European Journal of Sustainable Development Research
2025, 9(3), em0314
e-ISSN: 2542-4742
https://www.ejosdr.com/

Review Article

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A review of plastic waste management for a sustainable environment: Composition and approaches

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Citation: Orhorhoro, E. K. (2025). A review of plastic waste management for a sustainable environment: Composition and approaches. *European Journal of Sustainable Development Research, 9*(3), em0314. https://doi.org/10.29333/ejosdr/16359

ARTICLE INFO

Received: 23 Dec. 2024

Accepted: 21 Mar. 2025

ABSTRACT

Globally, the production, consumption, and environmental impact of plastics are all growing rapidly. We utilize plastics more often in our daily lives these days. They work, for instance, in the packaging of different food and beverage companies, cosmetics companies, pharmaceutical companies, and other industries that need to package their finished goods for public distribution in a safe and efficient manner. Plastic garbage can have a lot of detrimental consequences on the environment such as pollution, endangering wildlife, and releasing toxic chemicals if it is not properly treated and controlled. This review looks at the different techniques to manage plastic waste (PW) sustainably, the types and content of plastics, the life cycle of PW, the impact of PW on the environment, and future perspectives on plastic trash. The evaluated conclusion addressed the problems caused by inadequate processing of PW as well as potential solutions that could be provided to ensure a sustainable environment and reduce the causes of climate change, in line with the sustainable development goals. Significant environmental degradation has been seen as a result of the physical and chemical properties of plastic trash, its non-biodegradable nature, overuse, and negligence. Moreover, plastic so enters the food chain and poses a major threat to aquatic and human health.

Keywords: plastic wastes, sustainable environment, plastic composition, health effect, recycling, greenhouse gases

INTRODUCTION

Concerns regarding the devastating effects of plastic waste (PW) on the environment have been sparked by the rapid population growth (Sakarika et al., 2023). Its non-biodegradable nature and inappropriate disposal methods have made it a global issue. Between 1950 and 2022, 8.3 to 9.1 billion tons of plastic were produced, according to Aizudin et al. (2022) and Jiao et al. (2024). Household PW has increased dramatically since the COVID-19 pandemic began, resulting in a global waste management problem (Al-Tohamy et al., 2023a, 2023b). 359 million tons of plastic have been generated globally in the last two years; this amount is expected to increase due to population growth and rising consumption (Roy et al., 2022). According to current production numbers and trends, human activity is predicted to generate 26 billion tons of PW by 2050 (Lavoie et al., 2022). However, plastics are essential to the contemporary economy and aid in meeting fundamental human needs (Li et al., 2022). But one of the most urgent environmental problems nowadays is plastic pollution. As plastic pollution rises, its negative effects on the environment and human health are observed worldwide, ranging from clogged streams to damaged marine ecosystems (Kumar et al., 2021). Additionally, PW take longer to break down, which leads to the release of dangerous pollutants like furans and dioxins that are harmful to living things. To guarantee a sustainable future and establish a circular economy, this issue also offers an opportunity to alter how plastics are produced, used, and handled. Reaching the sustainable development goals of the UN agenda 2030 and safeguarding the future of our planet depend on reducing plastic pollution. The need to eliminate plastic pollution has never been more urgent. Governments are taking the lead on advancing negotiations for a historic global instrument to avoid plastic pollution, with support from the UN environment program and an Intergovernmental Negotiating Committee. This expected global tool, which takes a lifetime approach to plastics, addresses responsible waste and chemical management, product design, reuse, recycling, and sustainable manufacturing and consumption in an effort to reduce plastic pollution. As nations search for solutions that address the root causes of plastic pollution rather than merely its symptoms, exchanging real-world experiences and lessons learned is crucial to directing the discussion.

Nevertheless, because plastic pollution threatens human health, destroys vital ecosystems, and exacerbates social

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injustices, it undermines the foundation of a sustainable future. The ecology is subsequently impacted by this high PW through air pollution from open dumping, marine pollution from ocean dumping, and soil pollution from landfilling. It has been known to contribute to a decline in aesthetic appeal, impede water drainage systems, and cause a number of ailments. Even though 80% of the PW in the ocean comes from land-based sources, the amount of PW on land is far less well-documented than the quantity of plastic debris in marine environments. Understanding these impacts is essential to preventing plastic pollution and creating a more equitable and healthier world. Plastic is present in the food we eat, the water we drink, and the air we breathe. The average person consumes up to 50 plastic bags' worth of microplastics (MPs) per year. Accordingly, MPs and nano plastics (NPs) are commonly found in human bodies (Kumar et al., 2021). The link between plastic pollution and climate change is equally alarming. Almost the majority of the plastic we use today is derived from fossil fuels. In 2019, plastic manufacture and fossil fuel combustion accounted for 90% of global greenhouse gas emissions (Kaur et al., 2022). According to predictions, greenhouse gas emissions associated with the production, use, and disposal of plastics might account for up to 19 percent of the global carbon budget by 2040, with the aim of keeping global warming to 1.5 °C (Ali et al., 2021). Plastic pollution hinders both climate action and climate change adaptation because it kills important ecosystems like mangroves and coral reefs, which serve as barriers against storm surges and sea level rise. Burning PW releases toxic chemicals into the atmosphere, contributes to air pollution and climate change, and can clog drainage systems and restrict runoff, making flooding more likely. Sustainable management of PW is one of the primary challenges that is attracting the attention of all environmental concerns. The biggest obstacle to environmental protection is effectively and sustainably handling the massive volume of waste generated worldwide. Plastics are used extensively in almost every sphere of human existence, including manufacturing, piping, electrical and thermal insulation, furniture, healthcare, agriculture, and the creation of household and technological items. Plastic is anticipated to become even more useful because of its remarkable properties, which include high tensile strength, shock resistance, resistance to microbiological development, opacity and visibility, chemical resistance, and featherweight. However, the fact that this PW is not biodegradable creates waste management issues. Thus, this review will cover the types and composition of plastics, their life cycle, different approaches to handling PW, the health and environmental impacts of PW, and future possibilities.

Classification and Composition of Plastic

There are two primary categories of plastics: thermosetting and thermoplastics (Ali et al., 2021). High mechanical strength, thermal stability, and corrosion resistance are guaranteed by the crosslinked structure of thermosetting plastics, also known as designed polymers, such as polyurethanes (PUs), phenolic resins, and acrylonitrile butadiene styrene. Thermoset polymers are irreversible, non-recyclable petrochemical byproducts (Aizudin et al., 2022). Conversely, plastics such as polyethene (PE), polypropylene (PP), polyvinyl chloride (PVC), and polyethene terephthalate (PET) have flexible structures and linear chains that allow for easy form alteration with heat. Most plastics are composed of binder, filler, color, plasticizer, and other additives. On the other hand, thermoplastic is a petrochemical-based material that can be molded into countless shapes to suit a variety of applications when it is pliable. According to Khoaele et al. (2023), they can be recycled and utilized as main materials to produce more commodities with added value. According to Wrońska et al. (2023), plastic is currently the second most used material for food packaging. This has led to a spike in PW, which is one of the primary causes of marine animal fatalities (Al-Tohamy et al., 2022). Additionally, volatile organic compounds (VOCs) and greenhouse gases are released during the production of PU, polystyrene (PS), PE, PP, and PVC, which contributes to air pollution and climate change. Unfortunately, plastic packaging commonly contains petroleum-based synthetic chemicals that are harmful to human health, such as PU, PS, PE, PP, PVC, and others (Ali et al., 2021, 2023). These chemicals can leak into food or the environment. Furthermore, billions of tons of PW are discarded into the ocean and landfills, creating other plastic compositions such as NPs and MPs (Elsamahy et al., 2023). Both biotic and abiotic factors contribute to the breakdown of plastic, which also produces MPs (less than 5 mm) or NPs (less than 100 nm) (Elsamahy et al., 2023). Dust, tire abrasion, artificial coloring additives, and frequently used plastic materials are examples of secondary sources of MPs (Alexy et al., 2020). MPs and NPs are produced secondary to the use of plastics in fisheries, agroindustry, and home plastics (Ding et al., 2021). Both freshwater and marine environments contain MPs and NPs, which are tiny synthetic particles (Onyedibe et al., 2023). Marine animals may ingest them, which could lead to various ailments and even death (Hale et al., 2020). MPs may carry chemical contaminants and heavy metals that can accumulate in the food chain and threaten marine life (Huang et al., 2021). Besides, MPs and NPs can contaminate terrestrial ecosystems, which could disrupt nutrient cycles and negatively impact soil fertility (Kumar et al., 2021). The tendency of MP pollution to disrupt ecosystem services may have negative impacts on ecosystems, water quality, and sectors such as fishing and tourism (Abidli et al., 2019; Ding et al., 2021; Elsamahy et al., 2023). Addressing this issue requires cutting back on plastic use, improving waste management, and finding sustainable alternatives to single-use plastics (Ali et al., 2023). Today, the food packaging sector has two major challenges: developing a consumer-friendly packaging material and substituting biopolymers for plastic made from finite resources (Maurizzi et al., 2022). Enhancing the life cycle of plastics is also essential to prevent hazardous emissions, the release of improperly managed PW into the ocean, and the waste of energy and resources. One standardized analytical tool that aids in decision-making is life cycle assessment (LCA) (Askham et al., 2023). A comprehensive record of all resources extracted from the environment and pollutants discharged at each stage of the product or process system under study is produced by the life cycle inventory, an analysis phase of LCA (Stephan et al., 2019). Recovering PW, addressing industrial improvements in plastics manufacturing, which may involve the use of LCA, and promoting recycling to reduce the market attraction of plastics are the three phases that may be

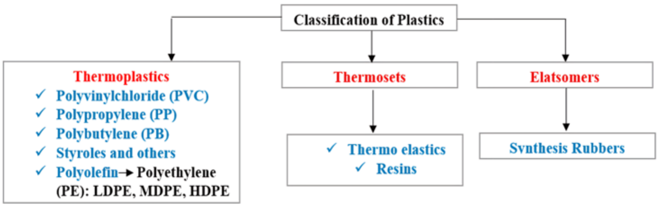

Figure 1. Classification/composition of plastic (Source: Authors' own elaboration)

implemented to reduce MPs waste (Prata et al., 2019). **Figure 1** shows the classification/composition of plastic.

Thermoplastics

The term "thermoplastic" refers to a polymer that melts crystals or crosses the glass transition temperature to become plastic and flow when heated. Since this process is reversible, the material can be created as a solid and then treated using techniques like molding or extrusion. Thermoplastics can be categorized according to the extent of their structural organization, including chemical bonding, as well as their characteristics and functioning. The thermoplastic PET is one type produced using fossil fuels. These days, the textile sector and bottle packaging both use it. Although PET was developed for industrial use, a sizable amount of it still ends up in the environment (Orhorhoro et al., 2016). High-density polyethylene (HDPE) is a thermoplastic polymer made from ethylene monomers. Polyethylene is produced via a polymerization event using comparable ethylene molecules. HDPE has a linear structure with minimal branching and is less expensive than other thermoplastics. It is produced under low pressures (10-80 bar) and low temperatures (70-300 °C). According to Bassiouny et al. (2016), HDPE is widely utilized in pipes, protective helmets, bottle caps, car fuel tanks, insulation, freezer bags, shopping bags, imitation wood planks, soap containers, cleaning supplies, and recycled wood-plastic composites. The largest producer of organochlorine, which can be considered a broad class of chemicals that have recently come under regulatory and scientific scrutiny because of its widespread use and detrimental effects on society, is PVC. The community is more negatively impacted by the majority of PWs that do not include chlorine than by PW (Liu et al., 2020). Vinyl chloride monomer, which is produced by the pyrolysis process, is joined with monomers to form a long chain of PVC, which is marketed as white powder. Pure PVC is combined with colorants, plasticizers, stabilizers, and other necessary additives to give it any specific properties that enable it to function as desired.

Low-density polyethylene (LDPE) is defined as a translucent, semi-rigid long chain of identical subunits, as opposed to HDPE, which is highly branched with long-chain and short-chain monomers. LDPE is produced by free radical polymerization under specific high temperature (80-300 °C) and pressure conditions. LDPE is composed of four to forty thousand carbon atoms with a large number of small branches and sub-branches. LDPE can be made in two ways: stirred autoclaving and tubular techniques. Examples of applications for LDPE include containers, drink cartons, bin-garbage, work surfaces, ring drink holders, laundry bags, machine parts, lids, playground fixtures, protective shells, computer hardwires, trays, bin-bags, and laundry bags. PP is a thermoplastic polymer with several applications. PP, a partially crystalline, half-non-polar chemical molecule that is a member of the polyolefin group, is created when propylene goes through a continuous chain polymerization reaction. Other benefits include its resistance to chemicals, which allows PP to be processed using a range of conversion techniques, such as extrusion and injection molding. Its physical and chemical properties are associated with chemical branching and high temperature resistance. PP can and will manufacture a variety of domestic products, including funnels, trays, bottles, buckets, and instrument jars (which can be cleaned frequently for use in a clinical context). It is a better material to employ than polyethylene because of its greater mechanical properties and colorlessness. PP is commonly used to make packaging tape, lunchboxes, crisp bags, straws, food containers, bottle caps, clothing, supplies, hobbyist models, and surgical tools and equipment (Wang et al., 2018).

Thermoset plastics

Thermosetting polymers are substances that cannot be reshaped by pressure or heat once they have taken on their final form. In their processed state, they are unreachable materials. Their chemical structure, which consists of a three-dimensional network that is chemically bonded, is what makes it so difficult to penetrate. During processing, a chemical reaction that can be started chemically or thermally produces this network. After being heated, these thermoset molecules cannot be remelted or reformed. Possible recycling sources Fiber or resin prepregs, end-of-life goods, and fibers or resins that do not fulfill criteria are the main sources of thermosetting composites. In thermosetting polymer composites, waste is reduced in size by mechanical methods to create small particles, and material is broken down in another useable form or converted into energy via chemical and thermal processes. Pyrolysis, fluidized bed, and incineration are the three most used thermal recycling techniques. In order to show that thermosets can be utilized to produce a range of materials with unique chemical and physical characteristics, they can change from a low-viscosity liquid to a solid with a high melting point. Customers may easily change and use thermosetting monomers or subunits due to their low viscosity; different additives are added to thermosets to maximize their performance and enable their usage in a range of specialized applications (Mullins et al., 2018).

Vinayagamoorthy and Rajmohan (2018) state that a number of thermoset PUs are also known as thermoplastic PUs. Urea, which is sold as a carbamate, is an organic monomer that is polymerized to produce a polymer called a PU. Because of its physical and chemical properties as well as its versatility, PU polymers are widely used in paints, upholstery, foams, adhesives, varnishes, and insulators, among other uses. Like other polymers, PUs depend on petrochemicals as a fundamental component or subunit in their main ingredients (Das & Mahanwar, 2020). Reinforced fibers, such as carbon, glass, etc., are the most valuable component in thermoset polymer composites. It is more expensive than the matrix of polymers. Therefore, removing those fiber constituents from that composite trash is advantageous and highly preferred.

Table 1. Substances released from particular PW burning and their associated environmental and health effects

Plastics	SRAB	Environmental effects	Health effects	References
Polycarbonates	CO	Greenhouse gases	It results in headaches, lightheadedness, and dizziness.	Abelsohn et al. (2002)
PET	Xylene	It lowers the quality of the air, particularly indoor air.	It irritates the eyes, lowers consciousness, damages the central nervous system, and hinders learning.	Lomonaco et al. (2021)
LDPE	Toluene	It lowers the quality of the air, particularly indoor air.	In addition to irritating the respiratory system and eyes, it can occasionally result in depression.	Lomonaco et al. (2021)
	Ethylene	It produces greenhouse gases, Ecotoxicity, and acidification of the air and water.	It irritates the eyes and shortens the throat and breathing.	Royer et al. (2018)
	PP	It contains Pb and Cd, which contaminate soil and drinking water.	It results in headaches, nausea, and dizziness; irregular heartbeats; unconsciousness; and/or asphyxia-induced suffocation.	Ross and Evans (2003)
	CO_2	It affects global warming and greenhouse gas emissions.	It makes breathing difficult.	Amthor (1991)
	CH_4	It contributes to climate change and greenhouse gas emissions.	It results in headaches, slurred speech, mood swings, face flushing, nausea, vomiting, and memory loss.	Royer et al. (2018)
HDPE	Acetone	It impacts the upper troposphere's hydroxyl (OH) and ozone production.	The respiratory system and eyes are irritated.	Folkins and Chatfield (2000)
	Benzaldehyde	When exposed to air, it autoxidizes to produce benzoic acid.	It impairs brain function by irritating the respiratory system, eyes, and skin.	Sankar et al. (2014)
PVC	Polychlorinated dibenzo-dioxin	The quality of the air deteriorates as a result.	It alters the liver function and has an impact on the respiratory system. Carcinogenic causes irritation of the skin, eyes, thyroid, immunological cells, and hormone levels, as well as a decline in learning and intellect assessments.	Zubair and Adrees (2019)
	Polychlorinated dibenzofuran	It causes the deterioration of air quality	It aggravates the respiratory system, eyes, and causes asthma.	Nkwachukwu et al. (2013)
	Pb	It causes dustiness in the air.	It results in weakness, anemia, and damage to the kidneys and brain.	Abelsohn et al. (2002) & Rosen (1995)
	Vinyl chloride	It degrades the quality of the air and drinking water.	It irritates the eyes and respiratory system, as well as the liver and central nervous system. causes blood-forming organs and asthma. carcinogenic and irritating to the skin, eyes, and lungs.	Wagoner (1983)

Note. SRAB: Substances released after burning

ENVIRONMENTAL AND HEALTH EFFECT OF PLASTIC WASTE

In addition to endangering the environment, plastic pollution also poses a health risk to present and future generations. When discarded, it accumulates in the environment until it reaches a crisis point because it can take up to 1,000 years to decompose (Navarro, 2020). In addition to harming soil, poisoning groundwater, and choking marine life, this pollution can have major negative health effects. There is a plastics issue throughout the planet. When PW burns in the atmosphere, pollutants including carbon monoxide (CO), dioxins, and VOCs can be inhaled by people. These drugs have been linked to birth abnormalities, endometriosis, cancer, and developmental issues in children. These compounds have the potential to cause neurological impairment (Anwar et al., 2021), immunological-related issues (Navarro, 2020), reproductive issues (Amereh et al., 2020), endocrine disruption (Halden, 2010; Rajmohan et al., 2019), and asthma (Slovak, 1981) even at low doses. Globally, plastic pollution is a problem. At every stage of their lifecycle–fossil fuel extraction, production, manufacture, usage, recycling, and disposal–plastics have a detrimental impact on both humans and the environment. Human rights, biodiversity, climate change, and human health are just a few of the many areas that are affected. The many chemicals and substances released from plastic components are listed in **Table 1**, along with the health hazards associated with them.

Throughout the plastic lifespan, humans are exposed to a wide range of harmful chemicals and MPs through direct skin contact, ingestion, and inhalation. Although research on the effects of plastics on health is still in its infancy, findings from studies so far suggest that plastic contributes to illness, disability, and early mortality at every stage of its life cycle (**Table 1**). According to Pandey and Saini (2017) and Boyle et al. (2020), heavy metals such as arsenic (As), lead (Pb), cadmium (Cd), and mercury can degrade water quality and reduce soil fertility when present in small amounts. Furthermore, we frequently observe various plastic items in water bodies like rivers, streams, ponds, and oceans, whether they are macro plastics or MPs. These plastics end up in the oceans after being generated on land, endangering the health of the environment (Jambeck et al., 2015; Kershaw et al., 2011). Plastics include harmful chemical additions and contaminants that pose a global health risk. Changing hormone activity (endocrine disruption), which can result in reproductive, growth, and cognitive impairment, or developing cancer are examples of health impacts that have been scientifically verified (**Table 1**). Numerous hazardous chemical additives survive in the environment, bioaccumulate in exposed creatures, and have a number of other recognized health effects. Additionally, studies have shown that MPs can be harmful to our health and serve as entry points for germs, which accelerates the spread of illnesses (Allen et al., 2019; Braun et al., 2021; Haodi et al., 2023).

Numerous published studies demonstrate that entanglement affects aquatic animals, such as fish, turtles, seabirds, and marine mammals. Unlike ingestion, which occurs in smaller animals, this behavior is often associated with large animals (Hoarau et al., 2014; Lavers et al., 2019). In addition, MPs induce inflammation, penetrate cellular barriers, and even cross highly selective membranes such as the blood–brain barrier and the placenta. The many health hazards linked to rising temperatures and extreme weather events brought on by climate change are exacerbated by plastics. Along the entire plastic value chain, health effects are also noted. Water and soil contamination, air pollution from waste incineration, worker exposure to chemicals, and pollution at extraction sites are a few examples. Human rights and environmental injustice are raised by the heightened exposure of vulnerable populations, such as women, children, workers in the informal waste sector, and marginalized communities. Furthermore, the substances created during deterioration may have both immediate and long-term effects on the ecosystem and living organisms. Some of the causes have been shown to be disruptions in the hormone systems of both invertebrates and vertebrates (Beaumont et al., 2019; Dris et al., 2015; Gunaalan et al., 2020; Peng et al., 2020). Plastics and other larger things can be easily identified and separated from water bodies. According to Chen et al. (2022), MPs (less than 10-6) and NPs (less than 10-9) are now considered emerging contaminants. Their micro/nano size limits their detection in water bodies, and no proven method for their effective identification and quantification has been discovered. Several studies have found that MPs are present in the stomachs of fish and numerous terrestrial species (Chae & An, 2017; Franzellitti et al., 2019; Gao et al., 2021). Humans are undoubtedly exposed to plastics through everyday items, medical equipment made of plastic, the food chain, and airborne plastic pollution, even though precise numbers are still unknown due to scientific inadequacies.

MANAGEMENT OF PLASTIC WASTE

The effective and accurate transformation of PW into innovative products that are better, economical, and ecologically friendly products is known as PW management. Environmental issues can arise from improper handling of PW, including littering that clogs drain, degrades the city's aesthetics, pollutes the air when burned, and interferes with waste manufacturing facilities. The most widely used conventional techniques for handling PW are incineration, landfilling, pyrolysis and recycling. **Figure 2** shows PW management strategics.

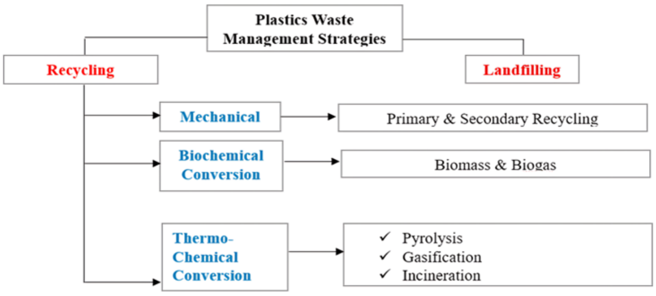

Figure 2. Plastic waste management strategies (Source: Authors' own elaboration)

Landfilling

All places and areas where we dispose of all disposable PW after use before it is buried beneath the earth's surface are referred to as "landfills." The landfill arrangement aims to protect the environment in all its forms by offering a safer location for the disposal of plastic trash. However, landfills are an excellent source of energy due to the carbon dioxide (CO_2) and methane (CH_4) gas produced during the biodegradation process. It keeps cities clean and hygienic by separating hazardous garbage from regular waste. This is also a cost-effective method of dealing with plastic garbage. This method has numerous disadvantages, including causing climate change and igniting the dangerous gas CH_4, despite its ability to remediate PW. It contaminates land and water and harms wildlife (Kedzierski et al., 2020).

Recycling

One way to lessen the amount of disposable plastic that is dumped into the environment is through plastic recycling. Recycling plastics is the process of disposing of PW at plastic recycling facilities and reusing plastic products in their original or modified form. Correction effected and highlighted yellow in main manuscript copy. Energy, chemical, and mechanical recycling are among the several kinds of recycling procedures (Orhorhoro et al., 2016). Making PW useful by procedures including grinding, washing, sorting, drying, re-granulating, and compounding is known as mechanical recycling (Orhorhoro et al., 2016). Worldwide, mechanical recycling accounts for the majority of plastic recycling. As with glass, this procedure ideally enables recycling a material back into the same application (sometimes known as a "closed loop"). However, some materials–like plastic–degrade after being recycled repeatedly because they lose their quality. As a result, the finished products will be of progressively lower quality. We use the phrase "cascade recycling" to describe this (Orhorhoro et al., 2016). Only PW may be recycled using the energy recycling method, which involves using the heat power supplied by these materials as fuel to incinerate plastic and turn it into both thermal and electric energy (Abdul-Latif et al., 2021). A relatively new process called chemical recycling promises to return material from any of the cascade steps back to the original, high-quality, raw material (Qureshi et al., 2020). In reality, chemical recycling is the general phrase for a number of distinct procedures. The way that these methods degrade polymers–the large molecules that comprise plastic materials–varies. Depolymerization, gasification, and pyrolysis are chemical recycling processes. Plastic recycling technologies can be separated into four sets: primary, secondary, tertiary, and quaternary. The PW is transformed into a product that shares traits with the original through primary recycling. Recycling plastics is vital to establishing a circular economy, wherein plastics are made, developed, used, reused, and recycled rather than discard. In the chain of plastic recycling, manufacturers of plastic materials exploit the materials from re-processors to make the material that "converters" use to make plastic packaging or products. Before selling, materials businesses frequently buy mechanically recycled polymers and mix them with virgin plastics. In order to create new polymers, they also buy the "feedstocks" from chemical re-processors. To create a circular economy, plastic materials must have a significantly higher recycled component. More so, secondary recycling is the process of processing PW to produce goods that differ from the original plastic materials in certain ways. Also, PW is treated in tertiary recycling to produce fuels and basic chemicals while quaternary recycling involves burning or cremation to recover the energy content of discarded polymers. The selection of recyclable materials and the subsequent segregation of PW are components of effective recycling procedures. A powder is then created by cleaning, shredding, aggregating, extruding, and grinding the spent PW. As a results of the rise in PW, recycling has received a lot of attention lately (Armenise et al., 2021). Two elements that influence how recyclable plastics are the presence of additives and contaminants (Kumar et al., 2021). During several important stages of the plastic recycling process, PW is transformed into new products. Common steps in this process include gathering, classifying, cleaning, shredding, melting, and pelletizing. Recycling plastic is crucial for reducing the harmful impacts of PW on the environment, removing pollutants, and conserving resources. It helps reduce greenhouse gas emissions, extend landfill life, and reduce energy consumption (Azike et al., 2022; Orhorhro et al., 2016; Raji et al., 2020).

Therefore, recycling plastic is an essential step in reducing PW's detrimental environmental consequences and conserving resources. PW is collected via recycling containers or designated collection sites from homes, workplaces, and public spaces. The collected PW is categorized by category and cleansed to remove contaminants. Both manual inspections and automatic sorting systems are commonly employed to ensure the purity of the materials (Cura et al., 2021). The selected plastic is cleaned to remove impurities and prepare it for further processing (Ojo & Shittu, 2023). The cleaned plastic is shredded into small flakes to facilitate melting. New products can then be made from these pellets (Almeshal et al., 2020). If recyclable plastics are contaminated with non-recyclable materials, the recycling process may be hindered and they may wind up in landfills (Le Pera et al., 2023). Furthermore, recycling plastic can be costly, requiring significant investments in infrastructure, machinery, water, and electricity (Gopinath et al., 2020). The quality of recycled plastic may deteriorate with each recycling cycle; often, the process involves adding hazardous chemicals or newly made plastic to restore desired attributes (Hahladakis et al., 2020). Finding out which plastic kinds can be recycled and where a particular plastic material can be processed might be challenging. Regretfully, there are no strict guidelines regarding the accessibility of recycling facilities. To identify the type of plastic, most plastic packaging has a recycling international code (RIC) label, which is a little triangle with a number within. To find out if local recycling programs accept the type of plastic, the RIC can be cross-checked with them. Nevertheless, while thermoset plastics have historically not been recycled, they may have been utilized for energy recovery through incinerators. In contrast, thermoplastics are usually recycled. Although thermoset polymers can now be recycled thanks to technological improvements, most recycling facilities do not recycle this kind of material, hence the recycling rate for these plastics is low. HDPE, PP, and PET are the three plastics that are recycled the most. These plastics, like plastic bottles, are frequently single-use and are only used once. Water bottles, soda bottles, milk cartons, shampoo bottles, and food containers are examples of single-use plastic products that are typically constructed from various types of plastic. Other single-use plastic products, however, are extremely challenging to recycle (aside from highly specialized facilities). These include multi-layered packaging, such crisp packets (because of the layer of aluminum within) and other plastics, including plastic film, which is frequently used to wrap food. A variety of plastics, such as nylon or PET, LDPE, PP, and PVC, can be used to make these products. Although these products are technically recyclable, recycling is frequently not supported by local facilities. This implies that various plastic kinds must either be shipped to specialized facilities, which is not always cost-effective, or disposed of in conventional methods.

Plastic recycling still faces numerous obstacles in spite of technological and recycling process advancements. Contamination is among the most significant problems. When a plastic product is combined with another material or substance, such food or dirt, contamination happens. Because the contamination will impede the melting and molding processes, recycling this material becomes challenging. To ensure that organics and plastics are maintained apart through management and education, source separation is a crucial part of the solution. The effectiveness of plastic recycling is one of the main questions surrounding it. Unfortunately, only a small percentage of plastic that may be recycled is recycled, which is one of the major issues with plastic recycling. According to current figures, just 15% of plastics are recovered globally, and only 9% of them are recycled. Before plastic recycling is a real answer to the issue of PW, much work needs to be done. Solving the problems of contamination, cost, and quality degradation is essential to maximizing the recycling process's efficiency. The United States' plastic recycling rate decreased from 9% in 2012 to 8.7% in 2018, according to Gourmelon (2015), suggesting that recycling problems still exist despite advancements in technology. Sarker (2011), on the other hand, found that 60% of the aggregate plastics recovered from South Asian waste, particularly from India, may be recycled. To solve the problem of PW recycling, the United States is giving priority to recycling PET and HDPE bottles. Some types are considered more significant than others due to their wide market presence and potential for recycling (Lavoie et al., 2020). The recycling rates for PET and HDPE bottles in 2018 were 29.1% and 29.3%, respectively. According to Baran (2020), almost 75% of the PW collected from waste sites was processed for energy recovery and recycling. One opportunity that the circular economy can offer is the remanufacturing of PW for reuse. Galafassi et al. (2021) claim that ground PW particles could be utilized as a basic element source.

Anaerobic digestion of bioplastics and composting (which requires controlled substrate humidity) are the most popular disposal techniques that yield fertilizer and biofuel. Some bioplastics are not compostable or biodegradable due to their petroleum-based composition (Ali et al., 2023). The most popular methods for dealing with various waste bioplastics include waste-to-energy, chemical recycling, thermochemical conversion, and biological remediation (Wojnowska-Baryła et al., 2020). Fossil-based polymers are made from nonrenewable resources like crude oil and natural gas. The ecology is severely harmed by the extraction and processing of these fossil fuels, which results in greenhouse gas emissions, habitat destruction, and water body contamination (Shamoon et al., 2022). Energy-intensive processes are used to convert fossil fuels into polymers throughout the production phase (Gopinath et al., 2020). The environmental impacts of manufacturing and processing plastics derived from fossil fuels are exacerbated by high temperatures and the frequent use of chemical additives (Hahladakis et al., 2020). Energy is used in these processes, and greenhouse gases and other pollutants are released. On the other hand, renewable resources like cellulose, corn, or sugarcane are typically used to make bioplastics. The specific feedstock and production methods used can affect the environmental impact of bioplastics, including factors like land use change and the potential for deforestation (Bishop et al., 2022; George et al., 2021). Though, compared to plastics made from fossil fuels, the processes used to produce bioplastics can be more energy-efficient (Schulze et al., 2017). Since they are affordable, adaptable, and durable, fossil-based polymers are utilized extensively (Pellis et al., 2021). Nevertheless, their sustained presence in the environment leads to the buildup of PW and the production of persistent contaminants. As for their resilience to disintegration, plastics derived from fossil fuels have the potential to negatively impact ecosystems, marine life, and human health (Walker & Rothman, 2020). The EoL scenarios of bioplastics vary according to their composition. Certain bioplastics are made to undergo particular processes, such as anaerobic digestion or industrial decomposition, in order to become compostable or biodegradable. Consumer education and the creation of an effective waste management infrastructure are both necessary to promote the proper EoL treatment of bioplastics (Dilkes-Hoffman et al., 2019). Fossil fuel-derived plastics contribute to persistent pollution, depletion of fossil fuel reserves, and an increase in greenhouse gas emissions.

Furthermore, bioplastics could reduce greenhouse gas emissions during production and reduce reliance on fossil fuels (Sheldon & Norton, 2020). Some bioplastics have the capability to biodegrade under specific conditions, which lowers pollution over time. Yet, the environmental impact of bioplastics depends on several factors, such as EoL treatment, waste management systems, energy sources, and feedstock cultivation techniques (Van Roijen & Miller, 2022). In order to conduct a comprehensive life cycle valuation, precise details regarding the type of plastic, manufacturing processes, and regional issues are required. By providing useful data regarding the overall environmental performance of different polymers, LCAs can aid in directing sustainable decision-making (Ali et al., 2023). LCA and the circular economy are crucial for plastic recovery as global plastic output increases (Schwarz et al., 2021). Since the industrial revolution, the existing economic system has generated waste. Among the issues brought on by this unsustainable system are resource depletion and increased emissions (Lebreton & Andrady, 2019). Countries including the United Kingdom, Canada, China, Finland, France, Japan, the Netherlands, and Sweden are already promoting the concept of a circular economy. Furthermore, in 2008, China spearheaded the implementation of the circular economy concept in an attempt to preserve energy, lower gasoline emissions, and advance sustainable development (Korhonen et al., 2018). All things considered, there are significant worries about the accidental release of PW into the environment, especially in maritime regions. Significant levels of PW, especially PE, have been found in marine environments, contaminating the ecosystem (Bhuyan, 2022). The circular economy, which seeks to restructure the plastics value chain and reduce greenhouse gas emissions, is one solution to this problem. Despite disposal, PW can be recycled into high-value products through the use of green chemistry, biotechnology, and mechanical techniques (Zhang et al., 2023). The circular economy and LCA are essential to plastic recovery and the transition to a more sustainable economic structure. Many countries have already adopted the circular economy strategy to reduce emissions, conserve energy, and advance long-term sustainability (Abad-Segura et al., 2020).

Incineration

The process of burning PW to produces heat, flue gas, and ash is term PW incineration. Inorganic waste components make up the majority of the ash, which can be carried by the flue gas as small particles or solid lumps. Flue gases are surplus gas by products of incineration that need to be cleaned of gaseous and particle pollutants before being released into the sky. Generally speaking, not all PW can be burned; some can withstand explosives and oxygen heating. Waste incineration has been a key component in the production of renewable energy from biomass resources. Incineration, including heat recovery, has been used more than 450 times in Europe and another part of the world (Abdul-Latif et al., 2021; European Commission, 2013). It is not necessary to use incineration to adequately treat all types of household waste plastic. We must be careful when deciding which polymers to burn in order to prevent these unanticipated explosive incidents.

Pyrolysis

Pyrolysis is the process of converting gases and fatty oils into hydrocarbons and extracting crude petrochemicals. It is even used to recover crude petrochemicals and create sustainable energy from plastic trash (Sharuddin et al., 2016). The pyrolysis process is separated into three main groups according to the amount of heat energy needed to break down plastic connections. Low, medium, and high temperatures are the basis for some types of media. Sonawane et al. (2014) claim that the corresponding temperatures that characterize the pyrolysis states can be divided into three groups: below 600 °C, between 600 °C and 800 °C, and over 800 °C. The two most prevalent forms of polymers found in daily human requirements are thermosets and thermoplastics, which make up around 80% of consumed plastics. This is based on their receptiveness to change and their ease of molecular reformation after heat treatment (Nabi et al., 2021). The products that are created during the pyrolysis of plastics depend on a number of factors, including reactor type, residence time, plastics, condensation setup, feeding setup, and temperature (Miandad et al., 2016; Qureshi et al., 2020; Shent et al., 1999).

Gasification

A promising technique for turning PW into useful energy products like electricity and syngas is PW gasification. Gasification is a flexible and perhaps eco-friendly method of handling PW because it may be utilized to produce heat or energy. However, the gasification technology has certain limitations and challenges. For example, biomass requires more space than fossil fuels, produces a lot of tar, produces soot at high temperatures during the biomass gasification process, and is difficult to produce pure syngas or syngas with low impurities (Lopez et al., 2018). CO, H_2, and CH_4 make up the majority of the synthesis gas produced by the gasification process, which breaks down PW using oxygen, steam, and air (Acomb et al., 2014). The most widely used technology for gasifying PW are entrained flow gasifiers, fluidized beds, and fixed beds (Lopez et al., 2018). When air is used as an oxidant, temperatures range from 800 to 1,100 °C, and when oxygen is used, temperatures can reach 1,500 °C. Although the majority of gasification processes are exothermal, meaning they produce heat, some of the related reactions are endothermal and need heat, which steam, the gasification agent, might supply. Burning PW releases harmful gases, such as CO_2, nitrogen oxide, sulfur oxide, and hydrocarbons (Panda et al., 2010). Therefore, compared to burning, gasification generates syngas that is more environmentally benign (Navarro et al., 2012). One disadvantage of gasification is that using air as a gasifying agent reduces the calorific value of the syngas produced.

Mechanical recycling

Mechanical recycling is the process of turning PW into secondary raw materials or finished goods without substantially altering the chemical makeup of the material. All thermoplastics can, in theory, can be mechanically recycled with negligible to no quality loss (Orhorhoro et al., 2016). The primary method for recovering PW is mechanical reprocessing, which involves heating, shredding, and remolding (Suzuki et al., 2022). The mechanical processing of PW mostly produces plastics with poor quality (Ragaert et al., 2017). The number of cycles of mechanical reprocessing is limited. Thermal conversion methods such as gasification and pyrolysis are commonly used to produce low-value products, such as syngas and other carbonaceous derivatives (Ray & Thorpe, 2007). Furthermore, during thermochemical conversion processes, high temperatures between 400 °C and 900 °C are maintained in order to overcome the unfavorable kinetics and thermodynamics of these reactions (Ray & Thorpe, 2007). One benefit of mechanical reprocessing is that it uses less energy and no dangerous chemicals. The disadvantage is that mechanical reprocessing often causes the tensile strength of polymers to decrease. Mechanically, PW can be processed in a number of ways. Each approach is better suited for particular applications and has pros and cons. There are two primary categories of polymer processing methods used to create high-quality plastics:

(1) primary methods, which include blow molding, injection, compression, extrusion, and roto-coating;

(2) secondary methods, which include calendaring and fabrication, roto-coating, thermoforming, coating, casting, etc.

Mechanical primary recycling method: Injection molding is the primary plastic processing technique. Products such as bobbins, buckets, spools, crates, bottle caps, jewel clips, and auto parts are processed by the injection method. Blow molding is another popular processing method that involves heating the raw material, also referred to as plastic pellets, with electricity and band heaters until the plastic melts and deforms (Romo-Uribe & Lichtenhan, 2021). Items created by blow molding include portable toilets, gas tanks, panels, armrests, air ducts, and some drinking bottles (Das & Mahanwar, 2020; Waring et al., 2018). The top of the mounted hopper holds the resins or raw thermoplastic materials used in extrusion processing, which fall into the extruder's barrel as a result of gravity. Colorants and UV inhibitors are added to complete the extrusion of plastics. Before the resin reaches the hopper, they can be added, and they can be liquid or pelletized (Alam et al., 2016). Extrusion is used to create a variety of materials, including sheets, strapping, pipes, and multilayer films (Alam et al., 2016; Szostak et al., 2021). The most popular method for thermosetting materials is compression molding, which is typically avoided when working with thermoplastics. As plastic is being produced, a heated polymer is injected into a hot mold cavity. This method uses heat and pressure to compress the material into the required shape. Other ingredients, such as plastic molding powder, are added to the mixture to give the finished product unique properties or to make it stronger (Asgher et al., 2020). The process of compression molding makes it easier to create materials with complex configurations of lengths, thicknesses, and complexity. Customers and companies from a range of industries want the products made with this approach because of their high strengths, hardness, and durability (Mendible et al., 2017). Compression molding procedures are used to create sockets, cisterns, plugs, engine handles, and engine casing switches. Different engineers use transfer molding, the primary method of plastic manufacture, in different ways to produce different rubber components. Throughout the manufacturing process, it is crucial to measure, arrange, and inject the right amount of molding into the pot. After that, the material is forced into the mold cavity by compression and heating (Ageyeva et al., 2019).

Mechanical secondary recycling method: Rotational molding is the plastic molding method that produces hollow things the best. This process does not require pressure, in contrast to earlier ones. Economically speaking, it is favorable to have a short production process since casting techniques make it less expensive and easier to handle (Ogila et al., 2017). In thermoforming, a plastic sheet is created using mold and either air or mechanical help. Several hundred psi or almost zero psi of air pressure can be employed. The pressure is produced by removing the air between the sheet and the mold at 14 psi, or atmospheric pressure. The sheets are heated to a malleable temperature to produce the necessary items, and then the finished product is cooled for subsequent use (Landsecker & Bonten, 2019). Calendaring is another secondary processing method used to make a variety of high-end plastics. It is also extensively utilized in the production of PVA and other modified polymers. The melted polymer is heated and compressed in the extruder, where calendaring wheels turn it into sheets (Mitsoulis, 2008). Another exciting and useful plastic processing technique is casting, in which liquid material is poured into a mold with a hole that resembles the shape of the intended final product. Once the liquid has solidified, it adopts the shape of the plastic that needs to be manufactured. A broken or detached casting that is removed from the mold to finish the processing is another term for the solidified section.

Biochemical conversion

Biochemical conversion refers to technologies that convert only biodegradable waste using microbial processes. MSW and agricultural waste have biogenic components that make them the ideal feedstock for these systems. Microbes biodegrade manmade polymers with a high molecular weight. However, there are limitations to the commercial utilization of these bacteria for biodegradation of high molecular weight synthetic polymers (Lear et al., 2021). By interacting with abiotic elements like heat and light, the bacteria alter the structures of polymers and provide an environment that is favorable for enzymatic breakdown (Amobonye et al., 2021). The bacteria are typically involved in the biodegradation of PW, compost, landfill leachate, and sewage sludge. The bacterium is capable of biodegrading both natural and synthetic polymers. Microbial biomass is one consequence of biodegradation (Siracusa, 2019). The biological conversion of plastic has the advantages of low processing temperatures and superior product selectivity. Nevertheless, they usually require extensive preparation and treatment phases.

SUMMARY AND FUTURE PERSPECTIVES

The issue of PW is a worldwide concern that requires attention. Since PW can have a catastrophic impact on both the ecosystem and long-term human health, it is imperative that action be taken to reduce its abundance in the environment. The fight against plastic pollution can be significantly improved by creating sustainable alternatives, cutting back on plastic use, recycling plastic trash, and putting rules and regulations into place. For example, as a way to combat plastic pollution, extended producer responsibility (EPR) legislation is becoming more and more popular in several US states and European nations (Tumu et al., 2023). According to EPR, producers and manufacturers, not consumers, bear the financial burden and liability for disposing of trash and packaging materials. Companies will be billed under an EPR for the collection and recycling of packaging materials, including cardboard boxes and plastic containers, as well as for disposing of any packaging materials that cannot be recycled (Tumu et al., 2023). Businesses are encouraged to create less plastic packaging and create a new market for recycled goods because it is more expensive to collect and recycle their own plastic products. Additionally, using bioplastics could lessen the amount of PW produced worldwide. Bioplastics are plastics composed of plant fibers, usually bamboo and cornstarch, rather than oil and other natural ingredients. They are comparable to conventional plastics in terms of durability and characteristics, and many of them may be recycled and biodegraded in industrial landfills. Moreover, they often have a smaller environmental impact because the plants they are made of do not need chemicals or pesticides to grow (Yoshida, 2022). Reducing the use of fossil fuels would also result from the switch to bioplastics. Using PW to create green technologies is another way to combat plastic pollution. Plastic highways, which are made wholly of or partially composed of recycled plastic, have been gaining popularity since they can accommodate even the largest vehicles. Over 60,000 miles of plastic roads were first installed in India over 20 years ago, and a Dutch start-up has constructed two 30-meter sections of bike track in the Dutch towns of Zwolle and Giethoorn, claiming to be the first recycled plastic bike path in history. According to studies, plastic roads could function on par with or even better than conventional asphalt roads (Watkins, 2022). They can withstand potholes, flood damage, and large temperature fluctuations and are generally more resilient. Recycling plastic is a crucial step in cutting down on PW and protecting the environment. More of the plastic we consume can be recycled and used again thanks to technological advancements and better recycling procedures. Remembering that not all plastics can be recycled makes it crucial to lessen our dependency on them. Besides, consumer choice is a significant factor, and businesses have a major role to play in this. Industries will respond appropriately if consumers decide not to purchase a product due to its plastic content. At first glance, it may appear that plastic recycling has a promising future. Plastic will still eventually wind up in landfills, though, because its use is only increasing. According to projections, half of the PW will not be recycled, and by 2060, it is expected to quadruple. Economic and population growth are two reasons why governments are losing the fight against plastic and why the usage of single-use plastic packaging is rising. Only with a sustained level of innovation and commitment from industries can we ensure that fewer plastics end up in landfills and in the environment. While there is a chance that the amount of PW that ends up in landfills and the environment will decrease as technology advances and more businesses adopt the use of recycled materials, the future of the environment is not bright if our plastic usage keeps growing as predicted.

Furthermore, the environment is impacted by human activity, and the increasing need for energy and resources has caused a significant change in the way PW is handled. The government and other pertinent stakeholders should put into practice suitable sustainable waste management strategies in order to maintain environmental sustainability. The government and pertinent institutions should create regulations that promote the continuous use of recycled PW for construction. Technologies for converting PW into textiles are still in their early stages of development. Public spaces and educational institutions can host awareness campaigns about the value of PW management and environmental sustainability. Innovation is a comprehensive strategy used to draw attention to the problems and difficulties associated with plastics derived from fossil fuels and bring about significant change. Solid PW has accumulated as a result of the use of plastics. The usage of biodegradable polymers is a key component of initiatives to reduce PW. Biodegradable polymers have the potential to replace the majority of the conventional polymers now in use, albeit at a low level. The cost problems of getting rid of PW can be fixed by producing materials that are equivalent. The development of commercially viable bioplastics can help address the issues of supply security and quick scaleup. This report details recent developments in the recycling and value-adding of PW, which are useful solutions to the PW problem from an application standpoint. Plastics firms may find answers in research on PW's recycling and value-adding. As a result, creating synthetic biology-based microbial cell factories would be a promising way to increase the adaptability of microorganisms and promote a circular economy for plastics. Research on the breakdown of different polymers is required to control the right bacteria. New low-energy chemical recycling catalysts that target different polymers must be developed in order to increase the recycling rate of plastics. As the amount of waste residue generated varies depending on the amount of garbage generated and the recycling technique used, it is problematic that there are no standards or laws governing the handling of residue produced by recycling technologies and their production facilities. PW can be used as a binder, aggregate, and fiber, replacing all of the components in cementitious composites with some acceptable negative effects.

Moreover, the catalytic conversion of PW and, consequently, the yield and distribution of the products are influenced by several other parameters, including the state of the PW, the presence of pollutants in the waste, and the types of reactors utilized in the thermochemical conversion process. Recycling procedures will also be enhanced by the development of novel catalysts, compatibilizers, and polymers using sophisticated computer modeling and data analytics. It is hoped that these initiatives will soon cause plastic recycling rates to rise above their present levels. Universities, research centers, polymer manufacturers, and lawmakers must collaborate to integrate renewable energy sources and streamline procedures. One effective technique for recycling plastic to create gasoline that is both efficient and scientific is pyrolysis. The refined physical and chemical processes are defending the benefits of pyrolysis technology. Many factors affect the plastic recycling process, yet PW's recycling companies continue to face many technical challenges. Technological problems brought on by multi-layer plastic polymers or additives like phthalates, brominated flame retardants, etc., make recycling plastic more difficult. PW is often managed via mechanical (sorting and reprocessing) and chemical (gasification, pyrolysis, etc.) techniques. Technology for chemical recycling is essential to the transition to a circular economy. To overcome these obstacles, a sustainable and efficient method of handling these waste products must be found. The handling of recovered plastics from MSW is one area that is very sensitive. The recycling system's high labor costs resulted in several issues, such as worsened water contamination and reduced operational reliability. Because of these limitations, research has shifted to alternative energy recovery techniques. Thus, considerable and careful technology led to the conversion of PW to energy. Modern technologies (pyrolysis, gasification, hydrocracking, and KDV) have employed a lot of plastic goods that are currently used to build bricks, tar, and concrete and are turned into fuel in order to minimize PW.

CONCLUSION

Multidisciplinary research is vital to solving the global issue of plastic pollution. By implementing a resource recycling system powered by sunlight and bioenergy that uses photocatalyst technology and microbial biotechnology to transform waste plastic into green resources and hydrogen. Also, utilizing scientific findings to create works of art, artifacts, curatorial interventions, publications, and other information products that the general public, policymakers, art enthusiasts, and academic audiences can comprehend. Additionally, scientific-artistic hybrid analytical and interpretative methodologies build projects that address people' alienation from the plastic they use and manufacture by utilizing a variety of platforms and evidence types. Besides, production processes, properties, and environmental effects of bioplastics must be thoroughly understood in order to build efficient PW management systems that promote a circular economy. We can successfully manage PW and integrate technological advancements thanks to this understanding. These programs support global sustainability goals, create new economic possibilities, and advance environmental sustainability. The present review article provides an overview of the current state of plastics and their trash, which are regarded as one of the main risks to aquatic life, humans, and territorial life. Furthermore, when PW is not managed properly, toxic chemicals such as CO_2, CH_4, As, and VOCs are released. Even at low concentrations, these chemicals can cause neurological, reproductive, immunological, asthmatic, and endocrine disruptions in humans as well as contribute to climate change. Reducing the detrimental effects of plastic pollution and promoting a more sustainable future require the implementation of effective PW waste management systems that consider the various elements that comprise the waste stream. A nation's environmental performance ranking may be impacted by how PW is managed. Numerous tactics and technological advancements have been implemented to address the issue of plastic pollution. In addition to saving a substantial sum of money, these methods will preserve the lives of people, animals, and the environment by recycling raw materials and reusing plastics. Furthermore, the security and welfare of every member of this ecosystem depend on the environment being kept safe. Recycling PW will help the economy grow by reducing production costs. It is not only financially viable, but it will also help eradicate infectious diseases that are carried by contaminated water and air. Nevertheless, the fact that there are multiple varieties of plastic is one of its drawbacks. Plastic can take many different forms, and not all of them are readily recyclable. PET, HDPE, and PP are the most widely recycled plastics while PVC, LDPE, and PS are all partially recyclable (at specialized facilities). Additionally, the way that different types of plastic are created can affect their capacity to be recycled; thermoset plastics are formed of polymers that create irreversible chemical connections and cannot be recycled, while thermoplastics can be remelted and remolded. Bioplastics, composite plastic, plastic-coated wrapping paper, and polycarbonate are a few types of non-recyclable plastics. Thus, the sorts of plastic that may or cannot be actively recycled vary by area, based on local facilities and programs. This is one of the main problematic aspects. Therefore, determining which plastic kinds can be recycled and where that particular plastic material can be processed can be challenging. Regretfully, there are no strict guidelines regarding the accessibility of recycling facilities. For this reason, a RIC label is seen on the majority of plastic containers.

Funding: No funding source is reported for this study.

Ethical statement: The author stated that, since there was no research or testing on humans or animals, the study does not need ethics committee permission.

Declaration of interest: No conflict of interest is declared by the author.

Data sharing statement: Data supporting the findings and conclusions are available upon request from the author.

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