

Marine debris: Evaluating sources, Impacts, and Practical solutions

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Abstract

Ocean preservation has been getting an indispensable goal for the international policy as human activities increasingly endanger the ocean ecosystem's integrity, which is usually summarized as "ocean health." Marine debris is one of the significant challenges for humankind and one of the greatest menaces to the sustainability of marine ecosystems throughout the world. marine debris produces a large-scale kind of unfavorable ocean health, safety, environmental, economic, and cultural impacts. The present study discusses the environmental, Socio-economical, and biological consequences of marine debris on the ocean. Finally, it provides practical solutions to decreasing these pollutants' adverse effects on ocean health.

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Keywords: Ocean health, marine debris, marine pollution, practical solution

1. Introduction

Humans have interacted with the ocean from the past to the present (Duarte, 2014)(Franke et al., 2020). The ocean plays a crucial role in securing human health and well-being; these include providing vital resources of energy and food for humans, employment and recreations, and, most importantly, it is a platform for transport and trading (Fleming et al., 2019). Nevertheless, world population sharp growth, unsustainable development ,and consumption patterns have risen pressure on the marine environment, e.g., through eutrophication, increasing greenhouse gas emissions, overfishing, marine debris, and driving ocean warming and acidification (Jouffray et al., 2020) (Franke et al., 2020) (Figure 1). Consequently, marine ecosystems are experiencing severe challenges, such that their vital functions are threatened by anthropogenic activities (Franke et al., 2020).

The ocean and human life are inextricably interconnected, and human well-being and wealth are entirely dependent on a healthy ocean. This study examines the various adverse effects of marine debris on marine ecosystems and discusses why these pollutants are the most important source of concern for ocean health's future. Globally, marine debris' impacts on the marine environment have attracted a lot of international attention over the past decade (NahmanII, 2020). Anthropogenic pollution (the by-products of human activities) can damage the

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economic value derived from such services. For example, marine plastic debris damage to marine biodiversity, coastal habitats, and fish stocks consequently bring adverse economic losses for humans, particularly coastal communities (NahmanII, 2020). The main reasons for increasing marine debris are a loss of adequate regular waste management and inadequate wastewater processing, ineffectual corporate social responsibility, natural hazards, illegal dumping, and littering (Kandziora, 2019). Much literature shows that within 4.8 and 12.7 million metric tons of plastic enter the oceans annually (Jambeck, 2015). The National Oceanic and Atmospheric Administration (NOAA) defines marine debris as “any persistent solid material that is manufactured or processed and directly or indirectly, intentionally or unintentionally disposed of or abandoned into the marine environment...” (<http://marinedebris.noaa.gov/>) (Prabhakar R. Pawar, 2016), (Brander, 2011). Marine debris includes consumer things such as metal, cans, fiberglass, rubber, cigarettes, glass or plastic bottles, balloons, bags, and other manufactured and produced substances that end up in the ocean and along the shore. It includes fishing gear such as lines, ropes, hooks, buoys, and other materials lost on nearshore or deliberately or accidentally discarded at ocean or sea. Marine debris in oceans is an aesthetic problem; it provokes considerable costs and can severely impact marine organisms and habitats. (Prabhakar R. Pawar, 2016). The most significant marine debris percentage consists of small sachets, paste tube, the cap, plastic bits, spoon, syringe, straw, pen assorted, bead, hair clips, plastic, and sponge (Sulochanan, 2013).

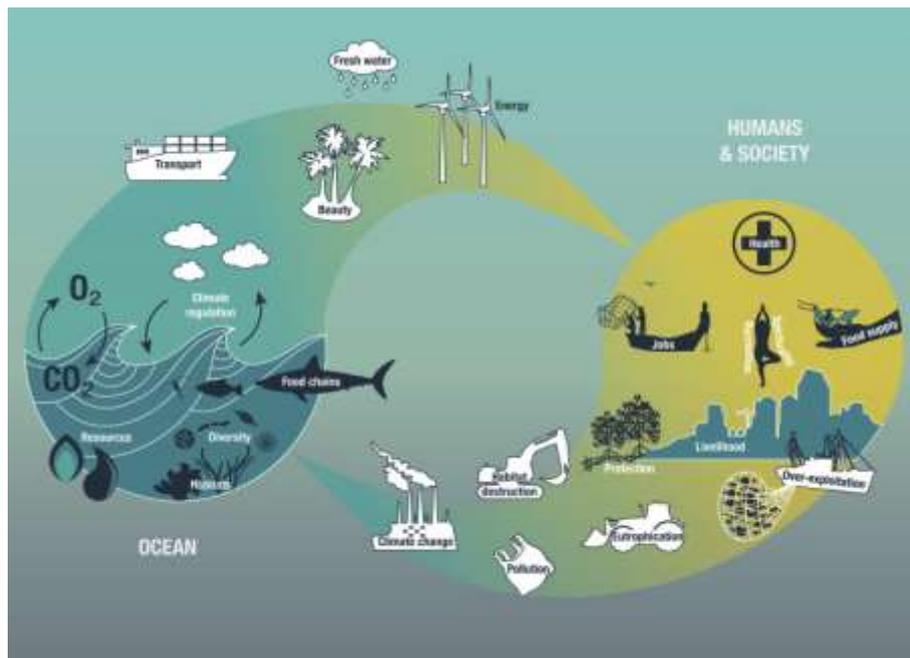


Fig. 1: Relationship Between the Ocean and Humankind (Franke et al, 2020)

2. Discussion

One of the significant challenges for understanding the dynamics of the ocean's health and its functioning is the potential impact of increasing the presence of debris (A.Loiselleab, 2021). Marine debris, specifically plastic debris, acts as an excellent menace source to the ocean and human health, aquatic and wildlife, economies, and various saltwater and freshwater ecosystems worldwide (Kandziora, 2019). Among the top 20 ocean polluters are

Sri Lanka, the Philippines, Indonesia, and countries with long coastlines such as China and Vietnam. (Jambeck, 2015). According to analyse the levels of plastic waste within the world's oceans, 50% of the world's plastic gets manufactured in Asia, According to Statista's ocean pollution by the country report. In 2010, China was responsible for 8.8M metric tons of waste considered 'mismanaged.' (Statista, 2010) (figure 2).

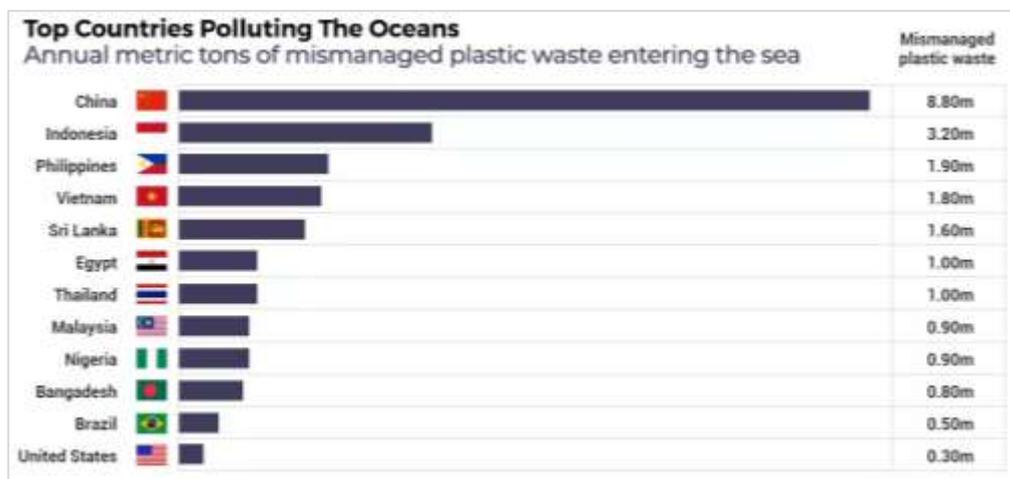


Fig. 2: Top countries Polluting the oceans. (2010)

In the following, we refer to the environmental and biological impacts of marine debris on the oceans' health:

A. *Environmental impacts of marine debris*

Numerous marine organisms and animals have been killed or injured by marine debris mainly because they become entangled in these or mistakenly eat debris instead of food and ingest it. Marine debris originates from both sea-based sources and land and can travel infinite distances. It also injures and kills wildlife, has the potential to transport chemical contaminants, and may pose a menace to the ocean and human health (Prabhakar R. Pawar, 2016). In the following, a summary of the impacts of marine debris on benthic ecology and in mangrove and coral reef ecosystems is provided:

- *Impacts of marine debris on benthic ecology*

Usually, good human population density leads to an increase in the amount of debris entering the estuaries that dump waste in the open areas and directly into the estuaries. In some open areas, the basement becomes dead zones and has layers of marine debris, and there was no benthic fauna. The plastics, when got trapped in the benthic ecosystem, develop a micro-community on them. Numerous studies have indicated that microplastics are mostly from the fishery. The related fishing activities have been found as the most important source for increasing the quantity of plastic in the marine substrate (Kripa, 2019).

- *Impacts of marine debris in mangrove and coral reef ecosystems*

The impact of marine debris on mangroves' physiology has not been studied intensively, but obviously, we know that Mangroves act as a trap for marine debris. Nowadays, direct dumping of domestic waste obstructs the

mangrove's tidal flow and decreases the healthy environment and habitat of several juvenile fishes and shrimps. The result of marine debris on coral reefs has been observed in many areas (Kripa, 2019). In some Islands, most of the debris was recognized, ultimately leading to the mortality of corals (Richards, 2019); furthermore, marine debris prevented the penetration of light in some areas (Senthilnathan. L, 2018), (Ranith, 2018).

B. Socio-economic impacts of marine debris

Marine debris is not only an environmental issue, but it can also have profound societal and economic implications. Marine debris influences various economic activities, corroborating the high diversity of consequences that marine debris can cause to ocean coasts and islands (K.Phama, 2020). Over the past two decades, a virtual explosion of research focused on quantifying plastics' ecological results in the marine environment with far less attention dedicated to its societal and economic implications (Newman et al., 2015)(K.Phama, 2020). Nevertheless, data shows that a wide range of economic sectors is being affected, acting as a vital economic burden for coastal communities, directly impacting shipping industries, fishing, and tourism (Mouat et al., 2010) (K.Phama, 2020). Beach clean-ups describe another substantial cost for coastal communities, even for small communities, the expenditures related to marine debris can be significant. Oceanographic models and empirical observations show that debris floating at the ocean surface leads accumulates in the middle of oceanic gyres in so-called garbage patches (Mouat et al.,2010). As a result, the shores of oceanic islands close to these zones often suffer exceptionally high levels of plastic pollution, despite being located far from significant source-areas of plastic waste (Lavers and Bond., 2018) (Pham et al., 2020) (Monteiro et al., 2018).

C. Biological impacts of marine debris

Globally, at least 86 % of sea turtle species, 36 % of seabird species, and 23% of marine mammal species are known to be influenced by marine debris, especially from plastic (Stamper, 2009). Ingested marine debris has been found to decrease stomach capacity, limit growth, lead to internal distress, Moreover, create an intestinal blockage; further, it can occur in strangulation, reduction of feeding capability, and in some cases drowning (Plot, 2010), (Allen, 2012). A significant concern about the toxic aggregates associated with plastics is that they can interrupt hormone management in the cells of organisms, change reproductive capacity and mating habits, and negatively influence offspring (Wuttke, 2010). Over 80% of recorded events between organisms and marine debris were associated with plastic, while 11% of all reported encounters are with microplastics ((GEF), (2012a).). In following, a summary of the impacts of marine debris in the food chain, fisheries and aquaculture, and human health is provided:

- Impacts of marine debris in the food chain

Rising the plastic concentration modifies zooplankton populations, resulting in their reproductive functions, survival, and fitness. Changes in related populations of marine organisms alter processes at the base of food webs, resulting in carbon cycles and marine nutrients. Furthermore, Microplastics' interaction with the marine organic matter also determines particle bioavailability for zooplankton and larger marine animals (A.Loissellea, 2021). Marine debris such as Microplastics has been seen in the Arctic and Sub-Arctic Sea with a potential transfer in the benthic trophic food chain (Kripa, 2019). in coastal China, Microplastics were observed in the muscle, gut, and

gills, meaning the warning to human beings via the food chain (Su L, 2019). Throughout feeding experiments using crabs and mussels, it has been shown that microspheres are carried through the food chain and that these small particles enter the stomach, ovary, and gills of crabs (K, 2013). These investigations indicate that ocean health, benthic ecosystems, and fauna, which depend on this, face a severe problem.

- *Impacts of marine debris on Fisheries and aquaculture*

The impacts of marine debris on ecosystems - together with the cumulative results of climate change, ocean acidification, and over-exploitation of marine resources - could put the fishing and aquaculture activities at risk (Mouat et al., 2010). now, there is a lack of information about the resulting impacts of marine debris on Fisheries and aquaculture, and the high dependency on seafood by a large part of the world's population suggests that additional research is required to illuminate the extent of these risks (Beaumont et al., 2019). Studies have shown uptake of microplastics by mussels, which are filter-feeding organisms. Mussels are not only ecologically important; they are also crucial for subsistence and economic harvesting (G., 2017). when ultimately harmful organisms are ingested, there is potential for marine plastics to influence human health. The accumulation of synthetic microfibrils, toxic chemicals, and persistent organic pollutants in fish tissue and shellfish can cause cancer, congenital disabilities, and compromised immune systems (Beaumont et al., 2019) (Hamid et al., 2018). finally, fish stocks could be affected by marine debris, the efficiency of commercial fisheries and aquaculture farms could potentially be negatively affected (NahmanII, 2020).

- *Impacts of marine debris on human health*

Degradation of the ecosystem and habitats services is one of the significant consequences of marine debris on human health, fishing by lost nets and pots can remove invertebrates and fish targeted by regional commercial fisheries. Marine debris decreases the aesthetic and recreational values of shores and marine resources and leads to reduce tourism. Further, fishing gear lost or discarded at sea may have the most significant result on humans due to impediments to commercial fishing. After that, marine debris can block ship propellers or steering systems and direct damage to vessels ,and Interfere with navigation. Furthermore, medical wastes, such as punctures syringes, glass ,and other sharp, dangerous items that are washed up on beaches, transfer of infections and disease, result in direct risks to beachgoers and may present a health risk, on the other hand, while human swimming may be injured by sharp debris accumulating on beaches. On the other hand, fish and crustaceans meant for human consumption may include (micro) plastics and act as a human health risk, and also, marine litter poses a safety risk for crews of sea vessels (Prabhakar R. Pawar, 2016).

3. Conclusions

Based on our findings, Marine debris is a problem along oceans, coastal waters, estuaries, and shorelines worldwide. It is any human-made, solid material that gains entrance into waterways either directly or indirectly and transboundary, as they were found in the marine environment and moved by currents to different direction; thus, we suggest a more comprehensive future study about the result of marine debris on ecosystem especially on organisms in the water or ecological alteration in distribution pattern, human health, and economic loss (Prabhakar R. Pawar, 2016). (Purba, 2019). Studies show that marine debris in the benthic habitat affects the biota and

decreases the primary productivity of the ecosystem micro-algal biomass reduced drastically, clearly indicating the impact on benthic ecosystems. It has been observed that an essential need to have a mass coastal benthic cleansing program is followed by good solid waste collection and segregation mechanisms all over the world. Also, there are still many information gaps correlating to sources, transport patterns, distribution of marine debris impacts (Kandziora, 2019).

Furthermore, the numbers of marine animals affected by negative interactions with marine debris show that actual amounts of marine debris necessitate being decreased (Werner, 2016). A recent study additionally notes that plastic particles can carry pathogenic species, leading to antibiotic resistance's potential development with other deleterious effects on marine organisms who will encounter these particles (Hale et al., 2020). Microplastics in the ocean are a part of the larger scenario of the plastic life cycle itself, from the request and giving to its incineration and waste generation. Section of the problem in addressing plastic pollution and develop solutions to mitigate its impacts also arises from the wrong perception that all plastics have the same composition, and thus, behave identically (Hale et al., 2020)(Rochman et al., 2019) (A.Loissellea, 2021).

Microplastics continuously fragment in the environment, generating smaller and smaller particles over time; this manner depends on several factors, including the physical, biological, and chemical conditions that the particles encounter. Hence, to properly understand microplastics' results in any ecosystem, it is necessary to measure across all size ranges and consider as many types of plastic polymers as possible (Hale et al., 2020)(Rochman et al., 2019) (A.Loissellea, 2021), These adverse consequences happen in the already compromised conditions of marine habitats, on the other hand, Socio-economic studies on the consequences of marine debris for stakeholders will be essential to provide good administration plans to decrease debris input in the marine environments at the regional and global levels. There is a poor understanding of marine debris's economic implications for coastal communities throughout the globe yet.

Accordingly, economic assessments may promote awareness and help future efforts to control the input of debris items at the source, and in parallel, will once more raise the alarm on the consequences of our increasing consumption of plastics (K.Phama, 2020). Recycling is the prevalent solution to the overuse of any marine debris, such as plastics. Thermal degradation may be the latest solution to repurposing and recycling plastics without creating further environmental degradation. Marine debris is one of the significant problems identified by fishermen, and they have demanded a solution for this. It is recommended that there be a National marine debris management Strategy with particular aims for the prevention and control of debris accumulating, spreading, and coastal and marine ecosystems affecting the fish production to increasing menace to resource sustainability.

A mixture of law and the improvement of ecological awareness through training are expected to be the best way to solve such environmental problems; as consequence, fines for those who litter in the oceans or coasts and incentives for prevention and waste reduction (Iñiguez, Conesa, & Fullana, 2016). It is vital to increase consciousness among people about this issue's significance and remind them what is thrown into the sea does not disappear. However, global efforts remind them that those abandoned items do not deteriorate and are very harmful to marine environments. The final solution to marine debris prevention is to perform a reliable marine debris strategy, namely the idea of "Zero debris".

3.1. Practical solutions to tackle marine debris

- The most practical method to overcome and decrease the damaging consequences of marine debris in the ocean is to prevent it from entering the marine ecosystem in the first place. This process needs to organize an

improved understanding of debris at the regional, local, and national levels; improved waste control efforts; education; anti-dumping campaigns; development of technology solutions; decreasing disadvantages of fishing gear at sea; and incentives to decrease debris.

- Education is essential to promote the actual condition of health in the oceans and could effectively change people's manners, particularly starting during childhood, and schools should organize activities every year to clean nearby shores (Iñiguez, Conesa, & Fullana, 2016).
- The conversion of marine debris to adhesive is a cost-effective, eco-friendly, practical, and economical method.
- An essential part of marine debris is connected to the fishing industry. It has been recommended that fishers follow some guidelines for waste disposal at ports, use bait boxes, and complete programs for fishing nets recycling (Iñiguez, Conesa, & Fullana, 2016).
- Plastic is now an essential part of human life's everyday activity, and one cannot control out the problems of plastic, but its disadvantages can be decreased to some extent; accordingly, it has to be controlled by human administration.
- Recycling is one of the most recognized methods possible to decrease waste in landfills and the ecosystem through the reuse of materials.

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