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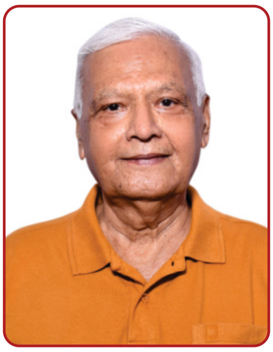
Plastosphere of Anthropocoene – a real threat to ecosystem health ?



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A man made ecosysyem – the plastosphere harbours living organisms thriving on microplastics, now ubiquitous in aquatic environment. According to an estimate, 51 trillion microplastics are floating on the surface of oceans. A small piece of microplastic measuring 5mm can host thousands of different microbial species. A plastosphere thus can be defined as " a microbial ecosystem that develops on the surface of plastic debris particularly microplastics in the aquatic environment". It was first described by a team of marine scientists (Zettler *et al*., 2013) while working on the micro-organisms of Atlantic Ocean.

Plastic was discovered in 1907 by Leo Backeland using formaldehyde and phenol. Since then its use by human society has exploded multifold. Between 1964- 2014, its applications increased twenty fold. Now, synthetic and semi synthetic compounds are used to make a variety of plastics viz. polyethylene (PE), polyethylene tetraphthalate (PET), polystyrene (PS), polypropylene (PP) and poly vinyl chloride (PVC) (Auta and Emenike, 2017; Lu *et al.,* 2021). In addition, more than 10,000 chemicals are employed in plastic manufacturing. About 2000 of these substances are likely to affect the environment and human health (Wiesinger *et al.,* 2021). Recent estimates claim that approximately 1.1 billion tons of plastic will be dumped in the natural environment by 2050.

Richard Thompson, a marine biologist coined the term microplastics (Mps) (Thompson *et al*., 2004). Fragmentation of plastic produces primary microplastics (MPs) which are less than 5mm in length. These particles are further classified as microfibers, microbeads, plastic litter and plastic pellets. Primary microplastics are further degraded through physical, chemical, biological, and photo -degradation processes into secondary microplastics. Present global load of MPs ranges from 93,000 to 236,000 metric tons (Ioakeimidis *et al*., 2016). MPs are not the only end products of plastics but are further degraded into nanoplastics (NPs). By definition, NPs measure less than 100 nm in size (Dawson *et al*., 2018). They are ubiquitous in air, water, soil and food and consequently, affect human health adversely (Lai *et al*., 2022).

Plastics contribute 80-85% of marine litter. Approximately, 5 to 13 million tons of plastics, on an average, enter the oceans per year (Auta *et al*., 2017). Around 229,000 tons of plastics are dumped every year into the Mediterranean Sea alone (Macias *et al*., 2019). The highest concentration of floating debris has been reported in this sea. Wang *et al*. (2020) documented the highest concentration of MPs in the West Pacific Ocean. MPs in the Indian Ocean including beaches, sub-tidal sediment, sediment of the ocean floor and surface waters have been reported by Thiemann *et al*. (2023). Finally, they settle down in the benthos and affect the marine organisms.

In atmosphere, MPs and NPs can travel long distance creating a never ending loop of plastic transport (Allen *et al*., 2022). Air borne MPs and NPs have been detected worldwide, especially in the northern hemisphere including France, Iran, China, Japan, Vietnam, Nepal, USA, Saudi Arabia, South Korea, Greece, Roamania, Pakistan and India (Ajith *et al*., 2020). Sources of MPs/NPs in air include indoor air pollution, wearing of tyres and atmospheric fallout (Dris *et al*., 2017).

Pollution of agricultural soil by MPs/NPs loaded agrochemicals has also been reported (Moeck *et al*., 2022). It has been argued that partition of MPs/NPs in different soil matrices can modify their bioavailability in plants. Further, apoplastic and synplastic pathways can facilitate their absorption by roots. Bioaccumulation of MPs/NPs may induce oxidative stress and gene expression changes that will determine the plant growth, biomass production and synthesis of secondary metabolites (Maity *et al*., 2022).

Prevalence of MPs/NPs in fresh water ecosystems has rarely been studied. According to Wagner *et al*. (2014), 80% of total plastic debris in the marine systems are derived from terrestrial sources that are transported by rivers. Major rivers of India *viz*., Ganges, Brahamputra and Meghna discharge 1-3 billion tons of MPs in the Bay of Bengal every day (Napper *et al*., 2021). The presence of MPs in ground water has also been reported (Selvan *et al.*, 2020a). Ubiquity of MPs/NPs in different eco-compartments leads to their presence in food chain/food web. Microalgae, the first trophic level in food chain are known to adhere to NPs, wherein they inhibit growth, reduce chlorophyll content, decrease photosynthesis and promote the formation of heteroaggregates. Zooplanktons, the second level of food chain are also affected by MPs/NPs. MPs/NPs are absorbed, transferred and biomagnified through food chain amongst rotifers, polychaetes, crustaceans, mollusks, echonderms and fish (Prata *et al*. 2017). Finally, MPs/NPs can reach human body and manifest into toxicity causing health hazards (Zhu *et al*., 2024). Food sources like vegetables, fish, sea food, table salt, sugar, honey, milk and even beer are known to be contaminated with MPs/NPs (Vitali *et al*., 2022). Food packed/stored in plastic ware constitute another source of exposure to MPs/NPs in humans (Yadav *et al.*, 2022). Many drugs and liquid pharmaceuticals are packed, stored and transported in plasticwares to consumers. NPs can reach skin, lungs, liver, kidney, heart and even immune system. Relationship between MPs/NPs and tumorogenesis has also been established. NPs may contain PAH that can cause DNA damage leading to carcinogenesis (Surya *et al*., 2024).

Serious attempts have been made in the recent past to address these problems at local and global platforms. An International Intergovernmental Negotiating Committee (INC, 2022) was set up by UN Environment Assembly (UNEA, 5.2). During Basel Convention (1989), 187 countries had committed to solve the plastic crisis. Ongoing researches on plastics and its chemical additives are covered by Stockholm Convention on Persistent Organic Pollutants (2001) and Rotterdam Convention on Hazardous Chemicals (1998). Environment Protection Agency (USA) has formulated a strategy," National Strategy to prevent Plastic Pollution: part 3 of a series on building a Circular Economy for all that offers an ambititious approach to recover plastics from other materials and prevent plastic pollution. EU policy on plastics aim to protect the environment and human health by reducing marine litter, green house gas emissions and dependence on fossil fuels. Ministry of Environment, Forests and Climate Change (MOEFCC) has enacted Plastic Management Rules, 2016 and Plastic Management Amendment Rules, 2022. Central Pollution Control Boards and State Pollution Control Boards enforce these rules and ensure the registration of plastic brand owners and fulfillment of environment protection rules.

Plastosphere is not a natural eco-compartment but has evolved due to various anthropogenic activities, mainly focused on micro and nanoplastics. Nonetheless, their production and use in different sectors by the society shows no serious concern to combat the problem. United Nations Environment Program in 2023 celebrated World Environment day with a slogan, **"Beat Plastic Pollution"**. In 2025 also, UNEP celebrated World Environment Day with a a slogan, **"Combat Plastic Pollution"**, with South Korea as the host country. Despite these efforts, projections on plastic production and consumption are alarming. Therefore, extensive eco-toxicological studies on MPs and NPs need to be encouraged. Strategic management policies warrant to be framed and effectively implemented before the society reaches a stage of "no return".

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