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Plastic Pollution: A Potential Threat on Health and Environment

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Abstract

At present plastics are essential elements in our everyday lives and are widely used in almost every industry and business sector. These are inexpensive, flexible, light, nontoxic, and durable materials that can be molded into any shape, and are found in soil, air, water, and food chains in the form of micro- and macro-plastic particles. It is one of the major physical and chemical pollutants in ecosystems. Now plastic production and consumption pattern is a linear model of "take, make, use, and dispose" that is a primary driver of natural resource depletion, waste generation, marine pollution, biodiversity, environmental degradation, climate change, chemical contamination, and adverse human health effects. Present worldwide plastic production becomes more than 400 million tons that is equal to produce about 11 tons per second and about 68 kg per person per year. The ocean is also containing more than 150 million tons of plastics. Rapid production of virgin plastics cannot establish circular economy if recycling and reuse environment is not established in the society. On the other hand, the costs of recycling plastic are higher than those of processing virgin materials. As a result, plastic recycling is not increasing as it should. In this article, effects of plastic on health and environment are discussed in briefly.

Keywords: plastic waste, circular economy, recycling, packaging, environmental impact

1. Introduction

Plastics are low cost and durable materials that are used on a daily basis globally due to significant benefits in the economy and improved quality of life (Mohajan, 2025b). These can be fragmented into small particles, such as micro-plastics and nano-plastics that can damage the environment (Lau et al., 2020). The low costs of producing and disposing of plastics have increased the amount of disposable plastic products and packaging entering the consumer market (CCME, 2018). About 330 billion single-use plastic carrier bags are produced annually and often used for just a few hours before being discarded into the environment (Lamb et al., 2018).

Plastics are not biodegradable products and can remain in the environment up to 500 hundreds years, and causes pollution and health hazards. At present the plastic waste is one of the main problems of our society (Babaremu et al., 2022). Annual use of plastics is about 110 kg per person in Europe and 140 kg per person in the USA that is used in the packaging, construction, and automobile industries (Material Economics, 2018).

Between 1950 and 2017, about 9.2 billion tons of plastic are estimated to have been made. About 400 million tons of plastic are produced globally each year that significantly impacting the environment only 14% of them is collected for recycling (Li, 2021). It is estimated that globally about 8.8 million tons of plastic waste enters into the oceans from coastal communities every year from land that harms wildlife, damages habitats and fisheries, and can transfer contaminants throughout the food chain that results at least $13 billion of damage to marine ecosystems worldwide every year (Jambeck et al., 2015). Single use plastic consumption and an expanding "throw-away" culture have increased the global plastic pollution (Geyer et al., 2017).

It is estimated that the GHG emissions from plastics in 2015 were equivalent to about 1.8 billion tons, and it will reach 17% of the global carbon budget by 2050 (Zheng & Suh, 2019). The transition from the wasteful plastic

linear economy to plastic circular economy (PCE) has become an essential policy to achieve sustainable plastic waste management (WM) and resource conservation (Addor et al., 2022).

2. Literature Review

A literature review is an overview of previously published works on a particular topic that tries to identify the gaps in the current knowledge (Galvan, 2015). It is a type of academic writing that provides an overview of existing knowledge in a particular field of research that summarizes, analyses, evaluates, and synthesizes the relevant literature within a particular field of research (Cooper, 1998). Samuel Fosso Wamba and his coworkers have stated that plastic WM represents a fundamental challenge in terms of environmental pollution and healthcare that is also a business in the context of the CE (Wamba et al., 2023). John Awuah Addor and his coworkers have examined the effect of innovation on the sustainability of plastic circular economy (PCE) using a two-state cyclical dynamic closed model of plastic WM based on ordinary differential equations. Their study supports PCE, environment, public health, water resources, and climate through reduced GHG emission, employment and poverty reduction that constitute strategic goals of the SDGs (Addor et al., 2024).

Roland Geyer and his coauthors have found that as of 2015, about 6,300 million tons of plastic waste had been generated, around 9% of which had been recycled, 12% was incinerated, and 79% was accumulated in landfills or the natural environment. They have estimated that if current production and WM trends continue, roughly 12,000 million tons of plastic waste will be in landfills or in the natural environment by 2050 (Geyer et al., 2017). Anindita Prabawati and her coauthors have provided information about stakeholders' participation in plastic WM in Central Jakarta. They have aimed to fill the gap by examining the most feasible partnership scheme that brings the most effective plastics waste handling and economic benefit. They have shown the plastics collection rate, recycling rate, benefit-sharing, and positive perspective among stakeholders (Prabawati et al., 2023).

Jefferson Hopewell and his coworkers have realized that plastic recycling is one of the most important actions to reduce harmful impacts on environment. Due to the combined actions of the public, industry, and governments, and development of advanced technologies and systems for the collection, sorting, and reprocessing of plastic, recycling has been increased (Hopewell et al., 2009). Filippo Corsini and his coauthors have aimed to gain insights into consumers' buying habits concerning recycled plastic that has received relatively little attention in prior research on the subject of environment friendly consumer behavior (Corsini et al., 2024). Marius Köder and his coworkers have shown that plastics pollute not only cities but also oceans and the environment. They have discussed circular economy approach to use recycled plastics to create products useful for their daily use (Köder et al., 2025).

3. Research Methodology of the Study

Research is a process of gathering and analyzing information to discover new knowledge that involves the collection, organization, and analysis of evidence to increase understanding of a topic (Patton, 2002). Methodology is a more general research strategy that determines how to conduct a research project (Bryman, 2008). Research methodology is the process of identifying, selecting, analyzing, and processing information about a topic that provides a framework and guidelines for researchers to clearly define research questions, hypotheses, and objectives (Niglas, 2010).

4. Objective of the Study

The word "plastic" is derived from two Greek words "Plastikos" which means fit for molding and "plastos" which means to remain molded. Plastics are made up of long chain synthetic and semi-synthetic molecules named polymers that have molecules which contains thousands of atom bonds together. Various types of polymers can be made from hydrocarbons, oxygen, nitrogen, chlorine, and sulfur that are derived from coal, natural gas, oil, and organic oils which are transformed into materials with desirable properties (Teegarden, 2004).

The main thing of plastic is it can be cast, pressed, and extruded in variety of shapes, such as films, fibers, plates, tubes, bottles, and so on (Mohajan, 2015). So that it has become a major part of the world economy. Plastic harms biodiversity, and depletes the ecosystem services needed to support life of all animals including human (Geyer et al., 2017). At present plastic pollution becomes a persistent growing problem worldwide. Main objective of this article is to discuss the harmful effects of plastic pollution on human health and environment (Mohajan, 2018). Other minor objectives of the study are as follows:

1) to highlight on production and use of plastic,

2) to focus on negative impacts of plastics,

3) to discuss plastic recycling.

5. History of Plastic

American inventor and industrialist John Wesley Hyatt (1837-1920) invented celluloid in 1869 that was used for movie film. In 1907, US industrial chemist Leo Baekeland invented Bakelite in New York that was the first fully synthetic plastic. He has coined the term “plastics” (Edgar & Edgar, 2009). Chemists Hermann Staudinger has been called the father of polymer chemistry, and Herman Mark is known as the father of polymer physics (Teegarden, 2004).

Birmingham metallurgist and inventor Alexander Parkes (1813-1890) patented Parkesine. It was considered as the first manufactured plastic that was a cheap and colorful substitute for ivory or tortoiseshell, and saves lives of million elephants and tortoises (Meikle, 1997). Nylon, a substitute of plastic is invented by American chemist, inventor, and the leader of organic chemistry Wallace Carothers in 1935 as a synthetic silk. Expanded polystyrene was developed in 1944 by Ray McIntire (Dennis, 2024).

5.1 Plastic Production and Consumption

More than 90% of plastic is made from nonrenewable and finite stocks of fossil fuels that accounts for 4-8% of world oil and gas production (Hopewell et al., 2009). In 1950, global plastics production was 2 million tons (Mohajan, 2020). The plastic production has increased by more than 20-fold between 1950 and 2015, and it is estimated that the global production of new plastic amounted to about 8.3 billion tons, out of which more than 6.3 billion tons were disposed of as waste (Geyer et al., 2017).

At present an annual output of plastics become about 400 million tons, and is expected to double by 2035 and almost quadruple by 2050 (Mohajan, 2025b). The plastic production is highly dependent on virgin fossil feed stocks, such as natural gas, oil, and other resources (UNEP, 2021). Plastic is produced 18% in Europe, 19% in the North America, China produces about 28% of global plastic, the rest of Asia produces 21%, Africa produce 7%, and Latin America produces 4% (Geyer et al., 2017).

Plastics consumption in Europe is about 60 million tons per year (Plastics Europe, 2020). Plastics are used in many sectors, such as packaging, building and construction materials, automotive manufacturing, medical devices, furniture, clothing, sports, toys, shoes, household appliances, transportation, personal goods, electrical and electronic goods, and agriculture (Material Economics, 2018).

5.2 Plastic Pollution

Plastic pollution is a universal continual growing problem that is affecting every nation. It is the buildup of various plastic objects and particles, such as plastic bottles, bags, and micro-beads on the surface of the earth that adversely affects humans, wildlife, and their habitat. It is a major environmental concern, since about 79% of all plastics we generate are ended up in some form in the environment through land and water (Zaman, 2023). Global plastic production has surged from 1.5 million tons in the 1950s to 400 million tons in 2023 that results environmental concerns (Li, 2021).

About 9.2 billion tons of plastic are estimated to have been made between 1950 and 2017. About 4.9 billion tons of these have been discarded either in landfills or elsewhere in the environment; it is expected to increase to 12 billion tons by 2050 (Prince-Ruiz & Finn, 2020). The ocean is estimated to already contain over 150 million tons of plastics, the amount of oceans plastic could triple by 2025, and it is estimated that there could be more plastic than fish in the oceans in weight by 2050 (UNEP, 2021). In a linear economic strategy, plastic waste is managed by landfilling, incineration, and composting (Mohajan, 2021a). Plastics are melted and molded into a new shape or turned into granules (Payne et al., 2019).

5.3 Negative Impacts of Plastics

Many toxic chemicals, such as benzene and vinyl chloride are released during the production of plastic that can cause cancer (Mohajan, 2021b). When plastic is used to package food; toxins and carcinogens can migrate from plastic containers to food and beverages inside the container. Smoke releases during burning of plastic that contains small particulates, hazardous substances, and GHGs that contaminate the environment (Yang et al., 2011).

The production, use, and disposal of plastics are related to enormous adverse externalities in the environment, economy, and society (Mohajan, 2021c). It is a major contributor to GHG emissions, and the combustion of waste plastics emits 390 million tons of CO_2 in 2012 (McKinsey & Company, 2016). Plastics can cause blockage of drainage and sewage systems that results water logging, flooding and spread of water borne diseases (Mohajan, 2025c). The top 20 polluting rivers of the world release 67% of all plastic waste into the oceans. These are threatening marine habitats that provide food, coastal protection, income, and cultural benefits to more than 275 million people (Lamb et al., 2018).

Some plastics contain toxic chemical additives, such as persistent organic pollutants (POPs), such as short-chain chlorinated paraffins (SCCP), polychlorinated biphenyls (PCBs), polybromodiphenyl (PBDEs), tetrabromodiphenyl ether (tetraBDE), pentabromodiphenyl ether (pentaDBE) (Tulashie et al., 2022),

octabromodiphenyl ether (octaBDE), decabro modiphenyl ether (decaBDE), bisphenol A (BPA), and phthalate that are related to various fatal diseases, such as mental, reproductive, and developmental diseases, and cancer (Hopewell et al., 2009). Plastics production consumes up to 6% of global oil production. It takes about 185 liters of water to produce a kilogram of plastic (Zygmunt, 2007).

5.4 Plastic Recycling

Recycling is a rapid and inexpensive solution to plastic pollution. The thought of plastics first came in the late 1950s, but the idea of recycling it takes place in the 1990s in the USA (Lange, 2021). Recycling has expanded rapidly over the last decades, and it is essential to actively promote and implement recycling strategies (Velis et al., 2022). When plastics are readily recycled called thermoplastics that are light, durable, moldable, hygienic and economic. These are upgraded through the manufacturing food and product packaging, car manufacturing, agriculture, and housing products (Grigore, 2017).

Plastic is much more difficult to recycle than materials like glass, aluminum or paper. Of all the plastic discarded so far, 14% has been incinerated and less than 10% has been recycled that saves virgin materials (UNEP, 2021). India has the highest plastic recycling rate with estimates ranging from 47-60%, the EU recycles 30%, China recycles 22%, and US municipal solid waste stream recycles only 9.5% of plastics (McKinsey & Company, 2016).

It is estimated that $80-120 billion worth of material value is lost to the global economy annually due to low recycling rate of most plastic packaging (Mohajan, 2025a). Recycling 1 ton of plastic packaging saves around 1.5 tons of carbon dioxide. Environment friendly upgrading of recycled plastic is necessary to enhance human living in worldwide (McKinsey & Company, 2016). Recycling plastics has many benefits, such as it saves energy and reduces GHG emissions. It is one of the most important actions currently available to reduce negative effects in environment and human health (Grigore, 2017). Recycling reduces dependence on landfills, preserves natural resources, protects the environment pollution, and reduces GHG emissions (Hopewell et al., 2009).

6. Conclusions

Degradation of ecosystems, human health, and overall quality of life are due to the rapid growth of industrialization and urbanization. Plastic is light, strong, easy to store and transport, can molded in any shape, and can hold almost anything that makes attractive to manufacturers and packagers. It has become one of the most widely used materials in our daily life. At present plastic waste pollution has become a significant threat to the global environment and human health. Efficient use of plastics is necessary to establish circular economy worldwide. To reduce global plastic pollution coordination among nations is urgently needed to reduce plastic consumption; increase rates of reuse, waste collection, and recycling; and expand safe disposal systems. At present plastic recycling is becoming popular day by day. Moreover, recycling waste plastic and manufacturing different kinds of products will create more job opportunity and can help the development of global economy.

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