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MICROPLASTICS: AN EMERGING CONTAMINANT WITH POTENTIAL THREAT TO AGRICULTURE

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Microplastics have recently drawn great attention on their environmental impacts due to their small particle size, ubiquity, bioavailability and negative effects on the ecosystem (Wright et al., 2013; Scheurer and Bigalke, 2018). Microplastics are generally defined as plastic particles <5 mm (Rilling et al. 2017). The term "microplastics" was coined by Thompson to describe the small plastic particles in the oceans in 2004. The majority of plastic include polyethylene, polypropylene, polystyrene, polyvinylchloride and polyethylene terephthalate (R.Geyer 2017).

Plastic products are widely used in everyday life, mostly due to the advantage of low cost, malleability and durability. In the past 50 years, the global production of plastic is about 9.1 billion tons, with an increasing annual rate of 8.7% (R. Geyer 2017). Because of enormous production and inefficiency management, the issue of plastic waste is no doubt a critical environment challenge. Although the recycling rate of plastic products is increasing, most of plastic are still released into the environment. For instance, an estimated value of 250 million tons plastics arrived in marine environments in 2015 (S.L. Wright 2017). The recalcitrant material is then slowly shredded into smaller particles once they enter into the environment. With the increasing exposure time, the degradation process will continue and produces even smaller particles. The thus formed microplastics have increased surface area. They can absorb various noxious substances, such as persistent organic pollutants and heavy metals, which make them more harmful in the long-term (Fendall and Sewell, 2009).

Primary microplastics are produced on purpose and used in cosmetic products and various industries. Secondary microplastics are degradation products of larger plastic waste. Both primary and secondary MPs are ubiquitously present in the environment. A study has shown 80% of the plastics in marine wastes come from the land (Andrady, 2011). Exacerbated by

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the copious use of single-use plastics, plastic constitutes 10% of waste generated worldwide (Matthew et al., 2011). To further clarify the distribution and impacts of microplastics, many scientists began to focus on freshwater and terrestrial systems (Kooi et al., 2018; Rochman, 2018). There are many pieces of evidence identified that MPs are also arising as freshwater pollutants. Eerkes-Medrano et al. (2015) have reviewed that early studies on freshwater ecosystems showed that the presence and interactions of MPs are as profound as those surveyed in the ocean. In addition, a biological study (Silva-Cavalcanti et al., 2017) found that *Hoplosternum littorale*, a widespread fish living in freshwater usually, could intake large quantities of MPs. The high incidence of ingestion may be due to the unique feeding behaviour and heavy environmental pollution. Likewise, the agroecosystem is a primary entry point for microplastics in terrestrial systems (Nizzetto, 2016; Rillig et al., 2017). A recent study (de Souza Machado et al., 2018) has shown that there maybe 4 to 23 times more MPs on land than in the ocean and that arable soil alone may contain more microplastics than the oceans. Contamination from the wide application of plastics as so-called “white pollution” (He et al., 2013) is becoming more and more serious. Scheurer and Bigalke showed that 90% of floodplain soils contain microplastics (up to 55.5 mg kg_1) in Switzerland.

Sources of Microplastics

The fast-growing plastic packaging Wastes

It is clear that the serious contamination of microplastics in the soil cannot be separated from the countless use of disposable plastic products. With the emergence of plastic resin, plastics are becoming increasingly dominant in the consumer marketplace. The largest portion of the application in the market is packaging (Jambeck et al., 2015). As early as 1977, polyethylene was converted into single-use grocery bags (Williamson, 2003; Weinstein, 2009). Since then, the application of plastics in packaging has been growing rapidly and made significant contributions to the convenience of a human's daily life.

The contamination from the wide application of plastics as so-called “white pollution” (He et al., 2013) is becoming more and more serious. In 1984, plastic packaging accounted for 53% of all plastic waste and in 1986, with 5.2 billion kilograms plastics were used in the packaging industry (Selke, 1988). Recent data indicate that over 90 billion flimsy ploy bags end up as non-recyclable waste and garbage annually (Li and Richter, 2015).

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The durability, unsustainable use, and inappropriate waste management lead to massive accumulation of plastic debris in the environment. In addition, during the process of deterioration, the additives and toxic substances in the plastics are released. These materials are relatively resistant to environmental breakdown and can be easily accumulated in the soil and water. Geyer et al. (2017) predicted that about 630 million tons of plastic waste would be produced, and 120 million tons would be transferred to landfills or natural environments by 2050. Lebreton et al. (2017) estimated that over 300 million tons of microplastics had been accumulated on the earth.

The wide application of Plastic mulch

Polyethylene was employed as a plastic film in 1938, and then it was extensively applied as plastic mulch in agriculture. Its introduction revolutionized the commercial production of selected crops and brought huge economic benefit to mankind (William, 1993; Steinmetz et al., 2016). It has been reported that the residual Polyethylene film in cropland soil reached nearly 10% of the total area (Ramos et al., 2015). Plastic mulch has a profound effect on the soil. Since the coverage of the film isolates the exchange of external air and water, it could elevate soil temperature as well as soil moisture, and increase soil biological activity to some extent. Subsequently, it may increase carbon and nitrogen metabolism; deplete soil organic matter storage (Li et al., 2007; Zhang et al., 2015).

However, when plastic mulch is embedded in soil, it undergoes numerous processes, such as physical crushing, chemical ageing and biodegradation, and is converted into microplastics (Blasing and Amelung, 2018).

Land application of microplastics containing sewage sludge

Microplastics are directly transferred to soil by applying synthetic fiber containing sewage sludge or plastic sediment from personal care or household products to the land (Habib et al., 1998; Zubris and Richards, 2005; Horton et al., 2017).To learn more about the main sources of microplastics in sewage outlets (cleaning products, plastic debris, clothing), Browne et al. (2011) collected samples of wastewater and found that polyester (67%) and acrylic (17%) fibers were the major plastic components. Subsequently, compared with the original waste materials, it was found that the proportion was very similar to the composition of textiles (78% polyester, 5% acrylic), so a decision was reached that the microplastics from sewage discharge outlet mainly came from washing-clothes.

Moreover, a piece of clothing from each wash by a domestic washing machine can produce N1900 fibers. MPs-containing wastewater is discharged into the sea without any restraint, and the unadvisable treatment of waste sludge further accelerates the distribution of MPs (Kerstin and Fredrik, 2014; Mintenig et al., 2017).

Microplastic pollution in soils

Although numerous studies reported the occurrence of microplastics in aquatic ecosystems, microplastics in terrestrial ecosystems have received relatively little attention. Once an entry in the soil, microplastics may persist, accumulate, and eventually reach high levels that can affect organisms and biodiversity. Additionally, microplastics can also act as a vector for the transfer of pollutants, either plastic additives or other toxicants absorbed from soil matrices, to soil biota and thus pose a hazard. For example, Zhang et al. found the high concentration level of organophosphorus esters and phthalic acid esters in microplastics collected from 28 coastal beach soils in north China. In fact, the terrestrial environments are the critical source of plastic rubbish in the water column. Soils were theoretically speculated to be the major storages for microplastics, which is a bigger store more than oceanic basins (L. Nizzetto 2016). Another study points out that the total value of microplastic contaminations on land might be 4-23-fold larger than that in the ocean (Horton A.A. 2017). Once microplastics accumulated in soils, the topsoil provides a degradative environment due to increased oxygen availability, and relatively high temperature (Y. Chae. 2018). Soil microbes and terrestrial organisms may accelerate the degradation of plastics into smaller

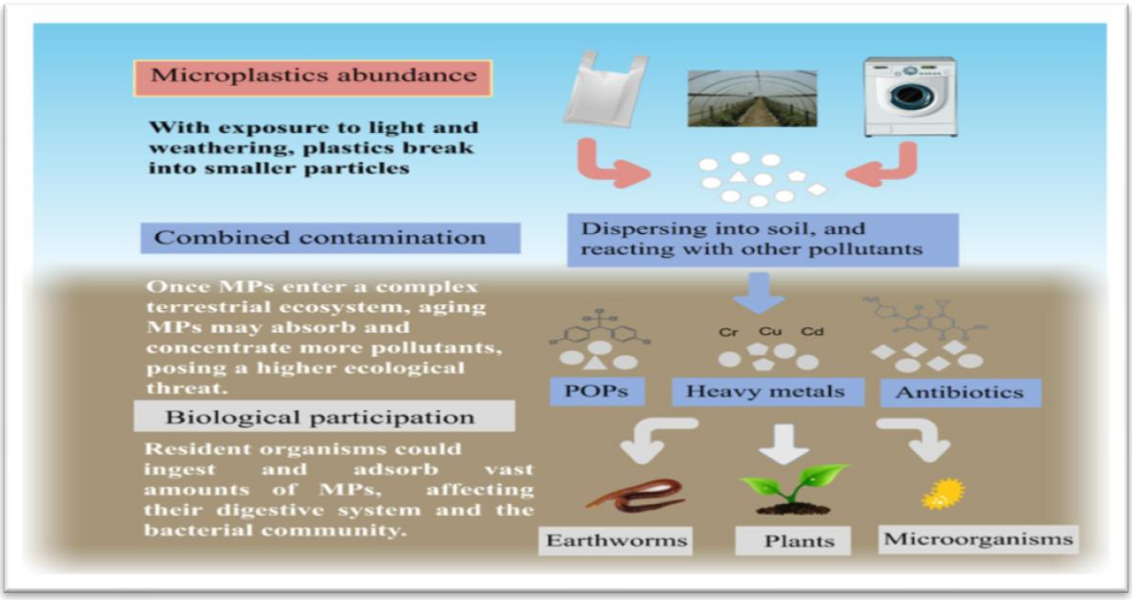

Fig: Microplastics as contaminants in the soil system (Source: J. Wang et al. 2019)

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particles. In addition, agricultural processes such as tillage and crop rotation may turn fragment plastic debris into microplastics. Microplastics in the topsoil might be incorporated into deeper soil by tillage, and even into the plough layer along large cracks.

Ecological risks of microplastics on soil organisms

Some review papers pointed out the potential effects of widespread microplastics and emphasized the adverse effects on biota. Soil organisms include various types such as fauna, nematodes, and collembolans.

- Gaylor et al. observed combined effects of biosolids or polyurethane foam microparticles and polybrominated diphenylether on earthworm *Eisenia foetida*
- They found that microplastics could exert toxicity to earthworms and has effect on mortality, growth and tunnel formation. In addition, earthworms can ingest microplastics, accumulate in the body and further transport to other organisms in the soil ecosystem.
- Recently, one study revealed that microplastics could be availably ingested by nematodes *Caenorhabditis elegans* (L. Lei 2018). The adverse effects of microplastics on nematodes include intestinal damages, oxidative damages.
- Some studies have shown the accumulation of microplastics in yeasts and filamentous fungi which indicates potential accumulation or magnification of microplastics along the soil food web.
- The impacts of microplastics in the aquatic plant have been reported. The plants cell wall is not available for entering of microplastics due to the high molecular weight and large size. So, smaller-sized micro- and/or nano-plastics may be taken up by plants.
- Lwanga et al. studied the transfer of microplastics in the terrestrial food chain.
- Microplastics have been detected in seafood, salt. Similarly, microplastics could be transported via the food chain in soil ecosystems, which may further threat human health to a certain extent.

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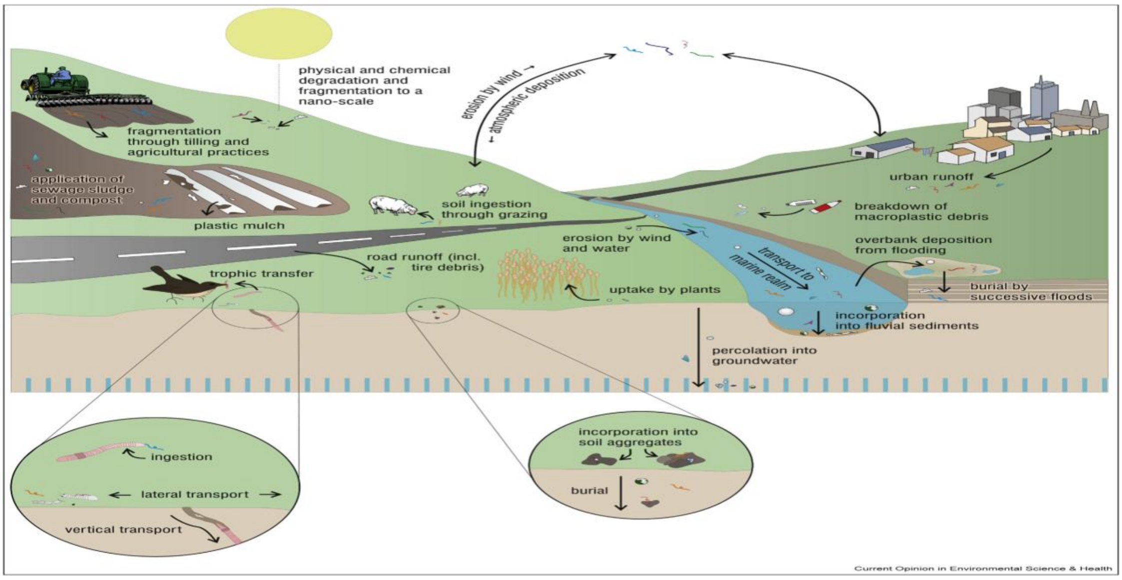

Fig: Fate of microplastics in soil

Possible Strategies to solve the problem of microplastics Pollution

- Removing plastic microbeads from personal care products. In 2015 the US government introduced the Microbead-Free Waters Act banning the sale of personal care products containing plastic microbeads, effective on 2017.
- Biodegradable or biocompatible plastics such as polylactatide, polyhydroxyalkanoates can replace traditional plastics for many applications.
- Improved solid waste infrastructure and management will decrease plastic debris entering rivers and the ocean and thereby decrease the rate of microplastics accumulation. Multiple uses of plastic products can also significantly reduce plastic wastes and decrease the formation of microplastics.
- Existing wastewater treatment facility should be upgraded to remove microplastics efficiently and to prevent microplastics from entering surface waters, such as rivers and the ocean.
- Development of clean-up and bioremediation technologies.
- Recycling of used plastics is an effective approach but recycling of used Styrofoam remains problematic, mainly due to costs. The use waste plastic as energy source and recovery of waste plastics as synthetic crude and valuable products will also reduce sources of microplastics.

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Steps taken by Government to reduce Plastic Pollution

- India's first Governmental Waste to Energy Plant developed in Bhubaneswar
- Development of Polycrack Technology – it is the world's very first patented heterogenous catalytic process which converts multiple feedstocks into liquid hydrocarbon fuels, gas, carbon as well as water. This technology is used to treat Municipal Solid wastes. All wastes are in general preferred as feedstocks for the unit. They are Plastics, Sludge, rubber tires etc.
- Waste in the poly crack plant is processed and converted into energy within 24 hrs.
- United Nations member states agreed to significantly reduce single-use plastics over the next decade (2030).It is the World's First global Commitment to curb Single –Use Plastics held in 2019.

Conclusion

- It is necessary to develop accurate, simple, efficient methods to assay microplastics in soils
- As Microplastics can be taken up by soil biota, it is important to investigate the potential toxicity of microplastics on soil organisms
- Little information about the source and fate of microplastics in terrestrial ecosystems
- The potential consequences for sustainability and food security have not been adequately analyzed
- Some soil enzymiological activity can develop with that some part of remediation can be done

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