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Marine Pollution – Terrestrial Invasion into Marine Life

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Abstract

The ocean accounting for 71% of the Earth's surface area harbours innumerable life and its diversity but has become the largest sink for human generated wastes. Our daily life is also closely linked with the ocean, the ocean food, marine-related products. However, the current situation of marine environment is not optimistic, marine pollution has become a very important topic in today's society. The oil spill incident; the oil Leakage incident; or the chemical incidents have caused significant and difficult recovery of the marine environment. So, how do we prevent and control the occurrence of these marine pollutions? How to restore and manage contaminated waters? This review article focuses on major marine pollution, its impact on marine and terrestrial life and how to prevent and manage marine pollution which is utmost import in island perspective. This underlines the need to generate awareness on better management practices among the stakeholders to deal with the issue of marine pollution particularly micro plastics and to aim sustainable management of the coastal environment.

Key words: *marine pollution, micro plastics, oil spill, impacts, pollution prevention*

Introduction

At a global scale, considering the ocean ecosystems as a whole and compared to other global threats, such as ocean acidification, overfishing, and increase of sea-surface temperatures, the significance of the impacts of marine pollution is less clear. Among the marine pollutants, marine plastics-related debris is an increasing concern (Schwarz *et al*., 2019; Henderson and Green, 2020) as they form a major source of pollution in the marine environment. More particularly, non-biodegradable materials in the marine environment such as derelict fishing gears, carry bags, synthetic packing materials, and polythene covers are some of the debris harmful to marine biota (Kaladharan *et al*., 2020). Plastics are also widely transported across marine systems owing to their buoyancy and durability (Napper and Thompson, 2020).

Marine plastic pollution is generating impacts on marine biota and ecosystems at many different levels (Ryan, 2016). Impacts are reported from a wide range of organisms, including microbiota, invertebrates, and vertebrates (Galloway *et al*., 2017; Law, 2017). An increasing number of reports document microplastic ingestion by marine invertebrates (Lusher, 2015); certain species also grow on large, floating plastic items, and can be transported to new habitats they had not previously inhabited (Kiessling *et al*., 2015). Interactions with vertebrates are best known, because vertebrates are larger and therefore more visible and recognizable than small marine invertebrates. Entanglement of seabirds and marine mammals in large plastic litter (nets, ropes, etc.) has been known since the early 1970s (Derraik, 2002). Similarly, ingestion of microplastics by fishes and seabirds is well known since about the same time period and the number of affected species and individuals are continuously increasing.

The risk of interactions between marine organisms and plastics is not equal across the oceans. It depends on feeding biology and amount of plastic litter in the environment where the organisms are foraging. For example, seabird species feeding at the sea surface are more susceptible to plastic ingestion than diving species (Ryan, 1987). Species that ingest small microplastics, such as many fishes and surface-foraging seabirds might be at highest risk in areas where microplastics concentrate, such

as the subtropical gyres, whereas species ingesting larger plastic items could potentially encounter these closer to the continental coasts where rivers and other human activities spill and accumulate large quantities of plastic litter (Rech *et al*., 2015; Fossi *et al*., 2017). Similarly, the risk of entanglement for marine vertebrates is likely to be higher in areas with large amounts of derelict fishing gear or coastal areas where ghost nets accumulate (Wilcox *et al*., 2013).

Based on the above studies it is likely that the risk of harmful interactions with marine plastic pollution depends on (a) the biology of the species, and (b) the distribution and abundance of the different plastic types. These aspects are discussed in details in this paper so as to give an overview of the types and status of marine pollution and its effect on the marine biota and environment.

Types of marine pollution

Due to intensive population and industry, a large number of waste water and solid waste dumped into the sea water, coupled with the twists and turns of the coast caused by poor water exchange, making the temperature, pH, salt content, transparency, biological species and quantity of traits change. At the same time recent reports on the issue of coastal pollution (Seetharaman *et al*., 2015), littering (Kaladharan *et al*., 2017), bioaccumulation in marine biota (Malakar *et al*., 2019), and issues of drifting debris in remote parts of the Islands (Das *et al*., 2016) indicate the growing menace of marine debris in many parts of the world particularly in the tropical oceans.

Marine pollution is characterized by oil pollution, sewage, red tide, accumulation of toxic substances, nuclear wastes, Garbage and plastic debris, agricultural and aquaculture runoff and even noise pollution (Fig. 1). As far as the country is concerned, coastal pollution is serious in Japan, the United States, Western European countries and the former Soviet Union countries. Pollution in Bohai Bay, the Yellow Sea, the East China Sea and the South China Sea is also very serious in China. In the Bohai Sea, which is the most polluted, the fishing grounds have been relocated, the fish have died and the red tide has spread (Zhang 2012).

In seawater eutrophication, 21% of large marine ecosystems will be at risk of eutrophication by 2050, mainly in East and South America and Africa. As far as human activities are concerned, large marine ecosystems are generally adjacent to densely populated areas, especially in large waters adjacent to developing countries, and are most severely affected by human activities. Among them, ocean acidification, seawater temperature rise, commercial transport and submarine trawling operations, are the most serious factors affecting marine ecosystems (Dong Guo & Martinez Osés, 2017). Consequently the ecological imbalance of the marine environment constitutes a hazard.

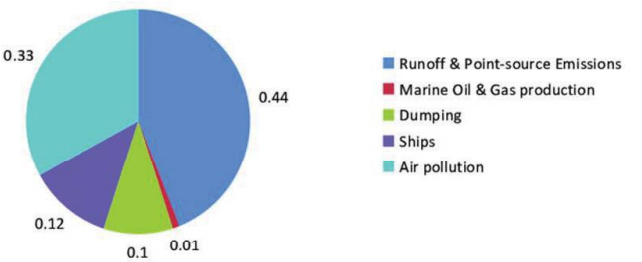

Fig. 1. Main sources of marine pollution

Plastics in the ocean

Plastics are synthetic organic polymers, and the versatility of these materials has lead to a great increase in their use over the past three decades, and they have rapidly moved into all aspects of everyday life (Hansen, 1990). These same properties happen to be the reasons why plastics are a serious hazard to the environment (Laist, 1987). Since they are also buoyant, an increasing load of plastic debris is being dispersed over long distances, and when they finally settle in sediments they may persist for centuries (Hansen, 1990; Ryan, 1987).

In the marine environment, the perceived abundance of marine life and the vastness of the oceans have lead to the dismissal of the proliferation of plastic debris as a potential hazard (Laist, 1987). The threat of plastics to the marine environment has been ignored for a long time, and its seriousness has been only recently recognised (Stefatos *et al*., 1999). The literature on marine debris leaves no doubt that plastics make-up most of the marine litter worldwide (Fig. 2). Several studies clearly indicate

the predominance of plastics amongst the marine litter, and its proportion consistently varies between 60% and 80% of the total marine debris (Gregory and Ryan, 1997).

Plastic materials also end up in the marine environment when accidentally lost, carelessly handled (Wilber, 1987) or left behind by beach goers (Pruter, 1987). They also reach the sea as litter carried by rivers and municipal drainage systems. There are major inputs of plastic litter from land-based sources in densely populated or industrialized areas, most in the form of packaging. A study on Halifax Harbour Plastic pellets can be found across the Southwest Pacific in surprisingly high quantities for remote and non-industrialised places such as Tonga, Rarotonga and Fiji. In New Zealand beaches they are found in quite considerable amounts, in counts of over 100,000 raw plastic granules per meter of coast, with greatest concentration near important industrial centres. Their durability in the marine environment is still uncertain but they seem to last from 3 to 10 years, and additives can probably extend this period to 30–50 years (Gregory, 1999).

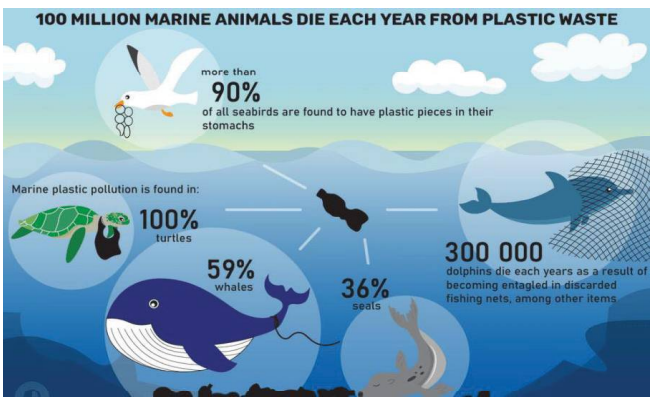

Fig.2. Entry of micro plastics into the marine life

Impact of plastics on the marine environment

The threats from plastics pollution to marine biota are large, but there is still relatively little information on the impact of plastics pollution on the ocean's ecosystems (Quayle, 1992). There is however an increasing knowledge about their deleterious impacts on marine biota (Goldberg, 1995). The threats to marine life are primarily mechanical due to ingestion of plastic debris and entanglement in packaging bands, synthetic ropes and lines, or drift nets (Quayle, 1992).

Since the use of plastics continues to increase, so does the amount of plastics polluting the marine environment. Robards *et al*. (1995) examined the gut content of thousands of birds in two separate studies and found that the ingestion of plastics by seabirds had significantly increased during the 10–15 years interval between studies. A study done in the North Pacific (Blight and Burger, 1997) found plastic particles in the stomachs of 8 of the 11 seabird species caught as bycatch. The list of affected species indicates that marine debris are affecting a significant number of species. It affects at least 267 species worldwide, including86% of all sea turtle species, 44% of all seabird species, and 43% of all marine mammal species (Laist, 1997).

There is also potential danger to marine ecosystems from the accumulation of plastic debris on the sea floor. According to Kanehiro *et al*. (1995) plastics made up 80–85% of the seabed debris in Tokyo Bay, an impressive figure considering that most plastic debris are buoyant. The accumulation of such debris can inhibit the gas exchange between the overlying waters and the pore waters of the sediments, and the resulting hypoxia or anoxia in the benthos can interfere with the normal ecosystem functioning, and alter the make-up of life on the sea floor (Goldberg, 1994). Moreover, as for pelagic organisms, benthic biota is likewise subjected to entanglement and ingestion hazards (Hess *et al*., 1999).

Several studies showed that plastic pollution is a threat to marine biodiversity, already at risk from overfishing, climate change and other forms of anthropogenic disturbance. So far however, that evidence is basically anecdotal. There is a need for more research (especially longterm monitoring) to assess the actual threat posed by plastic debris to marine species. Due to the long life of plastics on marine ecosystems, it is imperative that severe measures are taken to address the problem at both international and national levels, since even if the production and disposal of plastics suddenly stopped, the existing debris would continue to harm marine life for many decades.

Differential Risk of Marine Litter

Researchers have shown that across the Oceanic Gradient the risk of both ingestion and entanglement is highest where main foraging grounds overlap with accumulation areas of floating AMD (Wilcox *et al*., 2013). Studies showed that some species foraging in the highly productive HCS frequently interact with marine plastics (Fig. 3). However, many of these species feed in areas where hydrographic features, e.g., frontal systems or meso-scale gyres, concentrate food and also floating plastics (Pichel *et al*., 2007). Interestingly, one of the first direct observations of this phenomenon comes from the HCS off the central coast of Chile, where Bourne and Clark (1984) observed planktivorous seabirds feeding in a coastal front that also had concentrated large amounts of floating plastics. The high incidences of entanglement and also plastic ingestion, especially by sea turtles and some seabird species from the HCS, likely occurred in these temporary hotspots. These interactions are common in the productive upwelling systems of the eastern boundary currents and cause high risk for marine vertebrates despite the fact that densities of floating litter are lower than in the subtropical gyres.

In the open ocean, especially in the oligotrophic subtropical gyres, marine productivity is low, and often concentrated above seamounts or near oceanic islands. If these islands are located within the range of the litter accumulation zones of the subtropical gyres, some species are at high risk of negative interactions with floating plastics. Our review showed that planktivorous fish and seabirds living on the oceanic islands in the vicinity of the SPSG have high incidences of microplastic ingestion, possibly due to the extraordinarily high densities of floating microplastics in this region. The limited number of entanglement reports from this area is likely a combination of lower densities of marine vertebrates in the subtropical gyres and the limited number of observers, compared to the continental coasts.

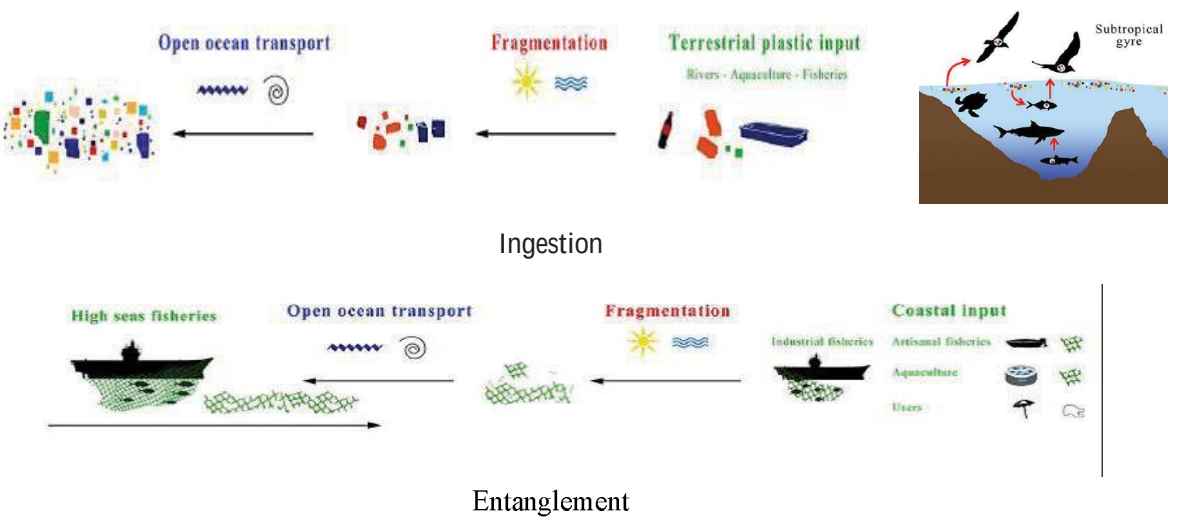

Fig. 3 Impact of ingestion and entanglement on marine life

Prevention and management of marine pollution

The marine environment has a huge impact on human life. The global warming caused by marine pollution and rising sea level also poses a great threat to mankind. Marine oil pollution caused by the destruction of the biological chain, environmental degradation and other issues are also very serious. Heavy metal pollution to the sea is a direct result of human life, heavy metals through the natural cycle into the ocean in the biological chain, and ultimately into the human body, the human health caused a huge impact. Therefore, protection of the marine environment is the responsibility and obligation of each of us. The following measures can be adopted to manage or prevent the marine pollution (World Bank, 2019). .

Ban single use plastic and adopt litter control policies

Many countries across the globe have banned single-use plastics and/or Styrofoam. Litter control can also include the use of natural drainage systems and urban design to prevent direct littering into drainage systems and waterways, better maintenance of drainage systems, beach and harbor clean-up services; and community-led programs for clean-ups. In this effort, it is important to strengthen national and regional policies and regulations, as well as increase efforts to ensure compliance and enforcement.

Reduce or recycle plastic

Fees / bans on import and use of common litter particularly such as single-use plastics bottles, straws, plastic bags, and single-use Styrofoam food containers in islands / island countries is highly desirable. This should also involve efforts to limit the production and use of plastic in non-recoverable items, such as microbeads in personal care products and cosmetics. Encourage reduction of use of non-biodegradable products or packaging, as well as reuse of plastic items.

Diminish discharge of untreated sewage

Increase treatment, recycling and reuse of wastewater. Connect all households to the sewerage system and reduce storm water-related pollution. Treated wastewater should be seen as a resource which, if used wisely and safely to avoid health problems, can be very beneficial in particular in small islands where fresh water resources are scarce.

Control chemical and industrial pollution

It is advisable to identify chemical pollutants hotspots, control the use and release of chemicals in artisanal mining, promote recycling of used oil in urban areas, and incentivize production of durable products that require less energy to manufacture and generate less waste. Further, partner with industries to implement better practices for the storage and handling of pollutants, and discharges from industrial sites.

Strengthen laws on marine litter

Reinforce institutional and legal framework to address marine pollution at regional and national levels. National policies and legislation should be aligned with international commitments for sustainable development such as the Sustainable Development Goals, and the Cartagena Convention along with its Protocol concerning pollution from Land Based Sources

Integrate prevention and control policies into national policy

Pollution control is relevant not just to coastal and marine resources but also to the development of tourism, agriculture, shipping, and industry. As such it should be part of economic and land-use planning, as well as integrated water management.

Build local expertise and technical capacity

Enhancing consumers' knowledge and capacity to make better decisions regarding their day to day waste production is critical to reduce marine pollution and incentivize such practices. Further, building up of local expertise to deal with the plastics and monitor its accumulation at regional level is highly desirable at global level.

Raise public awareness

Public education on local television, radio, social media, and websites can raise awareness, and the environment's importance to the region's welfare needs to be taught in the classrooms as well. This would entail involving ministries of education to introduce new material into school curricula so that children in upcoming generations will grow up with a grasp of the issue.

Establish partnerships to address marine pollution

Public-private partnerships should also be established to provide financing, improve public awareness, reduce the improper disposal of waste and develop innovative approaches to reduce marine pollution. These include civil society, the tourism and fisheries industries, coastal

developers, technology companies, institutions and coastal communities.

Monitor marine pollution in a systematic way

It is particularly important to understand key pollutants, identify pollution hotspots, and their impacts on marine biodiversity, fisheries, and human health. This information should be integrated into regional reporting processes to enhance regional cooperation.

Assess the economic impacts

Economic impacts of marine pollution should be better understood to prioritize and inform changes in pollution control policies. This requires common policy reforms.

Conclusions

In recent decades, with the expansion of human desired economic development, the pollution of the ocean is becoming more and more serious, so that the local marine environment has undergone great changes, and continues to expand the trend. More importantly, wastes and by products from terrestrial human activities ultimately end up in marine environment. This has become a serious concern as it affects not only the marine life but also linked terrestrial biological, geological cycles and global changes. The risk of microplastic ingestion seems to be high in nearshore waters, decreases above the continental shelf of the eastern boundary currents, but again reaches very high probabilities in oceanic waters associated with the gyre accumulation zones, especially for fishes and seabirds. It is nevertheless certain that the environmental hazards that threaten the oceans' biodiversity, such as the pollution by plastic debris, must be urgently addressed. This demands global thinking but local action that is a fundamental attitude to reduce such an environmental threat.

A combination of legislation and the enhancement of ecological consciousness through education are likely to be the best way to solve such environmental problems. The general public and the scientific community have also the responsibility of ensuring that governments and businesses change their attitudes towards the problem. Further systematic research on the ingestion and entanglement rates in marine vertebrates and their impacts on populations is required. Investigations to determine hotspots of marine plastic pollution will also enable prioritizing resources and to focus and steer conservation measures.

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