

## Microplastics as contaminants in marine environment.

### Los microplásticos como contaminantes en el medio marino.

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#### ABSTRACT

Since the mass production of plastics began in the 1940s, microplastic contamination of the marine environment has been a growing problem. Here, a review of the literature has been conducted with the following objectives: To summarise what are microplastics; To discuss the routes by which microplastics enter the marine environment; To assess spatial and temporal trends of microplastic abundance; to discuss the environmental impact of microplastics; and remedial measures; Microplastics are both abundant and widespread within the marine environment, found in their highest concentrations along coastlines and within mid-ocean gyres. Ingestion of microplastics has been demonstrated in a range of marine organisms, a process which may facilitate the transfer of chemical additives or hydrophobic waterborne pollutants to biota. A case study has also been done about the ingestion of microplastics by zooplankton groups in Kenya's marine environment. We conclude by highlighting key future research areas for scientists and policymakers.

Keywords—Micro plastics; marine organisms; marine environment.

#### RESUMEN

Desde que comenzó la producción masiva de plásticos en la década de 1940, la contaminación por microplásticos del medio marino ha sido un problema creciente. Aquí, se ha realizado una revisión de la literatura con los siguientes objetivos: Resumir qué son los microplásticos; Discutir las rutas por las que los microplásticos ingresan al medio marino; Evaluar las tendencias espaciales y temporales de la abundancia de microplásticos; discutir el impacto ambiental de los microplásticos; y medidas correctivas; Los microplásticos son abundantes y están muy extendidos en el medio marino, y se encuentran en sus concentraciones más altas a lo largo de las costas y dentro de los giros oceánicos. Se ha demostrado la ingestión de microplásticos en una variedad de organismos marinos, un proceso que puede facilitar la transferencia de aditivos químicos o contaminantes hidrófobos transmitidos por el agua a la biota.

También se ha realizado un estudio de caso sobre la ingestión de microplásticos por grupos de zooplancton en el medio marino de Kenia. Concluimos destacando las áreas clave de investigación futura para científicos y legisladores.

Palabras clave — Microplásticos; organismos marinos; Ambiente marino

## INTRODUCTION

For centuries, humans have been disposing of waste into the sea where it eventually deposits on the coastline or the seabed. Plastic product production was estimated at 2.63 billion kg in 2004 in the United States alone and increasing consumption over time is coupled to escalating levels of plastic in the marine environment via industrial discharge, littering and terrestrial runoff. Most polymers are highly persistent in the marine environment and only degrade slowly via photocatalysis when exposed to ultra-violet radiation. The lifetime of plastics at sea is not accurately known, but is estimated to range from years to decades, depending on the physical and chemical properties of the polymer. Plastics at sea eventually undergo fragmentation, leading to the formation of microscopic particulates of plastic or so called 'microplastics'. Due to their buoyant and persistent properties, microplastics have the potential to become widely dispersed in the marine environment via hydrodynamic processes and ocean currents. The impact that large plastic debris, known as 'macroplastics', can have on the marine environment has long been the subject of environmental research. The presence of macroplastics in the marine environment presents an aesthetic issue, with economic repercussions for the tourist industry, a hazard for numerous marine- industries (e.g. shipping, fishing, energy production, aquaculture) as plastic may result in entanglement and damage of equipment, and significant environmental concerns. The environmental impact of macroplastics include: the injury and death of marine birds, mammals, fish and reptiles resulting from plastic entanglement and ingestion, the transport of non-native marine species (e.g. bryozoans) to new habitats on floating plastic debris, and the smothering of the seabed, preventing gas-exchange and creating artificial hard-grounds, resulting from sinking plastic debris. In recent years, there has been increasing environmental concern about 'microplastics': tiny plastic granules used as scrubbers in cosmetics and air-blasting, and small plastic fragments derived from the breakdown of macroplastics.

## MICROPLASTICS

Whilst macroplastic debris has been the focus of environmental concern for some time, it is only since the turn of the century that tiny plastic fragments, fibres and granules, collectively termed "microplastics", have been considered as a pollutant in

their own right. Microplastics have been attributed with numerous size-ranges, varying from study to study, with diameters of <10 mm, <5 mm, 2-6 mm, <2 mm and < 1 mm. This inconsistency is particularly problematic when comparing data referring to microplastics, making it increasingly important to create a scientific standard. Recently, (Andrady, A.L.,2011) has suggested adding the term "mesoplastics" to scientific nomenclature, to differentiate between small plastics visible to the human eye, and those only discernible with use of microscopy. Different microscopy (optical, electron) and spectroscopy techniques (Raman, NMR, and FTIR) are used to monitor microplastic suspensions from the environmental samples. Microplastics are commonly used as scrubbers in cosmetics, hand cleansers and are used in air-blasting. The first evidence of microplastics fragments in the environment was reported in 1970s. After that many scientific organizations around the globe have discovered that microplastics are pervasive within the marine habitat and impacting negatively on marine biota. Two types of microplastics are found in the environment viz. primary and secondary microplastics.

Plastics that are manufactured to be of a microscopic size are defined as primary microplastics. These plastics are typically used in facial-cleansers and cosmetics, or an air-blasting media, whilst their use in medicine as vectors for drugs is increasingly reported.

Secondary microplastics describe tiny plastic fragments derived from the breakdown of larger plastic debris, both at sea and on land. Over time a culmination of physical, biological and chemical processes can reduce the structural integrity of plastic debris, resulting in fragmentation. Also they also breakdown due to UV rays coming from the sunlight.

#### SOURCES OF MICROPLASTICS ENTERING MARINE ENVIRONMENT

Marine litter results from the indiscriminate disposal of waste items that are either directly or indirectly transferred to our seas and oceans. In this section, we look at several sources of plastic litter and discuss both direct and indirect routes by which plastic can enter the marine environment. Whilst the emphasis of this review is on microplastics, in this section we also consider the indiscriminate disposal of macroplastics, as, with time, they have the potential to degrade into secondary microplastics.

Plastic litter with a terrestrial source contributes 80% of the plastics found in marine litter (Andrady, 2011). Such plastics include primary microplastics used in cosmetics and air-blasting, improperly disposed "user" plastics and plastic leachates

from refuse sites. With approximately half the world's population residing within fifty miles of the coast, these kinds of plastic have a high potential to enter the marine environment via rivers and wastewater systems, or by being blown off-shore. Microplastics used both in cosmetics and as air-blasting media can enter waterways via domestic or industrial drainage systems; whilst wastewater treatment plants will trap macroplastics and some small plastic debris within oxidation ponds or sewage sludge, a large proportion of microplastics will pass through such filtration systems. Plastics that enter river systems – either directly or within waste-water effluent or in refuse site leachates – will then be transported out to sea. A number of studies have shown how the high unidirectional flow of freshwater systems drives the movement of plastic debris into the oceans. Using water samples from two Los Angeles (California, USA) rivers collected in 2004–2005, quantified the amount of plastic fragments present that were <5 mm in diameter [Cole M, Lindeque P, Halsband C, Galloway T S, 2011]. Extrapolating the resultant data revealed that these two rivers alone would release over 2 billion plastic particles into the marine environment over a 3-day period. Extreme weather, such as flash flooding or hurricanes, can exacerbate this transfer of terrestrial debris from land to sea.

#### IMPACTS ON MARINE ENVIRONMENT

As the abundance of microplastics increases, its bioavailability to marine organisms also increases. The colour, density, shape, size, charge, aggregation and abundance of these tiny plastic particles affect their potential bioavailability to marine organisms. Biological interactions of microplastics with marine biota are key to understanding the movement, impact and fate of microplastics in the marine environment.

Interaction with marine biota: Recently, several studies on the ingestion of microplastic particles by marine biota has increased with most of the studies carried out in controlled laboratory experiments. The ingestion of microplastic particles has been observed in oceanic regions globally in a wide range of marine organisms. Ingestion of microplastics by marine organisms in most cases is accidental because the particle is often mistaken for food, although some can be specifically targeted by some organisms.

Microplastics, when ingested by marine organisms, cause chemical and physical harm. The consumption of microplastics by marine organisms may cause mechanical effects such as attachment of the polymer to the external surfaces thereby, hindering mobility and clogging of the digestive tract, or the effect could be chemical such as inflammation, hepatic stress, decreased growth. The consumption of microplastics is

common to a wide range of marine organisms representing different trophic levels including invertebrates, especially lugworms, mussels, barnacle; sea cucumbers, amphipods and zooplankton, and fish-eating birds, fishes, turtles, and mammals, which can interfere with the food chain as microplastics ingested by organisms in the lower trophic level including zooplankton and copepods, could pass up the food chain when lower trophic organisms are fed upon by organisms in the higher trophic level.

**Microplastics in fish:** Studies have reported the presence of chemicals in fish tissues which are the same chemicals that form plastics (H.S. Autaa,b,, C.U Emenikeb,c, S.H Fauziah,2017). Predator-prey interaction enhances the transfer of the toxic chemicals in greater concentrations since toxic chemicals from multiple sources can accumulate in the body. Concerns about the transfer of microplastics and harmful chemicals between trophic levels have resulted in laboratory studies being carried out to demonstrate the impacts of microplastics on marine biota. Several studies have also been undertaken to prove that microplastics are a peril for fish as mortality is prevalent before reaching maturity due to microplastic ingestion.

**Microplastics in other marine biota:** The issue of microplastic ingestion is not restricted to fish alone; zooplankton and sea turtles are also susceptible to microplastics. Outdoor mesocosm studies were carried out on the effect of microplastics on the health and biological functioning of the European flat oyster (*Ostrea edulis*) and on the structure of associated macrofauna. The organisms were subjected to low and high doses ( $0.8 \mu\text{g L}^{-1}$  and  $80 \mu\text{g L}^{-1}$ ) of biodegradable and conventional microplastics for a 60-day period. After exposure, it was observed that the respiration rates of *Ostrea edulis* were elevated in response to high doses of polylactic acid (PLA) microplastics which indicated that the oysters were under stress. Similarly, the abundance and biomass of associated benthic organisms which included periwinkles (*Littorina* sp.), isopod (*Idotea balthica*), and the peppery furrow shell clam (*Scrobicularia plana*) reduced. The reduction was attributed to reduced reproductive output and mortality due to microplastic ingestion and reduced feeding investigated microplastic ingestion by two ecologically important zooplankton in the North Pacific marine food web; the calanoid copepod (*Neocalanus cristatus*), and the euphasiid (*Euphasia pacifica*) using acid digestion method to assess the ingestion of microplastics by the zooplankton. Microplastic ingestion were 1 particle per every 34 copepods and 1 particle per every 17 euphasiids, with the euphasiids having the highest ingestion of microplastic particles ( $816 \pm 108 \mu\text{m}$ ) than in the copepods ( $556 \pm 149 \mu\text{m}$ ). The results proved that organisms at the lower level of the marine food web ingest microplastic particles which could be attributed to accidental or deliberate ingestion of microplastics by the organisms as microplastic particles can be mistaken for food.

Microplastics in sea salt: Abiotic sea products are a source of food for humans and there is a possibility that the presence of microplastics in the sea could lead to the contamination of sea products and potential transfer to humans. One of such products is sea salt. The presence of microplastics in sea salt has recently been proven through a study that detected 7–204 particles kg<sup>-1</sup>, 550–681 particles kg<sup>-1</sup> and 43– 364 particles kg<sup>-1</sup> of microplastics in 15 brands of rock/well salts, sea salt and lake salt, respectively. The microplastics found were polyethylene, cellophane and polyethylene terephthalate. This demonstrates that along with fish and shellfish (seafood), table salt also appears to be contaminated by microplastics.

#### CASE STUDY ON ZOOPLANKTONS AT KENYA'S MARINE ENVIRONMENT

Bulk surface seawater samples were collected from 11 georeferenced stations in the central part of Kenya. One sample was collected at each site using a 15-l stainless steel bucket to collect a total volume of 120 l or 0.12 m<sup>3</sup> of water, which was sieved directly through a 250- $\mu$ m stainless steel mesh. The samples were transferred into glass jars containing 70% ethanol for preservation and to help discolour the organisms, hence facilitating the identification of microplastics. Zooplankton samples per station were counted under the dissecting microscope, during which process 10 individuals were selected from each of the four groups (Chaetognatha, Copepoda, Amphipoda and fish larvae) on the basis of the important roles of these organisms in marine food webs. (Kosore et al. 2018).

Result: A total of 129 particles were found ingested by the zooplankton groups and they comprised only filaments and fragments. Filaments were the dominant shape, with fragments at just 0.04 particles. The sizes consumed by the different zooplankton groups were not measured; however, 36 of the 129 ingested particles were measured and categorized as 0.01–0.1 mm (n = 16), 0.1–0.4 mm (n = 16) and 0.5–1.6 mm (n = 4). For the filaments and fragments, black was the colour found most commonly (42%, n = 53), followed by red and brown (each 17%, n = 21), blue (13%, n = 19), green (9%, n = 13) and orange (2%, n = 2). White particles were not found ingested by any of the zooplankton groups throughout the study area.

#### MEASURES TO BE TAKEN TO REDUCE MICROPLASTICS IN THE OCEAN

The best and effective way is to not allow the plastics to enter the oceans. For that we should avoid using single use plastics. Also, government should initiate and try to reduce, reuse and recycle plastics.

There are not many ways to clean the whole microplastics from the oceans because there are billions of microplastics in waterbodies. Scientists and researchers are trying to find the best ways to clean microplastics that are already inside the ocean.

In 2019 some Dutch scientists designed a huge floating device to collect plastics from ocean. They successfully collected plastics and micro plastics for the first time ever. The huge floating device was designed to clean up an island of rubbish in the Pacific Ocean that is three times the size of France has successfully picked up plastic from the high seas for the first time. A giant C-shaped tube aims to collect 50% of the debris in the patch in five years. Driven by wind and waves, the floating barrier moves with the plastic and other rubbish. A sea anchor slows the barrier down. Rubbish catches up and is captured by the boom. Every few weeks, a support vessel arrives to collect accumulated debris for recycling.

The vast cleaning system is designed to not only collect discarded fishing nets and large visible plastic objects, but also micro plastics. The plastic barrier floating on the surface of the sea has a three metre-deep (10ft) screen below it, which is intended to trap some of the 1.8tn pieces of plastic without disturbing the marine life below. The device is fitted with transmitters and sensors so it can communicate its position via satellites to a vessel that will collect the gathered rubbish every few months.

## CONCLUSIONS

Plastic pollution in the marine ecosystem is in alarming condition because they are omnipresent in the natural surroundings, has harmful effects on marine biota and transferred along food web, which is an issue of concern. There is a pressing need to take severe measures to address the problem at international, national and local levels. Developing countries like India, Vietnam, Pakistan, Indonesia, Bangladesh, Thailand, Korea, China, Sri Lanka and Philippines are main contributors of plastic pollution in the marine atmosphere (Shivika S, Subhankar C9, 2017). Many developing countries have not formulated rules and regulations to control microplastic pollution. Therefore, it is recommended that local governments should introduce strong legislative rules and should encourage research to monitor the long term effects of plastic debris in the environment. New scientific data on micro plastics pollution should be formulated for conservation management, for normative guidelines and strengthen the basis for educational campaigns.

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