinated biphenyls, perfluorinated alkyl substances, polybrominated diethers, and pharmaceuticals and personal care products, and trace metals (such as Ag, Cd, Co, Cr, Hg, Ni, and Pb) on the MPs' surface (Atugoda et al, 2021).

6. Challenges and prospective of the microplastics research

Recently, MPs have been found in high concentrations in the oceans, freshwater, terrestrial environment, and organisms in recent years. The pollution of MPs is a growing concern, and it has been identified as the second most significant scientific topic in the subject of environment and ecology (He et al., 2018). Microplastics are everywhere because of poor plastic waste management (Padervand et al., 2020). Thus, unfortunately, the MPs concentration will continue to increase in the future, requiring more research into the impacts of MPs especially on soil (Hou et al., 2021). It is apparent that our understanding of MPs in terrestrial settings is quickly progressing. However, there is a significant knowledge gap regarding MPs contamination and its environmental consequences. Many uncertainties remain in several areas, including analytical methods, ambient concentrations, origins, destination, and ecological consequences of MPs in soils (He et al., 2018). In addition, the majority of published research has focused on the MPs in lab-simulated conditions, with just a few studies focusing on the MPs in natural environmental circumstances (Duan et al., 2021).

7. Conclusions

According to the previous states, gap of information, and many other reasons the MPs research has to be put on the research agenda especially in Egypt and developing countries. Addressing the important questions that should be answered and highlighting the potential negative impacts on many aspects in the environment is critical in the future research, in addition to organizing teams work, as well international cooperation. As well, establishing a possible guide for future research in this hot topic in needed

8. Conflicts of interest

The authors declare no conflict of interest.

9. Formtting of funding sources

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