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Review Article

Comments on Marine Litter in Oceans, Seas and Beaches: Characteristics and Impacts

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Abstract

Marine litter is observed along shorelines, pelagic, benthic marine and lake systems all around the globe. On beaches, litter creates aesthetic and related economic problems because a clean beach is one of the most important characteristics of a seaside resort required by visitors. Litter can reach the marine environment from marine or land activities but it is estimated that 80% originates from land-based sources. The marine-based sources of litter include all types of sea-going vessel and offshore installations, the most abundant plastic debris in the oceans being derelict (lost or improperly discarded) fishing gear. Most of marine litter is composed by plastics due to their greater durability and persistence, combined with plastic rising production and low rates of recovery. Special importance is linked to microplastics because their ubiquity, persistence, mechanical effects on biota and the ecosystem because of ingestion by organisms and their toxic potential. As plastics degrade they can release toxic chemicals initially incorporated during their manufacturing or persistent organic pollutants and heavy metals sorbed to their surfaces in the environment. Such toxins can disrupt endocrine functions and cause harmful reproductive and developmental effects in aquatic animals.

INTRODUCTION

Marine litter generalities

Marine litter (or marine debris), defined as 'any manufactured or processed solid waste material (typically inert) that enters the marine environment from any source' [1], is observed along shorelines [1,2], pelagic, benthic marine and lake systems all around the globe [3,4].

Specifically, marine debris on beaches creates aesthetic and related economic problems [5,6]. [7,8] have shown that five parameters were of the greatest importance to coastal tourists: safety, facilities, water quality, litter and scenery; [9] observed a clean beach is one of the most important characteristics of a seaside resort required by visitors. [10,11] commented upon the negative effects of beach litter, especially linked to the presence of potentially hazardous and unaesthetic items such as sanitary and medical waste, all of which cause damage to the local, national and international image of a resort. This is reflected in loss of tourist days and resultant damage to leisure/tourism related activities, since visitors are especially interested in coastal tourism - one of the world's largest industries [12], with beaches being a major player in this market [13,14].

Marine litter can reach the marine environment from marine or land activities [15,16] but it is estimated that 80% originates from land-based sources [17]. Land-based sources of marine litter include illegal dumping, landfills, storm-water drains, petrochemical plants and other industries, as well as direct inputs in coastal areas, for example trash left by recreational beach users, or fly-tipping and other improper disposal by consumers (e.g. toilet), which can be carried by wind, sewage, rain to rivers and the marine environment [18,19]. The marine-based sources of litter include all types of sea-going vessel as well as offshore installations [20], the most abundant plastic debris in the oceans being derelict fishing gear (nets, lines, traps), which has either been lost or improperly discarded. In six separate studies, fishing gear was found to represent on average more than 3% of the total number of debris items collected along marine shorelines [2], while in areas such as the North East Atlantic pieces of net, cord and rope are the second most common item found on the beach [14]. This is a function of locality though and in some places it is very high. Other offshore sources include illegal dumping of plastic waste from ships and the release of plastic resin pellets and other cargo when shipping containers are lost at sea [21]. To date, there is no standardised methodology to deal with sources identification [11,22].

DISCUSSION

The importance of Plastic and microplastics components

[23] postulated that the five biggest problems for the 21st century were: nutrient eutrophication, algal blooms, environmental oestrogens, alien organisms and pathogens and, last but not least, *plastics*. In the marine environment, on average, between 60% and 80% of shoreline debris items consist of plastics but the plastic fraction, in certain areas, can be as high as 95% [14,24]. Such values are essentially linked to greater plastic durability and persistence, combined with rising production of plastics and low rates of recovery [15,16]: a 25-fold increase in the production of plastic resin products was observed between 1960 and 2000 with a recovery rate of less than 5% [25,26].

Plastic debris exhibits a wide range of shapes; in addition to recognizable plastic objects, the most common shapes are fragments, films, pellets, lines, fibres, filaments, and granules. Plastic debris is often classified as either primary or secondary. Primary plastics are in their original or close-to-original form when collected, such as bottles, micro beads or resin pellets. Secondary plastic debris encompasses the smaller pieces of plastic resulting from the breakdown of primary debris through various environmental degradation processes [27]. The composition of plastic refers to the polymer type, which in turn determines the density of debris. Low-density plastics, such as polypropylene and polyethylene, produce debris that is less dense than water and therefore likely to remain afloat. Plastics that are denser than water and thus tend to sink include polyethylene terephthalate, polystyrene, and cellulose acetate.

In addition to aesthetical and moralistic issues of anthropogenic impact to the environment, plastic litter produces negative effects on biota and the ecosystem because of ingestion of micro- and mesoplastic by organisms [18,28] together with entanglement of animals in abandoned nets, fishing lines, ropes and ribbons [29,30]. Ingestion of plastic may cause internal bleeding, abrasion and ulcers, as well as of digestive tract blockage [19]. In littoral zones, accumulation of sinking plastic debris and the dragging of fishing nets may disrupt bottom sediments, displace or smother in fauna, and affect the structure and functioning of benthic microbial communities [23]. Accumulation of plastic debris in coastal areas can deter recreational usage, pose a hazard to swimmers and divers, and carry a risk of minor cuts or abrasion injuries to beach-goers [7,31].

Plastic debris in the environment will break down through a combination of photo- and thermal-oxidative degradation by ultraviolet (UV) radiation, mechanical weathering, and biodegradation, but complete mineralization may not be possible, or then only after hundreds or thousands of years [14,21,32]. As plastics degrade they can release toxic chemicals that were initially incorporated during their manufacturing or sorbead to their surfaces in the environment. These chemicals include phthalates, nonylphenols, bisphenol A (BPA), heavy metals, and polybrominated diphenyl ethers (PBDEs) [33-36], which can disrupt endocrine functions and cause harmful reproductive and developmental effects in aquatic animals [37].

Plastic debris may act as a vector for contaminants, including persistent organic pollutants (POPs) and heavy metals [38-42]. Sorption to plastics has been shown to limit the biodegradation of organic contaminants, increasing their persistence in the environment [3,33]. Plastic debris can also transport non-native species [29,43] and be colonized by microbes including possible pathogens [27,44]. Smaller plastic debris is also more bio-available—several aquatic species have been found to ingest microplastics [45,46], including commercial species —and the trophic transfer of plastics along aquatic food webs has been verified, hence posing a possible threat to aquatic ecosystems [21,33]. The possible transfer of plastic-sorbed toxins to humans through consumption of aquatic species is of concern, but it has yet to be demonstrated [47].

Plastic debris is variably classified according to size, origin, shape, and composition. While there are no international agreements upon size classes, 'microplastic debris' generally refers to plastic particles smaller than 5 mm and larger than 333 μm [48], because in most open-water studies neuston nets with a mesh size of 333 μm are used to collect debris [21,43]. Microplastics consist of plastic particles which result from the fragmentation of larger plastic items and those that are designed to serve as raw material (resin pellets) or to be incorporated in specific products (e.g. plastic microbeads included in cleansing products) [32]. Microbeads and other synthetic polymers are widely used as abrasive agents in a range of consumer products, including exfoliating creams, soaps, toothpastes, shampoos, lip gloss, eye liner, sunscreens, and deodorants. Microbeads that are flushed down sink and shower drains enter the wastewater collection system. Wastewater treatment plants (WWTPs) are currently not required to monitor microplastics in influent or effluent streams. Plastic resin pellets, which constitute a raw material used in plastics manufacturing, are also quite abundant in marine environments [32,49] and their presence is usually linked to losses during transport operations. Polyester and acrylic fibres have been widely observed in marine sediments [18]. Small plastic fibres are released from synthetic fabrics in washing machines. Households and textile laundering facilities may therefore represent a significant source of plastic fibres [50]. The fibres can be transferred to surface water bodies directly via the effluent discharges of WWTPs, or indirectly via their solid residues. When the latter are used as fertilizers and compost material on crop fields, the fibres may be remobilized and ultimately reach natural or man-made waterways [18,51,52].

FINAL CONSIDERATIONS

Plastics debris is one of the five biggest problems for the 21st century. Oceans, lakes and beaches across the globe are littered by such items. They are manufactured for different uses and purposes and are transported to coasts by wind, rivers, drainage systems or human activity. Offshore sources include illegal dumping of plastic waste from ships and the release of plastic resin pellets and other cargo when shipping containers are lost at sea. As a result, floating plastic fragments in the world's oceans have been reported since the early 1970s with the amount of debris recording a recognized exponential increase into the early 1990s.

Resin pellets, microbeads and breakdown of primary plastic debris through various environmental degradation processes form microplastics. They are especially important because of their ubiquity, persistence and toxic potential. Ingestion of plastics and microplastics may cause internal bleeding, abrasion, ulcers and digestive tract blockage [53,54]. Their degradation in marine/lake environments give as a result the release of toxic chemicals initially incorporated during their manufacturing as well as of absorbed persistent organic pollutants and heavy metals which can disrupt endocrine functions and cause harmful reproductive and developmental effects in aquatic animals. The possible transfer of plastic-sorbed toxins to humans through consumption of aquatic species is of concern, but it has yet to be demonstrated [47].

Considering the importance of marine litter, the European Commission presented, in 2013, the Final Report "Guidance on Monitoring of Marine Litter in European Seas" [55]. The objective of such document is to support Member States in the monitoring of the Marine Strategy Framework Directive (2008/56/EC) Descriptor 10. The Guidance document provides recommendations and considerations, including specific protocols to collect report and assess data on marine litter in a coordinated and harmonised way, namely regarding beach litter, floating and seafloor litter, litter in biota and micro-litter. Yet concerted action of international research groups towards an assessment of the current state of our beach and coastal systems and sea and ocean states is only in its early stages. Agreements on common methodology and intense collaboration and dedicated data collection are needed for inter-comparative studies on the different marine systems.

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