

Impact of Plastic Pollution on Ocean and Control Measures

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Abstract. As plastic production has increased exponentially in the last 15 years, plastic pollution has become one of the most serious environmental issues in the world, due to its nonbiodegradable properties. Therefore, plastic production has caused lots of problems for the natural environment and wildlife, especially the ocean and marine organisms. In this paper, the severity of plastic pollution and its effect on marine ecosystems are explained, and the measures that can reduce plastic pollution are discussed. In the future, people should limit the use of plastic products, and the improper disposal of plastic items should be prohibited. This study provides a theoretical basis for people to learn about how plastic pollution negatively affects the ocean environment and what humans can do to reduce the negative impact of plastic pollution on the ocean.

Keywords: Plastic pollution; marine ecosystem; impact; plastic recycling; plastic disposal.

1. Introduction

Plastic pollution has become one of the most serious environmental issues in the world. Even though plastic was invented only 100 years ago, its production has increased dramatically after the Second World War. A large portion of plastic products is disposable, such as plastic bags. However, these plastic products can persist in the environment for hundreds of years, which has a negative impact on the environment and organisms. Ocean suffers more from plastic pollution because most of the plastic waste generated on land escapes into the ocean. These plastics can affect ocean biodiversity and damage marine ecosystems. Therefore, it is necessary for people to work collectively to address this issue.

There is a lot of research that records the average production of plastics every year and the amount of plastic that flows into the ocean every year. Besides, several disposal methods have been proposed to recycle the plastic waste. Nevertheless, due to the different recycling rates in different countries and the low efficiency in collecting plastic waste, plastic pollution is not alleviated.

At the beginning of this paper, the characteristics and the production process of plastic will be introduced. Then, the plastic pollution in the ocean and its impact on marine organisms will be discussed. Moreover, the disposal and recycling of plastic waste will be proposed. Finally, this paper will discuss what individuals and society can do to limit the use of plastic products.

2. Current Situation of Plastic Pollution

Plastic has become one of the most crucial materials for modern society. It has been used in many different aspects of life, such as packaging, smart home appliances, and so on. Thus, plastic is produced on land on a large scale. It is recorded that plastic production in the world has increased from 1.5 million metric tons in 1950 to 395 million tons in 2018 [1]. However, a lot of plastic waste is not managed properly, for example, much plastic waste escapes into the environment without being recycled, incinerated, or kept in landfills. These wastes are detrimental to the ecosystem and the health of organisms. Because the ocean is downstream from the terrestrial land, a large amount of plastic waste is released into the ocean [1]. These wastes flow into the ocean through large rivers or streams. According to the statistics, about eight million tons of plastic waste is released into the ocean each year [2]. The ocean is full of plastic now, which has threatened the lives of marine animals and jeopardized the marine ecosystem. Hence, the issue of plastic pollution is extremely severe, especially in the ocean.

3. Characteristics of Plastic and Production Process

3.1. Characteristics of Plastic

Plastics are polymeric materials made from fossil fuels, and the molecules of plastics are very large, which look like long chains [1]. Generally, plastics have many properties, such as low density and electrical conductivity. The most important characteristic of plastics is plasticity, which means they can be made into different shapes. Plastics can be divided into 2 major groups. One kind of plastic is called thermoplastic, which can be molded again and again. Polyethylene and celluloid all belong to thermoplastic. Another type of plastic is called thermosets, which have a fixed shape and cannot be remolded. Common thermosets include polyester resin, melamine resin, and so on [3]. Plastic has different sizes. Macroplastics are plastic items with sizes more than 5mm. The longest length of microplastics is about 5mm-0.1 μm . Nanoplastics have a length smaller than 0.1 μm , which is ten times smaller than a single particle of fine clay.

3.2. Plastic Production Process

There are several steps to make plastics. Extracting fossil fuels like coal and crude oil is the first step as most plastic is made from fossil fuels. Secondly, the fossil fuels are sent into the distillation tower for a refinery. Distillation towers can purify the liquid product. For instance, when petroleum, which is hydrocarbons, is put into the distillation tower, it will be divided into different fractions, such as naphtha. Naphtha is the starting point or feedstock for many chemical materials and plastics. The third step is cracking, which is the chemical reaction that breaks down hydrocarbons into alkene or alkane. After cracking, monomers are linked together to form polymers through polymerization reactions. There are 2 kinds of polymerization reactions: addition polymerization reactions and condensation polymerization reactions. Addition polymerization reactions take place when the monomers are simply linked together. Condensation polymerization reactions take place when two monomers are linked together and form another product, like water. Fabrication is the last step. There are several types of fabrication methods, including molding, welding, and so on. Molding transforms the liquid plastic into a solid form with a specific shape via a molding machine [4]. Welding links two or more plastics together by heating them at a high temperature. For example, plastic welding rods are used to connect two pieces of plastic items. Welding rods have different colors to match the color of the plastic [4].

3.3. Plastic in the Ocean

Plastic production has increased considerably in the past 15 years. It is estimated that the number of plastic humans has produced in the past 15 years has exceeded the total amount of plastic produced in the last century [5]. What is more serious, many plastic products are not disposed properly: a lot of plastic items are discarded on the land, and ultimately escape into the ocean through rivers or streams or by littering. At the current times, about fifty to seventy-five trillion pieces of plastic and microplastic are in the ocean [5]. It is predicted that the total mass of plastic will be greater than the total mass of all fish in the ocean by 2050 [5]. Moreover, it takes 500 to 1000 years for plastic to degrade. Thus, the ocean has already been seriously affected by plastic pollution.

4. Impact of Plastic Pollution on Ocean Organisms

Plastic pollution is responsible for 80 percent of marine pollution [5]. Plastic pollution has a serious negative impact on marine ecosystems and ocean organisms. It will directly kill animals by ingestion. A lot of marine animals, from sea turtles to sea birds, are likely to ingest plastic items in the ocean, increasing the risk of suffocation. It can also kill animals slowly through entanglement. Furthermore, plastic will break down into microplastic after a period of time. When microplastic enters the body of marine species, it can harm wildlife by accumulating toxins and causing physiological changes. If plastic waste is not disposed properly, 99% of marine animals will ingest microplastic by 2050 [6, 7].

On the other hand, it will depress the photosynthesis rate of marine plants, such as algae, which leads to lower oxygen levels in the sea and the death of marine plants. Marine plants are a vital part of the ocean ecosystem. The decline in marine plant population will decrease biodiversity in the ocean and cause habitat degradation.

4.1. Impact of Plastic Pollution on Marine animals

Plastic has adverse effects on marine animals, for example, when marine wildlife comes across plastic, they are likely to ingest them accidentally, which leads to suffocation, entanglement, and internal injuries. When plastic enters the body of animals, it can block digestive tracts and damage the organs of marine animals, such as the stomachs. Moreover, entanglements will hurt the skins of marine wildlife and negatively affect their ability to move and hunt. Animals, like seabirds and sea turtles, will die slowly and painfully if they are trapped in plastic. It is reported that 914 marine species (226 kinds of seabirds, 430 kinds of fish, all sea turtles, and 86 kinds of sea mammals) have accidentally ingested plastic and suffered from entanglement [6]. Furthermore, there are 693 species of animals in the International Union for Conservation of National Red List, and 17 percent of them have been affected by ingestion of plastic and entanglement [6, 8]. Therefore, plastic in the ocean creates huge problems for the survival of the marine species. Fig. 2 is the impact of plastic pollution on marine animals.



Fig. 1 Photograph taken by Flip Nicklin.

<https://www.nationalgeographic.com/environment/article/plastic-pollution>

4.2. Impact of Plastic Pollution on Marine Plants

Plastic pollution can not only harm marine animals, but also it has a negative effect on ocean plants. For example, algae is one of the ocean plants that suffer from plastic pollution. The photosynthesis rate of algae will decrease if it is covered by plastic. The lower rate of photosynthesis means a lower level of oxygen in the ocean, causing the deaths of marine organisms and biodiversity loss [9].

Meanwhile, plastic has caused great damage to the mangrove forests, which are the trees that live in the coastal lines. The upper trunk and branches of mangrove forests are above the seawater, and the roots of mangrove forests are settled in salty sediment. Mangrove forests prefer wet and warm climates, so most of them are located in tropical areas, such as Mexico, Indonesia, and so on [10]. Mangrove forests are key parts of the ocean ecosystem since they provide habitats for numerous marine species and amphibious animals [10]. Mangrove forests are also primary habitats for seabirds

and some terrestrial animals [10]. They can protect coastal areas from erosion and tropical storms [10]. However, when plastic waste is carried into the sea, most of it accumulates in coastal areas and mangrove forests, resulting in lower tree health and lower biodiversity. It has been studied that 2700 plastic items are found in every 100 square meters of Javan mangrove forests, and plastic covers 50 percent of the forest floor in various locations [11]. It has been proved that the survival rate of trees declines when plastic waste covers the roots of trees completely [11]. Therefore, plastic pollution has a great impact on ocean plants and is associated with biodiversity loss.

5. Measures to Reduce Plastic Pollution

The massive production of plastic has affected our environment adversely, so there is an urgent need to manage plastic disposal properly and reduce the negative impact of plastic pollution on the habitat. Society has established several measures and developed several strategies to dispose plastic waste, such as incineration, landfills, and recycling. It is also very important for individuals to reduce plastic waste and raise their awareness of protecting the environment.

5.1. Incineration

Currently, there are 3 main strategies to manage plastic disposal, including incineration, landfills, and recycling. Incineration is the burning of plastic waste, and it forms ash, a small amount of hydrochloric acid, and other volatile gases. Incineration is one of the most essential methods to manage plastic waste. According to the data, People in the European Union usually generate 481 kilograms of plastic waste on average. Among this waste, 26 percent of it is recycled, 31 percent of it is landfilled, 15 percent of it is compost, and 26 percent of it is incinerated [12]. However, between 1995 and 2013, only 18 percent of plastic waste was incinerated [12]. Therefore, incineration is a critical plastic waste treatment. Incineration can decrease the amount of plastic waste in the environment and produce heat and power for a lot of human activities. However, incineration also has several drawbacks, such as high costs. Moreover, it will release ash and chemical gases that are harmful to humans and the environment, including nitrogen dioxide and sulfur dioxide.

5.2. Landfills

Landfills are the major plastic disposal method in the world now, which account for about 40 percent to 60 percent of plastic management [13]. Through this process, plastics are buried under the surface of the Earth. It generally takes a long time to dig deep holes where plastic waste is put. It also takes a long time for plastic to decompose and degrade naturally, usually about ten to one hundred years. Even though landfills can segregate plastic waste from the surface of the Earth, they pollute soil and underground water through permeable components in the plastic, such as heavy metals (Zn, Sn, Pd) and plasticizer phthalate [13]. Furthermore, they can release greenhouse gases, such as methane and carbon dioxide, into the air because of the decomposition of organic matter, which contributes to global warming and air pollution.

5.3. Recycling

Recycling is the process that converts plastic into its raw materials and reuses it to make new valuable items. There are 2 kinds of recycling: mechanic recycling and chemical recycling. Mechanic plastic recycling can be divided into 6 steps. The first step is collecting, which generally refers to collecting plastic waste. The second step is sorting. Plastic is sorted based on its size, material, and many other properties. The most common way to sort plastics is to put them on a conveyor belt, and an infrared detector will sort out the plastics with an actuator [13]. (figure D) Recently, X-ray fluorescence detectors were invented and can be used to recognize heavy metals trapped in plastic. After sorting out the plastic waste, it requires washing to remove contaminants such as dirt and other impurities from the plastic. Plastic is cleaned with detergents, using cold or hot water. The fourth step is resizing, which refers to granulating the waste into smaller particles. Resizing the plastic can

increase the surface area of the plastic and makes it easier to reshape [14]. This process is often done with metal and magnetic detectors to detect whether there is any metal left. The fifth step is the quality test. The quality of the plastic, including its density, melting point, and color, will be examined during this step. Moreover, the air classification will be tested. Air classification is used to describe how thin or thick the plastic particles are. The final step is compounding. The small plastic particles are melted together into plastic pellets and these pellets can be made into other materials for future production.

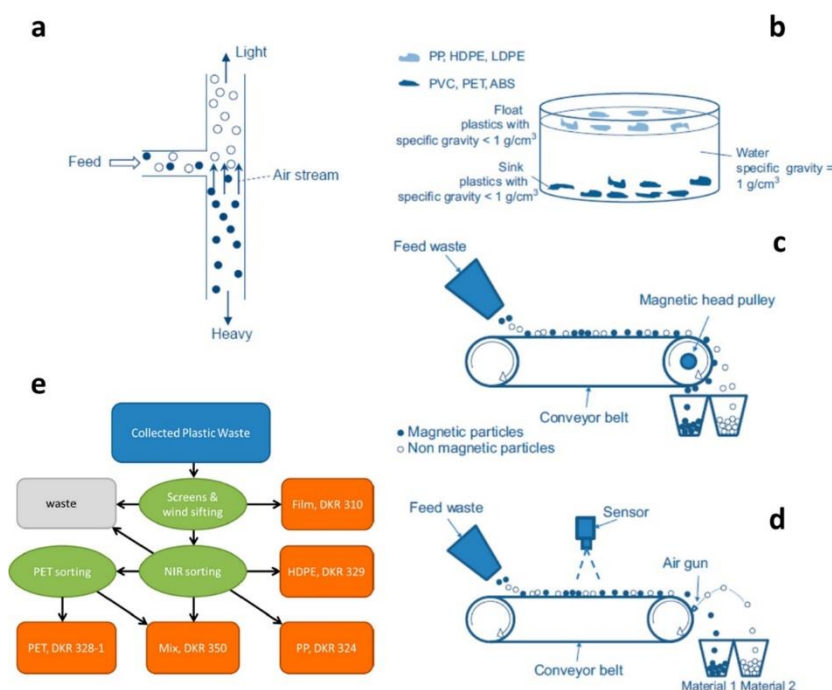


Fig. 2 Sorting technologies. (D) sensor-based plastic sorting
<https://doi.org/10.1021/acssuschemeng.1c05013>

5.4. Individual and Public Practices to Reduce Plastic Pollution

The best way to stop plastic pollution is to prevent plastic waste in the first place. Consequently, it is necessary for individuals to reduce plastic use. For example, bring a cloth bag to the supermarket rather than using plastic in the market. Moreover, reducing the use of disposable cups. Meanwhile, governments should carry out new policies to prevent new plastic waste from entering the oceans. Plastic pollution is an international issue that requires our collective effort, and a small change in our habits can make a big difference to the current situation.

6. Conclusion

In the last decades, plastic production has increased dramatically, and a lot of plastic waste escapes into the environment, especially the oceans, because of the irresponsible disposal of plastic waste. The current situation of plastic pollution is critical, because it has caused environmental degradation and imposed threats to live organisms. Individuals and society should reduce plastic use urgently and support the right legislation to prevent plastic waste from entering the environment. This paper discusses the production process and properties of plastic as well as the current situation of plastic pollution in the ocean and its negative effect on marine organisms. In the end, the disposal methods and solutions to plastic pollution are studied. In the future, the techniques of recycling plastic waste will be more efficient and cheaper, and degradable plastic might be widely used. This paper explains the impact of plastic pollution on the ocean and gives a brief introduction to the disposal method of plastic waste.

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