



Marine Plastic Pollution

Case study as course project for Environmental Management (ES401), IIT Bombay

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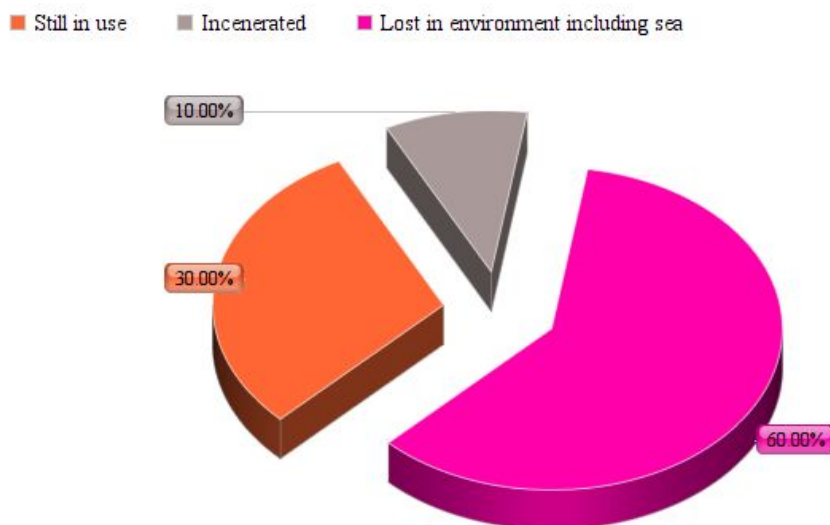
Motivation

With declaring UN theme for World Environmental Day 2018 as “*Beat Plastic Pollution*” to combat single-use plastic, the large push was identified for combating the plastic pollution in land. But there is another kind of severe pollution problem created by plastics which largely gets ignored just because of its non-proximity. The problem is about marine plastic pollution which has a profound effect on every living organism on earth. This report is an attempt to provide an overview on current issue, its magnitude, its implication and future of the marine plastic waste.

1. Introduction

Plastics are most widely used material in the world due to its physical and chemical properties. But most of the plastic which is manufactured is non-biodegradable and huge fraction of it ends up in large water bodies eg. Sea and oceans.

The plastic pollution was first introduced in the 1950s and the production worldwide has grown from **2 million Mt in 1950s to 380 million Mt in 2015** per year. The estimated amount of total plastic produced is 8 billion Mt since 1950, of which 30% is still in use while 10% are incinerated and a large fraction of 60% has gone into the environment including oceans. [Geyger et al., 2017]



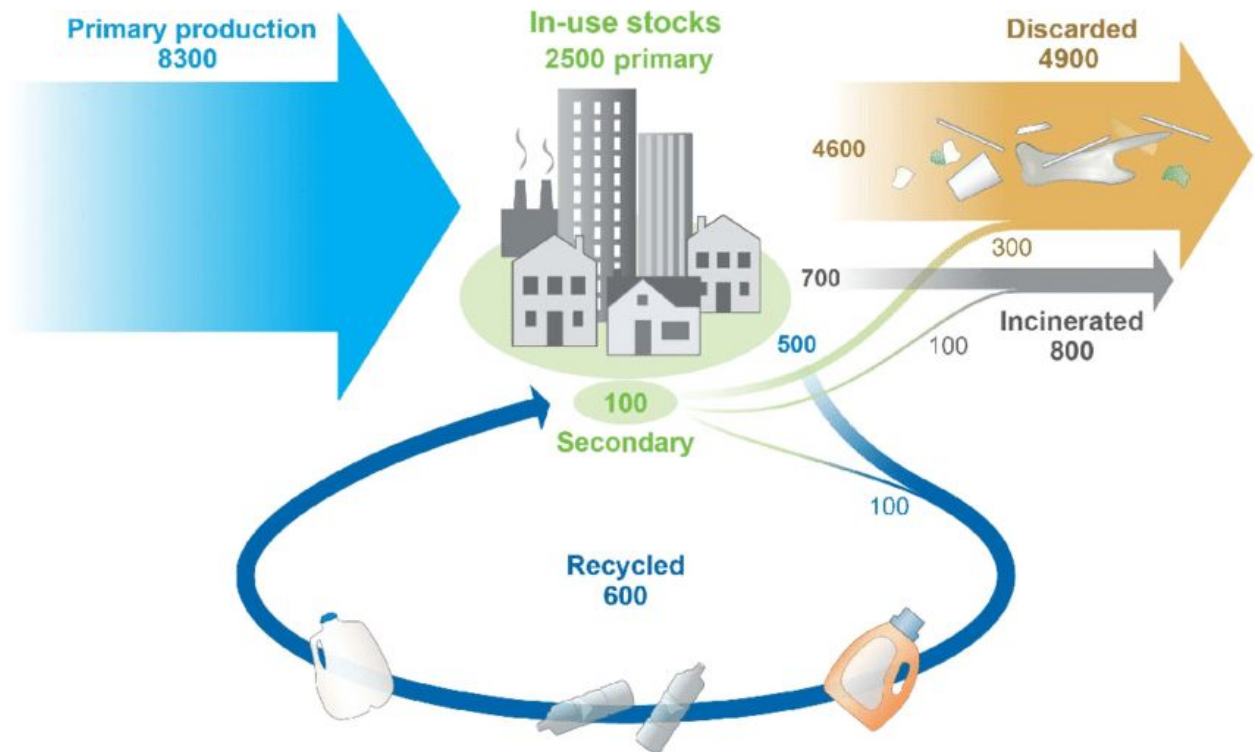


Fig. Global production, use, and the fate of polymer resins, synthetic fibres, and additives (1950 to 2015; in million metric tons).

https://www.researchgate.net/publication/318567844_Production_use_and_fate_of_all_plastics_ever_made/figures

This plastic pollution in the marine environment has adverse effects at multiple levels. Apart from being a threat to marine life plastic pollution also poses many problems for humans too eg. Formation of POP (Persistent organic pollutant), carrying microbes from one continent to another. The garbage in the sea is also a huge risk for certain industries eg. Fishing industry. Today a heavy amount of marine waste is washing up in the coastlines of countries which is particularly dangerous for the population near shore. People living on seafood are particularly at a very high risk of exposing to hazardous chemicals used for the production of plastic and ingested by the marine organisms.

Overall the problem of marine pollution is getting severe day by day and people all over the world are taking several initiatives for combating this issues. There are numbers of commitments, pledges, international laws in place specific to marine plastic pollution.

2. Identification of plastic waste

2.1. Types of plastic waste

2.1.1. Based on size the plastic: Differentiated into 3 categories

<i>Macro Plastic</i>	<i>> 5 mm in size</i>	<i>Fishing nets, plastic bottles, plastic bags, plastic utensils or any other visible plastic form.</i>
<i>Microplastic</i>	<i><5 mm to 1nm</i>	<p>Primary Microplastic- microbeads(from cosmetic products, textile industry, fibres) pellets etc.</p> <p>Secondary microplastic- Result of the breakdown of larger plastic into smaller pieces due to sunlight and weather.</p>
<i>Nano Plastic</i>	<i><1nm</i>	<i>These are extremely small plastic fragments.</i>

Table: Different types of plastic in oceans based on their size. <https://marinedebris.noaa.gov/info/plastic.html>

2.1.2. Based on chemical composition

Types	Common examples
<i>Polyethylene terephthalate</i>	<i>Drinking Bottles</i>
<i>Polyester</i>	<i>Cloths</i>
<i>Polyethylene</i>	<i>Carry bags</i>
<i>High-density polyethylene</i>	<i>Shampoo/Detergent bottles</i>
<i>Polyvinyl chloride</i>	<i>PVC plumbing pipes</i>
<i>Polypropylene</i>	<i>Straws</i>
<i>Polyamide</i>	<i>Bristles of brushes</i>
<i>Polystyrene</i>	<i>Food container</i>

2.2. Origin & Location of marine plastic waste

2.2.1. Origin

The largest amount of plastic waste in the sea comes from Asian coastline mainly China and USA. The amount of plastic entering the sea from the land is largely unknown. The estimate is around 275 million Mt is generated along the coastal countries (2010) from which 4.8 - 12.7 million Mt enter in the ocean. [Jambeck et al., 2015].

There is also a huge amount of plastic waste coming from the rivers too. It is estimated that around 90% of the total river plastic waste into sea comes from only 10 major rivers around the world (it includes three major rivers of India - Ganga, Indus, Brahmaputra). [Schmitt et al., 2017].

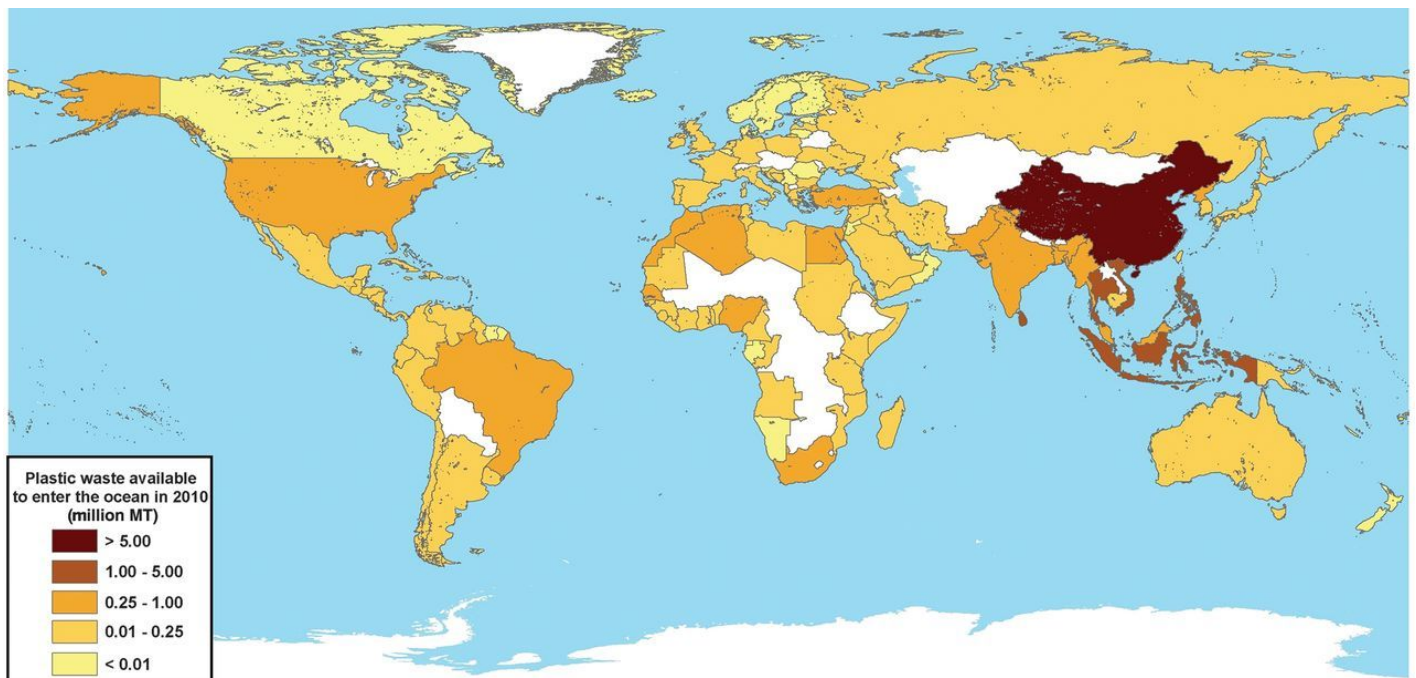


Fig. Global map with each country shaded according to the estimated mass of mismanaged plastic waste [millions of metric tons (MT)] generated in 2010 by populations living within 50 km of the coast. <http://science.sciencemag.org/content/sci/347/6223/768/F1.large.jpg?width=800&height=600&carousel=1>

2.2.2. Location

Majority of the plastic wastes are concentrated at the middle of the sea due to ocean gyres (Large system of circular ocean currents formed due to winds and rotation of the earth).

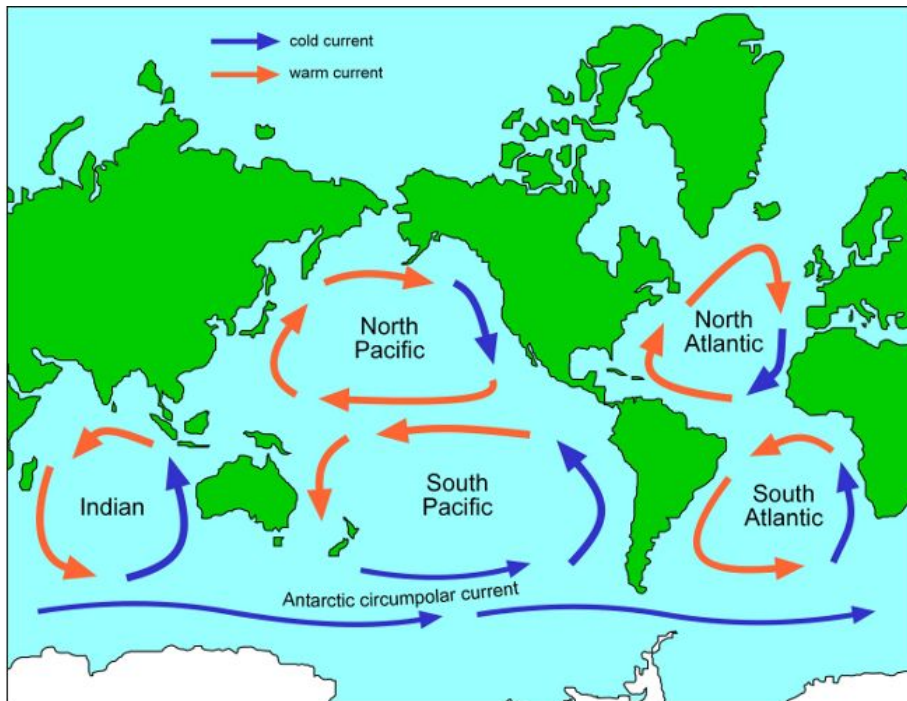


Fig. Major Ocean Gyres.
Source: Google

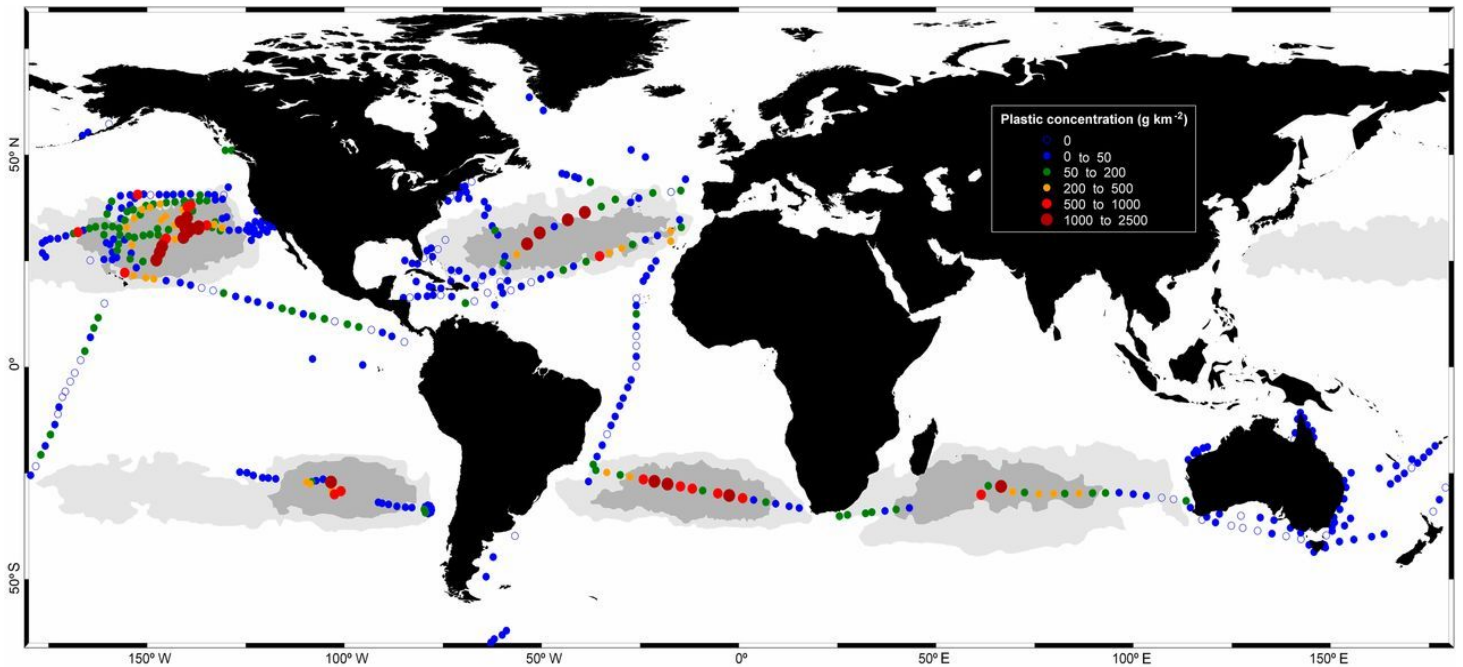


Fig. Concentrations of plastic debris in surface waters of the global ocean. Coloured circles indicate mass concentrations (legend on top right).

<http://www.pnas.org/content/111/28/10239>

Apart from major ocean gyres, there are high concentrations of plastic found in several other locations around the world eg. Mediterranean sea, Bay of Bengal etc. [Eriksen et al., 2014]. Also, low concentrations of plastic are found in the Greenland Sea and Barent Sea (Arctic). [Cozar et al. 2017].

3. Effects

3.1. Chemical Pollution

Many kinds of hazardous chemical are used in the manufacturing processes of the plastic for special properties eg. bacterial resistance. Also, microplastic could absorb many man-made pollutants including POPs. Many of these are very hazardous in nature and eg DDT, flame retardant, PCBs(Polychlorinated Biphenyls) and PAH(Polyaromatic hydrocarbon) etc. There are several other POPs released in the water bodies. These chemicals often end up in food web of the organisms, resulting in biomagnification and breakdown of the food chain.

3.2. Aquatic life

3.2.1. Macroplastic

Nearly all the life forms in the ocean get affected in some way by plastic pollution. The effects are very highly observed in the organisms which survive at the upper level in ocean or filter feeders (eg whale).

Since plastic resembles food for most of the organisms, most of the time it ends up in the gut of aquatic animals like turtles and seabirds. The ingestion of plastic inside any organism could be both direct and indirect (eg. feeding on the organism with plastic). Ingestion of plastic material could severely harm their metabolic activity and reproductive capability. Dead whales, turtle and birds washed up at the shores gives us a clear picture of the amount of plastic pollution which had entered and disrupted the food chain.

Another huge problem is posed due to the entanglement of the organisms inside the plastic waste, especially inside the discarded fishing equipments. Since these equipments eg. fishing net, fishing wire etc are very difficult to avoid, many aquatic animals mostly the large amphibians get entangled. Since these materials are very strong in nature, it restricts the growth of the animal and for most of the cases, death occurs.



Fig. Stunted growth due to plastic entanglement. Source: Google

3.2.2. Microplastic

Microplastic poses another kind of threat to the organism. It interferes with the ability to feed, reproduce and growth of the organism. Very fine microplastic particles can even end up inside the digestive lumens of animals' gut. It could also affect the energy uptake for few organisms which could result in the reproductive impairment. [Sussarellu *et al.* 2016]

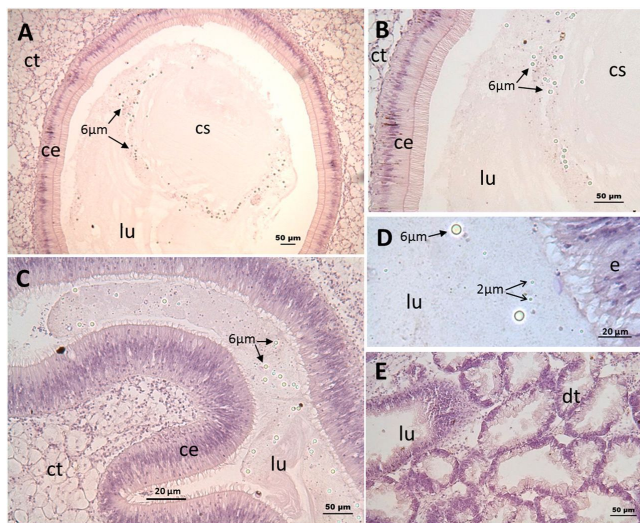


Fig. Micro Polystyrene beads of 2 and 6 μm were observed in the stomach lumen (A and B) and intestine (C and D) of exposed oysters but not in the digestive tubules (E). No beads were observed in control oysters. ct: conjunctive tissue; ce: ciliated epithelium; cs: crystalline style; dt: digestive tubule; lu: lumen; 6 μm : 6- μm polystyrene beads, 2 μm : 2- μm polystyrene beads.

<http://www.pnas.org/content/113/9/2430>

3.2.3. Nano plastic

Nanoplastics due to their small size can easily pass through the gut of the animal and could enter inside the circulatory system of an organism, this could generate an immune response against the foreign particle.

Nanoparticles could very easily travel through the food chain. I could also enter the brain and induce behavioural disorder. [Mattson *et al.* 2017]

3.3. Human life

3.3.1. Marine Litter

Marine litter which is near the shoreline is very dangerous for human activity. More shores are getting filled with the garbage from the ocean. These little apart from containing harmful chemical also contain sharp objects eg. hypodermic needles, metal scraps, glass pieces etc. These

pose a threat to public health. Most of these materials are contaminated with dangerous diseases.

The floating garbage also creates a problem of entanglement of any human, it could result in drowning etc. It is a threat to swimmers.

Entanglement of ship propeller can cause severe damage to the ship and crew, it could also result in casualties. Also, large floating patches of garbage create a problem for navigation in the sea and has a threat of having collision with large floating debris.

3.3.2. Seafood

Marine organisms contain microplastic in their body which when eaten by human poses a number of problems for health. Eating small fish which are devoured completely including gut exposes humans to more amount of microplastic than eating larger fish in which only flesh is eaten. This exposes human to a number of toxic substances which have potential health hazards.

Risks due to nanoplastics are also there in which has higher mobility as compared to microplastics. They could readily enter inside the tissue. Due to their large surface area to volume ratio, the amount of chemical that it could adsorb per unit mass is high, which expose the human to a high concentration of chemicals.

3.3.3. Contaminated litter

Plastic is a very durable material which can travel a large distance on the ocean without degradation. Only after few hours of submersion in seawater the microbial films began to grow over the surface of the plastic. This niche is also suitable for many kinds of organisms. This waste plastic could then transfer these microbes and parasites to huge distance and could spread more disease. The marine litter provides more chances of survival to parasites for travelling large distances. This is a very alarming situation since a small number of microbes can create a large scale epidemic. Also, most of the plastic waste generated on land before reaching the sea passes through the sewage which is highly polluted and

hence contributes significantly to the contamination. These diseases are also prevalent in marine creatures which are a threat to the aquaculture industry. [Zettler et al. 2013]

4. Policies and awareness

4.1. Policies

All over the world Government took various measures and implemented policies so as to reduce the usage of single use plastics(plastic bags).

Some countries implemented taxes on manufacturers and also in retail stores which used single-use plastic bags.

Countries like the USA, Australia and UK imposed some form of ban (partial/full).

European countries imposed a fee on plastic bags and kept revising it at different intervals. Germany and Denmark banned plastic bags as early as 1991 and 1994. Countries in Asia, Africa and remaining Europe on imposing ban and levies on plastic bag consumptions.

Whether these bans were successful or not is a story in itself. Across continents of North and South America plastics were banned or levied only on few places.

Developing countries with coastal borders like India and China had the most contribution towards plastic pollution in waters. Ban in the state of Maharashtra in India is a recent example. Ban imposed in Chinese markets has shown a significant decrease in plastic usage and production. A similar ban in some parts of Australia also showed similar effects. There are still some countries where no laws have been passed for ex. New Zealand.

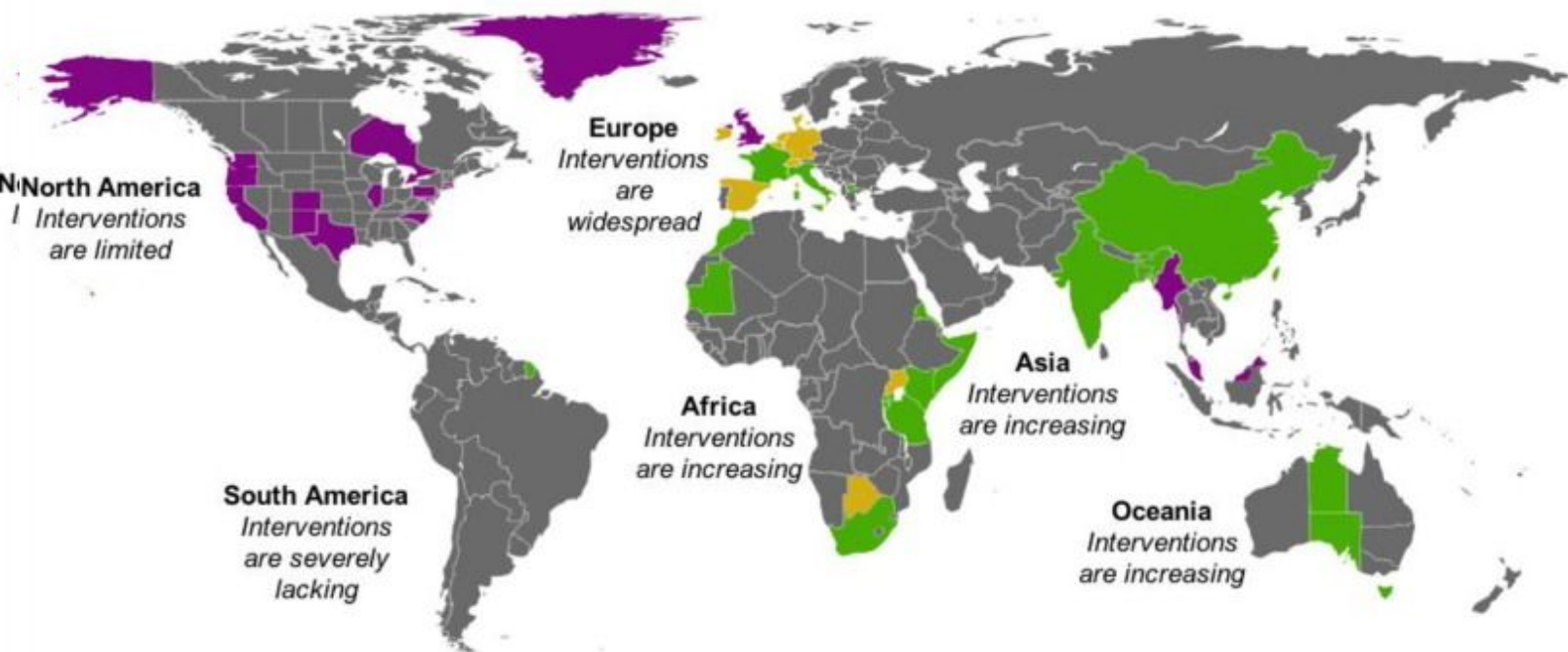


Fig. . ■ Plastic bags banned ■ Taxes on some plastic bags ■ Taxes on some plastic bags; Microbead policies: Primary source of Microbeads pollution is through cosmetics and exfoliators. The beads from the wastewater due lack of treatment go to the oceans through drains. These are then ingested by aquatic animals and microorganisms and enter our food chain. Although there less intervention against microbeads but some countries in europe like Netherlands etc. are serious and has expressed their goal of microbead free cosmetics. Inn west US and Canada are also acting towards microbead free cosmetics

<https://www.sciencedirect.com/science/article/pii/S0025326X17301650#bb0425>

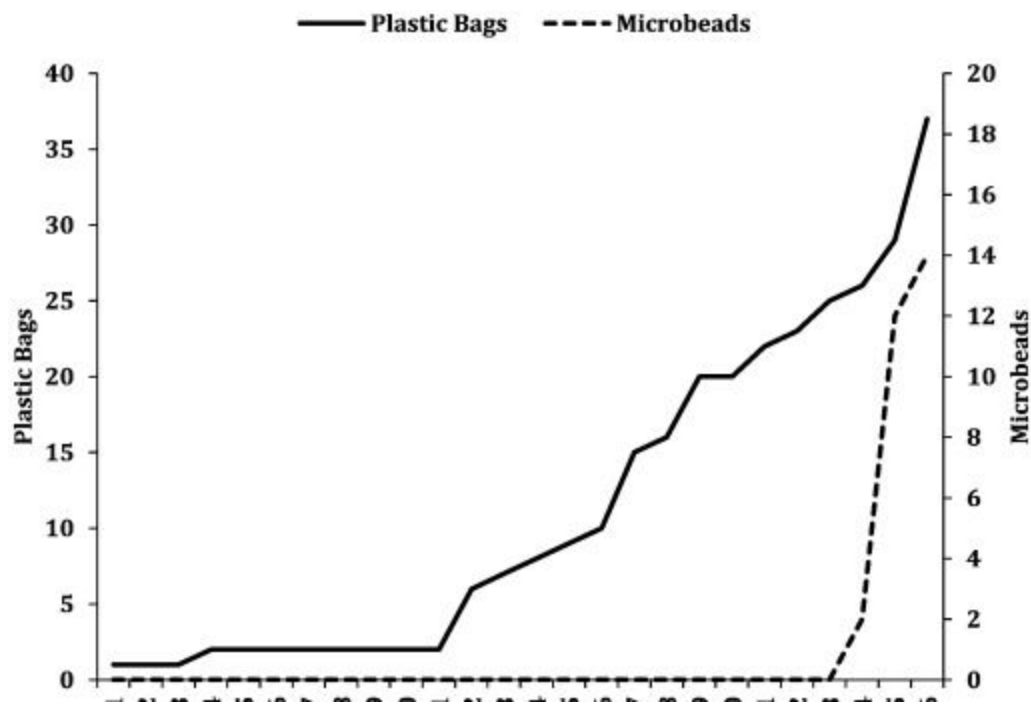


Fig. Global acts against plastic and beads against time.

<https://www.sciencedirect.com/science/article/pii/S0025326X17301650#bb0425>

4.2. Awareness

With such problem ahead of us a collective action of recycling and reducing the use of plastic should be taken. Awareness among the common people is the main factor in reducing the use of plastic products.

One such example is the public support to ban the Microbeads and is acted on by big companies, NGOs and policymakers. Some of the states in the US and Canada have either regulated or banned microbeads. Combined efforts of the public have resulted in successful beach clean-ups, education and awareness outreach.

4.3. Innovation

The Ocean CleanUp-It is one of the largest projects to collect trash from the 'Great Pacific Garbage Patch'.

The Ocean Cleanup is developing an autonomous system, which uses ocean currents to collect plastic, moving in the same direction as plastic. The Collector due to wind and waves moves faster than the plastic and hence captures the plastic. The collected material can be recycled and converted to useful products, selling that would make the project self-sustainable.





Source: <https://www.theoceancleanup.com/>

5. Our Views:

The current scenario of marine pollution is very alarming. Although there are many rules and policies in place to gain control over these situations, but it doesn't seem very effective. The continuous inflow of garbage in the sea is constantly increasing, and with unavailability of landfill more and more countries will be switching to ocean dumping as their last resort.

Many countries have taken steps and pledge to cut down the plastic pollution in oceans but at the same time, there are several countries including developed nations eg. New Zealand and Sweden don't have any kind of policy in place. We need a stricter international law regarding this issue.

We need more research in this field. The effects of the pollution on the sea had not been quantified very accurately.

Further, we need a collective consciousness about this issue. Since the ocean has no boundaries, hence there should be an active cooperation among the countries for curbing the issue of marine plastic waste.

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