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Impacts of Plastic Waste on the Environment and Human Health: A Narrative Review

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Abstract

Plastic is one of the most useful materials ever produced. Its renowned contribution to various fields is unprecedented. The natural characters of plastics including its inert nature, resistance to rust, and durability are among the major characters that allowed its very wide, and versatile spectrum of use, hence making it rather inseparable part of our lives. Plastic is a non-degradable material that takes years to break down once landfilled. In addition, plastic production may also provoke some serious public health effects among people living near production sites. Residues of plastics reaching the marine environment can cause substantial damage to marine lives, with the possibility of affecting people who feed on contaminated fish. Single use plastics are particularly posing potential damage to humans and environment alike. The present study portrays some parts of the negative impacts of plastics inflected on some environmental attributes, with special reference to marine environment and human health. The study has also explored how the public would conceive plastic waste problems and how to manage it. Various views were reported, expressing various alternatives.

Keywords: plastics; waste; residues; management; impacts; public view

Introduction

Plastic history

The first invented plastic polymer goes back to 1869 marking a revolutionary finding that helped millions around the globe from the social and economic constraints caused by the growing need of natural resources, especially wood [1]. Plastics, the affordable new invention has created a new added value for use in myriad purposes. The Second World War ushered a new era for industry and innovation that allowed the introduction of plastic. The need to preserve the scarce naturally produced material has opened the door to synthetic material as a major priority. Nylon, invented in 1935, as a man - made silk was extensively used for war gear including, ropes, helmet liners, parachutes and many others. The emergence of the plastic industry has thrived rapidly after the war, and plastic has become a major issue at production and use levels [1].

Public concerns about plastic waste

The rosy expectations about plastic has had its unforeseeable end when huge volumes of plastic debris were seen in large quantities floating in the oceans in early 1960s, [2], and the perception about plastic as the dream material was gradually fading away (Figure 1).

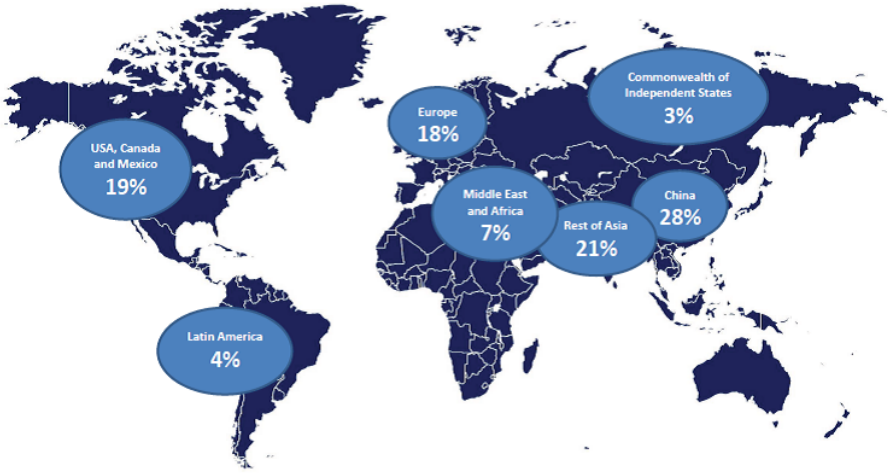

Figure 1. Global distribution of plastic production (Barra and Leonard, 2018)

With the growing interest in environmental safety and integrity, the persistence of plastic became a big taboo that alarmed environmentalists. The rosy image of plastic has fallen even further in the following decades 1970s and 1980s as worries about plastic waste became an alarming fact [3]. The growing volume of literature and research that uncovered the impact of plastic on human health was the last straw, and the entire perception to plastic has dramatically changed (Figure 2).

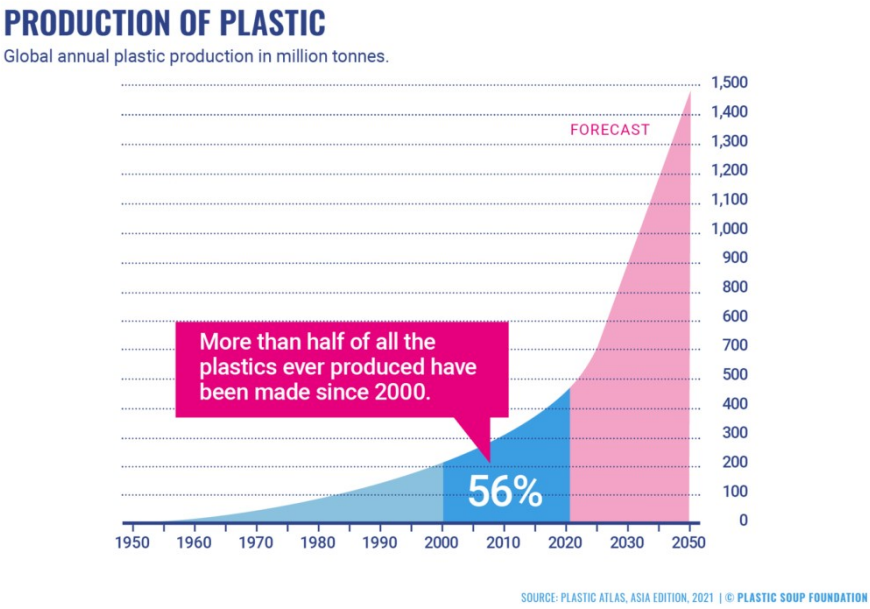

Figure 2. Source: (Plastic Soup Foundation, 2021)

Plastic impacts, the other side of the coin

The massive scale of plastic production and the inefficient disposal practices have been of growing effects on human wellbeing and the environment, including impacts on biodiversity, marine pollution climate change, and chemical pollution, meriting stringent measures [4]. Plastics are used in very wide sectors of industries and services that include, but not restricted to toys, construction, packaging furniture, packaging, automotive manufacture, shoes. Plastic is also a main component of many other commonly used objects that include, but not restricted to electronic appliances, vehicles, aircrafts, agriculture tools, and so many other utilities and components. Such big demands for plastics was reflected in a massive production that exceeded the production of any other man - made material [3], Plastic production has hit a record volume of twenty-fold between 1964 and 2015, reaching 322 million metric tons (Mt) [5]. One of these studies indicated that annual plastics production at world level has increased from 2 Mt, up to 380 Mt between 1950 and 2017 [3]. Meanwhile, plastics production is likely to double by 2035 and is expected to quadruple by 2050 [6].

Plastic in the environment

Plastic is one of the most largely produced synthetic materials at global level (Figure 1, 2 and 3). As a result, huge volumes of plastic waste and debris constitute a stagnant issues at global level. Plastic is also a very stable and persistent material that stay in the environment for a long time up to 500 year [7]. The long persistence of plastic could inflect substantial damage, affecting biodiversity, and various ecosystem services that support life.

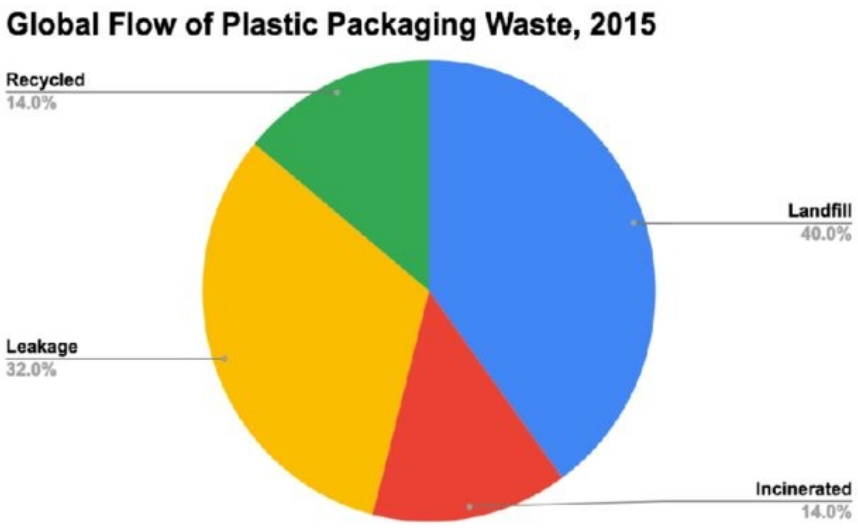

Figure 3. Global flow of plastic packaging waste, 2015

It is currently well acknowledged that plastics are the biggest threat to coral reefs after climate change. It increases the likelihood of disease outbreaks by more than 20 times, threatening marine habitats that provide food, coastal protection, income, and cultural benefits to millions of users in various parts of the world [7]. Plastics are also easily transported for long distances starting from source areas, and tend to accumulate in oceans as their major and final sinks [7-9]. Marine pollution caused by plastic debris, especially microplastics, is an issue of considerable concern with the volume of plastics in the ocean is reaching million tonnes/year (Figure 4) [10-12].

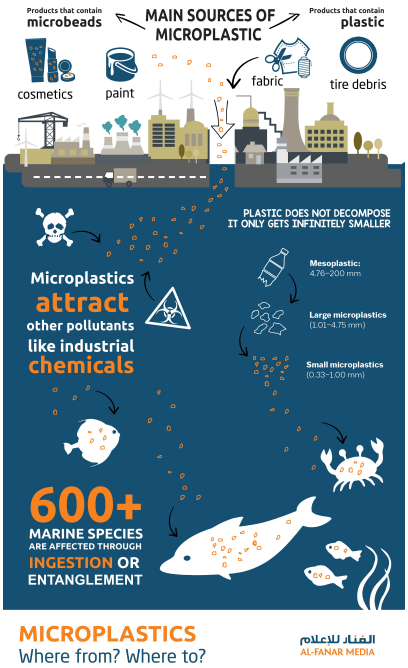

Figure 4. Plastic Micro plastic in marine environment. Source: (Blanket 2017)

Once enters the marine environment, plastic would disintegrate into very small pieces (microplastics), easily picked up by marine organisms, including fish and other, ending up in the food chain, and eventually moving to humans causing substantial damage to fish consumers. Waste plastics would also cause substantial damage to terrestrial and fresh-water systems, including ingestion and entanglement of animals, blocked drainage systems besides many negative aesthetic impacts. Because of the light

weight of plastic it tends to transport easily from source points in comparison to other dense materials such as glass and metals.

Sources of marine plastics pollution

Some reports have indicated that an average of around 80%–90% of ocean plastic originate from land sources. This would include but not necessarily restricted to rivers, fisheries, ships, cruises, aquaculture, private boats and ships. Reports have also indicated that almost 80%, of plastics leaking into oceans is a result of inefficient collection schemes and lack of good waste management infrastructure in many countries [11].

Godfrey et al. [13], also added that there is no doubt that the leakage of waste into the environment, and plastic into our oceans, must be stopped. How this is achieved must be determined by each country, based on their set of conditions, in partnership with key stakeholders from business and civil society, and must be appropriate for local conditions.

Potential impacts of plastics on humans and human health

Various reports have portrayed the wide impacts of plastic waste on human health and wellbeing [14]. The uptake of marine biota of nanoplastics and microplastics is one of the major factors that cause substantial harm to marine biota.

Impacts are caused by their physical nature if ingested and by transfer of chemicals associated with them, including persistent organic pollutants (POPs) and endocrine disruptor chemicals (EDCs).

Because of their affinity to attract and absorb water insoluble chemical species present in the marine system, microplastics tend to accumulate high concentrations of POPs and other toxic chemicals. Hence serving as a pathway for their transfer to aquatic organisms, and eventually human beings [15]. One of the most worrying impacts of plastic leaking into the marine environment is the release of endocrine disturbing chemicals including phthalate esters, an extensively used chemical in the production of plastics. Experimental research on animals have already demonstrated that even at low-level, exposures to endocrine disturbing chemicals (EDCs) may cause transient and permanent changes to endocrine systems. This is mainly because of the ability of EDCs to compete, mimic, and also disrupt the ability to produce of endogenous hormones [16,17].

Box 1

How to Deal with Single Use Plastics Waste

More than 60 countries have introduced bans and levies to curb single-use plastic waste. Plastic bags and, to a certain extent, foamed plastic products like Styrofoam have been the main focus of government action so far. This is understandable. These plastic products are often the most visible forms of plastic pollution. It is estimated that one1 to 5 trillion2 plastic bags are consumed worldwide each year. Five trillion is almost 10 million plastic bags per minute. If tied together, all these plastic bags could be wrapped around the world seven times every hour. It is too early to draw robust conclusions on the environmental impact that bans and levies have had. In 50 per cent of cases, information about their impact is lacking, partly because some countries have adopted them only recently and partly because monitoring is inadequate. In countries that do have data, about 30 percent have registered drastic drops in the consumption of plastic bags within the first year. The remaining 20 per cent of countries have reported little to no change. Of the countries that have reported little to no impact, the main problems appear to be (i) a lack of enforcement and (ii) a lack of affordable alternatives. The latter has led to cases of smuggling and the rise of black markets for plastic bags or to the use of thicker plastic bags that are not covered by the bans (UNEP 2018).

Exposure to EDCs also has the potential to impair reproduction, resulting in low birth rates and potential loss of biodiversity. It also can affect thyroid function, and metabolism, causing increased incidence and progression of hormone-sensitive cancers [18]. Research has also suggested that embryo and developmental periods are critically sensitive stages to EDCs [15].

EDCs may also impact cellular and/or animal models at extremely low concentrations [19]. Nevertheless, other studies showed some conflicting results on the possible hazards to humans consuming micro and nanoplastics [20]. However, according to Gallo et al, [19] the worst case scenario of exposure to microplastics that followed the consumption of a portion of mussels of about (225 g) would be in the range of 7 μg of plastics (Figure 5).

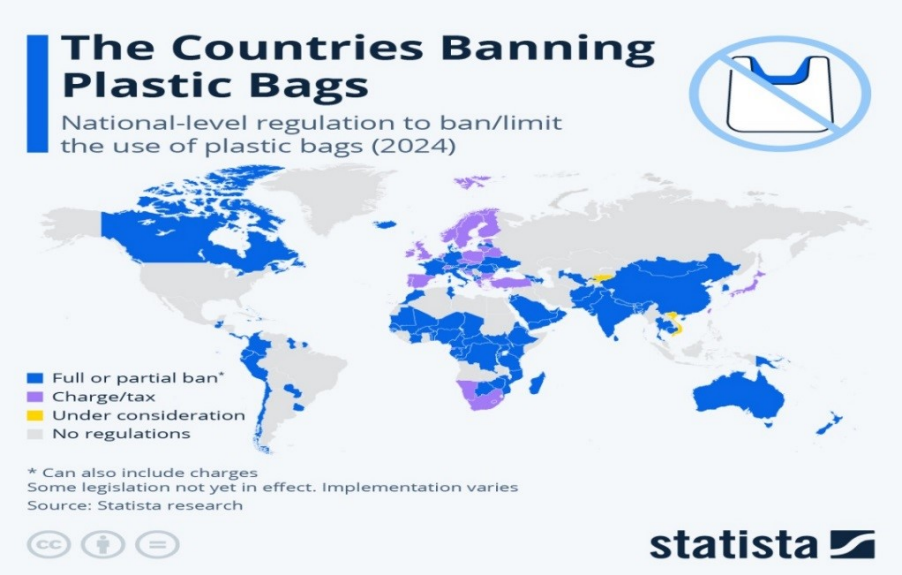

Figure 5. Source: (Statista, 2024)

Box 2

UN Single-Use Plastics: A Roadmap for Sustainability

The benefits of plastic are undeniable. The material is cheap, lightweight and easy to make. These qualities have led to a boom in the production of plastic over the past century. This trend will continue as global plastic production skyrockets over the next 10 to 15 years. We are already unable to cope with the amount of plastic waste we generate, unless we rethink the way we manufacture, use and manage plastics. Ultimately, tackling one of the biggest environmental sources of our time will require governments to regulate, businesses to innovate and individuals to act. This paper sets out the latest thinking on how we can achieve this. It looks at what governments, businesses and individuals have achieved at national and sub-national levels to curb the consumption of single-use plastics and offers lessons that may be useful for policymakers who are regulating the production and use of single-use plastics (UNEP 2018).

There is no doubt that the leakage of waste, including plastic wastes should be stopped and this is the responsibility of each country. A number of countries has already banned / or limited the use of some type of plastics especially single use plastics (Figure 5). However, restriction measures should be based on a bundle of conditions including the participation of major stakeholders including civil society, business community, and must be appropriate for local conditions [21,22]. To reach this end the following could be part of the implementation plans:

* eradicating excessive plastic packaging on products such as food;

*eliminating the non-essential use of micro-sized plastics in personal care products;

* promoting the use of renewable and recyclable alternatives to plastics, for example, wooden cutlery as an alternative to disposable plastic utensils, and cellulose-based materials as a replacement for plastic packaging and bags.

How plastic and plastic waste is conceived at societal levels, a local survey based view

Part of the present study has meant to assess and understand how our local community, with its mosaic components would conceive plastic and plastic waste and its impacts. A simple list of questions was designed to address major layers of the community with special reference to working class people, including delivery staff, taxi drivers, and the likes.

The highlights of the responses could be summed up in the followings:

* The vast majority acknowledged the usefulness of plastic and the role it plays in their lives and at societal levels.

* The vast majority stated that no other material can possibly replace plastic in performing the various services it provides to the community.

* The vast majority, ranging around 70% indicated that plastic like glass is a non- degradable material.

* Awareness of the environmental impacts of waste plastic was rather limited, in the range of 8%-10 %.

* Awareness about the environmental impacts of plastic on marine environment was very low and mounted to about 10%.

* About 30% of the respondents indicated that waste plastic could be recycled through shredding and reuse as filling material.

* One of the suggested ideas was to crush plastic waste turning it to powder, and mix it with building components such as cement, or to tar used for paving the roads. According to this view, the use of mixed plastic powder would strengthen cement and tar, at very economically cheap cost.

Conclusion

Plastic has greatly benefited modern society but has also become a major environmental and public health concern due to its persistence and widespread accumulation. Reducing plastic pollution requires effective waste management, increased public awareness, and the adoption of sustainable alternatives through the combined efforts of governments, industries, and communities.

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Author contributions

Mohamed Tawfic Ahmed, 60% suggesting the topic, writing the text - Sarah S Greish 20% topic discussion, collecting review, organizing references., Naglaa M Loutfy, 20%, topic discussion, collecting review, organizing references.

Ethical approval

Ethical approval of the present study has been in line with the Suez Canal University regulation.

Consent to participate

The purpose of this study is to show the magnitude of the impacts caused by plastic waste. This in turn would help promoting awareness and applying environmentally sound methods for plastic waste.

Consent for publication

We hereby provide consent for the publication of the manuscript detailed above, including any accompanying images or data contained within the manuscript.

Conflict of interest

There is no conflict of interest regarding this research paper.

Data availability statement

The data that support the findings of this study are openly available through relevant internet sites.

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