

Deterioration of aquatic environment by disposal of plastic litter: a review

Trishna Sarkar, Koushik Saha

Abstract— This review paper describes the sources of plastic debris found in water bodies and their fatal effects over the aquatic life. Plastic being versatile in properties considered as one of the most important man-made product that has been formed in large quantity and is used worldwide for various purposes in our day to day life. Due to longer life-span and resistance to degradation, most plastic litter which has ever been introduced into the environment still continued to exist. Plastic litter in the marine environment cause detrimental effect on aquatic life through plastic ingestion and entanglement. Most of the aquatic organism engulfs plastic debris as a source of food causing interference in food chain. Finally, suggestion have been recommended to control the amount of plastic entering the marine environment and governments should play an important role in creating public awareness of plastic pollution by introducing regulation over the use of plastic additives to control plastic contamination in marine ecosystems. In addition, new technologies should be adopted to reduce the plastic pollution in marine environment and make it fit for existence of aquatic life.

Index Terms— Plastic litter, source, effects, pollution, marine environment.

1 INTRODUCTION

Disposal of plastic contaminant in the natural environment has drawn much attention from both general civic and the researchers. Plastic considered as one of the most important man-made product that has been formed in large quantity and is used worldwide for various purposes in our day to day life. Nearly 280 million tons of plastic are produced each year for manufacturing of containers, utensils, packaging materials and other purposes [1]. Most of this plastic wastes are disposed of in the marine environment creating threat to health and safety of marine life. Chemically, plastics are synthetic or semi-synthetic organic long hydrocarbon chain polymer that are lightweight, low cost, strong, tenacious and corrosion-resistant [2]. Since plastic are made reliable by adding different additives extracted from oil, microorganisms cannot identify plastics as their food and thus plastics are not subjected to natural degradation [1]. Only physical forces such as winds, waves and ultraviolet radiation can breakdown larger plastics into smaller pieces in the marine environment [3].

The most commonly used plastics and abundant polymer are low-density polyethylene (LDPE), high density polyethylene (HDPE), polyethylene terephthalate (PET), polypropylene (PP), polyvinyl chloride (PVC), polystyrene (PS), nylon, teflon and thermoplastic polyurethane (TPU). [2] As a consequence, these high polymers plastics are very commonly found in the environment, importantly in aquatic environments [4][5].

The lasting nature of plastics is a matter of concern because of all the everyday plastic which has ever been introduced into the environment still continued to exist either as whole items or as fractional item [6]. Plastic not only make their way into the aquatic environment but are also more easily consumed by aquatic organisms as a source of food which act as carrier for the chemical transfer of pollutant within the food chain and thus disturbing the marine life [7]. It has been estimated that annually, more than 500 billion plastic bags and 35 million plastic bottles are used by the consumers, many of which ends up in our marine and along our shoreline creating negative impact over freshwater biodiversity and ecosystem [8]. Lightweight and highly floating nature of most of the plastic waste is capable of travelling along with the currents for thousands of miles distance, thus affecting the marine wildlife [9]. For example, pill bottles from India travels along with oil and detergent containers from Russia, Korea, and China and ultimately have been found on the southern parts of Hawaii [10]. This review paper describes the sources of plastic debris found in water bodies and their fatal effects over the aquatic life. Finally, suggestion have been recommended to control the amount of plastic entering the marine environment and raise human awareness over the effects of plastic litter.

2 SOURCE

The major sources of plastic waste can be widely distinguished into land-based sources and ocean-based sources. The land-based source of plastics includes plastic bag usage and solid waste disposal contributing 80% of the plastic debris in the marine environment [11]. For example the coastal recreational activities related debris, mainly consists of direct discard of food and beverage packaging material, beach toys and recreational articles by beach users [12]. A study by Redford [13] found that huge amount of plastics debris derived from raw manufacturing materials were transported onto beaches due to accidental handling and other processes. Other land-based sources include wastewater effluent that are transported from wastewater treatment plant to the marine environment [14] [15]. Also certain extreme natural hazards like hurricanes or flooding increase the transport of land-based debris to the ocean [16]. It has been found in

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California river waters volume increased due to accumulation of microplastics that increased from 10 to 60 plastic particles m^{-3} after a storm [17]. The Ocean-based debris include fishing-related, and ship or boat-related sources which account for the remaining 20% of marine environment. In 1975, the sinking of a fishing vessels into the sea incident resulted in 135,400 t of plastic fishing gear and 23,600 t of synthetic packaging material into the sea [18]. Currently, an estimated 640,000 t amount of fishing gear discarded into the ocean environment every year, which amounts to approximately 10% of the total sea debris [19]. These discarded fishing items, including fishing lines, nets and ropes, floats and packaging material, at certain depths within the ocean, which may cause the entanglement of aquatic organisms.

3 The effect of plastic in aquatic life

There are few information are found about the pollution of plastic waste in marine environment. It is directly or indirectly affecting the food chain of aquatic life. Among all the marine mammals, seals are mostly affected because it store toxins in their blubber. The fishes and mammals those belongs the top most place of aquatic food chain are directly or indirectly affected by consuming toxins mixed with the polluted sea-water or other small fisher those have directly consumed higher level of toxins[20]. Though these plastic is increasing now in days, the pollution of marine environment is increasing with the same rate as well. Robards investigated about the gut content in body sea-birds and got in his studies that the plastic particle indigestion by sea-birds becoming greater in amount during in an interval of 10 to 15 years in between his investigations[21]. According to an investigation in North Pacific plastic particles are observed in body of 8 sea-bird species out of 11 are affected [22]. The total percentages are 86, 44 & 43 of all sea-turtle, sea-birds and marine mammals are affected respectively and this problem is mostly ignored because the amount of victim is very small with respect to the large area of occasion.

Some experiments were done by Rayan on seabirds to find out the affects of plastic particle in body of seabirds [23]. He also found out the result of same investigation done with some domestic chicken. It was observed that mixing polyethylene pellets with the food of birds can decrease the food digestion capacity of birds and due to that the birds consumed small quantity of food. So less food consumption reduce the energy and strength of the birds. Connors and Smith [24] had observed that engulf of plastic particles prevent the formation of fat deposits and thus adversely affecting their reproductive system, reducing the breeding capacity. Spear noticed the negative activities of plastic particle consumed by seabirds in their body, it become more harmful when plastic particle get stored in the stomach of seabirds, stop the secretion of gastric enzyme, limits steroid hormone levels, and affect the reproductive system[25] [26]. The engulf of plastic particle by fish and seabirds can slow down food consumption capacity which may cause damage the organs from inside and it leads to death [27] [28][29][30].

The amount of the harm, will differ among various category. Laist [31] and Fry et al. [32] examined and studied that developed chicks can recognize the plastic particle during consuming food and spit those up to make their food free from organic polymer and pollutant. Most of the chicks from Laysan albatrosses (*Diomedea immutabilis*) in the Hawaiian Islands are inefficient to spit up plastic materials that sore in their stomach and damage internal organs of their body. On a

survey it is shown that plastic particles accumulate in body of 90% chicks [33]. Antarctic and sub-Antarctic seabirds are also suffering from the same problem [34]. Similarly Wilson's storm-petrels (*Oceanites oceanicus*) collected plastic particle from their stomach in winter from different places [35]. Plastic can also destroy the ecosystem of marine environment due to its unique properties. It makes smooth layer on the surface of seafloor. This smooth layer is responsible to prevent the contact between sea water and pore water. Lack of contact can close the gas interchange between sea water and pore water this may destroy the organism of benthos.

4 Suggestions for control of plastic debris.

The transport of plastics in our ocean environment and the effects on aquatic life has been researched for over 30 years. The huge effects of plastic waste is reaching far than that is previously thought. Therefore, only option left is to find innovative solution for the proper collection, separation with recycling and reuse of plastics debris to reduce the negative impacts on marine life as well environmental ecosystem. Governments should play an important role in controlling plastic contamination in marine ecosystems. More resources should be provided to investigate the long-term effects of plastic debris, especially microplastics, on marine organisms. Because microplastic pollution is still increasing day by day, the potential threats on ecosystems remain uncertain. In addition to regulation, it is important to increase concern and investments in the development of plastic collection by means of various technologies. Several advanced technologies have been developed for the collection of plastics from waterbodies such as "plastic-eating drone" has been proposed as a solution for cleaning up marine plastic refuse. This technology relies on an autonomous device that consists of trapping net, which could collect plastic debris from ocean waters [36]. Though many people would go for the idea of recycle household plastic items with the assumption they can all be fully recycled, only about 10 % of plastics are being recycled back into plastics[37]. In most of the cases plastics are deposited in landfills or incinerated [38]. Several methods for chemical recycling involving gasification or smelting are currently implemented over plastic debris [39]. Thermal degradation may be the new method to recycling of plastics without causing any further environmental deterioration [40]. Petroleum-based plastic are heated upto a temperature of 25 to 430 °C followed by conversion into liquid hydrocarbon fuel, during this thermal degradation process, [41]. It is recommended that if the amount of plastic waste circulating in the ocean gyres can be gathered using collection vessels, then this waste can then be converted into hydrocarbon fuel [38]. Moreover, public awareness should be created about the problems produced by microplastics, an important step towards changing people's overview regarding plastic consumption. Because the matter of plastic litter into sea is not common to the general public, it has been suggested to raise public awareness of plastic pollution on the international political agenda. A number of national and international regulations exist for preventing plastics pollution. Regarding this, awareness should be raised by launching different campaigns programme to those stakeholders that play an important role in plastic littering, including plastics industries, marine businesses and general civic. It has been suggested to organise campaigns on a global scale by large multinational organisations, such as the United Nations Environment Programme (UNEP) and the International Maritime Organisation (IMO), to arise concern about the fact. It has been recommended that high biodegradation materials such as starch may be used instead of non-degradable and synthetic material[42]. Also bio-

degradable material will be more readily degraded by bacteria and fungi, reducing the durability of these plastics in the natural environment [43].

5 Conclusion

In compact plastic litter in water bodies and beach sediment is very common that come from sources, land-based and ocean-based. Different activities like domestic, industrial, fishing and recreational play the most important role as contributors. People generally discard plastic in landfills or burn them, but burning plastics generally produces some harmful gases like furans and dioxins, which are considered as hazardous greenhouse gases and obviously play an important role in ozone layer depletion of atmosphere. The introduction of plastic litter in the marine environment cause detrimental effect on aquatic life through plastic ingestion and entanglement. Most of the aquatic organism engulf plastic debris as a source of food which act as carrier for the contaminant transfer of pollutant within their body; these organisms may also become entwined in the plastic, which can be dangerous even deadly. Finally governments should play an important role in creating public awareness of plastic pollution by introducing regulation over the use of plastic additives to control plastic contamination in marine ecosystems. In addition, new technologies should be adopted to reduce the plastic pollution in marine environment and make it fit for existence of aquatic life.

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