Multidisciplinary

Effects of plastic wastes in the earth's ocean environment and implications for climate change

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Abstract

This discussion paper focuses on the menace of plastic wastes in the earth's ocean environment and its implications for climate change. The sequence of discussion would begin with a description of ocean plastic wastes, the causes of plastic wastes, the effects of plastic wastes, how the plastic wastes affect climate change and at the end we propose some plastic waste removal strategies.

Keywords: the ocean, menace of plastic wastes, climate change, plastic waste removal strategies

1. Description of plastic wastes in the ocean

One of the most enduring material men has created is plastic and it could take hundreds of years for it to degrade. Research has shown that it is possible that plastic does not even fully degrade but becomes microplastics which are tiny particles that can be eaten by marine animals. These microplastics can end up in the body and tissues of these animals entering the food chain and lead to disasters for the planet and its inhabitants. Nowadays, humans are more familiar to the consequences microplastics pose to life. This awareness has made them to develop effective strategies of curbing the menace of plastic wastes in the ocean. Plastics are transported and converged in the ocean where currents meet. This in effect signifies that the big plastic islands are made as a result of this phenomenon. Scientists who studied plastics in the Atlantic have calculated that there are 580,000 pieces of plastic per square kilometer (Andrews, 2012) [1].

The presence of plastic in the ocean is on the increase and plastic pollution is still one of the main causes of extinction of marine species, health problems for humans and animals and destruction of ecosystems. Plastic debris is currently the most abundant type of litter in the ocean, making up 80% of all marine debris found from surface waters to deep-sea sediments. Plastic is found on the shorelines of every continent, with more plastic waste found near popular tourist destinations and densely populated areas. Marine plastic pollution is the accumulation of plastic objects (plastic bottles and much more) in the Earth's ocean environment. This is a serious menace as it adversely affects marine life and by extension human and as well is a major contributor to climate change.

Commonly found plastics include cigarette butts, food wrappers, beverage bottles, straws, cups and plates bottle caps and single – use bags. Once the plastic gets into the ocean, it decomposes very slowly, breaking into tiny pieces, which can enter the marine food chain and become incredibly damaging to sea life. The main source of ocean plastic pollution is land based, as a matter of fact, it has been reported that up to 80% of plastics in the ocean originates from land.

Some key facts about plastics in the Ocean

- An estimated Eight (8) million pieces of plastic wastes find their way into our ocean and causes pollution daily.
- 79% of plastic waste is sent to landfills or the ocean, while only 9% is recycled, and 12% gets incinerated.
- An approximate 25 trillion macro and 51 trillion microplastic litter our oceans today.
- They make up 80% of all marine pollution and around 8-10 million metric tons of plastic end up in the ocean each year.
- The Environmental Protection Agency, EPA stated that basically 100% of all plastics human beings have ever produced are still in existence meaning that it is difficult to completely destroy plastics. Generally, plastic takes between 500-1000 years to fully decompose.
- Presently, there are about 50-75 trillion pieces of plastic and microplastics in the oceans. These plastics are either broken down into microplastic particles, or float around and end up as garbage patches or plastic accumulation areas in the center of the ocean or as seen in Figure 1 below.

Fig 1: Pile up of plastic garbage patches

Figure 2 gives a description of the 10 most common plastic items that constitute waste items that litters the earth's ocean environment as of today.

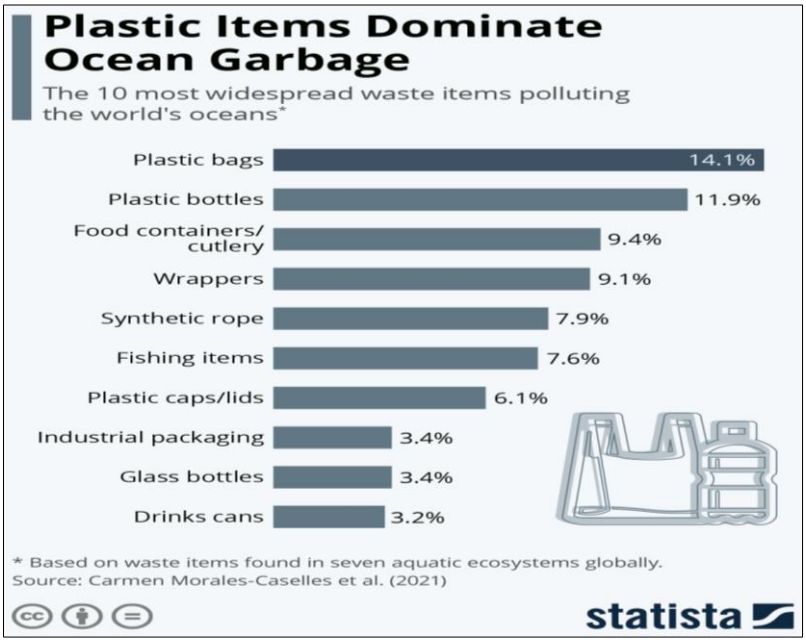

Fig 2: List of 10 common plastic waste items found in the Ocean (Statista Source in McCarthy, 2011) [13].

2. Causes of plastic wastes in the oceans

The majority of plastic pollution in ocean is caused by littering: we buy or use disposable plastic items (food wrappings, plastic bags, razors, bottles, etc.) and do not dispose them properly, which cause them to end up in the water ways and eventually in the ocean. Rainwater and wind carry plastic waste into streams and through drains. Drains lead to the ocean; careless and improper waste disposal is also a big contributor. Illegal dumping of waste adds greatly to the plastic surge in our oceans.

Many plastics and microplastics are as a result of improper manufacturing processes and about 20% of the plastic pollution in the ocean comes from industrial fishing. Also, some of the plastic in the ocean originates from ships that lose cargo at sea. Another large source of plastic waste at sea making up to about 10% is the abandoned plastic fishing nets and longlines. When the polystyrene foam that is used to make the floating frames of fish cage makes its way into the sea, they sink into the bottom of the ocean contributing to a serious marine pollution.

Factors promoting the surge of plastic wastes in the oceans

Several factors contribute to increasing amount of plastic wastes in the oceans. These include but are not limited to the following:

- Plastic is cheap, readily available, and its use is widespread.
- The world's population is growing and so is urbanization.
- We have a disposable mentality when it comes to plastic instead of embracing recycling.
- Plastic takes over 400years to fully decompose.
- Marine shipping and fishing industries activities.

In addition to the above factors, the plastic produced is single use, that is; it is meant to be discarded immediately after it has served its purpose. For instance, straws, plastic carrier bags and water bottles are frequently produced; they are easily thrown away after use thereby increasing the amount of waste entering landfills. This in turn increases the amount that eventually goes into the oceans. Since the ocean is as well the point where thousands of rivers terminate, tonnes of loose litter and wastes from landfills flows downstream through rivers and ultimately deposit into the sea causing an increase in the amount of plastic therein. At the initial stage, the plastic may stay in coastal waters, but it can soon be picked up by rotating ocean currents, and transported almost everywhere in the world.

Microplastics can come from a variety of sources including larger plastic pieces that have broken apart, resin pellets used for plastic manufacturing, or in the form of micro beads, which are small, manufactured plastic beads used in health and beauty products. Single – use plastic bags are commonly used to carry groceries to and from the store, yet they are one of the most common ocean plastic products in marine debris. Plastic bags are harmful to aquatic species. Sea turtles, for example, often mistake floating plastic bags for jellyfish, ingesting them or getting entangled. Rainwater and wind carry plastic waste into streams and rivers and through drains. Figure 3 shows sources of marine pollution throughout the plastic life cycle.

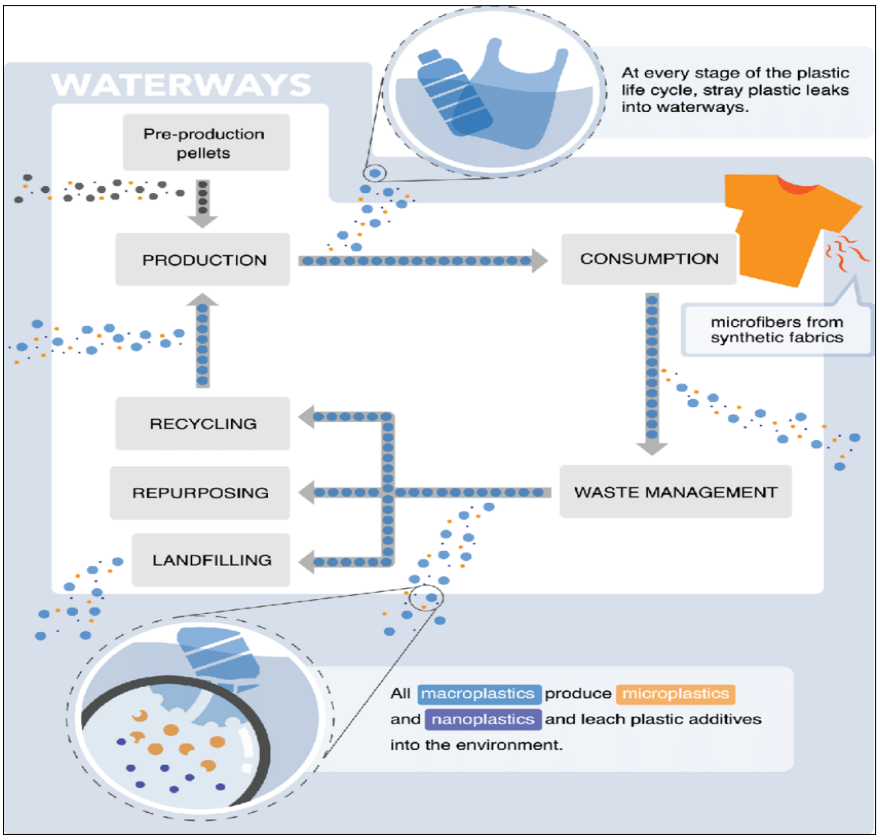

Fig 3: Sources of marine pollution throughout the plastic life cycle (adapted from Natalie *et al.*, 2023) [11]

3. The effect of plastic wastes in oceans

Although the production and use of plastic is still at its highest, the recycling data are not encouraging as only about 10% of the plastic produced is currently being cycled while the rest is either incinerated, causing air pollution, and ending up in the oceans and environment. The most visible impacts of plastic debris are the ingestion, suffocation and entanglement of hundreds of hundreds of marine species. Marine wildlife such as seabirds, whales, fish and turtles mistake plastic waste for prey; most of them then die of starvation as their stomachs become filled with plastics. The physical impacts on marine lives are entanglement, ingestion and starvation. The chemical impacts are the buildup of persistent organic pollutants, transport of invasive species and pollutants from polluted rivers to remote areas in the ocean.

Plastic marine debris can smother wildlife, restricting the flow of oxygen and greatly impacting these deep-water environments. Large debris such as shipping containers can also crush habitats and leave lasting damage, not only from the physical destruction but also from releasing toxins into the sediment. Plastic pollution can alter habitats and natural processes, reducing ecosystems ability to adapt to climate change, directly affecting millions of people's livelihoods, food production capabilities and social well-being. For instance, fishes in the North Pacific ingest 12,000 to 24,000 tons of plastics every year and this can cause intestinal injury and death and transfers plastic up to the food chain to bigger fish, marine animals, etc (Chauvin & Johnson, 2018) [4].

Plastic items that are floating can help transport invasive species, which leads to the threats for marine ecosystems, biodiversity and the food web (Moore, 2023). Processes affecting the transport of plastics into the ocean are described in Figure 4.

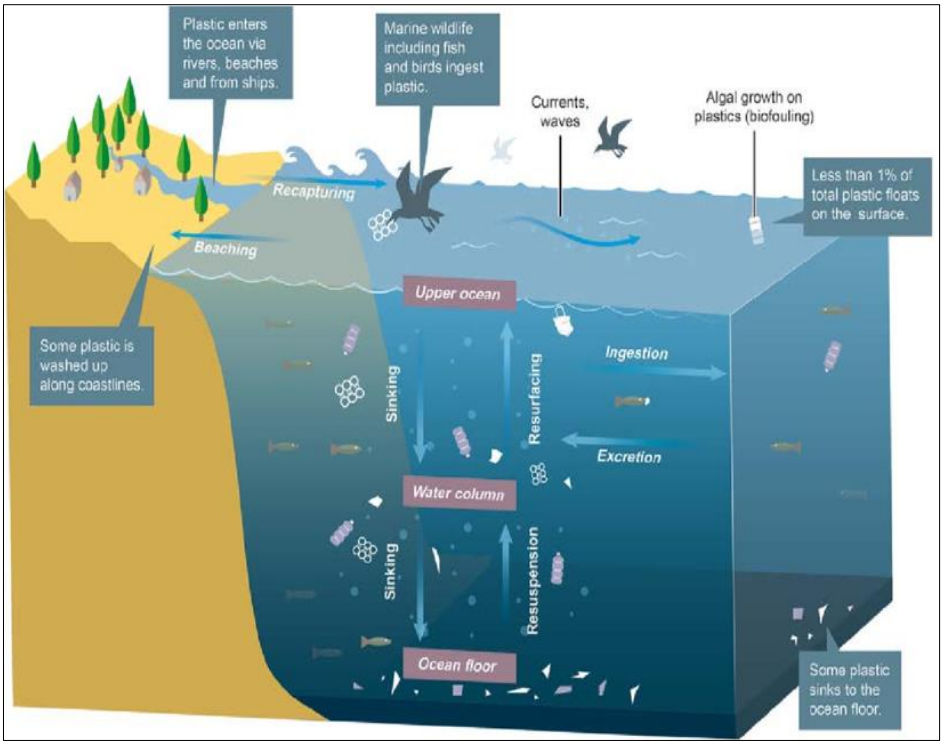

Fig 4: Processes affecting the transport of plastics into the ocean (After Harb *et al*., 2023) [8]

4. Implications for climate change

Plastic in the oceans may also interfere with the oceans capacity to absorb and sequester carbon dioxide, thus creating another pathway through which plastic pollution contributes to accelerate climate change. Plastic pollution can alter habitats and natural processes, reducing ecosystems' ability to adapt to climate change, directly affecting millions of people's livelihoods, food production capabilities and social well-being. It threatens ocean health, the health of marine species, food safety and quality, human health, coastal tourism and contributes to climate change. Solid waste contributes directly to greenhouse gas emissions through the generation of methane from the anaerobic decay of waste in landfills, and the emission of nitrous oxide from our solid waste combustion facilities. Once the plastic is in the ocean, it decomposes very slowly, breaking into tiny pieces known as microplastics, which can enter the marine food chain and become incredibly damaging to sea life. The main source of ocean plastic pollution is land based – 80% of plastic in the ocean originates on land.

Additionally, during the incineration of plastic waste, carbon monoxide and methane mostly from landfills are released into the atmosphere causing increasing emissions and worsening global warming. Figure 5 showcases the differences and biodegradability of different types of plastics (Adapted from the work of Ford *et al*., 2022) [7].

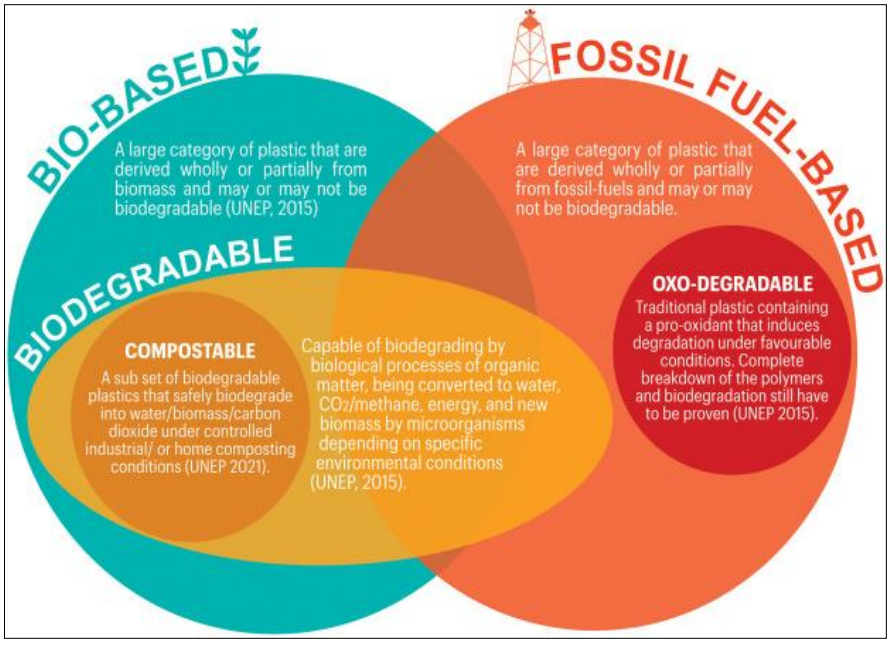

Fig 5: Differences and biodegradability of different types of plastics (After Ford *et al*., 2022) [7]

5. Plastic waste removal strategies

Plastic pollution is unarguably an issue that requires global attention and cooperation because its effects are devastating and can affect the entire planet and its inhabitants. It is a threat to the health of the ocean and marine species, food safety and quality, human health, coastal tourism, and contributes to climate change.

When the presence of plastic in the oceans is reduced, it will help to save both the marine species and ecosystems also improve the overall health and that of the environment. Although it is hard to take back microplastic from the deep of the ocean, with the introduction of new technologies, larger marine debris could be caught. As postulated by scientists, the best approach is to prevent plastic waste from entering rivers and seas from the beginning (Marta Fava, 2022) [5]. This can be done through the improvement and implementation of the waste management systems and recycling respectively. Also, the design and usage of disposable packaging, and the reduction in the production of unnecessary single-use plastics is very important to be reconsidered. Figure 6 shows a model that can also be employed to reduce and or remove plastics in the Earth's ocean environments in a bid to mitigate the menace and its impact on climate change.

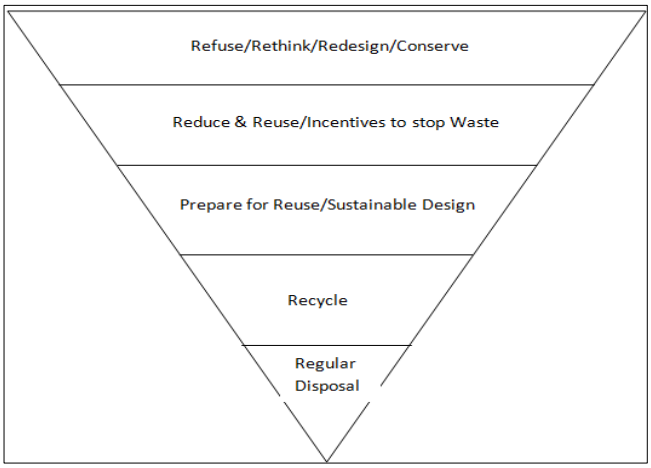

Fig 6: Plastic Wastes Removal Model

Other strategies that could be adopted to remove plastic waste in the oceans include:

- Reduction in the use of plastic. We can change our habits and be more committed to make a difference especially when using the single-use plastics since it constitutes about 49% of all marine pollution. This we can do by swapping plastic bags for reusable bags; reducing the use of disposable plastic cups, plates, cutlery, and bottles; buying food in bulk to avoid plastic wrappings that are not useful. Metallic or glass food containers and storage options can be used to replace plastics.
- Taking part in or organizing a clean-up. We can volunteer to pick up plastic litter that can block waterways thereby preventing them from getting to the ocean in the first place.
- It is very important to support laws that aim to reduce the manufacture and use of plastic, improve recycling facilities and better ways to manage waste.
- Supporting research and organizations. If we have a deep knowledge of the effects of plastics in the ocean, we can start implementing better policies that will benefit everyone through proper research and innovation (Bryce & Flora, 2020) [2].

Furthermore, cleanup of ocean systems which is made up of a large floating net-like barrier three meters deep that forms a large U shape which is slowly towed by two ships is another effective strategy of removing plastic in the ocean. The natural flow caused by the movement directs plastic to the central retention zone. Although every single piece of plastic cannot be removed from the oceans, intercepting plastic in rivers, and cleaning what is already out there, can significantly decrease the debris floating in the accumulation zones of the ocean.

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