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Mitigation of waste threats to the environment through plastic waste management

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Abstract. Plastics and plastic-based products are increasingly used for various purposes alongside technological, industrial, and population growth because they are lightweight, strong, flexible, easily molded, corrosion-resistant, easy to color, effective thermal and electrical insulators, and relatively affordable. This study employs a qualitative method with a descriptive approach. The purpose of this study is to provide an overview of governmental mitigation efforts in addressing waste-related threats through plastic waste management. The results indicate that Indonesia generates approximately 3.2 million tons of plastic waste entering the oceans annually, positioning it as the second-largest contributor globally after China. Consequently, Indonesia is the largest contributor of plastic waste in Southeast Asia, with plastic materials requiring hundreds of years to degrade. Excessive plastic waste adversely affects human health and the environment and may eventually lead to hazards such as flooding as well as air and soil pollution. Therefore, mitigation through effective plastic waste management is necessary to reduce the risks associated with excessive waste. Such mitigation may be implemented through technological, social, economic, cultural, and institutional approaches. Technological approaches include the application of pyrolysis, hydrothermal methods, and the use of environmentally friendly raw materials. Social and cultural approaches encompass public awareness activities and community engagement. The circular economy framework may also be applied as an economic approach. The institutional approach involves the participation of central and local governments in implementing existing policies and regulations, as well as formulating new regulatory measures aimed at reducing plastic waste.

Keywords: Environment, Mitigation, Plastic, Threats, Waste

Introduction

Contemporary life is increasingly inseparable from plastic. Plastic products are increasingly used alongside population growth, technological advancement, and industrial development due to their lightweight nature, malleability, and relatively low cost as insulating materials. Plastics are widely applied in packaging, construction, transportation, medical equipment, and various other sectors because of their flexibility and durability. However, despite these advantages, plastics exhibit a major drawback, namely their high resistance to degradation. A single plastic bag may take approximately ten to twelve years to decompose, while a plastic bottle, with a more complex and thicker polymer structure, may require up to 20 years. Styrofoam, which is commonly used as food packaging, may require up to five centuries to fully degrade (Dilthey, 2022). These prolonged degradation periods cause plastic waste to accumulate continuously, thereby polluting the environment and exacerbating ecological challenges.

Plastic waste has become one of the most pressing environmental challenges of the twenty-first century. Since its invention in the early twentieth century, plastic production and consumption have increased dramatically, generating millions of tons of waste annually. Inadequate waste management has resulted in significant environmental and health impacts. Plastic waste contaminates oceans, rivers, and soils, thereby disrupting ecosystems and threatening biodiversity. Furthermore, microplastics generated through degradation processes are now widespread in water, air, and food systems, potentially increasing health risks for both humans and animals. At present, plastic waste is predominantly disposed of in open dumping sites, with only a small proportion entering formal recycling systems. Vidilaseris (2016) estimates that approximately 150 million tons of plastic waste are currently present in the oceans, with at least 8 million tons entering marine ecosystems annually. Meanwhile, global plastic production continues to increase, reaching an estimated 440 million tons in 2024 (Clarke, 2025), compared with 400 million tons in 2022 (Ritchie et al., 2023). Although bioplastic production reached 1.44 million tons in 2024 (Santos, 2024), this volume remains marginal relative to conventional plastics.

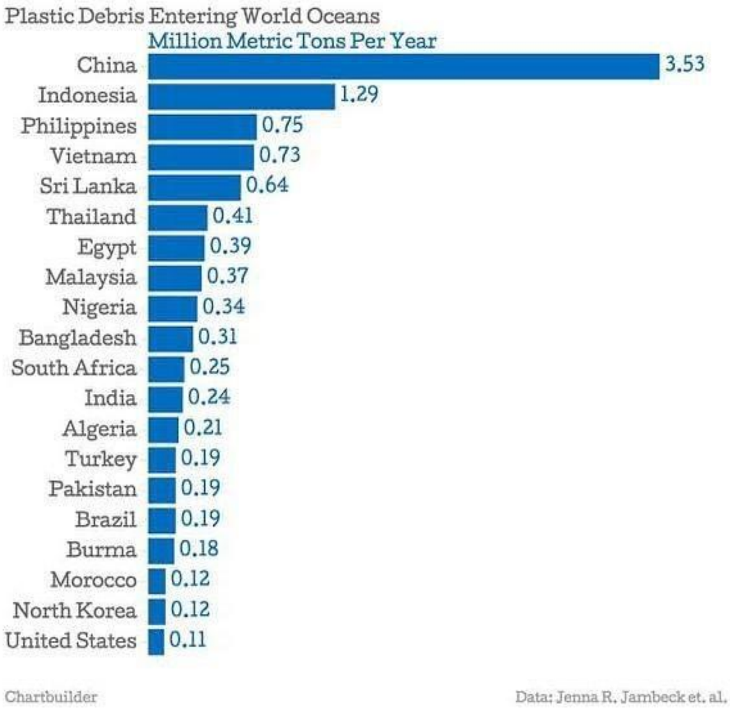

Chart.1 Ranking of Countries Producing Plastic Waste Entering the Marine Area
Source: Ambari, 2019

Despite this alarming trend, public awareness regarding the appropriate use and disposal of plastic remains limited. Jambeck's influential study (2015, cited in Ambari, 2019) identified Indonesia as the world's second-largest contributor of plastic waste entering the oceans after China, although its methodology has been subject to debate. Data from Indonesia's Ministry of Environment and Marine Affairs indicate that 10.95 million pieces of plastic waste were generated annually from only 100 retail stores, equivalent to 65.7 hectares of plastic bags or approximately 60 times the size of a soccer field (Arbi, 2019). These figures highlight the urgent need for regulatory intervention to reduce plastic waste before it escalates into a broader ecological crisis.

Approximately 40% of single-use plastics are consumed in packaging, dominated by Polyethylene (PE), Polyethylene Terephthalate (PET), Polypropylene (PP), and Polystyrene. When combined with a disposable consumption culture, these plastics contribute to pollution, resource depletion, and soil degradation. In Europe, approximately 70% of collected plastic waste is either incinerated or landfilled, while in the United States, 53% of solid waste is disposed of in landfills, with recycling accounting for only 6% of total demand (Narancic & O'Connor, 2019). In Indonesia, plastic waste accounts for approximately 15% of total waste, with only 10–15% recycled, 60–70% disposed of in landfills, and the remainder entering rivers, lakes, beaches, and marine environments (Amani, 2018). These patterns indicate that marine plastic pollution is not confined to individual nations but represents a transboundary issue requiring urgent collective mitigation efforts.

Several previous studies have sought to address the global plastic problem from various disciplinary perspectives. Dilthey (2022) emphasized the extremely long degradation periods of various types of plastics, underscoring their persistent threats to ecosystems. Vidilaseris (2016) provided estimates of marine plastic pollution, indicating the presence of approximately 150 million tons of plastic waste in the oceans, with an annual inflow of at least 8 million tons. Clarke (2025) highlighted the continued rise in global plastic production, which reached 440 million tons, while Ritchie et al. (2023) traced the exponential growth trajectory of plastic use since the twentieth century. Santos (2024) analyzed the development of bioplastics as an alternative, noting that current production volumes remain marginal relative to conventional plastics. Jambeck's influential work (2015, as cited in Ambari, 2019) identified national contributions to marine plastic waste, placing Indonesia second after China, although the study's methodology has since been subject to critique. Meanwhile, Narancic and O'Connor (2019) examined waste disposal practices in Europe and the United States, finding that most plastics are incinerated or landfilled, with recycling rates remaining extremely low even in industrialized nations. Amani (2018) further emphasized that plastic pollution is not confined by national borders but represents a transboundary environmental threat requiring global cooperation.

Although these studies have generated valuable insights, they remain fragmented and are primarily oriented toward ecological or technical dimensions, such as degradation, production, recycling, and global waste flows. Few studies have examined the socio-economic, cultural, and institutional factors that drive plastic consumption and shape waste management outcomes in developing contexts. In particular, Indonesia's case is frequently highlighted in statistical terms but is rarely examined holistically through a multidimensional framework that simultaneously accounts for technological, behavioral, economic, cultural, and governance perspectives. This situation reveals a research gap: while existing literature documents the magnitude of plastic waste and its ecological risks, it has not sufficiently linked consumption patterns, waste governance systems, and broader implications for disaster risk and sustainability.

The novelty of this study lies in its attempt to address this gap by adopting an integrative and interdisciplinary approach to plastic waste management. Rather than isolating technical or ecological factors, this research situates plastic waste within a broader governance framework encompassing social practices, economic incentives, cultural norms, and institutional arrangements. By grounding the analysis in Indonesia's local realities while drawing connections to global challenges, this study contributes theoretically by enriching academic discourse on plastic waste governance and practically by offering evidence-based recommendations for policy and institutional reform. In doing so, this study advances beyond prior research by positioning plastic waste not only as an ecological hazard but also as a complex socio-environmental issue that requires coordinated, cross-sectoral solutions.

Based on these identified gaps, this study aims to provide a comprehensive understanding of plastic waste mitigation. Specifically, the objectives are: first, to examine the characteristics and behavior of plastics, particularly their impacts on human health and the environment; second, to review plastic waste management through a multidimensional framework encompassing technological, social, economic, cultural, and institutional aspects; third, to analyze challenges and opportunities for implementing plastic waste management strategies in Indonesia while considering their global relevance; and fourth, to propose strategic recommendations for strengthening policies and practices toward more effective and sustainable plastic waste mitigation. Through these objectives, this study not only expands the academic discourse on plastic waste management but also offers practical insights for policymakers, industry actors, and society at large. Ultimately, it underscores the importance of viewing plastic pollution as a cross-sectoral and interdisciplinary issue that demands collaborative and innovative solutions to safeguard environmental sustainability and human well-being.

Methods

This study aims to provide an overview of governmental mitigation efforts in addressing waste-related threats through plastic waste management. This study employs a qualitative descriptive approach using a documentation-based research method. According to Creswell (2018), qualitative research is a process of understanding phenomena by exploring the meanings of social or humanitarian problems. Data and information are collected from academic sources, government reports, and publications by non-governmental organizations that are relevant to the topic and support the literature review on waste hazard mitigation. Data analysis is conducted after data collection through three steps: first, data reduction; second, data presentation; and third, interpretation of the processed data using relevant theoretical frameworks and applicable laws and regulations.

Result and Discussion

Types of Plastic

Plastic is a synthetic or semi-synthetic material produced through polymerization via organic condensation or addition processes. To increase its added (economic) value, plastic production may involve the incorporation of additional substances. Figure 2 illustrates the formation of Polyvinyl Chloride (PVC) polymer derived from vinyl chloride monomers. Plastics generally consist of carbon-based polymers, sometimes combined with elements such as oxygen, nitrogen, chlorine, or sulfur. These materials are characterized by long chains of atoms bonded together to form polymers.

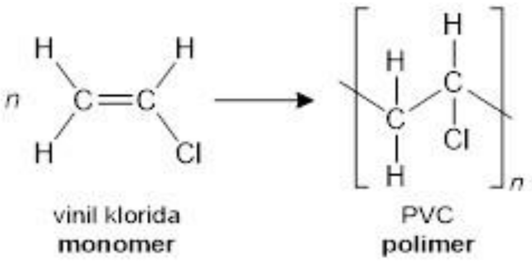

Figure 1. Polymerization of Vinyl Chloride to Polyvinyl Chloride (PVC)
Source: Mcavoy, 2025

According to PlasticsEurope (2018), plastics are classified into two main types, namely thermoplastics, which can melt at certain temperatures, and thermosets, which undergo irreversible hardening; these categories are illustrated in Figure 2. Thermoplastics exhibit reversible behavior and can be reshaped in response to temperature changes, becoming solid again upon cooling. In contrast, thermosets cannot be reshaped and do not adapt to temperature changes, making the process irreversible. When subjected to heat during the curing process, thermoset plastics decompose and form char because they can no longer be softened.

Figure 2. Categories and Differences between Thermoplastic and Thermoset
Source: Mcavoy, 2025

Plastic Category

According to the Plastic Industry Society (1988), as cited in Brydson (1999), thermoplastics can be classified into seven categories. These categories are presented in Figure 3.

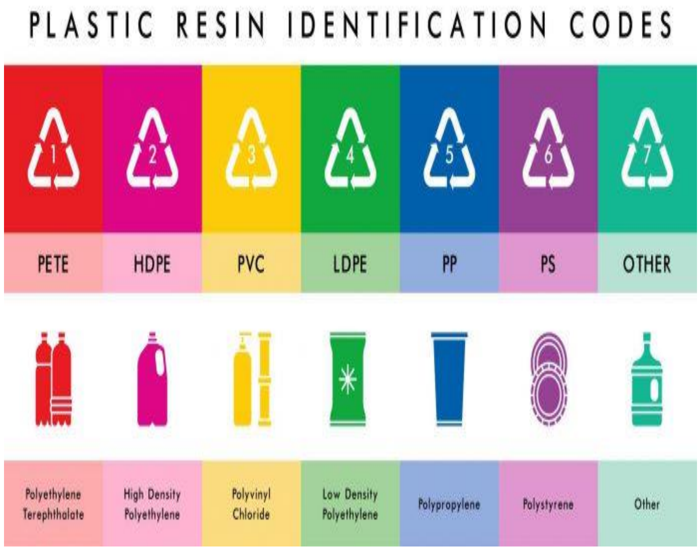

Figure 3. Seven Types and Identification Codes for Plastic Resins
Source: Brydson, 1999

Seven Types of Plastic

The seven types of plastic are discussed in detail below (Nicholson, 2006).

1. Polyethylene Terephthalate (PET)

   Polyethylene Terephthalate (PET) can sometimes absorb the odor and taste of food and beverages stored inside. Items made from this plastic can generally be recycled. This type of polyethylene terephthalate contains substances with carcinogenic properties, such as antimony trioxide, the release of which may increase when the material is exposed to elevated temperatures for extended periods. PET plastic is commonly used in household products such as carpet fibers, ropes, clothing, beverage bottles, and medicine bottles, as illustrated in Figure 4.

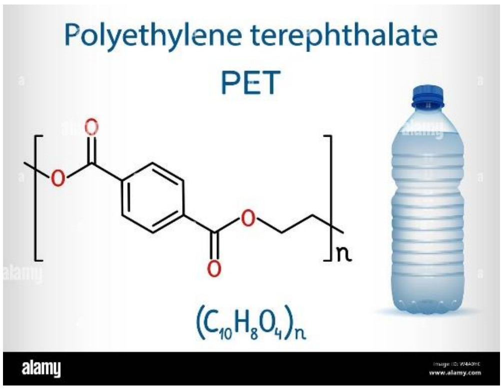

Figure 4. Polyethylene Terephthalate
Source: Nicholson, 2006

2. High Density Polyethylene (HDPE)

   High Density Polyethylene (HDPE) is generally recyclable and has a higher density than PET. Figure 5 illustrates several products made from this plastic, including milk bottles, motor oil containers, shampoo, conditioner, detergent, and bleach bottles. This type of plastic is considered relatively safe for use with food and beverages. However, HDPE bottles should not be reused as food or beverage containers if they were not originally intended for such purposes.

Figure 5. High Density Polyethylene
Source: Nicholson, 2006

3. Polyvinyl Chloride (PVC)

Certain types of Polyvinyl Chloride (PVC) can sometimes be recycled. PVC is commonly used to manufacture pipes, as well as products such as children's toys, plastic wrap, detergent bottles, blood bags, and medical equipment (Figure 6). These items may pose health risks if PVC comes into contact with food or is ingested. PVC is the second most widely used type of plastic after polyethylene. In terms of disposal, PVC presents an environmental pollution concern because it can pose serious health risks.

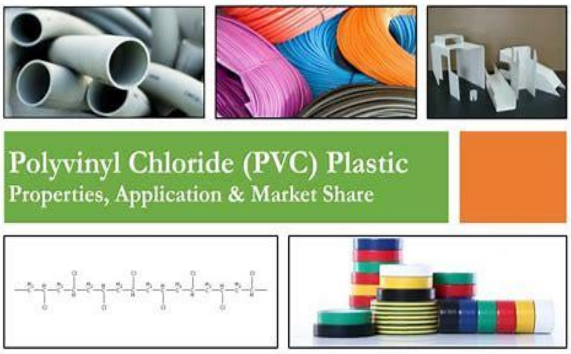

Figure 6. Polyvinyl Chloride
Source: Nicholson, 2006

4. Low Density Polyethylene (LDPE)

Low Density Polyethylene (LDPE) has a relatively simple polymer structure and low density. This type of plastic is widely used and relatively difficult to recycle. It is also considered relatively safe and tends to be durable and flexible. Products such as film wraps, sandwich packaging, squeezable bottles, and plastic shopping bags are made from LDPE plastic (Figure 7).

Figure 7. Low Density Polyethylene
Source: Nicholson, 2006

5. Polypropylene (PP)

Polypropylene (PP) is a material that can sometimes be recycled, although the process is not straightforward. PP is strong and can generally withstand higher temperatures. Plastic bottle caps are often made from PP because it is considered safe for food contact; accordingly, it is used in margarine containers, yogurt bottles, syrup bottles, lunch boxes, and prescription bottles (Figure 8).

Figure 8. Polypropylene
Source: Nicholson, 2006

6. Polystyrene (PS)

Although polystyrene is technically recyclable, it is difficult to recycle in practice. Items such as disposable coffee cups, plastic food containers, plastic cutlery, and packaging foam are commonly made from polystyrene (Figure 9). Polystyrene can release styrene when exposed to heat, which may disrupt the nervous system and brain, as well as affect the lungs, liver, and immune system.

Figure 9. Polystyrene
Source: Nicholson, 2006

7. Other

This seventh category includes plastics that are not defined under the six primary identification codes. Polycarbonate and polylactide, which are difficult to recycle, are classified under code 7. Polycarbonate (PC) is a material used in products such as baby bottles, compact discs, and medical storage containers. Polycarbonate is among the most commonly used plastics within this category. Because it contains bisphenol A (BPA), this type of plastic has been restricted in many applications due to its potential to cause health problems, including chromosomal damage and reduced sperm count. The use of polycarbonate in infant formula packaging and baby and toddler feeding bottles has been banned in several countries.

Figure 10. Other Types Plastic
Source: Nicholson, 2006

Impact on Health and the Environment

Various studies indicate that the use of plastics that do not meet safety standards may pose health risks and potentially trigger cancer. In addition, plastics are difficult for microorganisms to decompose, causing plastic waste to accumulate and disrupt the environment through pollution and adverse health effects. Efforts to reduce plastic waste through open burning are not considered an appropriate solution, as combustion produces hazardous and toxic gases that pollute the atmosphere. These gases can cause respiratory problems, while scorched residues do not necessarily form fertile humus and, if buried, may lead to soil contamination.

PVC plastics are typically treated with plasticizers to enhance flexibility. Epoxidized Soybean Oil (ESBO), Di(2-Ethylhexyl) Adipate (DEHA), Polychlorinated Biphenyls (PCBs), Acetyl Tributyl Citrate (ATBC), and Di(2-Ethylhexyl) Phthalate (DEHP) are examples of such plasticizing agents. These substances raise concerns because clinical studies have indicated potential health risks. For example, exposure to PCBs has been associated with tissue damage and cancer in humans. Consequently, the use of PCBs has been prohibited in many contexts (Karuniastuti, 2013).

In Japan, PCB poisoning, known as *yusho*, is characterized by symptoms such as skin pigmentation, skin lesions, metabolic disorders, and weakness in the hands and feet. It has also been associated with miscarriage and congenital disabilities. Therefore, appropriate use of plastics is recommended to minimize health risks, including preferential use of polyethylene, polypropylene, or alternative natural materials when possible.

Dye contamination represents another concern in plastic production. For example, the use of black plastic bags for fried foods should be avoided due to potential health risks. According to Karuniastuti (2013), certain substances in plastics may decompose and generate radicals that can be harmful to the human body. The disposal of plastic waste constitutes one of the contributing factors to contemporary environmental degradation. Plastic bags represent problematic waste due to their persistence and management challenges. Plastics continue to accumulate and degrade slowly, thereby polluting soil and groundwater due to their prolonged degradation periods.

Oil-based plastics are highly resistant to biodegradation; therefore, once released into the environment, they tend to accumulate and exert negative environmental impacts. The prolonged process of separating hazardous chemicals from plastic waste in landfills carries risks, including potential groundwater contamination. Approximately 50% of waste found on European beaches and in surrounding seas consists of single-use plastics.

Hundreds of thousands of seals, penguins, turtles, whales, dolphins, and seabirds are killed annually due to entanglement in or ingestion of plastic debris, including microplastics, in marine environments. Scientific studies have demonstrated that microplastics affect the biophysical properties of soil, altering its ecological functions. Therefore, rather than causing immediate mortality alone, plastic pollution may induce gradual but significant changes in ecosystems worldwide (Narancic & O'Connor, 2019). Plastic waste originating from land and transported to the ocean can fragment into microplastics measuring approximately 0.3–5 mm through physical and chemical processes, which may be ingested intentionally or unintentionally by marine organisms and subsequently enter the human food chain. Plastic waste on land also poses significant risks, as it endangers human health and contributes to unsanitary environmental conditions.

In greater detail, the impacts of plastic waste on soil and aquatic ecosystems have been well documented in recent scientific literature. A global meta-analysis reported that plastic residues and microplastics (MPs) significantly impair soil functions, reducing soil water movement by 14%, dissolved organic carbon by 10%, and total nitrogen by 9%, while plant height and root biomass decreased by 13% and 14%, respectively (Zhang et al., 2022). Plastic pollution in wetlands also alters soil–plant systems by increasing soil organic matter and carbon by 28.9% and 34.2%, while decreasing inorganic nutrients, bacterial diversity, and enzyme activity by 5.9–14.2%; plant biomass and photosynthetic efficiency declined by 12.8% and 18.4%, respectively, and greenhouse gas emissions (CO_2 and N_2O) increased substantially (Zhao et al., 2024).

Moreover, numerous studies highlight that microplastics alter soil biophysical properties by damaging soil structure and reducing aeration, water permeability, and water-holding capacity, which in turn lowers organic carbon levels, disrupts nutrient transfer and nitrogen cycling, impairs microbial activity, and reduces plant productivity; agricultural yields decline substantially when plastic accumulates at levels of 72–260 kg per hectare (Zhang et al., 2022). These findings comprehensively illustrate how plastic waste disrupts soil ecology, plant growth, nutrient cycling, and ultimately threatens ecosystem resilience and food security.

Mitigation of Plastic Waste on the Environment

There are various approaches to reducing the environmental impacts of plastic waste. To reduce plastic waste, waste management must be implemented throughout the plastic production cycle. The contemporary plastic production system has traditionally followed a linear economic model—take, make, and dispose—with limited recycling. In a circular production cycle, plastics are recycled and reused to produce value-added materials, including biodegradable polymers such as polyhydroxyalkanoates (PHA). The introduction of biodegradable plastics through recycling may enable the controlled and sustainable reintegration of carbon from plastics. Figure 11 illustrates a circular production cycle.

Figure 11. Circular Waste Production Cycle
Source: Narancic & O'Connor, 2019

Plastic Circle Production

Much research on plastic waste management aims to reduce plastic waste to prevent environmental pollution. Various approaches have been applied, including technological, economic, social, and cultural strategies.

1. Technological Approach

   Emerging technological innovations offer potential solutions for managing plastic waste through conversion into fuel. For instance, pyrolysis has been shown to produce alternative fuels. A study conducted in the Seribu Islands reported that at 550 °C, using a specific blend of LDPE, PP, PET, PS, and HDPE, pyrolysis produced up to 0.805 tons of diesel-equivalent fuel per 1,000 kg of plastic, indicating potential environmental and economic benefits (Raharjo et al., 2025). Another investigation on polyethylene pyrolysis reported that at 350 °C, the resulting pyro-oil exhibited physical properties closely resembling kerosene, performing better than conventional diesel in this context (Yuliansyah et al., 2015).

   Although methods such as hydrothermal treatment—using heated water at controlled temperatures—have been theoretically proposed to facilitate plastic degradation by converting chlorine into less harmful salts, empirical evaluations of these techniques remain limited. Public understanding of these emerging processes also appears limited, underscoring the need for clearer dissemination and targeted educational efforts (Ambarwati, 2023).

   In parallel, the development of biodegradable plastics by industry actors represents another strategic avenue. For example, PT Chandra Asri utilizes Asrene Degradable Grade polyethylene, which reportedly degrades within one to two years under exposure to sunlight or mechanical stress (Raharjo et al., 2025). PT Tirta Mitra produces Oxium and Ecoplas; Oxium accelerates degradation through ultraviolet radiation and heat, while Ecoplas incorporates biological additives, such as tapioca, to enhance biodegradability. Similarly, Enviplast, developed by PT Inter Aneka Lestari Kimia, is composed of starch and vegetable oil derivatives, enabling more rapid degradation through interaction with bacteria and environmental factors (Yuliansyah et al., 2015).

   From a governmental and infrastructural perspective, advanced waste management strategies include transitioning landfill operations to controlled or sanitary systems, capturing methane emissions, and optimizing energy recovery technologies such as Waste-to-Energy (PLTSa), Refuse-Derived Fuel (RDF), biodigesters, and maggot-based biomass treatment. These strategies align with Indonesia's objective of achieving Zero Waste Zero Emission in the waste sector.

Furthermore, public engagement tools such as Reverse Vending Machines (RVMs), also known as "Trash ATMs," have been piloted to incentivize recycling. In Bali, the Ministry of Marine Affairs and Fisheries, in collaboration with Plasticpay and Bank Syariah Indonesia (BSI), introduced RVMs that allow users to exchange PET bottles for points redeemable through the Plasticpay application. This initiative has since expanded to cities such as Bogor and Semarang, illustrating broader institutional adoption in urban centers (Ambarwati, 2023). Finally, in the maritime domain, Presidential Regulation No. 83 of 2018 mandates a 70% reduction in marine plastic debris by 2025, reflecting Indonesia's strategic commitment to combating marine pollution through blue economy initiatives and policy instruments.

2. Social, Economic and Cultural Approach

By involving communities in plastic waste management, a social approach to waste reduction may be realized. Community leaders may be engaged to campaign about the health risks associated with plastic use. They may also be encouraged to promote the use of natural materials, such as banana leaves for food wrapping or reusable baskets. In addition, community leaders and educators should receive education and training related to waste management practices.

Social approaches are also implemented by the Ministry of Environment and Forestry through the designation of February 21 as National Waste Awareness Day (HPSN), aimed at reminding and campaigning to all stakeholders about the importance of waste management. A cultural approach must also be adopted. For example, waste management behaviors have been incorporated into *wayang orang* performances. Children should be educated from an early age to avoid littering behaviors.

A key element in effective waste management and recycling is the integration of all stakeholders involved in sustainable waste management. The circular economy approach, as reported by the Packaging and Recycling Alliance for Indonesia Sustainability Environment (PRAISE), represents one economic strategy for waste management that should be developed sustainably (indonesia.go.id., 2019). The circular economy framework promotes a paradigm shift by viewing used plastic packaging not as waste but as a commodity with development potential. Under this approach, used plastic packaging can retain its value and be utilized optimally through reuse, recycling, or remanufacturing.

This approach can not only create new economic value chains but also reduce negative environmental impacts, such as waste accumulation in landfills or marine environments. This method may contribute positively to environmental protection and therefore warrants implementation. The main principles of sustainable economics are reflected in the 5R framework: Reduce, Reuse, Recycle, Recovery, and Repair.

Research by Calleja (2019) supports the circular economy approach, stating that a new plastics economy is one that eliminates waste, maximizes value, and uses plastics efficiently. By doing so, environmental protection may be enhanced through reductions in marine litter, greenhouse gas emissions, and dependence on imported fossil fuels.

3. Institutional Approach

Addressing plastic waste requires regulations and strategies that are integrated with economic growth, social stability, and environmental protection to support sustainable development. Although specific laws and regulations governing waste exist, more targeted regulations for plastic waste management can be derived from these frameworks. According to Article 15 of Law Number 18 of 2008 on Waste Management, producers are required to take responsibility for packaging waste, particularly by adjusting business models to reduce or eliminate the use of single-use plastic packaging. Governments possess significant authority to encourage manufacturers to reduce the use of single-use plastics. Ministries such as the Ministry of Maritime Affairs and Fisheries, the Ministry of Environment and Forestry, and the Ministry of Industry have initiated internal campaigns to limit plastic use.

Regional governments at both provincial and district/city levels have enacted regulations (Perda/Perkada) and governor circular letters prohibiting the use of single-use plastics within their jurisdictions. In Bali Province, Governor Regulation No. 97 of 2018 initially banned items such as plastic bags, styrofoam, and straws. This policy was further strengthened by Circular Letter No. 2 of 2025, effective February 3, 2025, which prohibits regional government units, BUMDEs, and schools from providing drinking water in plastic bottles and food in plastic packaging (Imelda, 2025). Additionally, Circular Letter No. 9 of 2025, issued on April 2, 2025, effectively banned the production, distribution, and provision of single-use plastic bottled water under one liter—including cups and half-liter bottles—across six sectors: government, traditional villages, businesses, hospitality, education, markets, and places of worship (Warokka, 2025).

In Jakarta (DKI Jakarta), the literature indicates earlier implementation of local regulations, such as Governor Regulation No. 55 of 2021 on Waste Reduction and Handling and Governor Regulation No. 102 of 2021 on Waste Management in companies and designated areas, both derived from Regional Regulation No. 3 of 2013 aimed at reducing single-use plastics (Kinasih, 2024). Meanwhile, in South Sumatra Province, the governor issued Governor Regulation No. 23 of 2021, which mandates reductions in the use of single-use plastic bags (Ismawati, 2022).

From a socialization perspective, the Ministry of Environment and Forestry has conducted outreach and campaigns to address plastic waste generation since June 2018. A key emphasis is that governments must demonstrate commitment by enforcing regulations and imposing sanctions on violators. Policies related to plastic waste have also been implemented in international contexts; for example, since August 2019, San Francisco International Airport has discouraged and prohibited the sale of bottled mineral water in plastic containers. San Francisco International Airport became the first airport to be designated plastic-waste-free in 2021 (Hasugian, 2019). This case may serve as a relevant reference for Indonesia in efforts to reduce plastic waste.

In Indonesia, waste management challenges remain critical. National data indicate that in 2023, total waste generation reached 56.63 million tons, of which only 39.01% (approximately 22.09 million tons) was properly managed, while the remainder was disposed of in open landfills that do not meet modern management standards. However, by 2024, waste reduction had reached only 13.13% and waste handling 46.69%, remaining far below national targets (Nugroho, 2025a).

In addition, the Ministry of Environment and Forestry has established an action program for plastic waste management, as outlined by Nugroho (2025b), which includes the following components:

a. Mapping of plastic waste problems
Mapping the management of difficult plastic waste such as single-use items, microbeads, eating and drinking utensils, single-use packaging, plastic bags, polystyrene (for example styrofoam), flexible plastic (sachet and pouch). The largest composition of plastic waste is plastic bags.
b. Stages of plastic waste reduction
In relation to the number of existing stockpiles and the difficulty of handling them, the handling priorities according to type are as follows:
    1) Starting from plastic bags, the emergence of plastic items, cutlery, styrofoam and sachets is gradually being limited. It is recommended that people avoid it and use plastic that can be used many times.
    2) Other single-use plastics are recycled, such as drinking packaging (bottles, glasses, boxes), food packaging (mica, jars).
    3) Other plastics are recycled and reused, such as casings for electronics and household appliances.
c. Zero Waste Zero Emission
The Ministry of Environment and Forestry has prepared an action plan to achieve Zero Waste Zero Emission from the waste subsector. Some of the steps in this plan include:
    1) Improved management of final disposal sites using controlled/sanitary landfill methods and utilization of methane gas until 2025.
    2) No construction of new landfills from 2030, with the use of existing landfills until the end of their operational life.
    3) Reduction of illegal burning starting in 2031.
    4) Optimization of waste management facilities such as PLTSa, RDF, SRF, biodigester and maggot for biomass waste.
    5) Strengthening waste sorting at source and utilizing waste as raw material for recycling.
    6) Build and develop waste banks.
d. Revitalization of the Adipura Program
The Ministry of Environment and Forestry is taking corrective steps by revitalizing the Adipura Program to encourage accelerated increases in local government capacity in waste management. This program also involves instruments such as regional incentive funds and special allocation funds, as well as the application of Waste to Electrical Energy (WEE) and Refuse Derived Fuel (RDF) processing technologies.

Conclusion

Addressing plastic waste requires changes in human behavior as well as the adoption of appropriate technologies. Plastic waste should be managed in an integrated manner involving multiple stakeholders, including government, communities, and organizations or companies. Although the regulatory framework is relatively comprehensive, its implementation remains limited. Governments need to establish clear policies and regulations, accompanied by effective sanctions for violations. The public is expected to commit to avoiding littering and to sorting recyclable waste, particularly plastics. Individuals are also encouraged to reduce plastic use as much as possible. Governments should support these community commitments by providing adequate facilities and infrastructure, such as effective waste transportation systems and mechanisms for distributing sorted waste. Equally important is the role of companies in assuming responsibility for the products they produce. Companies are expected to develop and produce environmentally friendly products. For a circular economy to generate positive environmental impacts, this approach needs to be implemented consistently. To minimize risks to human health and the environment, both virgin plastics and plastic waste should meet applicable quality standards. Ultimately, reducing plastic waste is essential to achieving a cleaner and more sustainable environment.

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