ADVANCEMENTS IN PLASTIC WASTE MANAGEMENT: A COMPREHENSIVE REVIEW OF RECYCLING, REMOVAL, AND MAINTENANCE STRATEGIES IN BANGLADESH

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ABSTRACT

The increasing quantity of plastic found in daily trash dumps has been a significant cause for concern in recent decades due to its detrimental effects on the environment. A study shows that 646 tons of plastic waste are collected daily in Bangladesh, of which only 10% is recycled and 37.2% is improperly disposed of. Some of this waste is directly discharged into riverbanks, causing severe harm to aquatic ecosystems. Moreover, in developing countries, plastic waste collection and maintenance are often carried out using mechanized and scientific methods; however, in Bangladesh, these tasks largely depend on manual labor, exposing workers to serious health risks. This review paper addresses the problem of inefficient plastic waste management in Bangladesh by systematically analyzing existing recycling, separation, and disposal practices, along with their environmental and social implications. A structured literature review methodology was adopted, synthesizing peer-reviewed articles, government reports, and case studies from major Bangladeshi cities to evaluate mechanical, chemical, and advanced recycling technologies. The paper reviews a variety of recycling approaches, including mechanical, chemical, and biological processes, and assesses their environmental impact, limitations, and effectiveness. It also critically examines recent advancements in recycling technologies and upcycling methods, highlighting their potential to improve plastic waste recovery and sustainability. The findings indicate that inadequate source segregation, overreliance on informal labor, and limited local recycling infrastructure significantly reduce recycling efficiency, while regions such as Cumilla and Khulna demonstrate comparatively better performance due to semi-structured systems. Advanced recycling techniques, such as pyrolysis and chemical depolymerization, show strong potential for managing mixed and contaminated plastics, although economic and technical barriers remain. Data from various districts in Bangladesh—including Rajshahi, Khulna, Jashore, Natore, and Dhaka—were analyzed to identify key challenges and opportunities within the national plastic waste management framework. The review concludes that coordinated policy support, improved segregation practices, technological investment, and public awareness are essential to achieving sustainable plastic waste management. Finally, targeted recommendations are provided to enhance recycling efficiency and guide future research and capacity-building initiatives in Bangladesh.

Keywords: *Plastic waste, environmental hazard, recycling, opportunity, eco-system*

1. INTRODUCTION

With more than three thousand small and large plastic companies, plastics was ranked as Bangladesh's 12th highest export-generating sector in the 2017–18 fiscal year.(*Annual Conference Report - FY 2019 | Reports | U.S. Agency for International Development*, n.d.) Bangladesh's per capita plastic use rose quickly due to its rapid development, rising from 2.07 kg in 2005 to 3.5 kg in 2014.(Mourshed et al., 2017). 3000 tons of plastic garbage are produced daily, making up 8% of all waste generated.(M. S. Islam et al., 2017) According to a different study, in 2005 the average amount of plastic garbage created in cities was 5.15%, while in municipalities the average was 3.58%. The average percentage rose to 8.45% in cities, 7.31% in municipalities, and 7.35% in urban regions in 2014.(Enayetullah I, 2014). Even though Bangladesh consumes less plastic per person than other developed and nearby nations, much of the world's plastic garbage is improperly managed based on statistics from 2010. (Ahmed Saju et al., n.d.)

The population of Bangladesh, a rising middle-income nation, is currently estimated to be 168 million, with a density of about 1400 people per square kilometer. By 2025, that number is predicted to increase to over 177 million. Currently, this nation generates 21,332 tons of solid waste (SW) every day. By 2030, this estimate is expected to rise to 47,000 tons per day, with Dhaka city subsidizing roughly 6870 tons per day(Ahammed & Azeem, 2013). The management of MSW is seriously threatened by Dhaka's rapid development into an expanded megacity with a population growth rate of 6% annually and garbage generation accelerating due to the city's rapidly expanding industries and population.(Marie, 2009) For example, almost 550 tons of plastic garbage are generated every day, mainly in Dhaka city.(Development, n.d.) In recent years, the plastics market, whether focused on domestic or exports, has risen dramatically (about 20% yearly), indicating huge potential for future expansion and investment. (Afrooz, 2016)

Plastic trash constitutes a substantial portion of Bangladesh's total environmental pollution.(Chowdhury et al., 2021a) The combustion of plastic releases toxic smoke and extremely dangerous gasses into the atmosphere.(Hossain et al., 2021a) Open-air burning produces lithophilic metals (Ca, Si, Na, Mg, Al, P, Fe) and toxic heavy metals (Cd, Pb, Cr, Ni, Cu, Zn) that cause several deadly illnesses in living things. (Font et al., 2004; Valavanidis et al., 2008; Wagner & Caraballo, 1997) According to research, plastics inhibit the development and activity of soil microbes, which lowers soil productivity and nutrients(Udochukwu et al., 2021). Aquatic environments are also contaminated by plastic garbage. For instance, more than 60% of the trash litter discovered on Bangladesh's four major beaches—Laboni, Inani, Ananda Bazar, and Patenga—is contaminated with plastic.(Qi et al., 2018). The irresponsible and uncontrolled release of plastic into the environment from various man-made sources seriously disrupts the ecosystem and the organisms that make it up(de Souza Machado et al., 2018). Bangladesh's plastic pollution puts the environment and general public's health at serious risk. Particularly in densely populated locations, the open burning of plastic garbage in urban areas produces harmful chemicals like dioxins, which can cause respiratory disorders, an increased risk of cancer, and other major health concerns.(Khatun Syed Yusuf Saadat Afrin Mahbub, n.d.)

For reducing those harmful effects, a proper management and recycling of those wastes has to be ensured. Advanced Recycling techniques such as pyrolysis, chemical recycling, and gasification provide complex approaches to the management of plastic waste.(*What Is Plastic Recycling and How to Recycle Plastic - Conerve Energy Future*, n.d.) The recycling rate of plastic trash in Bangladesh varies by area; in Dhaka, for example, only 37.2% of plastic waste is recycled, suggesting inefficiency (Daily Observer, 2023). With a 98% recycling rate, Cumilla's recycling industry effectively handles 720 tons of plastic trash every month(Dipu, 2023). By capturing harmful emissions and turning organic waste and plastics into electricity, a double-chamber incinerator can enhance waste management(*A Sustainable Plastic Waste Management for Dhaka City*, n.d.). Innovative materials like the Sonali Bag, bioplastics, and bagasse-based goods, in conjunction with waste-to-energy techniques like pyrolytic gasification and incineration, offer efficient trash management while producing valuable materials and energy. (Mahmood et al., 2023).

2. REVIEW PROCESS

This literature review included the objective of giving a concise summary of the causes, methods, upkeep, sorting, and recycling of plastic garbage in Bangladesh. The review was carried out through a careful analysis of the corpus of available material. Scholarly publications that have undergone peer review can be found using a variety of databases, including Research-gate, IEEE, Elsevier (ScienceDirect), Google Scholar, Scopus, and SpringerLink. The publications included building grading systems, books, reports, articles, scientific journals, and grey literature (government documents, policy announcements, and reports). At a glance a systematic review of 60+ studies published between 2010–2025. Though newer publications covering cutting edge research took priority, the publishing window was not rigorously confined. Reported data were compared across multiple studies to identify consistent trends rather than conducting original statistical testing.

3. PRODUCTION OF PLASTIC WASTE

3.1 Several sources of plastic waste

Current everyday toiletries, such as toothpaste, shampoo, bath soap, body cream, and almost all items, are available in plastic wrap in different sizes from as tiny as a single-use. Street food and tea stalls have replaced porcelain plates and cups with single-use plastic items. Therefore, the uncontrolled usage of polymer wraps neoliberalizes the current affordability and demand for consumer goods. Drinking water, beverages, snacks, food items, and most of the daily food items come in some sort of plastic case or container. Most of these plastic items have no use right after consuming the product inside them. (Nadiruzzaman & Afrin Esha, n.d.)

The rise in plastic waste is largely due to the extensive use of polyethylene bags, particularly in Dhaka, where 14 to 15 million bags are used daily. Single-use plastics are commonly found in everyday items such as bottles, bags, packaging, wrapping, flyers, food storage, and household goods. Restaurants, airlines, hotels, and supermarkets majorly contribute to plastic waste in the service industry.(Ahmed Saju et al., n.d.)

In addition, plastic waste from China, India, and Nepal enters our rivers, canals, and other bodies of water of Bangladesh by flowing down the Ganges, Yamuna, and Brahmaputra rivers due to the topographic condition(Akter, n.d.).

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3.2 Types of plastic

Table 1 shows the types of available plastics and their examples found in municipal solid waste (Ahmed Saju et al., n.d.; Hossain et al., 2021b; Mehedi Hasan et al., n.d.).

Table 1: Classification and source of plastic found in waste

Type	Usage	Characteristics
HDPE	Shower soap cases, detergent bottles, shampoo bottles, milk and oil containers, buckets, toys	Moisture resistant, more stiffness, lightweight
LDPE	Plastic grocery bag, food wraps, bubble wrap etc	High durability and flexibility, moisture resistant
PP	Straw, tape, diapers, sauce and	Withstand high temperature,

	ketchup bottles, medicine packaging, DVD/CD	detergent, acid and base resistant
PS	Coffee and tea cup, food containrers, egg cartoons	Rigid foam material
PVC	Pipes, door frames, floor and furniture coverings	Lightweight, cost effective, durable, chemical and weather resistant
PET/ PETEE	Bottles of soft drinks, mineral water, polyester clothing or rope	Strong, lightweight,
Others	polycarbonate and bio plastic polylactide	Eyewear lenses, exterior lightings

4. COLLECTION AND SORTING OF PLASTIC WASTE

Almost all plastic materials are recyclable, but for the recycling to be possible it is necessary to separate the different types of plastics. The total global production of plastics grew from around 1.5 million tons in 1950, to 299 million tons in 2013 (Faraca & Astrup, 2019).
Recycling requires the collection and sorting of waste. A significant portion of the energy and financial expenditures associated with recycling are incurred by these processes. Compared to other recyclables, plastic comes in more variants, making sorting it more challenging. Comparatively, about 75% of waste plastics are composed of six types of commodity polymers; the remaining 25% are made up of a wide range of other polymers, including synthetic fibers and polyurethanes, which can have a variety of chemical structures. Depending on the additives they include, even materials made of the same type of polymer may not be compatible when recycled. However, distinct polymers are frequently incompatible with one another. The substances that are added to polymers to enhance their performance are called additives; these include stabilizers, fillers, and colors. The most valuable plastics are clear ones because they may be dyed, but black or highly colored polymers are less sought after since they might cause stains on objects(Hahladakis et al., 2018).
Technologies and methods for sorting plastic have been created, and there are numerous ways to incorporate them. Accurate sorting is crucial since thermoplastic matrix types may become inconsistent with one another, even though no method is 100% effective (Al-Salem et al., 2009).
Manual sorting by a trained operator is expensive but highly efficient. Operators sort materials based on product type, which often aligns with specific material categories. PMD is a waste collection scheme in Belgium for Plastics, Metals, and Drink cartons. Citizens use a specific bag for these materials, which is cheaper to dispose of than regular household waste. The scheme includes solid bottle packaging (like water and detergent bottles), metal cans, and drink cartons. The collected waste is sorted at facilities into various materials: PET (clear, blue, green), cable sleeves (HDPE), window profiles (PVC), children's swimming pools (PVC), and plexiglass (PMMA). and sometimes PP. LDPE is also included through labels attached to the packaging (Ragaert et al., 2017a).
It could be harder to recycle because of this variance in quality. As bioplastics and biodegradable plastics become more common, waste plastic sorting may become increasingly more challenging, even if they currently only make up a small percentage of household waste. There are usually several sorting steps involved in the processing of plastic waste (Lange, 2021; Pandey et al., 2015)
These include sorting material by shape using a sifter or by hand; removing sludge; filing on polypropylene; and, finally, measuring and mixing the material into recyclable products. External materials can be eliminated (sink-float) by employing a stream's severity or even an air gushing procedure (air clustering algorithm). Also useful for metal removal are magnetic metals, such as ferrous metals' magnetic qualities or nonferrous metals' magnetic repulsion (Serranti & Bonifazi, 2018).
The plastic waste generation rate increases about 7.5% per annually in Bangladesh (Mourshed et al., 2017)The waste management system in Dhaka is antiquated and depends on manual labor. Three steps are involved: first, rickshaw vans collect the waste, then Tokais scavenge the waste, and finally, landfills dispose of the waste. Recyclable materials are sold to companies and sent to recycling

facilities. Private dealers also recycle plastic, while the Dhaka City Corporation takes care of extra waste (M. S. Islam et al., 2017).

Due to its dense population and scarce resources, Bangladesh confronts considerable hurdles in the collection of plastic garbage. Consequently, there is an abundance of plastic waste in landfills and oceans. In order to address this problem, Bangladesh has implemented a trash identification method based on deep learning, which enables the identification and detection of solid garbage in photos in real time (Chowdhury et al., 2021b).

The current state of plastic waste sorting in Bangladesh is quite worrying due to insufficient infrastructure and management. Neglecting plastic waste, particularly microplastics, poses a serious threat to both human well-being and the environment (Barua et al., 2020).

5. SEPARATION OF PLASTIC FROM MUNICIPAL SOLID WASTE

Separation of plastic represent one of major problematic process in waste plastic management system e.g. it is very difficult to distinguish shredded bottles of PVC from shredded PET bottles and this separation process has to be done prior to next process because presence of PVC may decrease the quality of whole batch (Dodbiba & Fujita, n.d.).

Various techniques for separating plastics materials have been recently developed. These techniques can be divided in two main categories, i.e. wet separating techniques and dry separating techniques (Serranti & Bonifazi, 2019).

5.1 Wet Separation Techniques

5.1.1 Sink float

This method is based on density used to separate plastic wastes. Lighter plastics like PP and PP float in water, while denser ones like PET and ABS sink. However, this method requires additional steps to fully separate mixed plastic waste into single material stream (Ragaert et al., 2017b)

5.1.2 Forth floatation

It is similar to the sink-float method but involves adding frothers, depressants or surfactant to make one plastic’s surface more hydrophilic than the other. This technique is used to separate binary plastic mixtures and is achieved through four method i.e. Gamma radiation, Absorption, surface modifications, physical regulation(Wang et al., 2015)

5.2 Dry Separation Techniques

5.2.1 Tribo-electric separation

This dry separation technique is used to separate binary plastic mixtures through tribo-electric charging. Plastic particles are rubbed together to create surface charges and then passed through an electric field. This method is applicable to various polymers based on their tribo-electric charging sequence (Wu et al., 2013).

5.2.2 Magnetic Density Separation

MDS is an advanced density-based technique that uses a magnetic fluid as the separation medium to separate plastic particle with small density differences. The process employs bidirectional magnetic projection, where mixed materials are separated simultaneously in paramagnetic medium. The materials move to their respective landing zone, either upward or downward guided by the combined forces of buoyancy, gravity and magnetic field created by a permanent magnet placed next to container (Ragaert et al., 2017b; Serranti & Bonifazi, 2019)

5.2.3 Optical sorting

It is an automated process that uses optical instruments like cameras and lasers for sorting materials, replacing traditional manual methods. Currently NIR is commonly used to separate different types of plastic (Ragaert et al., 2017b)

6. PLASTIC WASTE RECYCLING AND MANAGEMENT

6.1 Types of Recycling

In Bangladesh, there are two main methods for recycling plastic: advanced recycling and conventional (mechanical) recycling. Each has specific applications and methodologies.

6.1.1 Conventional (Mechanical) Recycling

This is the most used technique for recycling thermoplastics. This procedure involves gathering, sorting, cleaning, and melting plastics before using injection molding to convert them into new goods. Since common plastics like PET and HDPE can be remelted and reformed without significantly losing their qualities, this approach is both cost-effective and ideal for recycling them. It efficiently handles large quantities of plastic trash, generating a range of industrial materials, packaging, and consumer items (*What Is Plastic Recycling and How to Recycle Plastic - Conerve Energy Future*, n.d.)

6.1.2 Advanced Recycling

This technique includes pyrolysis, chemical recycling, and gasification provide complex approaches to the management of plastic waste. Without the presence of oxygen, plastic is broken down via pyrolysis, which yields crude oil that can be processed into fuel or fresh plastic. These techniques work especially well with contaminated or mixed polymers that are not good candidates for mechanical recycling. While gasification turns garbage into syngas, which is used to generate power, chemical recycling transforms plastic polymers into monomers for higher-quality plastics. Even though they are expensive, these methods manage various plastic waste streams and produce useful byproducts that help the circular economy.(*What Is Plastic Recycling and How to Recycle Plastic - Conerve Energy Future*, n.d.)

Though they are technically demanding, new chemical processes such as pyrolysis and de-polymerization are being investigated to transform plastics into hydrocarbon fuels. These methods are acknowledged in Bangladesh for their ability to lower pollution and produce energy, and they present promising answers to the nation's intricate problems related to plastic waste.(Sakib et al., n.d.)

6.2 Plastic Waste Recycling Scenario in Bangladesh

The recycling rate of plastic trash in Bangladesh varies by area; in Dhaka, for example, only 37.2% of plastic waste is recycled, suggesting inefficiency. This emphasizes how, in order to lessen environmental impact, more recycling facilities and better waste management are required. (*A Sustainable Plastic Waste Management for Dhaka City*, n.d.)

With a 98% recycling rate, Cumilla's recycling industry effectively handles 720 tons of plastic trash every month. However, 2% of non-recyclable garbage, such as plastic bottle labels, is disposed of incorrectly, underscoring the need for improved waste management and segregation. (Dipu, 2023)

By recycling 69% of daily waste, Khulna's informal sector-driven plastic waste management system saves 8.6 million BDT annually. Recyclers efficiently manage 75% of the 15 tons of plastic garbage that are processed each month, demonstrating the effectiveness of existing methods as well as their limits (Moniruzzaman et al., 2012) (Hossain Emom et al., 2024)

Plastic garbage in Natore is divided into three categories: PET bottles, hard non-processed plastics, and hard processed plastics. Collection stores collect more than 1.54 tons every week, of which 1.069 tons are recycled. For transport to bigger facilities in Islambagh, Dhaka, the procedure entails shredding, cleaning, drying, and packing. Nonetheless, non-recycled hard plastics still need to be transported to other locations for processing, such as water filters and refrigerator garbage.(Mahmudur Rahman, 2020)

Approximately 80.56% of the plastic garbage collected in Sylhet City is processed in Dhaka, indicating the limitations of the local capacity as well as the interconnectedness of Bangladesh's

recycling system. The recycling industry in Sylhet is notable for having a large proportion of female employees, highlighting the critical role that women play in the recycling economy.(Sakib et al., n.d.)
Eighty percent of Jashore's recyclable plastic garbage goes unprocessed since the area lacks a sufficient recycling infrastructure. The majority of the waste is handled by a small number of businesses and transported to Dhaka, which compromises both cost-effectiveness and environmental sustainability. This emphasizes how urgently better infrastructure and local recycling capabilities are needed.(Firoz Kabir et al., n.d.; Kabir et al., 2021). In Rajshahi the recycling efficiency considering both HDPE and PET plastic is approximately 60% (Bari et al, 2025).
All things considered, Bangladesh's recycling difficulties highlight the necessity of improved local processing and more effective trash management. Improving recycling sustainability and effectiveness depends on addressing these problems, which calls for spending money on infrastructure and all-encompassing waste management plans.
Figure 1 shows the typical flow diagram of plastic waste recycling process in Bangladesh

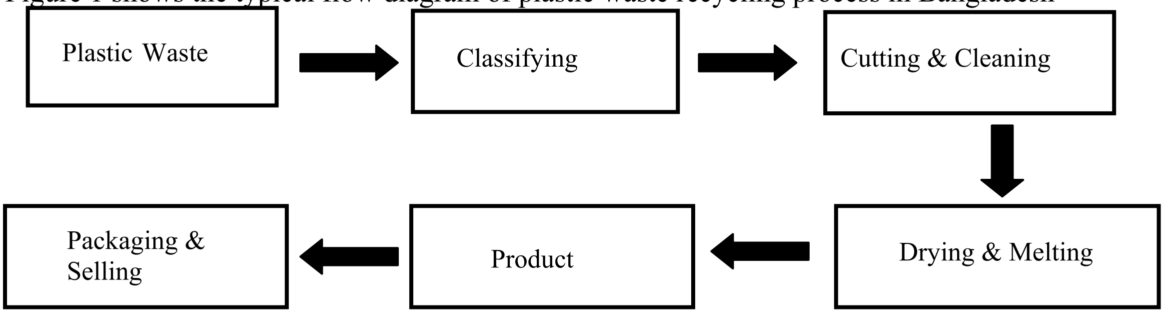

Figure 1: Typical flow digram of waste plastic recycling process in Bangladesh

6.3 Benefits and Innovations in Plastic Waste Management in Bangladesh

Advanced recycling techniques like pyrolysis have the potential to improve waste management. Plastic waste can be pyrolyzed to create fuel and syngas, resolving difficulties with low recovery rates and antiquated technology. Pyrolysis has the potential to be advantageous for the environment and the economy despite its high starting costs and variable feedstock. (Nayin et al., n.d.)

Innovative materials like the Sonali Bag, bioplastics, and bagasse-based goods, in conjunction with waste-to-energy techniques like pyrolytic gasification and incineration, offer efficient trash management while producing valuable materials and energy. These developments highlight the necessity of spending more money on long-term strategies to deal with plastic trash. (Mahmood et al., 2023)By capturing harmful emissions and turning organic waste and plastics into electricity, a double-chamber incinerator can enhance waste management. By making dangerous byproducts inert, vitrification procedures can help landfills become sustainable.(Mahmood et al., 2023)

Tests have shown that plastic bricks could be an environmentally benign substitute for red clay bricks, demonstrating the possible use of discarded plastic to create inventive building materials. Regarding durability, more research is required.(Rauniyar et al., 2024)
Tailored waste management plans that prioritize cutting-edge technology and effective separation are necessary in certain places, such as Saint Martin's Island. (Tabassum, n.d.)
Improving trash segregation and recycling requires robust policies and effective public education. A thorough waste management system is still required even if NGO initiatives have reduced water contamination.(Shahen, 2024) Figure 2 shows the overall flow chain of plastic wastes generated in household. Figure-3 shows the recycling efficiencies of platic waste accross various districts of Bangladesh.

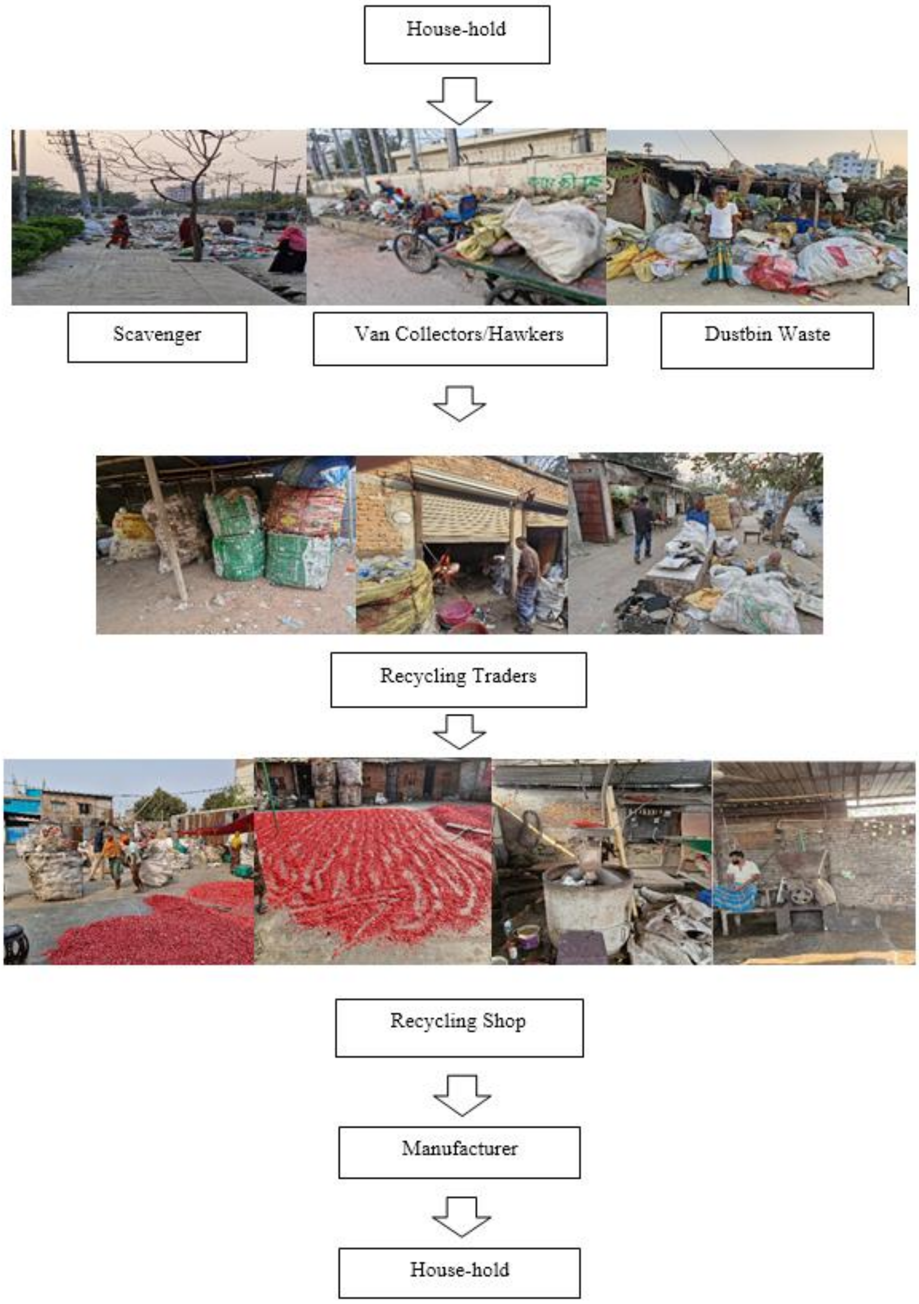

Figure 2: Informal Plastic Waste Flow in Bangladesh

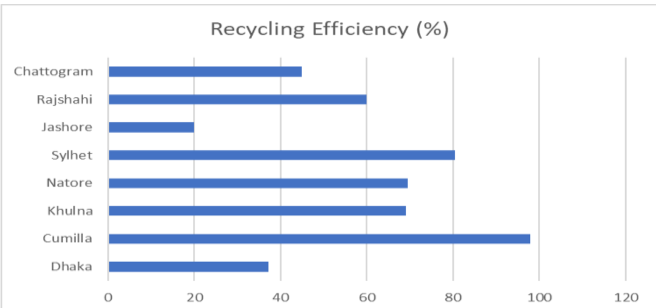

Figure 3: Comparison of plastic waste recycling efficiency (%) across major districts of Bangladesh.

7. EFFECT OF IMPROPER MANAGEMENT OF PLASTIC WASTE

Effects of improper management of plastic wastes on the various elements of environment are mentioned in Table 2.

Table 2: Effect of plastic waste on different elements:(M. R. Islam et al., 2023)

Element	Effects of plastic wastes
Soil	Microplastics in soil can alter soil texture, increase bulk density, raise water evaporation, reduce nutrients, and directly harm plant roots, affecting growth and nutrient uptake. Microplastics with phytotoxic properties can create a hydrophobic barrier in soil, while Bisphenol A also adds to soil toxicity. Plastic mulching release toxic additives that promote soil infertility. CTR (Car Tire Rubber) is a major plastic pollutant in roadside farmland, harming soil with hazardous chemicals like carbon black, clay, silica, sulfur, pigments, oils, resins, and short fibers.
Water	Microplastics can disrupt growth and change feeding behaviors because of their significant ingestion. During waste water treatment, fragmented or degraded microplastics (MPs) are often release into water resources, leading to several environmental issues. Improperly treated wastewater can allow hazardous substances from plastics, like plasticizers and flame retardants, to enter aquatic organisms' tissues. MPs, due to their weathered, long-lasting, and hydrophobic nature, can absorb and carry additional pollutants into aquatic life.
Air	Fossil fuel use and greenhouse gas emissions contribute to air pollution and climate change by consuming fossil fuels and releasing significant greenhouse gases. Burning plastic release toxic smoke and hazardous gases, which are harmful to health. The combustion process produces toxic heavy metals (e.g. cadmium, lead) and other dangerous substances that can cause that can cause serious health issues. Burning PVC releases phosgene, highly dangerous chemical that can cause severe health problems. Decomposing plastics in landfills, assisted by microbes, releases methane, a potent greenhouse gas.
Ecosystem	MPs, a subset plastic waste, persist in environments with low light and oxygen, such as soil, for over 100 years, affecting soil micro-organisms and their function. MPs can accumulate in earthworms and be transferred to other organisms through the food chain

8. CONCLUSION

This review indicates that plastic waste management in Bangladesh is at a critical crossroads, influenced by swift urbanization, rising consumption, and inadequate waste management infrastructure. While localities like Cumilla and Khulna exhibit encouraging recycling efforts via informal and semi-structured systems, the national recycling rates remain low and erratic. Suboptimal segregation, excessive dependence on human sorting, and insufficient local processing capabilities persistently hinder the efficacy of mechanical recycling, resulting in substantial volumes of mixed and contaminated plastics being disposed of in landfills, waterways, and open settings. These practices substantially contribute to soil deterioration, air pollution, disruption of aquatic ecosystems, and major public health hazards. Advanced recycling techniques, such as pyrolysis, chemical depolymerization, and gasification, present viable solutions for managing intricate waste streams and reclaiming energy or valuable materials. Nonetheless, its effective execution necessitates considerable investment, specialized knowledge, and robust regulatory supervision. Innovations like biodegradable products, plastic-based construction materials, and enhanced waste-to-energy systems exhibit potential but necessitate further research and confirmation. To advance a sustainable circular economy, Bangladesh must reinforce source segregation, augment decentralized recycling capabilities, formalize the responsibilities of informal garbage workers, and improve public awareness. Coordinated policy initiatives, technology advancement, and community engagement are crucial for mitigating environmental impacts and ensuring sustainable resilience in plastic waste management.

DECLARATION OF USE OF AI

Artificial intelligence tools were used only for idea development, language improvement, and maintaining the logical sequence of the manuscript. No AI tools were used for data analysis, result generation, or scientific interpretation.

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