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The Plastic Age: Plastic durability and flexibility from invention to destruction

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Abstract
Plastics have become an essential part of life, found in the majority of life spans, including medical kits in hospitals, such as syringes, catheters, IV tubes, and sterile packaging, enabling safe, modern medical practices due to their durability and flexibility. On the other hand, plastic packaging significantly extends food shelf life. It is also involved in transportation construction, agriculture, and drinking water distribution systems. A detailed search revealed that the role of plastic in daily life has become routine, from toothbrushes to cars, laptops, mobile phone covers, and the construction of buildings. The discharge of plastic after its prime use poses a threat to life, as it is nonbiodegradable and does not truly break down, persisting in soil and water reservoirs. The persistence consequences of the accumulation of microplastics in the food chain include endocrine disruptors, carcinogens, cancer, reproductive disorders, metabolic diseases, cognitive issues, thyroid problems, and reproductive toxins. Moreover, microplastics can interact with other environmental toxins, acting as carriers of pathogens and toxic chemicals (e.g., PCBs & heavy metals) into organisms. Because only 7% of plastic waste is recycled, the remaining 93% is disposed of, releasing toxic chemicals into soil and water reservoirs. Recent studies showed accumulation of plastic in mothers' breast milk, alarming for infants who will be exposed to this contamination from the day of entry into the plastic age. The important part of this plastic age is the infants born in the present era and recipients of the impact from the first mother's feed, while it is nearly impossible to eliminate all plastic debris, modern society faces an urgent need to significantly reduce, reuse, and better manage plastic to mitigate these health and environmental risks.

Keywords: Plastic, life, shelf life, toxic chemicals, environmental risk

Highlights

- Durability and flexibility are significant properties of the plastic
- Now an essential part of life
- Threatening life as nonbiodegradable
- Interact with environmental toxins and act as carriers of the pathogens

1. Introduction

Plastic, an important part of life, has brought humanity into the plastic age, just as a few decades ago, humans lived in the Stone and Iron Ages. The 20th and 21st centuries have been justifiably characterized as the "Plastics Age" due to the extensive production, widespread use, and profound impact of plastic materials on modern society (Science Museum).

Microplastics are found in the open atmosphere, including water, soil, and air, and reports indicate that 2.7 million tonnes of microplastics leaked into the environment in 2020, an estimate expected to double by 2040. "It is likely accurate to say that microplastics are now persistent in the environment," says Gardner, whose division focuses on mitigating plastic pollution in lakes, rivers, and oceans (UN Environment Programme).

The present advanced or modern age is related to the plastic age, as plastic is an unavoidable part of the current era. John Wesley Hyatt was the first man to synthesize a synthetic polymer in 1869, inspired by a New York firm's offer of $10,000 for anyone who could provide a substitute for ivory (https://www.britannica.com/science/Bakelite, www.acs.org). By treating cellulose derived from cotton fiber with camphor, Hyatt discovered a plastic that could be crafted into a diversity of shapes and duplicate natural substances such as tortoiseshell, horn, linen, and ivory, which later became revolutionary. (https://www.britannica.com/biography/John-Wesley-Hyatt)

Plastics permeate every part of humanity, from toothbrushes to eating on plastic plates with plastic spoons to preserving food in plastic containers (Rodrigues et al., 2019). This declares that it's impossible to get through a day without encountering some form of plastic. Humanity is a beneficiary of the plastic age, as humans have learned how to make and use synthetic polymers, which were initially derived from natural substances like cellulose, which is part of the plant cell wall and provides strength, but are now more often made from the plentiful carbon atoms provided by petroleum and other fossil fuels (Benefits of Plastics).

Synthetic polymers are made up of long chains of atoms, arranged in repeating units, often much longer than those found in nature. It is the length of these chains and the patterns in which they are organized that make polymers strong, lightweight, and flexible. In other words, it's what makes them so plastic (chem.libretexts), as shown in the following equation, which shows that plastic forms from monomers like ethylene and styrene (Fig.1). Numerous monomers, known as styrene, polymerize to form a long-chain plastic, polystyrene.

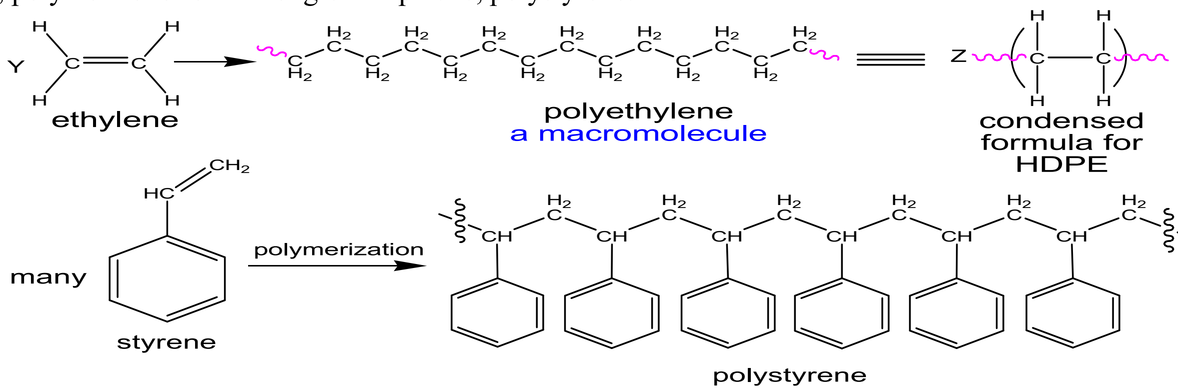

Figure 1: Polyethene and Polystyrene (chem.libretexts)

These properties make synthetic polymers exceptionally useful, and since we learned how to create and manipulate them, polymers have become an essential part of our lives. Especially over the last 50 years, plastics have saturated our world and changed the way that we live. The original, entirely synthetic plastic invented by Leo Baekeland in 1907 (www.sciencehistory.org), which contains no natural molecules. Plastics entered a golden age during World War II, with new uses and greater adaptability, and plastic production in the United States increased by 300% (https://www.blueland.com/articles/history-of-plastic). Plastics challenged traditional materials and replaced them due to their shape-adaptability(www.sciencehistory.org). But now, human beings are increasingly becoming aware that the widespread adoption of plastics has not been without consequences for their health and the environment. Nowadays, disposal of plastic in various forms, like bottles, Nylon, and other packaging materials, in the open atmosphere results in the breakdown of larger plastics into smaller particles, sometimes as tiny particles smaller than 5mm, found in different places, including soil and water reservoirs, which pose a threat to humanity. They are now usually discarded in the open air without treatment, especially in developing countries.

1.1. The journey of the plastic from synthesis to contamination

Synthesis of the plastic → use of the plastic → discarded into the open atmosphere → Plastic waste degraded into microplastics → microplastics in soil and water → absorption in plants, and Fish, which animals like chicken, cows, goats, etc. can eat → MPs enter into the milk and meet → in chicken → Meat and eggs. → Fish → Seafood → Humans consume milk, meat, Fish, and plants, thereby affected by the hazards of their own invention. The Figure (2) shows how humanity is under stress from its own inventions, leading to destruction.

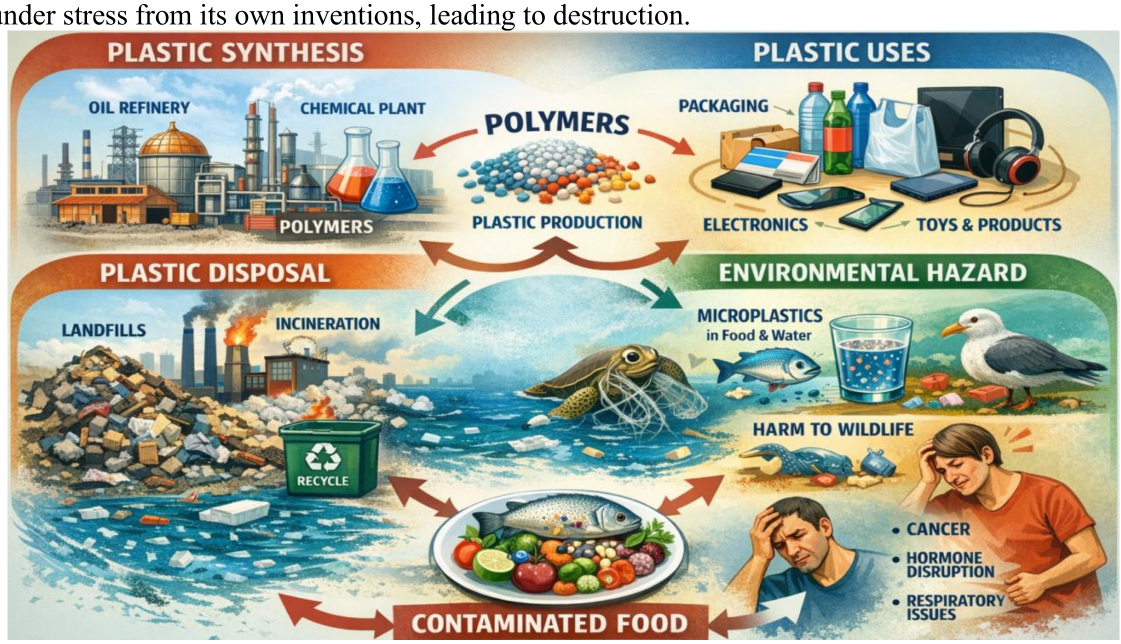

Figure 2: shows the journey of the invention of plastic from its initial use to its current environmental contamination, which threatens sustainable food production and food security.

1.2. Accumulation of Plastic

Microplastics can bioaccumulate in the food chain, including fish and shellfish that ingest them, which are then consumed whole by humans, potentially reducing nutritional value and increasing contaminant loads in foods (Ryan et al., 2009). Also, soil contamination affects crop growth and nutrient uptake, and may alter microbial activity in agricultural soils. Researchers are still trying to understand the long-term, cumulative effects of microplastics on human health, with studies showing that they can cross cell membranes and trigger chronic inflammation (Dessì et al., 2021). With the vast majority ending up in landfills, the ocean, or being incinerated, releasing toxic chemicals into the air. Microplastic entry into soil results in contamination (Nizzetto et al., 2016) and effects on crop growth and nutrient uptake, altering microbial activity in agricultural soils and threatening sustainable food production and food security (Sharma et al., 2017; Borriello et al., 2023).

1.3. Presence of Microplastics in the Food Chain

The detected microplastics typically range from a few micrometers to several millimeters in size and are composed mainly of polyethylene (PE), polypropylene (PP), polyethylene terephthalate (PET), and polystyrene (PS). Fibers and fragments are the most frequently reported shapes, suggesting both environmental and processing-related origins. Saraluck et al. (2024) reported that 38.98% of MPs, including polypropylene, polyethylene, polystyrene, and polyvinyl chloride, were detected in breast milk samples (23 of 59), displaying various morphological and chemical characteristics (Fig. 3). However, they also report that there was a significant taxonomic difference between the Bacterial microbiota: *Staphylococcus* and Streptococcus dominated the MPs-detected group, while *Enterobacter*, *Escherichia*, *Pseudomonas*, and *Acinetobacter* dominated the non-detected group. Moreover, the MPs-detected group had a more even distribution of bacteria, especially bacteroides. Recent studies have confirmed the presence of microplastics (MPs) in a variety of dairy products, including milk, powdered milk, yogurt, cheese, butter, and infant formula. Quantitative analyses have shown that processed dairy products, particularly powdered milk and infant formula, often contain higher levels of microplastics than raw or minimally processed milk. This trend highlights the role of industrial processing, packaging, and handling in the contamination of microplastics.

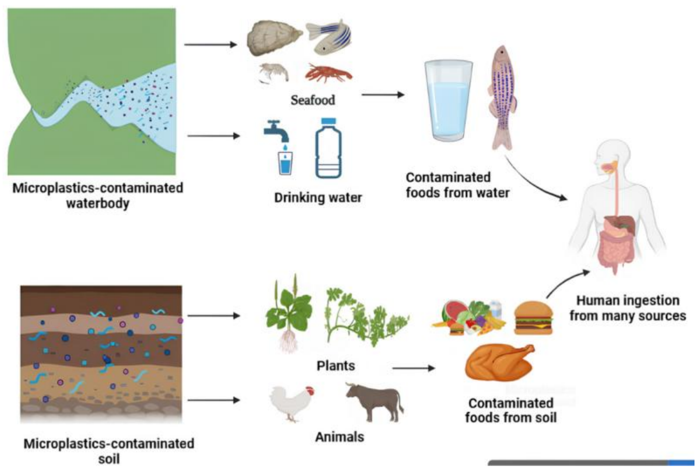

Figure 3: Shows how microplastics pose a threat to humanity by contaminating the soil and water resources

Conclusion

It was concluded that replacing natural materials with plastic has made many of our possessions cheaper, lighter, safer, and stronger. Despite growing mistrust, plastics are critical to modern life. Perhaps most importantly, inexpensive plastics raised living standards and made material abundance more readily available. Without plastics, many possessions we take for granted might be out of reach. Microplastics in food are not immediately toxic, but they pose a long-term health and environmental risk due to accumulation, chemical exposure, and biological effects. Scientists widely agree this is a preventive-action issue, not one to ignore.

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Conflict of Interest

NA

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