

# Impact and Solution of Marine Plastic Pollution: A Review

Ravinder Singh<sup>1</sup> and Gunjan Khatri<sup>2</sup>

Department of Computer Applications

Maharaja Surajmal Institute (An affiliate of GGSIPU), New Delhi, India

ravindersingh@msijanakpuri.com<sup>1</sup> and gunjanlive.khatri@gmail.com<sup>2</sup>

**Abstract:** Ocean Plastic pollution is considered as a critical anthropogenic concern. There are several land based and water based contaminants that are primary sources marine plastic pollution. The accumulated plastics in the ocean basins can be broadly classified into the following five levels based on their sizes: mega-, macro-, meso-, micro- and nano-plastics. Microplastics in primary and secondary forms reveal a major distribution in the water. Microplastics are consumed by marine animals through which they enter the food web and affect the lifecycle of every living organism. Socio-economic impacts, Ingestion, entanglement, starvation, suffocation, most probably leading to death of organisms are some of the profound amount of negative impacts of plastic debris in the oceans on the ecosystem. The global production of plastic has only increased within past years. Developing and developed countries contribute their parts in the pollution in their own ways. Asia remains to be the major plastic producer in the last decade. Immediate and appropriate steps have to be taken in order to stop marine plastic pollution. Existing and adopted policies, legislations and initiatives at global, national and even local levels play a crucial role in reducing plastic debris in the oceans. Preventing accumulation of plastic in the coastal area, abiding by the 4-Rs (Reduce, Reuse, Recycle and Refuse), waste management and water consumption are some of the ways by which marine plastic pollution can be prevented or at least be reduced. On the whole, this paper provides an overall view of the age old problem of plastic accumulation in the marine ecosystem and the hazardous impacts it can have on the life on earth. Towards the end it offers with some of the solutions to the problem that can be our first step towards healthy oceans and safe future.

**Keywords:** Deadly trio; Anthropogenic ; Giga-tonnes; Polymers; Micro-plastics; Garbage patch; marine debris; Polychlorinated biphenyl(PCB); toxic compounds; Micro-beads.

## I. INTRODUCTION

Water is the principal constituent of Earth's hydrosphere. The total volume of water on Earth is evaluated around 333 million cubic miles, where 97.5% is salt water and 2.5% is fresh water. It covers approximately about 71% of Earth's surface. Water is never sitting still because of the water cycle. So, our planet's water supply is constantly moving from one place and form to the other. It exists in the air as water vapour, in rivers and lakes, in the ground as soil moisture, in icecaps and glaciers, in aquifers but the oceans hold the maximum portion of about 96.5% of all Earth's water. <sup>(1)</sup>

Water covers over 70% of the earth's surface. They carry out about primary production and support the greatest biodiversity on earth. Moreover, they are one of the largest carbon reservoirs, holding up to 54 times more carbon than the atmosphere. The global oceans divide into five major oceans and many seas based on historical, cultural, geographical, scientific characteristics, and size variations. The Atlantic, Pacific, Indian, Arctic and the Antarctic are the most known marine systems invaded by mankind.

The marine and coastal systems provide various priceless benefits, namely:

- Climate regulation
- Transportation and Trade
- Food, fibre, wood and water
- Pharmaceutical components, oil, mineral sources
- Nutrient cycle, breeding grounds

- Oxygen production
- Recreation and tourism
- And other socio-economic benefits

But today the oceans are not in a good health. Marine scientists at Oxford University recently warned that “the world’s ocean is at high risk of entering a phase of extinction of marine species unprecedented in human history” This decline in ocean health can be attributed to a combination of acidification, climate change and pollution.

### 1.1 Pollution

The release of impurity into the environment is termed as pollution. Many anthropogenic activities for instance burning of fossil fuels, agricultural and industrial production, use of fertilizers and chemicals among others generate pollutants that can find their way into the ocean. It was believed that the gigantism of the ocean could dilute pollutants enough to eliminate their impacts. However, some pollutants can significantly affect marine ecosystems and cause deadly harm to species all over the food web.

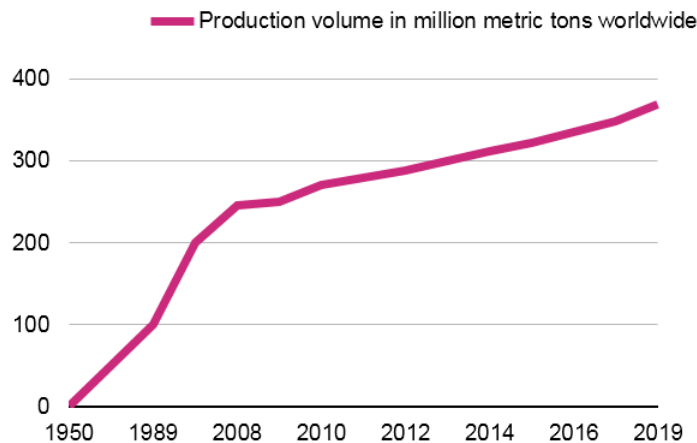
A positive news is that through innovative science and technology, uniform monitoring, environmentally-aware policies, and established and efficient treatment methods some of the impact of pollution can be contained and minimized. Many well-planned steps have already been taken:

- “Scrubbers” have been installed in coal power plants to reduce atmospheric emissions of pollutants
- Pollutants in sewage are broken down using microorganisms
- Buffer zones and wet lands have been created along rivers and streams to absorb excess fertilizers
- Oil spill are treated with oil dispersants

### 1.2 What are plastics and why are they used around the world?

#### A. Findings and Analysis

Polymers are the complex organic compounds that are produced by polymerisation and are capable of being moulded i.e cast into various shapes and films or drawn into filaments and can be used as textile fibres. A type of synthetic or man-made polymer is termed as plastic A plastic is a type of synthetic or man-made polymer.<sup>(3)</sup> Annually, around 50kg of plastic is produced per person around the globe, with production doubling every ten years.



In developed countries, almost a third of total plastic produced is consumed in packaging and roughly the same in buildings applications such as piping, plumbing<sup>(4)</sup>etc. Rest of the uses consist automobiles, furniture and toys.<sup>(4)</sup> On the contrary, the application of plastics vary for developing countries for instance, 42% of India’s consumption is used in packaging<sup>(4)</sup>. In the medical field, polymer implants and other devices used for medical purposes are derived at least partially from plastic.

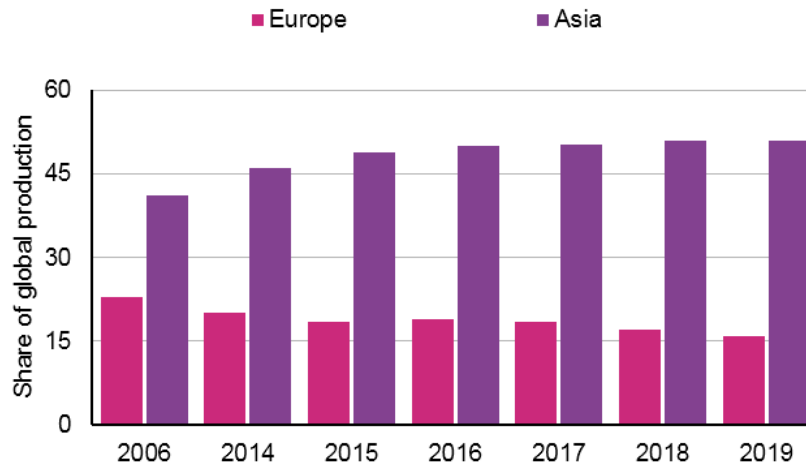
The following graph shows the annual production of plastic worldwide from 1950 to 2019<sup>(5)</sup>. According to graph we can deduce that plastic production has only increased since its invention over the past years. This can be due to the tremendous properties of plastic, for instance:

- Good safety and hygiene properties for food packaging



- Durability and longevity
- Easily mouldable into any size and shape ie. versatile
- Light in weight when compared to other material which reduces fuel consumption during transportation.

The graph below shows the annual share of plastic production in Europe compared with Asia:



According to the graph, the plastic production in Asia has only increased over past years.

Estimations show that Asia produces half of the plastic in the world. In 2019, Asia produced approximately 51% of the total plastic produced in the whole world. Which actually made it the world's largest plastic producer. Plastic production in India has increased by 10% since 2006. Where China remains major plastic producer with approximately 31% of global production.<sup>(5)</sup>

Whereas the European plastic production shows variable trends. Though less than Asia but Europe became the third largest producer of plastic worldwide in 2019 by accounting for 15% of total plastic production. However it fell slightly in 2020 to 367 million metric tons<sup>(6)</sup> probably due to the pandemic.

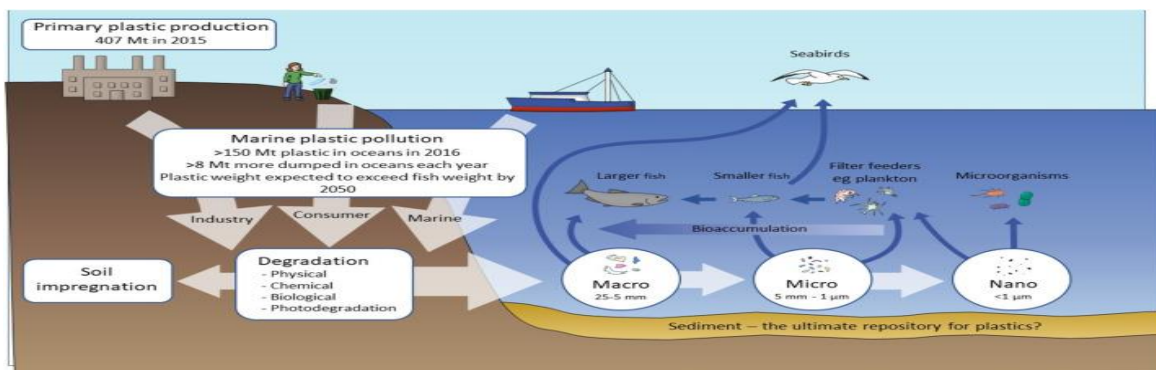
Considering the large production volumes and the longevity of plastics, it is not surprising that plastics are found in the environment. Eventually towards the end of the 20th century, the plastic industry started promoting recycling concerning the environment. However, the production of virgin plastic continued. The main companies producing plastics were not sure about the economic viability of recycling at the time. Moreover, the economic viability has never been improved either. Plastic collection and recycling is largely considered ineffective because of complexity required in cleaning and sorting used plastics. Thus, most plastic produced is not reused, it is either captured in landfills taking thousands of years to decompose. Ultimately leading to plastic pollution. Plastic pollution can be found in almost all of the water bodies. Plastics create garbage patches in the oceans and contaminate the terrestrial ecosystems.

### 1.3 Plastic and the Oceans

Everything is connected in spirit of nature. Aquatic ecosystems and the terrestrial ecosystems are inter-connected, due to which the changes in one have impacts on the other. Anthropogenic activities have stressed coastal and marine ecosystems for decades. These stresses include pollution and the physical destruction of the environment. Our ocean is being flooded with mainly two types of pollution: chemicals and trash. Accumulation of debris or litter is one of the human-induced threats on marine and coastal ecosystems that occur due to unsustainable development, construction activities, improper waste disposal and many more reasons. The trash encompasses all manufactured products- plastic litter is persistent in the ocean basins when compared with other categories of debris such as cloth, paper, food -waste, rubber, sanitary waste, metal, medical plastic waste, smoking and firework litter this is due to durability, longevity and light weight of plastics. Plastic takes hundreds of years to decompose, making it the most problematic pollutant. Plastic debris end up in the ocean in a variety of ways which makes the pursuit to stop plastic pollution more difficult There are five categories in which plastics found in the ocean can be classified based on size, that are, mega-, macro-, meso-, micro- and nono-plastics. Although there is no specified nomenclature<sup>(6)</sup> but differentiating between these is necessary as the size of plastic particles determine their



impact. Mega-, macro- and meso-plastics range in size from a few metres down to 5mm. These are identified by naked eye and mostly include wrappers, drink containers, single-use plastic bags, cigarette butts and medical and personal hygiene items such as syringes, sanitary pads and diapers. Moreover, large volume of mega- and Macro-plastic debris originate from ocean-based sources and include various items, for instance, fishing equipment, primarily in locations with intensive fishing activity.<sup>(7)</sup> In recent past, the focus of plastic pollution has been shifted from macro- to micro-plastics. The term micro-plastic is used for small plastic particles of different origins, sizes and chemical composition. Plastic compounds take up to years to get degraded in smaller fragments<sup>(8)</sup>. This fragmented plastic with size smaller than 5 mm are known as micro-plastics<sup>(9)</sup> and are highly persistent in the ecosystem. Based on shapes, sizes and chemical composition, there are two types of micro-plastics, primary and secondary.



Under the action of ocean waves and changing environmental conditions, winds and ultraviolet (UV) light, Larger plastic debris slowly degrades into small fragments with various size ranges extending from meter to micrometer. Micro-plastics that are the product of weathering are referred to as secondary micro-plastics whereas micro-plastics produced industrially in the form of plastic-based granulates or pellets that are found as micro-beads in cosmetics (often used as abrasives and bulking agents in health and beauty products, micro-beads easily wash down residential drains and pass right through the filters in wastewater treatment plants) are referred to as primary micro-plastics. Secondary micro-plastic occurs through chemical and physical razing and degradation processes of micro-plastic (plastic bags, plastic bottles, fishing nets or styrofoam (a kind of expanded polystyrene used especially for making food containers) products). As far as can be ascertained today, secondary micro-plastic is the main source of entry into the environment<sup>(10)</sup>. Nano-plastics - particles up to 100 nm in size<sup>(6)</sup> - make up the least understood area of marine litter but are potentially the most hazardous. Due to the lack of appropriate detection methods it has not been possible to assess the presence of nano-plastics in natural aquatic systems. High surface area to volume ratio of nano-plastics may promote absorption of toxic compounds, potentially leading to toxicity to marine life once nano-plastics have penetrated into cell membranes<sup>(10)</sup>.

#### 1.4 How come plastics end up in the oceans?

Operational oceanography data helps to track plastic pollution and identify its sources. Numerical models estimate the route of plastic which shed light on how plastic is distributed across the global ocean, hence revealing accumulation zones. There are three main variables that are used to determine how the debris enters the ocean, namely, watershed outfalls, population density and maritime activities.<sup>(11)</sup> Most plastic marine litter is the result of illegal dumping and poor waste management of trash. Terrestrial plastic litter is flushed into the ocean by storms and river systems or is directly discharged into coastal waters. Waste can also escape whilst being collected or transported to landfill sites if waste management procedures are inadequate.

According to the estimates, at least 60% of plastic floating in the ocean is exported from coastal to the open ocean waters. Beach goers may leave litter behind, which can include cigarette butts, food and beverage packaging, and plastic beach toys. Irrigation pipes, fertilising pellets and containers used in agricultural sector produces a significant quantity of micro-plastics that is ultimately found in the ocean. The retail sector contributes to about 40% of all plastics produced. Mostly for food and drink packaging, which are essential for hygienic reasons. Building and creation of infrastructure and services that takes place for tourism increases the quality of plastic flushed in the seas. In fact, this is the cause for 40% of the plastic pollution

in the Mediterranean Sea. The construction sector produces a large amount of plastic waste especially large infrastructure projects.

Unfortunate natural events can lead to any kind of waste accumulation into the water bodies. Though uncommon, such events can cause substantial environmental damage. In 2011 for instance, Japan's Tohoku tsunami produced a quantity of floating debris comparable to 3,200 years' worth of 'normal' debris input.<sup>(12)</sup>

Boats, ships and offshore industrial platforms are also potential sources of marine debris. It has been calculated<sup>(13)</sup> that about 1.15 to 2.41 million tons of plastic waste enters the ocean every year from rivers. Boats may accidentally lose or deliberately dump fishing equipment into the ocean. Cargo ships may discharge litter into ocean by accident

"It is interesting to note that fishing-related debris accounted for 20% of the total by number but 70% by weight, with floats/buoys predominating. Such items are a common component of shoreline debris in mid-ocean islands."<sup>(14)</sup>

### **1.5 Impact of Marine Plastic Pollution**

Plastic pollution in the ocean can have a far-reaching environmental, social and economic impacts.

#### **A. Impacts of Plastic Contamination in Marine Ecosystem on Environment**

Marine litter places additional pressure on the oceans that are already severely strained by the impacts of human actions.<sup>(15)</sup> These existing stresses contain warming up and acidification due to CO<sub>2</sub> emissions, overfishing and pollution by heavy metals and persistent organic pollutants. Although the complete scale, extent and spacial distribution of the environmental impact of it is unrevealed, there is clear evidence from field and laboratory-work that plastic debris threatens marine life and ecosystems in numerous ways:

Ingestion and entanglement are some of the critical issues associated with macro plastic fragments. Where, the entanglement effect is comparatively higher than the ingestion in coastal and marine systems. Entanglement and ingestion of macro plastic litter can be both lethal and sublethal. As a direct results of it, coastal or marine biotic organisms die or get injured lethally.

Abandoned fishing gear can continue to 'ghost fish' for long periods of time while in the marine environment.<sup>(16)</sup>

Ingestion can lead to physical damage or blockage of the intestinal tract, which can lead to infection, starvation, loss of mobility and potentially death; reproductive and other health disorders due to the uptake of polychlorinated biphenyl (PCB)-contaminated plastic fragments acting as a vehicle for PCBs into marine food chain.<sup>(17)(18)(19)</sup>

The human health effects of ocean pollutants such as methyl mercury and PCBs are already known. Maternal consumption of contaminated seafood can impact the developing brains of infants in utero, reduce IQ and increase children's risks for autism, ADHD (Attention deficit hyperactivity disorder) and learning disorders. Risks for cardiovascular disease and dementia is increased when adults are exposed to methyl mercury. The human-made chemicals can reduce male fertility, damage the nervous system, disrupt endocrine signalling and increase risk of cancer. HABs produce potent toxins that can accumulate in fish and shellfish which can intern cause neurological impairment and rapid death. HABs become airborne and can cause respiratory disease. Pathogenic marine bacteria cause gastrointestinal diseases and deep wound infections. With change in the temperatures, climate and increasing pollution, it is certain that *Vibrio* infections such as cholera will increase in frequency and expand to new areas. All of the health impacts of ocean pollution fall disproportionately on vulnerable populations in the Globe.

Floating litter can act as a vector for the transport of species, with slow travel rates providing time for species to adapt to the changing environmental conditions. The introduction of non- native species through this transport mechanism can have detrimental effects on marine species diversity<sup>(20)</sup>



**B. Impacts of plastic contamination in marine ecosystem on Society**

Marine debris can impact the society in many ways such as it can cause direct short-term public health issues due to entanglement of anchors in abandoned fishing gear that can be the cause of vessel breakdowns leading to loss of human lives. Entanglement of swimmers and scuba divers can impact their health and in extreme cases lead to their death. Indirect, long-term impacts on quality of life such as recreational opportunities, loss of aesthetic value as a coast littered with plastic does not look as pretty and welcoming as a pristine beach<sup>(21)</sup>

**C. Impacts of plastic contamination in marine ecosystem on Economy**

Every year economic damage of around \$13 billion happens due to plastic pollution in marine ecosystems<sup>(22)</sup>. The damage includes the loss in the fishing and tourism industry along with the cost of beach clean ups. We already know that tremendous properties of plastic is the reason behind its popularity. However it is also known that plastic doesn't degrade. In fact, it disintegrated into micro-plastics that are consumed by the fishes. It is estimated by the scientists that there are more micro-plastics in the oceans as compared to the stars in the Milky-way. China stopped accepting used plastic for recycling on 1 January, 2018<sup>(23)</sup>. China's recycling facilities were overwhelmed because of contaminated recyclables. Due to which, many government aided recycling programs have come to a halt. Which has only made plastic pollution problems worse. Without China, recycling process is coming out to be too expensive for many countries.<sup>(24)</sup> All over the world, 127 countries have banned some specific types but not all kinds of plastics.<sup>(25)</sup>

"The greatest threat to our planet is the belief that someone else will save it" -Robert Swan

**1.6 Solutions**

This plastic problem is enormous, but it can be solved and immediate efforts should be made to look upon and strengthen existing international legislative framework that addresses marine plastic pollution.

**A. Governments should act immediately**

Research institutions and industries need to work collaboratively to redesign products and rethink use and disposal to reduce micro-plastics. Governments should insist the consumers of their nations to shift to more sustainable plastic consumption patterns which will actually require solutions to go beyond waste management and consider the whole material flow of plastic products in the environment.

**B. We must reduce our plastic dependency**

Reducing our own consumption of single-use plastics is the most easy way in which we can get started. Single-use plastic consist of water bottles, plastic straws, glasses, cups, utensils, dry cleaning sheets, use and throw containers or any other plastic article that is once used and then discarded. Many countries have started imposing a ban on disposable plastics and plastic bags. They have also established concrete targets to reduce plastic consumption and manage waste. In order to take global plastic consumption down, this effort must be scaled up. Public can do its part by refusing to use these products

People should participate or organise cleanup drives for beaches or any other local water body and remove plastics from the oceans or prevent them from entering the ocean in the first place. These drives are the most direct and effective way to fight marine plastic pollution. People can alone or with any friend or family member can directly go to any beach and collect plastic waste. Otherwise, people can participate in any local no-governmental organisation.

Increase fees and taxes on polluting plastics: Plastics produced these days act as a source to both climate emissions and pollution because they are produced from oil. In spite of that, Renewable plastic is still expensive than fossil plastic. Governments should take immediate actions by implementing a tax or a fixed amount of fee on plastics. This fees must be changed keeping in mind that recycled plastic should become cheaper than fossil plastics.

Increased waste management where the problem is greatest: Developing countries are the reason for bulk of plastic. fast increase and a swelling socio-economic class means that the consumption of plastic is increasing quicker than the capability to handle the plastic waste, and thus abundant of the surplus finally ends up within the ocean. China and land area unit among the countries that manufacture the foremost plastic waste. As a part of the answer, a global aid programme ought to be established to develop waste management and utilisation infrastructure.

**C. Avoiding products that consist of Micro-beads**

Micro-beads” are the tiny particles that are frequently becoming one of the major source of ocean pollution. They are found in face-scrubs, beauty cosmetics, body washes and enter the oceans through sewage which is consumed by marine animals. In order to prevent this. We should avoid products that consist of microbes by looking labels like “polythene” and “polypropylene”. We should eat food that is healthy for both the ocean and us. Such kind of food is available in well-managed fisheries.

**D. By Exploring the Oceans**

“People try to protect what they love.” -Jacques-Yves Cousteau

We should get outside and explore the sea around us. If there is no nearby sea or ocean, we should visit our local lake or river in order to learn how the watershed connects to the ocean. There are plenty of online opportunities to explore the oceans, as well. We need to dive into the ocean and read fun and interesting facts about all kinds of animals from sharks and seals to octopuses and clown fishes.

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