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# Plastic debris: A threat in marine environment

**Amarpreet Kaur Kalra**
SGTB Khalsa College, University of Delhi, Delhi, India

**Abstract**
Plastics are integral part of the society and have varied application. They are composed of a network of molecular monomers bound together to form macromolecule (polymers). A polymer may contain additives like plasticizers, stabilizers, lubricant, UV absorbing material, flame retardants to improve performance. The rise of plastics since the mid $20^{th}$ century, both as a material element and also as a growing environmental pollutant, has been widely described. Plastic pollution represents one of the most significant environmental problems facing mankind. There is massive accumulation of plastic debris and its degradation products in marine ecosystems. A large number of marine species is known to be harmed or killed by plastic debris. Marine animals are mostly affected through entanglement and ingestion of plastic litter. The plastic ingestion is increasing in sea birds that will reach 99% of all species by 2050. Waste water treatment plants have been identified as a potential source of microplastics. Plastics are widely dispersed in sedimentary deposits and their amount likely to grow several folds over the next few decades. Enhancement of the ecological consciousness through education, a proper legislation, and effective waste management systems can be the best way to solve such environmental problem.

**Keywords:** plastic debris, pollution, microplastic, marine species, legislation

## 1. Introduction
World plastic production has surged over the last decades, from 1.7 million tones in 1950 to 322 million tons in 2015, and is expected to double again over the next 20 years. Owing to their contribution of unmatchable properties and reasonable cost, plastics are the ubiquitous workhorse material of the modern economy. Plastics are increasingly used in various sectors of packaging, health care, construction, transportation, and electronics and have brought immense economic benefits to these sectors [1].

## 2. Analysis of Microplastics
Plastics in the environment are categorized as macroplastics and microplastics. Macroplastics are >5mm (Plastic bags, bottles, fishing nets etc.). Microplastics have diameter less than 5mm. Some microplastics in the form of granulate or pellets are found as microbeads in cosmetics, facial scrubs and toothpaste. Nanoplastics are less than 100nm in diameter. Most of the time they are intentionally produced for drug delivery, detergents or cosmetic use. Microplastics are not easily visible, but can be analyzed by various methods like fourier transform infrared spectroscopy (FTIR), scanning electron microscopy with energy dispersive X-ray spectroscopy (SEM-EDS), and Infrared (IR) and Raman spectroscopy. Several other methods such as pyrolysis – gas chromatography (Pyr-GC) combined with mass spectrometry, high temperature gel permeation chromatography (HT-GPC) have also been developed. With Pyr-GC, both the polymer composition of microplastics and additives can be simultaneously analysed [2, 20].

The density of the plastic debris is often determined by the composition of the plastic. Low density plastics (polyethylene, polypropylene) generate debris that is less dense than water and thus remain afloat. Plastics with densities greater than $1g/cm^3$ should sink in water [3]. Plastic debris in the environment will break down due to different processes such as photo-and thermal –oxidative degradation by ultraviolet (UV) radiation, mechanical or physical weathering, biodegradation. On degradation they release toxic chemicals into the environment. These include phthalates, bisphenol A (BPA), heavy metals and polybrominated diphenyl ethers (PBDEs) which disturb the endocrine functions and cause harmful reproductive and developmental effects in aquatic animals. Approximately 10-20 million tons of plastic end up in the ocean each year.

**Table 1:** Classes of plastics with their densities and common uses, which are commonly encountered in the marine environment

| Plastic class | Abbreviation | Density ($g/cm^3$) | Common uses |
|---|---|---|---|
| Low density polyethylene | LDPE | 0.91-0.93 | Plastic, bags, container lids, diapers, squeezable bottles. |
| High density polyethylene | HDPE | 0.94-0.98 | Detergent and cleaner bottles |
| Polypropylene | PP | 0.83-0.92 | Ropes, carpets, bottle caps auto parts |
| Expanded polystyrene | EPS | 0.01-0.04 | Foam cups, fish boxes, clamshell containers plates, trays, snow sports helmet |
| Polyethylene terephthalate | PET | 0.96-1.45 | Soft drink and water bottles, strapping |
| Polyamide (nylon) | PA | 1.02-1.16 | Toothbrush bristles, fishing nets, rope |
| Polystyrene | PS | 1.04-1.1 | Plates, cutlery, optical disk cases |
| Polymethyl methacrylate (acrylic) | PMMA | 1.16-1.20 | Medical devices, LCD screens |

| | | | |
|---|---|---|---|
| Polyvinyl chloride | PVC | 1.38-1.41 | Pipes, shower, curtains, flooring |
| Polycarbonate | PC | 1.20-1.22 | Battery cover in smart phones lens in eye wear, automotive components |
| Polyurethane | PU | 1.2 | Building and constructions, varnish, automotive parts |
| Acrylonitrile butadiene styrene | ABS | 1.04-1.06 | Electronic equipment casing, computer keyboards. |
| Poly tetra fluoro ethylene | PTFE | 2.10-2.30 | Wires, gears, cables bearings, nonstick coating |

## 3. Microplastics in Marine Environment

The occurrence of microplastics is investigated in the marine environment. These are found in the oceans worldwide, including remote regions like Antarctica and Arctic sea ice. Fragments that sink in sea water are then moved by tidal and storm-driven currents in shallow water and by various gravity driven currents. Buoyant micro and macroplastics have been found to accumulate in the North Atlantic, South Atlantic, North Pacific, South Pacific and Indian Ocean gyre [4-7]. In aquatic environments, fibres, fragments, granules are commonly found particle types, and PE, PP and PS are the most frequently found polymers.

Microplastics are ingested by a variety of species ranging from protozoans to marine invertebrates including amphipods, ciliates, mussels, fish etc. Ingestion of plastic may cause internal bleeding, abrasion, ulcers, blockage of digestive tract, organ damage from leaching toxins. Small microplastics might also be taken up via the gills surface [8]. Excess of plastic eventually bioaccumulate in food webs and are linked with various endocrine disruption disorder and decreased fish population. The hormone disruption in animals finally results in lower fertility, weakened immune system, sexual disorders (feminisation of male fish, bird, mammals) and various other deformities. Plastic ingestion could increase the buoyancy of fish making it difficult for mesopelagic fish to return to deeper waters [9].

Wildlife entanglement in plastic can happen in a number of ways and the results can be devastating. Once an animal is entangled it can drown, incur wounds or be less able to catch food or avoid predators. Young fur seals have been documented as being badly affected [10] and it appears the decline in the Hawaiian monk seal and the northern fur seal has been aggravated by entanglement of young animals. There have also been sightings of whales towing masses of tangled rope and other debris, including crayfish pots and buoys [11].

Experimental studies have revealed that amphipods, barnacles and lugworms ingest microplastics [12]. Studies on mussels indicate that microplastics are translocated from the gut to the circulatory system within 3 days and then persist in circulation for over 48 days [13]. The research also found a higher number of smaller particles (3.0 μm microspheres) in the circulatory fluid than larger particles (9.6 μm microspheres), which indicates that these smaller particles have greater potential for accumulation in tissues of organisms.

Movement of fishing gear across shallow reefs can damage coral substrate and hence affecting the reef structure. Sharp-edged microplastics may injure gill tissues and the intestinal tract. Countless marine animals and sea birds become entangled in marine debris or ingest it. A study done in the North Plastic found plastic particles in the stomach of 8 of the 11 seabirds species caught. Marine debris affects atleast 267 species worldwide, including 86% of all sea turtle species, 44% of all sea bird species and 43% of all marine mammal species. Fulmars (a type of seabird) reduce the size of plastic particles in their muscular stomach and excrete them back into the environment in the form of microplastics. They estimate that fulmars reshape and redistribute about 630 million plastic particles every year, representing about six tons in plastic mass [14].

Microplastics may function as vectors for sorbed hydrophobic pollutants. There is clear evidence that contaminants like hexachlorinated hexanes, polycyclic aromatic hydrocarbons, polychlorinated biphenyls and polybrominated diphenyl ethers are enriched on microplastics. Such pollutants might be transported to remote sites as Arctic. Several studies have demonstrated that contaminants, which had been sorbed to microplastics, are transferred to organisms ingesting these microplastics. If ingested, plastic has the potential to transfer toxic substances to the food chain. This could present a direct and important route for the transport of chemicals to higher animals [15,16]. Phthalates and BPA affect reproduction and impair development in amphibians. Biomass accumulation on plastic or biofouling with micro-organisms, plants or algae onto plastic debris causes it to become heavier and eventually sink.

Teuten *et al.* (2009) [17] investigated in more detail the uptake and subsequent release of one POP – phenanthrene – on three major plastics: polyethylene, polypropylene and polyvinylchloride. In all cases they found that pollutants adsorbed onto the plastics at a much higher rate than onto natural sediments. However, desorption (or release) of the phenanthrene occurred more rapidly from sediments than from plastic. This has several possible consequences as it could mean the plastic acts like a sink for the pollutants by lessening their availability to the environment, or it could mean that it increases their lifetime in the environment by hindering their disposal by natural means, such as microbial degradation. There is therefore a debate as to whether plastic debris acts as a sink for pollutants or as a storage and transport vessel whose impact ultimately depends on the fate of the plastic

It is predicted that the global quantity of plastic in ocean will nearly double to 250 million metric tons by 2025 or one ton of plastic for every three tons of fish.

Marine debris adversely the economy of many coastal countries which rely on tourism [18]. Macroplastic debris represents a navigational and structural hazard to shipping vessels and other small marine vehicles [19].

Coastal and subtidal sediments appear to be sinks for microplastics. Microscopic concentrations in sediments are higher than those in the sea surface layer and in water column.

## 4. Conclusion

Plastic waste is a major global challenge. Its degradation takes up to one thousand years, it is becoming a long-lasting environmental problem. Waste management has a large part to play in preventing plastic waste becoming harmful. Incorrectly managed landfills may cause waste to reach the environment, as well as the additional issue of chemicals from plastic waste escaping in the leachate. Prevention in this area can come by imposing bans, which prevents the disposal of plastic waste in the sea.

A sustainable step towards tomorrow's cleaner and healthier environment is the need of the hour. Formulation and application of incentive policies for recycling activities and establishing recycling funds are suggested. Disposal practices in tune to international guidelines and safety are needed

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