

## Plastic marine pollution

### Abstract

The aim of this paper is to analyse plastic marine pollution, alternative solutions, the role of relevant actors and the effectiveness of these actions in resolving ocean pollution. First, the paper breaks down plastic marine pollution into its main causes, actors, and effects. It highlights how human activity is pushing the world's oceans to the brink of collapse. After this brief introduction aimed to better understand the possible actions against this problematic, the study provides an overview on international legislation and multilateral initiatives that have been proposed all over the years to fight against the plastic pollution crisis. Finally, it examines the effective role of the various innovations that are trying to resolve the problem of plastic pollution affecting the marine environment. The data for this study were obtained through research on academic texts and official websites. This topic is analysed in an objective way and by reporting considerations of different academic authors.

**Keywords:** plastic marine pollution; effects of plastic crisis; international legislation; multilateral initiatives; alternative solutions

### Introduction

“Because 96 percent of the water on earth is in the ocean, we have deluded ourselves into thinking of the seas as enormous and indestructible. We have not considered that earth is a closed system. Once destroyed, the oceans can never be replaced. We are obliged now to face the act that by using it as a universal sewer, we are severely over-taxing the ocean's powers of self-purification. The sea is the source of all life. If the sea did not exist, man would not exist. The sea is fragile and in danger. We must love and protect it if we hope to continue to exist ourselves.” (Cousteau 1971) It is evident that

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human activity is pushing the world's oceans to the brink of collapse; this environmental challenge has been made by humans and it is the humans' responsibility to collaborate in order to solve it.

This study will analyse plastic marine pollution, alternative solutions, the role of relevant actors and the effectiveness of these actions in resolving ocean pollution. The data for this study were obtained through research on academic texts and official websites. This topic is analysed in an objective way and by reporting considerations of different academic authors. Thus, the paper breaks down plastic marine pollution into its main causes, actors, and effects. After this brief introduction aimed to better understand the possible actions against this problematic, the study provides an overview on international legislation and multilateral initiatives that have been proposed over the years to fight against the plastic pollution crisis. Finally, it examines the effective role of the various innovations that are trying to resolve the problem of plastic pollution affecting the marine environment.

## Main causes, actors, and effects of marine pollution

Oceans, covering 70% of the Earth's surface, ensure carbon sequestration, climate regulation, and primary production, making life possible on our planet (Miyazaki 2005). A vast majority of human activities are directly or indirectly linked to and dependent on our oceans, including shipping and transportation, fisheries and food supply, recreation and tourism, and offshore exploration for minerals and petroleum (Lovinson 2018). Excessive production, use, and consumption of plastic items and single-use plastics, which characterise everyday-life habits today, are no longer sustainable and pose an imminent threat to our oceans, coastal communities, food chain and, potentially, even to our own health (Barclay 2013).

Mass production of plastics began in the 1950s and some of the earliest accounts of plastic debris in the marine environment were recovered as early as in 1960s as fragments and pellets ingested by seabirds; from then on, over the next decades, there has been a rapid and substantial increase in anthropogenic debris on the ocean surface, bottom and beaches worldwide (Barnes et al. 2009). The versatility of these materials and their being lightweight, strong, durable and cheap have led to a great increase in their usage over the years. The study conducted by Geyer and his team (2017) points out that most monomers used to make plastics, such as ethylene and propylene, are derived from fossil hydrocarbons: none of the commonly used plastics are biodegradable; as a result, they accumulate, rather than decompose, in the natural environment. That

study also underlines that the only way to permanently eliminate plastic waste is by destructive thermal treatment, such as combustion or pyrolysis; thus, near-permanent contamination of the natural environment with plastic waste is a growing concern. Geyer and his team estimate that 2500 Mt (30%) of all plastics ever produced are currently in use; between 1950 and 2015, cumulative waste generation of plastic waste amounted to 6300 Mt. Of this, approximately 800 Mt (12%) of plastics have been incinerated and 600 Mt (9%) have been recycled. So, as these authors note, around 4900 Mt, 60% of all plastics ever produced, were discarded and are accumulating in the natural environment; despite not being biodegradable, sunlight weakens these materials, causing fragmentation into particles known to reach millimetres or micrometres in size.

There are many sources of plastics accumulating in the environment, either from direct dropping and dumping of litter on land or at sea, blowing from landfill sites, losing in transport or involuntarily dispersing in the surrounding eco-systems (Barnes et al. 2009). Ships are the major source of plastic debris in the oceans: Horsman (1982) estimated that merchant ships dump 639,000 plastic containers each day around the world. Typically, from 40% up to 80% of mega and macro marine debris items are plastic, much of it packaging, carrier bags, footwear, cigarette butts, lighters, and other domestic items; fishing-related sources of debris are also common, especially in the more remote islands (Barnes et al. 2009).

Many marine species are known to be harmed and/or killed by plastic debris by the ingestion of plastic litter; other less known threats include the absorption of polychlorinated biphenyls from ingested plastics (Derraik 2002). The effects of ingested plastic particles on seabirds include blockage of gastric enzyme secretion, diminished feeding stimulus, lowered steroid hormone levels, delayed ovulation, and reproductive failure (Azzarello–Van-Vleet 1987). The harm from ingestion of plastics is nevertheless not restricted to seabirds: polythene bags drifting in ocean currents look much like the prey items targeted by turtles (Isangedighi et al. 2018). Young fur seals are attracted to floating debris, too and plastic loops can easily slip onto their necks: many seal pups grow into these plastic collars which sever the seal's arteries or strangle it (Weisskopf 1988). Whales are also victims, as lost or abandoned fishing nets are caught in their mouths or wrapped around their heads and tails (Weisskopf 1988). Moreover, larger pieces of plastic debris in the ocean have been proved responsible for the transport of foreign species to new habitat, where they threaten to damage the autochthone ones (Rochman et al. 2013). Another pressing issue concerning marine plastic pollution is represented by microplastic and microbeads that wash yearly into our oceans and seas

(Gabbatiss 2018). They physically harm wildlife endangering the world's ecosystems and can ultimately be eaten by people, through seafood, clams, mussels, etc. Plastic debris are themselves potentially toxic and they have the likeliness to absorb other pollutants, too. According to a hazard-ranking model based on the United Nations' Globally Harmonised System of Classification and Labelling of Chemicals, the chemical ingredients of more than 50% of plastics are hazardous, with some specific chemicals that can even accumulate in the blood or be carcinogenic (Rochman et al. 2013). The monomers making up other types of plastics, such as polyethylene (used to make carrier bags), are thought to be more benign; however, materials can still become toxic by picking up other pollutants, such as pesticides and organic pollutants (Rochman et al. 2013).

According to the data of the Jambeck study, China, Indonesia, the Philippines, Vietnam, Sri Lanka, Thailand, Egypt, Malaysia, Nigeria, and Bangladesh are the top ten producers of ocean plastic pollution. China, as the biggest producer, produces between 1.32–3.53 MMT (million metric tons) of plastic marine debris per year; Indonesia is ranked second generating between 0.48-1.29 MMT/year. The coastal European states, collectively, take the 18th place, while the US ranks 20th. As a matter of fact, it is evident that developing countries do not possess waste management infrastructures similar to those in the advanced countries and, therefore, they register and cause higher volumes of plastic marine debris despite their lower waste generation rates (Jambeck et al. 2015). In fact, sixteen of the top 20 polluters are middle-income countries where fast economic growth is not accompanied by major improvements in waste handling (Sample 2015).

In various location across the world's oceans, 5 garbage patches, also called "ocean gyres", have been discovered. These huge garbage patches, mostly composed of plastic debris, normally develop in the middle or high sea, due to strong currents and winds that create the conditions for their accumulation in specific areas. These gyres are growing in their extension every year and the largest one, the North Pacific Gyre, has now grown to more than twice the size of the state of Texas and three times that of France (Alfonseca 2018).

Even though plastic debris tends to accumulate in specific places in the oceans, most of it will in the end sink to the seafloor where plastic accounts as the most prevalent form of debris. More than 70% of the ocean's floating plastic will eventually sink to the bottom and more than 94% of ocean plastic has been estimated to be found on the seafloor (Sherrington 2016).

Human activities are responsible for a major decline of the world's biological diversity, and the problem is so critical that combined human impacts could have accelerated present extinction rates to 1000–10,000 times the natural rate (Lovejoy 1997).

## International legislation, multilateral initiatives and relevant actors

The threat of plastics to the marine environment has been ignored for a long time and even the plastics industry failed to predict the great boom in the production and use of plastics of the past 30 years (Derraik 2002). Plastic pollution, as many other problems conceptualised as “global problems”, is the cumulative result of actions taken at various levels; solving this problem requires collective action and many actors at diverse levels need to change their day-to-day activities to prevent plastics from ending up in the oceans (Frost 2018). Although the first and most important solution of all remains a necessary reduction in plastic consumption and waste, there have nevertheless been some attempts to promote the conservation of world's oceans through international or transnational legislation:

- the United Nations Convention on the Law of the Sea (UNCLOS), established in 1982, provides rules governing all uses of the oceans and their resources (United Nations 1982);
- the London Convention generally prohibits the dumping of specific hazardous materials (Environmental Protection Agency 2018);
- the MARPOL convention covers different regulations and limits the discharges at sea including solid waste and plastics (Chasek 2013);
- the Basel Convention regulates the movement of hazardous waste, including some plastics, and obliges its members to ensure that such wastes are managed in a sustainable manner (Basel Convention 2018).
- Common Law plays an important role also in the environmental field.
- Unfortunately, very few states observe the obligations to which they have committed themselves, and these agreements have proved mostly unsuccessful in reducing marine debris; furthermore, these regulations are mostly focused upon limiting intentional dumping rather than preventing unintentional pollution (Harrabin 2018).

Together with international legislation an important role is played by multilateral initiatives, such as:

- The UNEP Global Programme of Action: it aims to prevent the degradation of the marine environment from land-based activities by facilitating the realisation of the duty of states to preserve and protect the marine environment (UN Environment).
- The Honolulu Strategy: it offers a framework for a comprehensive and global cooperative effort to reduce the ecological, human health and economic impacts of marine debris worldwide (Basel Convention).
- The Global Partnership on Marine Litter (GPML): its main goal is to protect human health and the global environment by the reduction and management of marine litter, through several specific objectives (UN Environment).

The Global Environment Facility, established in 1992, together with UN agencies, proved to be very important in mobilising funds and financing many projects oriented to protect and save the marine environment (Basel Convention).

Despite the different transnational conventions and multilateral efforts, together with regional marine protection agreements and customary law aimed at preventing an increase in pollution, all these tools seem to have failed to prevent a growing increase of plastic pollution (Ringius 2001).

The main actors commonly involved in environmental global politics issues are: nation states; international organisations; environmental NGOs; corporations and industry groups; scientific bodies and experts (Chasek et al. 2013). Subnational actors are starting to embody increasing relevance and environmental NGOs are strongly emerging as major players in global environmental politics (Chasek et al. 2013). Considering that most of the recycling burden of many developed countries is shipped overseas to be processed, mostly in China, developed countries' responsibility to help developing countries to catch up on waste management practices and facilities becomes more evident: in 2018 China has decided to ban the import of several varieties of foreign solid waste and this has led to a waste management crisis in many countries (Kottasová 2018).

Due to the long life of plastics in marine ecosystems, it is imperative that severe measures be 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 (Derraik 2002). There is a need for a multi-level coordination and action to improve waste management infrastructures and practices. The collaboration between governments, NGOs, civil society and scientific and industry groups becomes a priority in order to share knowledge and find appropriate solutions.

## Sustainable solutions and their effectiveness

Scientists claim that reducing mismanaged plastic waste by 50% in the top 20 ranked countries would cut the amount of plastics likely to end up in the oceans by 41% in 2025 (Sample 2015).

A report by the MacArthur Foundation (Ellen MacArthur Foundation et al. 2016) claimed that innovation can solve the plastics problem. However, as the study of Mateo Cordier and Takuro Uehara (2018) underlines, the MacArthur Foundation's report does not tell how much innovation is needed and does not study its feasibility either. Cordier and Uehara try to answer this question by developing an ecological-economic world model that simulates plastic waste emission by human activities; innovations will be simulated in an economic sub-model. The results of the study suggest that to reach significant abatement of plastic waste accumulated in the ocean, upstream and downstream solutions must be combined across the social-ecological system; in addition, several of these solutions will require a change in mentalities to spur individuals to act collectively (Cordier–Uehara 2018).

Diverse responses to the plastic pollution crisis and different plans of action for reducing plastic marine pollution have been proposed over the recent years. Some examples of concrete solutions are: closed-loop recycling; landfill sealing to avoid plastic waste leakages; inciting industries to replace plastic materials with other recyclable materials; converting plastics into fuel; classifying plastics as hazardous materials; composting and using biodegradable plastics.

- Closed-loop recycling consists of bringing the products back to the company or industry of manufacture so that they can be reused or reconditioned without a loss of material.
- The creation of more efficient landfill sealings is essential to avoid plastic waste leakages and so to reduce the dispersion of plastic in the environment.
- The contribution of industries to promoting alternative materials is important to reduce the production of plastic packaging and therefore the plastic pollution problem.
- Converting waste plastics into fuel is a viable solution to recycle them; through depolymerisation, pyrolysis, catalytic cracking and fractional distillation it is possible to obtain from plastic waste different fuels such as petrol, kerosene, and diesel.

- By classifying plastics as hazardous materials, an important reduction in plastic pollution could be expected; it would allow environmental agencies to have wider power to restore affected habitats and prevent more dangerous debris from accumulating, given the stricter regulations associated with hazardous materials (Lovinson 2018).
- As Emily Joy Frost notes in one of her papers, biodegradable plastics have the potential to solve a number of waste management issues, however, for the moment it seems that they are just used to complement other disposable plastic waste minimisation efforts; furthermore, the degradation process relies on exposure to sunlight, oxygen and it is influenced by temperature, making the process potentially long. Even worse, as the same study underlines, the degradation of this kind of plastics in the stomach of turtles does not occur fast enough to avoid their death.

Emily Joy Frost's article (2018) is also interesting because it analyses other alternatives to plastics. As the author notes:

- reusable bags, especially the cotton and cloth versions, are durable and washable and thus they represent a great alternative to plastics. However, many of them are made of plastics or have a hard-plastic bottom; for these reasons they are not the most efficient solution to the plastic waste crisis;
- using other recyclable materials, such as glass, which is an ideal reusable material for the storage of food. However, if glass is used as a short-term disposable product, its impact on the environment can be just as bad as using plastic alternatives.

Without doubt, the era for us to remove short-term single use plastics from our lives has come; we need to move away from short-term solutions and start working towards a long-term goal with re-useable and environmentally friendly alternatives (Frost 2018). Furthermore, the power of education should not be underestimated, and it can be more effective than strict laws, such as the Suffolk County Plastics Law (in New York, USA) that banned some retail food packaging and was inefficient in reducing beach and roadside litter (Ross–Swanson 1995). In conclusion, solving this problem requires collective action and many actors at different levels need to change their day-to-day activities to avoid plastics ending up in the oceans (Cordier–Uehara 2018).

## Conclusion

This work tried to underline how strong the human impact is on the environment. Human activities are responsible for a major decline in the world's biological diversity, leading to an acceleration of the present extinction rates to a drastic level (Lovejoy 1997). Once recognised plastic pollution as a “global problem” caused by actions taken at different levels, the most appropriate response seems to be the changing of many actors' habits at all levels (Frost 2018). All kinds of plastic debris, polluting our oceans and seas, have proved harmful not only for wildlife but for humans as well (Gabbatiss 2018, Rochman et al. 2013). Despite all the efforts to find resolute solutions, the accumulated plastics will harm the environment for centuries to come. By all means, it is man's duty to concentrate all the efforts to remove short-term single use plastics from our daily life, opting for more sustainable solutions with regard for the future of our planet.

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