# MICROPLASTIC POLLUTION IN SOIL

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Plastics have a place in all spheres of human activities due to their durability, affordability, flexibility, water resistance and availability. These synthetic organic polymers though have enormous societal benefits, their large quantum of production and consumption, and inefficient management of plastic wastes which degrade at an extremely slow rate, makes their build up everywhere including the ocean, soil, sea and surface water bodies, animal body, and even in human body though food chain. Physical, chemical or biological degradation of plastics form microplastics (MPs), which are plastic particles, fibres, films and other forms of plastic with a particle size of < 5mm. In the field of environment and ecology, microplastic pollution is already listed as the second important scientific issue.

## SOURCES OF MICROPLASTIC

Pollution of marine system with MPs is mainly due to anthropogenic actions, wind currents, coastline geology etc. MPs may also get transported through inland streams to the marine system. Though there are many reasons behind the pollution of terrestrial system with MPs, agriculture soils get contaminated through practices such as use soil amendments viz., compost and sewage sludge, plastic-coated fertilizers, plastic mulches (Figure 1), irrigation pipelines, an use of wastewater, lake and river waters for irrigation. Some other sources include tire abrasion, landfills, illegal waste dumping, littering along the roads and trails, road runoff, and atmospheric inputs.

Figure 1: Horticultural crops growing under plastic mulching

## MICROPLASTICS ABUNDANCE

Plastic wastes are a part of almost all ecosystems. Huge demand of plastics is the prime reason for the presence of MPs widely in the environment. According to the USA based ‘Clean Water Action’, at least 267 species got affected worldwide with marine plastic pollution (*cleanwater.org/problem-marine-plastic-pollution#).* Singh et al (2023) reported that MP contamination in the soil matrix of Bhopal in India is ranged from 180 ± 13.44 particles/kg to 2.5 ± 0.71 particles/kg. Plastic wastes in the study area mostly belonged to the category of PE, PP, PVC, and PET that are commonly used in food packaging, water bottles, grocery bags, garbage bags, etc.

Studies conducted in the coastal areas of Tamil Nadu (TN) in India to assess the accumulation and contamination of aquatic habitats with MPs reported abundance of MPs varying from 439 ± 172 to 119 ± 72 (High Tide Line) and 179 ± 68 to 33 ± 30 (Low Tide Line) items $kg^{-1}$ of sediments in the high and low-tide sediments (Sathish et al, 2019). Major MP polymers identified in the study area were polyethylene (73.2%), polypropylene (13.8%), nylon (8.2%), polystyrene (2.8%) and polyester (2%). MP debris in the sediment samples of Tuticorin coast ranged between 25±18 items/$m^2$ and 83±49 items/$m^2$ and average size of MPs were in the range of 0.05 mm to 5 mm. MP fragment concentrations in estuarine sediments along the TN coast were reportedly 30.2 mg $kg^{-1}$ (Uppanar), 9.4 mg $kg^{-1}$ (Vellar) and 11.7 mg $kg^{-1}$ (Coleroon). Subramanian (2023) reported MPs in the bodies of epipelagic and mesopelagic fishes @ 3.64± 1.7 items/individual.

## PLASTIC DEGRADATION

Degradation of plastic is an extremely slow process. Plastic is very stable to various physical, chemical and biological agents. Photodegradation, thermo-oxidative degradation, hydrolytic degradation and biodegradation by microorganisms are the principal mechanism for plastic degradation. UV radiation, action of sunlight and rain water can also weaken plastic molecules and makes them brittle to form microplastics. The life span of some of the synthetic thermoplastic polymers is presented in Table 1.

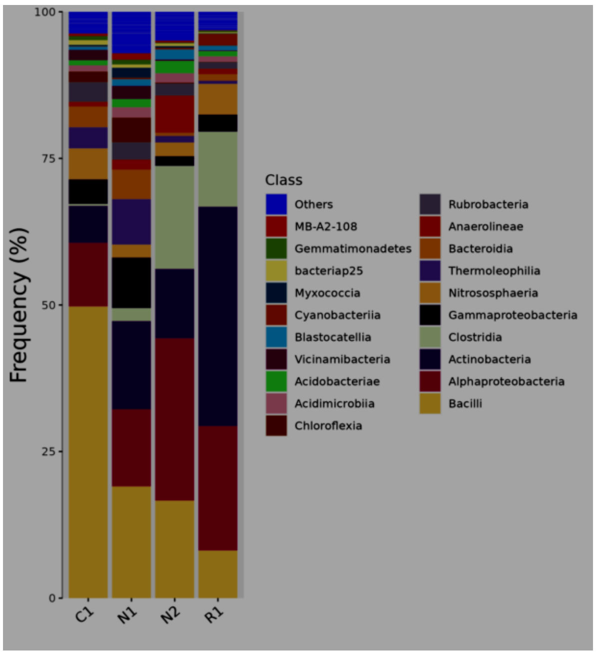
Researchers across the world identified some microbes have the ability to degrade MPs in soil. Rathore et al. (2021) reported that members of Actinobacteria group involved in the biodegradation of plastic materials in marine environments. Kublik et al. (2022) listed *Rhodococcus, Streptomyces, Nocardioides, Arthrobacter,* and *Aeromicrobium* as prominent groups of organisms for biodegradation of plastics. The study conducted by ICAR-Indian Institute of Soil Science, Bhopal to assess the soil microbial diversity of farm fields using plastic as mulching material identified an increased proportion of actinobacteria in soil metagenome (Figure 3.).

Figure 2. Abundance of plastics at city waste dumping site

Table1: Life span of some thermoplastic polymers

| Plastic Polymers | Life span (years) |
|---|---|
| Polyethylene terephthalate (PET) | 450 |
| Polyvinyl chloride (PVC) | 50-150 |
| Polystyrene | 50-80 |
| Polypropylene | 10-600 |
| Low density polyethylene | 10-600 |
| High density polyethylene | > 600 |

(Source: Mohanan et al, 2020)




C1= No mulching; N1, N2 & R1 = Soil under plastic mulch

Figure 3. Microbial diversity in plastic mulched soil

## CONSEQUENCES OF MICROPLASTICS

Consequences of MP contamination on environment are countless. In aquatic environment, the inhabiting organisms ingest MPs as such or through their food. Ingestion and accumulation of MPs and their additives by marine organisms are harmful to the animals *per se.* The bio-accumulation and subsequent transfer of MPs to organisms of upper trophic level through food chain may invite more harmful results when the MPs interfere with their physiological processes. MPs affect plants' performance by altering soil structure, microbial activity, nutrient transformation and movement / persistence of contaminants. Chemicals additives use in the synthesis of plastics, may adversely affect ecosystems and their inhabitants (Sun et al, 2024). MPs may alter the functioning of organisms like soil dwelling invertebrates, plant pollinators, fungi etc. and the impacts vary with soil type, plant/animal species, and MP type.

Similar to the marine system, trophic transfer or bioaccumulation of MPs can also be occurred in the terrestrial organisms. With the adsorption of hazardous substances such as heavy metals, persistent organic pollutants, pesticides, pathogenic microorganisms and antibiotics, the ill effects of MPs may become amplified. Jiang et al (2020) reported gut inflammation, damage of intestinal cells and polystyrene-MPs induced DNA damage in earthworms (*Eisenia fetida)*. Wang et al. (2023) observed that polystyrene, polyethylene, and polypropylene MPs inhibit shoot extension in amaranth and disorganize the root cells of seedlings due to the reactive oxygen species (ROS) damage in the roots. MPs may affect the seed germination due to blockage of pores on seed coat and thus interfering with imbibition process. As per studies, MPs can also enter into plants through foliar opening or cracks and transported to various parts of the plant via apoplastic routes (Roy et al, 2023). The prolonged persistence of MPs in soil impedes the water infiltration along the soil profile and reduces ground water recharge. MPs can apply selection pressures on soil microorganisms which can further change soil microbial community structure and diversity which ultimately affect soil processes and function. Extensive research work is required to find the effect of MPs on soil processes and functions with respect to different soil types.

## ALTERNATIVES TO PLASTICS AND PLASTIC MULCH

**Organic or Living Mulch:** Cover the soil surface by growing cover crops or using crop residue contribute plant nutrients to the crop by decomposition. However, the living mulch (cover crop) may compete for nutrients and water with the main crop

**Biodegradable Plastics:** Bio-degradable plastics are synthesized from renewable raw materials, micro-organisms, petrochemicals, or combinations of all three. Bio-based plastics can be degraded more rapidly by the action of microorganisms into carbon dioxide thus eliminate the possibility of accumulation besides being non-toxic to living organisms in the soil. They harbour all the major property of synthetic plastics hence can be possible replacement of synthetic plastic. However, relatively higher cost and lower durability (Figure 4.) of biodegradable plastic mulch are the major limitations for their wide use in agriculture.


Figure 4. Pictures showing durability of **(a)** synthetic & **(b)** biodegradable mulch after two cropping seasons

## CONCLUSION

Agricultural plastic mulching is useful in improving crop productivity by soil moisture conservation, reducing soil evaporation, modulating soil temperature and minimizing the weed growth and disease occurrences. However, inefficient management of discarded plastic mulch may lead to accumulation and formation of micro-plastic and others secondary derivatives in soil which may adversely affect biological activity and diversity. Many studies have shown to cause change in proportion of various microbial taxa in soils mulched with plastic film. Alternative materials for mulching including crop residue and biodegradable plastic can be encouraging to reduce the ill effect and environment burden due to MPs. Further research studies are needed to explore the effect of micro plastics on soil processes and functions with respect to different soil types.

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