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Microplastic Impact on present day life

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The ocean is vast: it covers seven tenths of the planet, is on average about 4,000 meters deep and contains 1.3 billion cubic kilometers of water (97 per cent of all the water on the surface of the Earth). There are, however, 7 billion people on Earth. This means that each one of us has just one fifth of a cubic kilometer of ocean as our portion to provide us with all the services that we get from the ocean. That small, one fifth of a cubic kilometer portion generates half of the annual production of the oxygen that each of us breathes, and all of the sea fish and other seafood that each of us eats. It is the ultimate source of all the freshwater that each of us will drink in our lifetimes.

Unfortunately society has used the ocean as a convenient place to dispose of unwanted materials and waste products for many centuries, either directly or indirectly via rivers. The volume of material has increased with a growing population and increasingly industrialized society (Figure1) .Solid materials, typically waste, that has found its way to the marine environment is called marine debris.Marine debris from natural sources, such as floating vegetation or volcanic ash deposits, is commonplace in the ocean. Unfortunately, man-made debris has increased substantially, particularly in the past hundred years.

Plastic is becoming one of the leading category of marine debris. Plastics have become indispensable for human society. As a consequence of its intrinsic properties and its modification potential, these polymers are excellent materials for several purposes such as packaging, clothing, building material and pharmaceuticals. This high applicability has led to an increasing production over time. Most plastic waste get released into the environment due to improper human behavior (e.g. littering) and/or the lack of a good waste management. Plastics have infiltrated the natural environment via several ways.

Figure 1 - Polluted beach

Plastics are present in the environment in a wide variety of sizes, ranging from meters to 58 micrometers (Barnes et al., 2009). The smallest form of plastic litter is called micro plastic (Figure2).At present, there is no universally accepted definition regarding the size of microplastics. Many authors have defined microplastics as particles smaller than 5 mm (Arthur et al., 2009), while others have set the upper size limit at 1 mm (Claessens et al., 2011). But the value of 5 mm is more commonly used. Microplastics have been reported in the water column and marine sediments worldwide. Logically, plastics with a density that exceeds that of seawater (>1.02 g.cm-81^3) will sink and accumulate in the sediment, while low-density particles tend to float on the sea surface or in the water column. However, through density-modification even low-density plastics can reach the sea floor. It appears to be more abundant in densely populated areas.

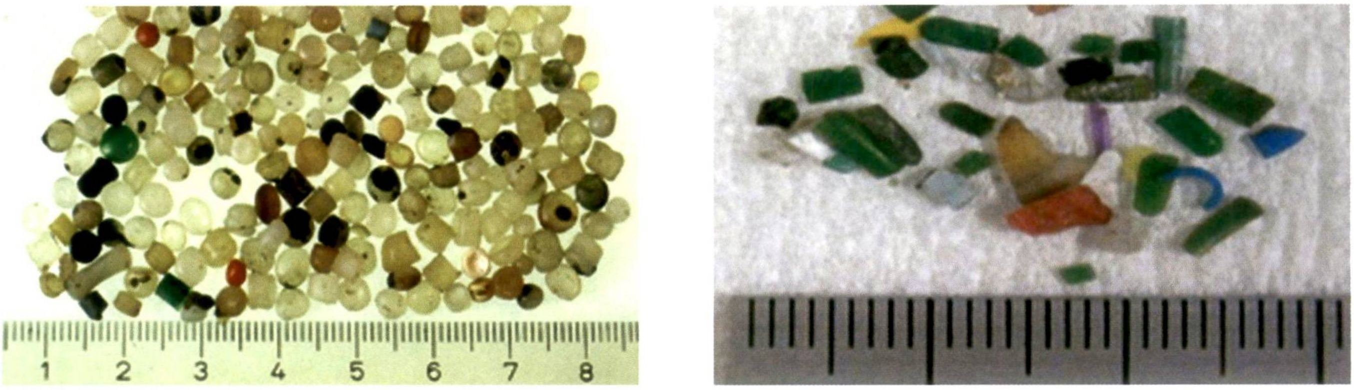

Figure 2 - Microplastics particles

Origin of Microplastics

Many different types of plastic are produced globally, but the market is dominated by 6 classes of plastics: polyethylene (PE, high and low density), polypropylene (PP), polyvinyl chloride (PVC), polystyrene (PS, including expanded EPS), polyurethane (PUR) and polyethylene terephthalate (PET). These types of plastics accumulated and that is the origin of microplastics. Basically there are two pathways that microplastics can be produced. They are primary and secondary pathways.The distinction between primary and secondary microplasticsis based on whether the particles were originally manufactured to be that size (primary) or whether they have resulted from the breakdown of larger items (secondary). It is a useful distinction because it canhelp to indicate potential sources and identify mitigation measures to reduce their input to the environment.

Figure 3 - Primary microplastics

Primary microplastics include industrial 'scrubbers' used to blast clean surfaces, plastic powders used in molding, micro-beads in cosmetic formulation, and plastic nanoparticles used in a variety of industrial processes (Figure 3). In addition, spherical or cylindrical virgin resin pellets, typically around 5 mm in diameter, are widely used during plastics manufacture and transport of the basic resin 'feedstock' prior to production of plastic products. Scientists have investigated the contribution of the use of domestic washing machines and concluded that washing synthetic garments contribute considerable numbers of microplastics to marine environments.

Secondary microplastics produced as a result of fragmentation from larger items. The production of microplastics by the fragmentation of larger plastic items is most effective on beaches, with high UV irradiation and physical abrasion by waves. Once submerged, cooler temperatures and reduced UV means fragmentation becomes extremely slow. Secondary microplastics can occur during the use phase of products such as textiles, paint and tires, or once the items have been released into the environment. Both weathering and fragmentation rates are relatively rapid on beaches but generally several orders of magnitude slower, decreasing in the following order; plastics floating in water, in the mid-water column or in the marine sediments. The degradation on beaches may be enhanced by the higher UV radiation, higher sample temperatures and mechanical abrasion attained by the beach litter, although some interaction between those factors is expected. The relative rates of degradation of plastic in different compartments of the marine environments have not been quantified but in any event depends on the plastic. However, the degradation of floating plastic is well known to be impeded by low water temperatures.

The general lack of research information on weathering and fragmentation of plastics in the marine environment is a very significant gap in relevant scientific knowledge. Lack of data on how the combined effects of photo-oxidation, fragmentation, mechanical abrasion and additive chemicals affect the formation of microplastics is a significant barrier to the production of reliable quantitative models to describe the behavior of plastics and microplastics in the ocean.

Microplastics are categorized in different classes, based on their overall appearance using simple features such as shape, colour, etc.Types that re-occur frequently are: pellets, fragments, granules, fibers, films and Styrofoam.

Origin of Microplastics

Sources of litter can be characterized in several ways. One common method is to classify marine litter sources as either land based or ocean-based, depending on where the litter entered the sea. The plastic accumulated on land may eventually end up in the ocean via riverine or wind-driven transport. On the other hand, tides and wave action bring plastic back to land. Regarding the marine environment, land-based sources contribute the most to the plastic pollution, but there are local differences. Fisheries for instance introduce plastics as a result of discarding and losing fishing equipment such as nets and lines. Especially in areas with high fishing intensities, litter mainly originates from fishing gear. Another source of litter is aquaculture installations. Through time, this sector has become an important way of producing fish. Materials used to hold suspended cultures, such as buoys, ropes and floats, are sometimes released in the environment. Some items can be attributed with a high level of confidence to certain sources such as fishing gear, sewage-related debris and tourist litter. So-called use-categories provide valuable information for developing reduction measures. Land-based sources include mainly recreational use of the coast, general public litter, industry, harbors and unprotected landfills and dumps located near the coast, but also sewage overflows, introduction by accidental loss and extreme events.

Uptake and Effect in Marine Organisms

As microplastic abundances in the environment increase, organisms inhabiting marine systems are more likely to encounter these particles. Numerous factors such as size, density, shape, charge, colour, aggregation and abundance of the plastic particles affect their potential bioavailability to a wide range of aquatic organisms. The accumulation of marine debris can alter and degrade marine habitats through physical damage caused by abrasion, shearing, or smothering, and can change the physical and chemical composition of sediments. Physical damage often impairs critical nurseries and refuges used by many different organisms that occupy these habitats and may reduce the quality of habitat for organisms whose daily activities (e.g., feeding, reproduction) require the use of specific environments. Degraded marine habitats reduce the resilience of marine life and their ability to survive in open waters and on the ocean floor. In addition, changes in marine habitats can alter complex marine ecosystems and ultimately affect yields of important commercial fisheries resources and reduce local biodiversity (Figure 4).

Figure 4 - Ingested microplastics in fish

The damage to sea life is staggering: at least one million seabirds and hundreds of thousands of marine mammals die each year due to the pollution. Ingestion of and entanglement in marine debris by marine animals has increased by 40% in the last decade. Detecting plastic ingestion by marine birds is more straightforward. Because chicks are fed fish or to her food from the open sea, monitoring their food intake may give an indication of plastic ingestion by certain species. Moreover, marine birds not only ingest plastic particles directly, but also receive a proportion through the guts of their prey (Figure 5).

Figure 5
The unaltered stomach contents of a dead albatross chick

Furthermore, plastics can transport invasive species and toxic substances over great distances. Many different plastic substrates with various forms and surface topography are used as rafting materials by various organisms. It has been observed that the type of plastic and the form of the fragments strongly influence the kind of species that are harbored by the rafting material and also host different communities than natural substrates.

Marine organisms and their habitats can become contaminated by potentially harmful chemical compounds leaching from plastic debris. Additionally, the accumulation of microplastics in benthic and beach sediments may alter the quality of marine habitats for many animals by imposing uncertain physiological and toxicological risks on these inhabitants, ultimately including humans. The abundance of microplastics found in all marine habitats and their potential impacts to both the habitats and foundation species warrant continued investigation.

As in other marine habitats, plastic litter can negatively affect oyster reefs. When plastics rest on the seafloor in these habitats, smothering, ingestion, and exposure to toxicants can occur. Plastic litter may also inhibit gas exchange between the sediment and water rendering areas devoid of oxygen. Microplastic Particles may be ingested and accumulated by oysters, leading to physical effects. They can uptake polystyrene beads. The beads were ingested when incorporated into aggregates composed of their normal food sources. After ingestion, the beads were transported to their digestive glands, creating possibilities for toxicological effects and the potential to transfer microparticles to higher trophic levels.

High concentrations of plastic debris could thus potentially impair the health of corals(Figure 5). It was found that corals may mistake microplastics for prey and can consume up to 50 µg of plastic at a rate similar to their consumption of plankton. It is uncertain how this ingestion affects coral energetics and growth, or if reef growth in general is threatened. As with shallow coral reefs, deep sea corals also encounter microplastics.

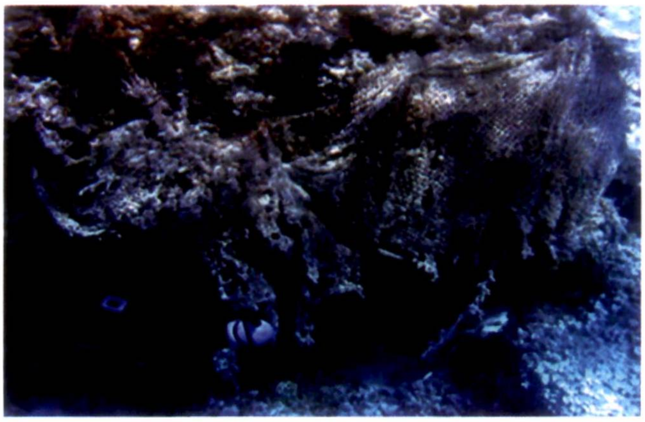

Figure 6 - Threatened coral reef

Microplastic particles such as fishing nets can impact benthic environments by smothering, abrading, and changing the sea bottom structure. Derelict nets can modify the sea floor by scouring the seabed and trapping fine sediment, which can suffocate plants and animals. Plastics on the sediment caused anoxic conditions, reduced primary productivity and organic matter, and lowered infaunal invertebrate abundance. A review by Moore (2008) stated that the accumulation of plastics on benthic sediments can inhibit gas exchange between overlying watersand sediment pore waters while smothering benthic inhabitants. The discovery of microplastics in benthic habitats is added concern for the consequences of marine debris, as they can be ingested by filter-feeding invertebrates, potentially producing deleterious effects to the organisms as well as their predators.

Habitat degradation due to marine debris has far-reaching impacts on biodiversity since many critical areas, such as coral reefs, mangroves, marshes, and seagrass, serve as breeding grounds or nurseries for nearly all marine species. Marine debris not only damages habitats directly via physical and chemical impacts, but it can also lead to reduced recruitment and reproduction for certain species, which may indirectly alter or degrade critical nurseries and other fragile ecosystems.

Considering the factors influencing the physical impacts of microplastic ingestion in vertebrates reporting global impacts including: internal and/or external abrasions and ulcers; and blockages of the digestive tract, which can result in satiation, starvation and physical deterioration. In turn this can lead to reduced reproductive fitness, drowning, diminished predator avoidance, impairment of feeding ability, the potential transfer of damaging toxicants from sea water and ultimately death. Other feasible impacts have been suggested are: blockage of enzyme production; diminished feeding stimulus; nutrient dilution; reduced growth rates; lowered steroid hormone levels; delayed ovulation and reproductive failure; and absorption of toxins. There is potential for microplastics to clog and block the feeding appendages of marine invertebrates or even to become embedded in tissues.

A majority of studies have documented microplastics in the guts of organisms, an organ that is not generally consumed directly by humans. Exceptions to this include shellfish such as mussels, clams and some shrimps that are eaten whole or with their gut. It reviews the routes of uptake of micro and nanoplastics into humans through the food chain and the potential consequences for human health.

Origin of Microplastics

Education and public engagement are often referred to as ways of improving public understanding and working towards social solutions for environmental problems such as microplastic accumulation. But to achieve societal change and to complement existing legislation, there is a clear need to influencing perceptions and behavior. The scientific community has to promote greater awareness of the impacts of plastics and microplastics in the marine environment and has to include the expertise from the socialsciences. But not only the legislations has to become improved, there are still several knowledge gaps, which have to be filled. The role of plastics and microplastics to act as a vector for the transfer of organisms is another possibility has to be evaluated. Education of a community about the problems of marine debris may help to prevent some of the problem, and education in schools can help not only for children to learn good habits but also can spread the knowledge to their families. Policy-makers and other decision-makers in the public (e.g. municipalities) and private sectors (e.g. manufacturing, retail, tourism, and fisheries), need guidance now on how best to target the microplastics issue.

Plastic pollution is a major threat in terms of ecology, economics and ecotoxicology, and is likely to continue to increase in the next decades, amplifying its hazardous effects. At least it will help to reduce the current issue of the dangerous era of microplastics in present day life.