

IMPORTANCE OF BREAKING THE PLASTIC CHAIN; LOOKING TO ERASE PLASTIC WASTAGES FOR A SUSTAINABLE FUTURE

Md. Shafkatul Islam¹, Farheen Hossain²

^{1,2}Chittagong University of Engineering and Technology, Raozan, Chattogram 4349,
Bangladesh

ABSTRACT

Plastic, a serious issue in today's world causing significant trouble in the world. Environmental impact due to plastic also cannot be ignored. This is a review paper aiming to identify the way to manage plastic which is surrounding us from every corner. Huge amounts of plastic waste are being generated every day in Bangladesh. This study examines the detrimental impacts of plastic waste in Bangladesh and explores sustainable management practices and alternatives to plastic for environmental preservation. The study also emphasizes the social, economic, and environmental challenges posed by plastic waste. It also highlights policies and strategies for sustainable waste management to mitigate these impacts. By reviewing the current practices and proposing alternatives to plastic usage, this paper aims to contribute to the development of comprehensive policies for sustainable environmental management in Bangladesh.

Key Words: *environmental impact, management of plastic wastages, alternates, policy*

INTRODUCTION

Plastics are synthetic organic substances composed of massive molecular chains known as polymers. These materials can be manipulated into diverse configurations through techniques like extrusion, molding, casting, or spinning. Contemporary polymers exhibit highly coveted attributes, including an exceptional strength-to-weight ratio, remarkable thermal stability, superior electrical insulating capacity, and robust resistance to corrosive agents such as acids, alkalis, and solvents.

The advent of synthetic polymers, utilized in the production of plastics such as polyethylene, polypropylene, polyester, and polyamide (e.g., nylon), has profoundly transformed the nature of product containers, packaging materials, and carry bags. Despite their utility, the majority of these polymers lack biodegradability, rendering them persistent environmental pollutants once disposed of, thus posing significant waste management dilemmas. (Plastic Waste: Redesign and Biodegradability, 2011).

Plastic is a significant component of inorganic waste in the municipal solid waste (MSW), we generate daily. But, Plastic waste can harm the environment by losing its structural integrity and breaking down into smaller fragments when subjected to various stressors. (Papac Zjačić et al., 2023). Plastic contamination poses significant threats to both marine and terrestrial ecosystems, jeopardizing biodiversity. Beyond facilitating the spread of invasive species, it can cause entanglement, consumption, and mortality among wildlife. (Anunobi, 2022).

The prolonged ramifications of plastic contamination on ecosystems may encompass alterations to soil composition and habitats, disruptions in sedimentation processes, aquatic ecosystem imbalances, and perturbations in carbon and nitrogen cycling, among other effects.

The primary origin of plastic waste arises from residential and commercial operations, which are typically gathered and conveyed to landfill sites for processes such as recycling, incineration, or disposal. An additional significant contributor to plastic waste stems from intensive and semi-intensive agricultural practices, which utilize plastic products like covering films, shading nets, mulch layers, packaging materials, and wrapping films. (Briassoulis et al., 2013). Furthermore, in many instances, plastic refuse ultimately finds its way to landfill sites or the marine environment, leading to contamination of both soil and water. (Chae & An, 2018). Additionally, atmospheric pollution resulting from the release of odors, microorganisms, and pathogens is commonly triggered by the open dumping and burning of plastics. (Rillig, 2012). Still, after all this, the global manufacture of plastics continues to escalate incessantly. Plastic waste generation saw a dramatic surge during the COVID-19 pandemic, driven by a sharp increase in the use of masks, gloves, and ongoing production of polythene. It is estimated that an additional 14,500 tons of plastic waste—comprising masks, gloves, and regular polythene—were

produced in just one month, from March 26 to April 25, following the detection of the first COVID-19 case. Among this, 3,076 tons were generated solely in Dhaka, the capital of Bangladesh. In 2019, global plastic production reached an astounding 368 million metric tons. Disturbingly, a mere 9% of this plastic underwent recycling, while 12% was subjected to incineration. The overwhelming remainder, 79%, found its way into landfills or dispersed across the natural environment, contributing to the escalating crisis of plastic pollution. (Vuppaladadiyam et al., 2024) Currently, approximately 50% of global plastic production is dedicated to single-use products, with only 9% of plastic being recycled. Studies indicate that by reusing just 10% of plastic items, the volume of plastic waste entering the oceans could be reduced by half (Accelerating Reuse Models to Achieve a World Free of Plastic Waste | World Economic Forum, n.d.).

Bangladesh is a fast-developing country with a population of 166 million. Despite the challenges posed by its high population density, the country has achieved commendable economic growth. Currently, there are over 3,000 plastic industries, both large and small, operating nationwide. In the fiscal year 2017-18, plastic emerged as the 12th largest export-earning sector in Bangladesh. (COMPREHENSIVE PRIVATE SECTOR ASSESSMENT, 2019). The pie chart shown in figure 1, illustrates the accurate percentage distribution of global plastic production by region in 2023. It highlights the substantial role of China and Asia overall in global plastic manufacturing, with other regions playing smaller but significant roles. China, the dominant producer, accounting for 33% of global plastic production. Rest of Asia (excluding China and Japan), Contributed 19%, the second-largest share. On the other hand, North America produced 17%, ranking third. Europe (EU-27+3) accounted for 12% of global production and Middle East and Africa represented 9% Central and South America, made up 4% and Japan and the CIS (Commonwealth of Independent States) each contributed 3%. (Global Plastic Production Share by Region 2023 | Statista, n.d.)

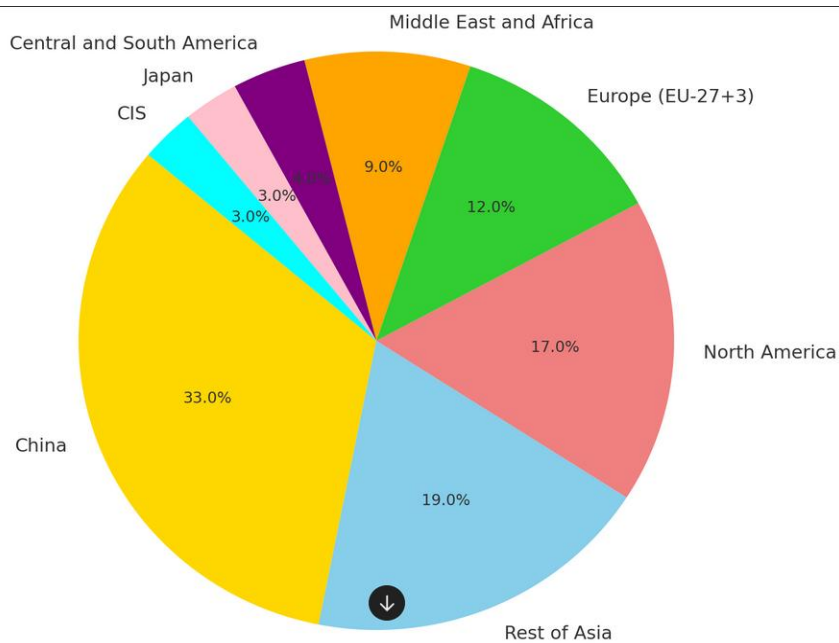


Figure 1 Distribution of global plastic materials production in 2023, by region.

The worldwide output of thermoplastics is anticipated to climb steadily, reaching 445.25 million metric tons by 2025, followed by increments to 483.19 million, 516.18 million, 546.17 million, and 570.18 million metric tons in the years 2030, 2035, 2040, and 2045, respectively. This upward trajectory is expected to persist into the subsequent decades, culminating in a projected 590 million metric tons by 2050—a surge exceeding 30% compared to 2025 levels. Historically, between 2010 and 2020, global plastic production expanded significantly, escalating from 270 million metric tons to nearly 370 million metric tons. (Global Plastics Production Forecast 2025-2050 | Statista, n.d.)

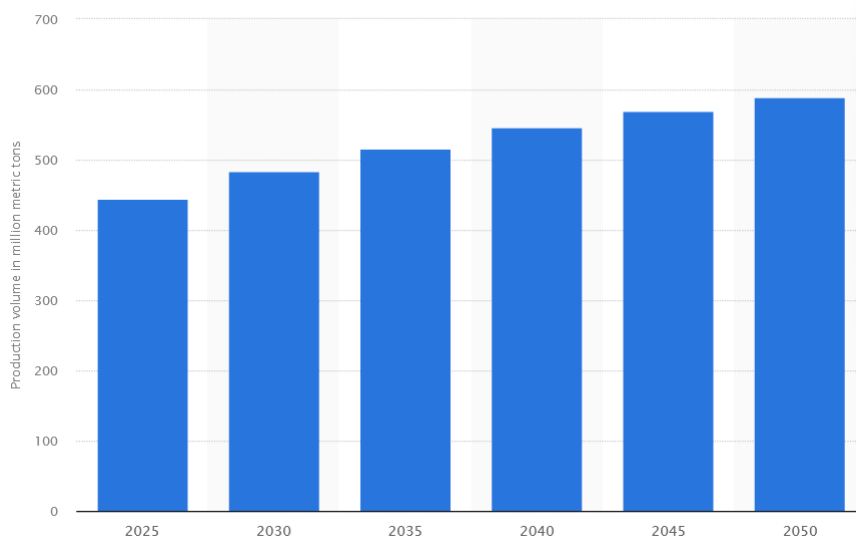


Figure2 Production forecast of thermoplastics worldwide from 2025 to 2050 (in million metric tons)

Despite this alarming increase, waste management practices to address the growing plastic pollution threat remain inadequate. Open dumping and incineration are commonly employed solutions, but these methods severely harm soil organisms, fertility, and overall soil health, which in turn negatively impact agricultural sectors. Furthermore, the burning of plastic waste releases toxic gases such as CO_x, NO_x, and contributes to greenhouse gas emissions. (de Souza Machado et al., 2018a). So, the escalating proliferation of plastic has now emerged as a significant menace. Efficient and enduring methods of managing plastic waste—such as collection, sorting, recycling, and treatment—are crucial for overcoming the pollution challenges posed by these materials. While these efforts should be implemented on a global scale, the approach to sustainable waste management often highlights the divide between developed and developing nations. (Stock et al., 2020). In developing nations, the absence of robust laws, policies, and regulations, combined with inadequate infrastructure for managing plastic waste, obstructs the effective implementation of waste management systems. Other significant factors, such as obsolete or ineffective technologies, insufficient technical support, and, crucially, a lack of financial resources to execute waste management strategies, further exacerbate the inadequate handling of waste materials. (S. Hossain et al., 2021). Consequently, communities in these nations bear the brunt of plastic pollution and the ensuing environmental catastrophes, such as global warming and the emission of greenhouse gases (GHGs), which are directly associated with the reckless disposal of plastics. (*Plastic-Leakage-and-Greenhouse-Gas-Emissions-Are-Increasing-OECD*, n.d.). To foster a circular economy in Bangladesh, it is crucial to reinforce the triadic principles of diminishing, repurposing, and reprocessing materials, particularly plastics. This article offers a comprehensive synthesis of existing literature on key subjects such as plastics, plastic waste, environmental repercussions, and waste management strategies. This paper seeks to support the creation of evidence-driven policies and strategies to build a more robust and sustainable plastic waste management system in Bangladesh, focusing on both the opportunities and challenges within the plastic waste management value chain. In sum, policymakers across governmental, commercial, and societal sectors will derive substantial insight from this comprehensive examination of Bangladesh's methodologies for managing plastic waste. By advancing systemic transformations and sustainable practices, Bangladesh can carve a path toward greener, more regenerative progress.

METHODOLOGY

This paper is mainly a review paper focusing on the importance of plastic waste management, recycling of it. An overall review of plastics impact on environment, how other countries are dealing with it and how Bangladesh may deal with this specific issue

Paper source:

- The main source of the paper was google scholar since it is easy to find all the papers on a specific topic in one place in this site. (<https://scholar.google.com/>)
- RESEARCHGATE (<https://www.researchgate.net/>)
- ScienceDirect (<https://www.sciencedirect.com>)

- Springer Nature (<https://www.springernature.com/gp>)

These were the main sources of paper findings, despite these sites are a few more sites which were visited and collected some papers.

Paper selection: We have found a good number of papers related to the topic plastic waste, its management, importance of recycling it, and how plastics affect the environment both in the world and in Bangladesh.

We have chosen paper based on these things in a paper:

- Focused on plastic pollution in environment and in living beings
- Explaining plastic waste management
- Importance of plastic waste management and recycling it
- Provides various types of data about plastic waste management, recycling of plastic, in the world or in Bangladesh
- Papers that explaining about the alternatives of plastic
- Papers that giving idea on how can we reduce plastic use, how it can be mitigate

Data Source: We have found some qualitative data from a few well recognized data sites such as

- World Bank Databank (<https://databank.worldbank.org/>)
- Statista (<https://www.statista.com/>)
- World Population Review (<https://worldpopulationreview.com>)

Limitations:

- Limitations of paper: No such papers in some specific cases specially in the case of Bangladesh, there is a limited number of papers based on plastic pollution in Bangladesh, recycling of any plastic material etc.
- Data unavailability: It was difficult to find out specific data especially in the case of Bangladesh.

CLASSIFICATION OF MOSTLY USED PLASTIC MATERIALS IN BANGLADESH:

To mitigate plastic, it is necessary to know about its beginning, its properties. the material by which it is made. Here we tried to classify some of the most used plastic materials in Bangladesh.

PE (Polyethylene or polythene): PE is the most used plastic material in Bangladesh even in the world. It's a polymer. Plastic bags, plastic films, bottles and containers. HDPE (High Density-Polyethylene) is the most common type of PE. The low-density polyethylene is known as LDPE (Low-Density-polyethylene). It does not cause any harm when it is in contact with food items or water though produces toxicity by emitting gases which is harmful for living beings. This type of plastic, whether it is made by HDPE or LDPE takes 10~450 years to decompose.

PP (Polypropylene): PP is a common thermoplastic polymer. It has many quality properties such as water permeability resistance, mechanical properties, flame resistance. Plastic bottles, caps, household goods (jars, plastic chairs) are some mostly used plastic materials. Comparatively it takes less year (20~30) to decompose. Some of the polypropylene products are recycled but it loses its quality after a few uses.

PVC (Polyvinyl Chloride): A high strength thermoplastic mainly used in pipes, construction sites, medical devices. Other plastic materials such as high thickness plastic jars, containers, toys, medical additives are made of it. PVC plastics are mainly popular for their high durability, water resistance, and good resistance against chemical additives such as oils, acid. It's also famous for its recyclability. But PVC plastics are not biodegradable, and contain toxic chemicals which are harmful to human health. Some of the PVC plastics take 1000 years to decompose.

PS (Polystyrene): PS is a thermoplastic used to manufacture plastics such as packaging, toys, food containers, plastic boxes, packing foams etc. It is popular for some of the electronic product manufacturing. PS is not biodegradable thus takes hundreds of years to decompose in the environment. Its breaks down very easily which in case ingested by any fish or somehow enters the food chain of human causes various types of harm. It releases toxic chemicals when burnt

PET (Polyethylene Terephthalate): The most commonly used plastic single use of beverage bottles. It is also used in common plastic material such as packaging, containers, medical equipment, plastic films, photographic films etc. Famous for its durability, recyclability. It takes less energy in production compared to other plastics materials. It also has the same disadvantages like other plastic materials. It is not biodegradable, some of the PET polymers take 450 years to decompose thus affecting the environment chemically and causing pollution.

Apart from these there are some more plastic materials such as PUR(Polyurethane), Polycarbonate (PC), Acrylonitrile Butadiene Styrene (ABS), Polyamide (Nylon), Polypropylene Terephthalate (PPT). These plastic materials are not only popular in Bangladesh but also in the whole world.

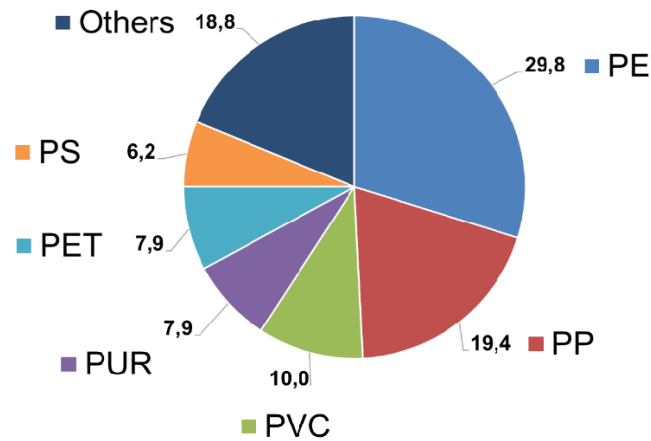


Figure 3 The worldwide percentage distribution of plastics by type of plastic

The pie chart above shows the percentages of distribution of plastics materials in the world(Palencia et al., 2026)

RESULTS

IMPACTS OF PLASTIC POLLUTION: The impact of plastic pollution is a huge topic to research. It left behind nothing to create its impact. Every section of the environment such as water, air, soil are affected by plastic pollution. Besides the environment, other living beings are all affected by plastic waste pollution. Here we describe a few parts of the environment, living beings (Human & animals) are affected by plastic waste pollution.

WATER: Water is one of the most important things in the environment. Human as well as other living animals, plant life rely on water. But nowadays water is being contaminated comprehensively. This problem along with plastic pollution is increasing proportionally. As per World Population Review annually plastic waste into waterways is about 47,830 TONS(*World Population by Country 2024 (Live)*, n.d.). Due to plastic waste the most affected area is water. Since there is no specific dump yard or waste management system in Bangladesh, almost all of the plastic waste such as plastic bottles, water juice can, plastic bags, polythene, pens, food packets end up their journey falling into the river/canal. Even the drainage systems of all the cities are being destroyed by plastic wastages. This causes water clogging and finds no way to flow. Due to this reason when there is a little amount of rain, the cities go under the water for some hours. The rain water also could not find any proper way to wash out from the street, as a result, the cities are under water. A research paper back in 2004 found the reason behind water clogging in Dhaka city where the waste management system was one of the main reasons. (M. A. Hossain et al., 2022). It is a harsh reality that even in today's date the situation remains the same, in fact in some cases it is even worse. As most of the plastic waste went to canals through the drainage way, investigation says that there were 65 canals around Dhaka city covering some famous rivers, but now there exists only 43 canals.(M. A. Hossain et al., 2022). rest of the canals are now plastic dumping zones. Same result we will have if we went to investigate the scenario in other cities as well. As the area of discharge point of the canals is reduced by plastic waste, resulting in the low discharge of these canals to rivers. Discharge $Q = AV$; A=Area of the discharge point of any canals. There used to be a public transportation system between these canals which has been destroyed now. Canals was a source of getting fresh fish previously, since the water being contaminated this source is also destroyed now. The main reason behind these hazards is, usually plastic objects are made of chemical things,

when these chemical additives are mixed with water, the water is contaminated. The plastic blocks the sunlight coming directly to the canals. Plastic surface blocks the sunlight from reaching the aquatic plants and causes them to die, the decomposition of these plants will reduce the amount of dissolved oxygen thus causing the canal fish to die(S. Hossain et al., 2021). Apart from this there are more several issues with plastic waste and rivers. The scenario is even more complex when we see that all these plastics ultimately reach the ocean by rivers. Almost 50% to 80% of the discarded plastic reaches the seashore, ocean surface(Barnes et al., 2009). Another way through which plastic reaches water is from marine vessels. These plastics directly reach water or the living microorganisms, fish and are a reason for their death(Chowdhury et al., 2021). Amount of plastic entering into the ocean depends on many factors, it is found that about 8 to 10 million tons of plastic went into the ocean, also accounting for 80% of marine pollution. Plastic waste kills more than 100, 000 marine species every year(Cózar et al., 2014). Plastic waste is physically hard for the life living in water. Many fishes consider plastic as food mistakenly, thus this plastic causes them to die. Apart from plastic wastages in the canal or river if we look at how it is polluting the water, the hazard view is even worse. Sometimes microplastics are found in drinking water. Reports say that 4,000,000 particles probably ingested and internalized by humans in one year(Angnunavuri et al., 2023) Drinking this water many people face death in recent times. To be specific more, microplastic is the main reason that leads us towards the negative situation. Though there is a limitation of the source about how much microplastic are present in the drinking water, as per WHO reports based on 9 report they identified that microplastic ranged from 0 to 10,000 particles/L(Microplastics in Drinking-Water, n.d.)

As Bangladesh is an over populated country, so it is in the most dangerous risky zone of consuming microplastic through drinking/using water. Further research must go on the amount of microplastics people are consuming, the rate of people affected by this issue and of course idea to mitigate the way through which microplastics are coming into the water.

AIR: The combustion of plastics releases toxic smoke and hazardous gases, including phosgene, a chemical weapon from WWI, posing severe health risks(Islam et al., 2023) Open burning of plastic materials generates heavy metals and lithophilic elements, leading to fatal diseases and environmental contamination. Heavy metals are emitted into the environment through activities like metal refining, waste incineration, and industrial processes involving plastics and rubber. Once airborne, they traverse vast distances before settling on soil, vegetation, or water, dictated by their density. These elements resist degradation, remaining in the ecosystem for decades. Their persistence poses long-term ecological and health hazards. Again, decomposition by microbes emits methane, a key driver of global warming. Exposure to plastic toxins causes respiratory, neurological, and immune system damage, often resulting in cancer. Improper disposal of battery casings further contaminates soil with harmful chemicals. In developing nations, such as Bangladesh, informal waste burning is prevalent, exacerbating the carcinogenic and environmental threats. oil and gas extraction results in air contamination at every stage, including production, processing, transmission, and storage, with 87% of 46 studies revealing increased emissions. During the pre-production phase, each well requires 2,300 truck trips, further contributing to pollution(Sarkingobir et al., 2021) Diesel truck emissions release harmful substances like BTEX and particulate matter. Breathing in these pollutants can cause heart-related issues, respiratory problems, and worsen asthma symptoms.in 2008, the decomposition of solid waste in landfills resulted in an estimated release of 20 million tonnes of CO₂ equivalent (eqCO₂) into the atmosphere. CO₂ is also emitted when plastics and plastic products are burned, contributing to the greenhouse effect by trapping radiant heat, which prevents it from escaping the Earth and leads to global warming.(Chandegara et al., 2015)The estimated ingestion of microplastics (MPs) from dust is approximately 3,223 particles for children and 1,063 particles for adults.(Kibria et al., 2023a). Again, incineration of PPE plastic wastes reportedly generates various [air pollutants](#),(*Air Pollutant - an Overview | ScienceDirect Topics*, n.d.) [particulate matter](#) (PM) (*Atmospheric Aerosol - an Overview | ScienceDirect Topics*, n.d.)smaller than 10 µm in diameter (PM₁₀), PM smaller than 2.5 µm in diameter (PM_{2.5}), and heavy metals.(Rai et al., 2021)

Table 1 Air constituents, source of pollution and its consequences (Source: Table made by Author's)

Constituents	Source	Consequences
ozone	Reaction of VOCs and NOX in sunlight	Methane and Pollutants from Oil and Gas Production: Oil and gas production emits over 9 million tons of methane and VOCs annually, which contribute to ozone

formation, creating harmful ground-level smog that affects rural and urban areas. Toxic Emissions from Plastic Incineration: Burning plastics releases hazardous pollutants like mercury, dioxins, and PAHs, which are linked to cancer, reproductive issues, and severe environmental harm.

Global Dispersion of Pollutants: Emissions from plastic incineration, including toxic metals and organic compounds, can travel long distances, accumulating in ecosystems and entering the human food chain.

Inhalation of Microplastics: Airborne microplastics, primarily found indoors, pose a health risk when inhaled, potentially causing lung damage and other respiratory issues over time.

Health Risks from Particulate Matter: Particulates and smoke from plastic waste incineration contribute to respiratory conditions, particularly in vulnerable populations such as children, the elderly, and those with pre-existing lung conditions.

Penetration of Microplastics into the Body: Inhaled microplastic fibers can bypass the lung lining, enter the bloodstream, and translocate throughout the body, potentially leading to long-term health problems

Methane (CH ₄)	Oil and gas production	Methane is a potent greenhouse gas that contributes to global warming by trapping heat in the atmosphere.
Volatile Organic Compounds (VOCs)	Oil and gas production, plastic burning	VOCs react with nitrogen oxides (NOX) in sunlight to form ground-level ozone, contributing to smog formation.
Particulate Matter	Plastic incineration, diesel exhaust	Fine particles in the air can cause respiratory problems, particularly in vulnerable groups (children, elderly).
Toxic Chemicals (BTEX, PAHs, Dioxins)	Plastic burning and incineration	These chemicals are carcinogenic and can lead to respiratory and cardiovascular diseases.

Heavy Metals (Mercury, Lead, Cadmium)	Plastic incineration	These metals are neurotoxic and can cause long-term health issues, affecting the nervous system and organs
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SOIL: The impact of plastic waste in the field soil is at high risk in Bangladesh. With industrial development the rate of manufacturing and disposal of plastic has increased significantly. Here the maximum area does not have any proper waste management system let alone plastic, daily a huge amount of plastic waste is consumed by the landfills(He et al., 2019). About 79% of global waste goes to landfills.(Ng et al., 2018). Since humans and all the other living beings had to rely on soils, it is necessary to look at how it is being affected by plastic waste. Macro and microplastics are damaging the soil properties rapidly. The properties of soil such as porosity, bulk density, saturated hydraulic conductivity, water content, water stable aggregates (WSA) are changing via macro and micro plastic(Maqbool et al., 2023). It is known that the solid plastic requires a long time to decompose. Plastic bags take a minimum of 20 years whereas plastic bottles take about 450 years to decompose(*How Long It Takes Everyday Items to Decompose – The Waste Management & Recycling Blog*, n.d.) It is found that long term use of plastic not only destroys the above surface of the soil but it also affects the sub-surfaces of the soil and it is more difficult to mitigate the plastics which are now already in deeper soil(S. Li et al., 2022). In some case it even goes thousands of years also. These results in soil contamination, decreasing soil fertility, destroying soil microorganisms which were essential to maintain soil health. It also hinders the growth of plants blocking the roots. Macro and micro plastics have negative impact on crop growths also, crop-soil properties are negatively impacted with time and macroplastics over 240 kg/hectare excluding Olsen potassium and microplastics over 10,000 mg /kg excluding plant chlorophyll(Gao et al., 2022). Both the macro and micro plastics affect the above and down surface part of the wheat plant during observing its growth(Qi et al., 2018). In case of macroplastics with soil it results very different in test of compaction, unconfined compressive strength test, CBR (California bearing ratio) and resilient modulus (Mr.) test when there is macroplastics like plastic bottles are present in the soil verses when the presence of macroplastic in soil is low(Hassan et al., 2021). Since large particles of plastic, especially when it is in the sub-surface of the soil, the water could not be squeezed out from the soil thus results in these tests being absolutely different. Macro plastic also causes waterlogging in the soil thus soil properties badly affected through it. But since macro plastic can be detected through naked eyes and its removal is also easier compared to micro plastics. Understanding this the main concern is with micro plastics. Micro plastic (< 5 mm) pollutes the soil in many ways. Changing soil properties to destroy necessary microorganisms impacts everywhere. Plants height decreases significantly due to increasing macro and micro plastics. The cycle of nutrition (N, P and K) in a plant also changes, sometimes the amount of these molecules is higher and sometimes it decreases(Graf et al., 2023). This proves the effect in microbial organisms affected by micro plastics. Some microorganisms such as bacteria or fungi are destroyed by these plastic materials. As the amount of micro plastics are increasing, some research models suggest that the number of micro plastics should not exceed 2128 mm/kg to maintain current soil properties at least 50%. (Kim & Rillig, 2022). The less amount of micro plastic remains in the soil the percentage will increase. With bulk density micro plastics increase the pH of soil(Joos & De Tender, 2022). As these plastics contain chemical additives, which sometimes results in toxic organic matter also. In some case behaviour of soil along with microplastic varies depending on the type of microplastics. In some research it is found that the water holding capacity increased and bulk density decreased when there is PS(Polystyrene) fibers microplastic present in the soil but there is noting significant change when microplastic type PE (Polyethylene) or PAA (microplastic derived from poly acrylic acid) are presents in the soil, again from another study we see that in the presence of PS fibers no change in bulk density but water bearing capacity has increased. (de Souza Machado et al., 2018b; Zhang et al., 2019). Microplastic can affect the hydraulic conductivity/permeability of the soil also which could result in negative soil microbial activity along with soil fertility.(Qian et al., 2018). Interaction between microplastic and soil may result in unpredictable results or cause environmental impact, which is a more serious problem for soil.(Guo et al., 2020). Microplastic also creates its impact on the evaporation of soil. Presence of plastics in soils significantly increased the water evaporation. The more micro sized plastic were used the increasing rate of evaporation was also increased.(Wan et al., 2019). Microplastic also alters the soil biophysical properties that lead to complex changes in soil behaviour.(Alimi et al., 2018). since it contains toxic element such as polybrominated diphenyl ether (PBDE), perfluorochemicals (PFOS), heavy metals such as zinc, copper, lead etc. components(J. Li et al., 2018). Apart from all these there are more significant issues continuing between the microplastics and soils. Ecological or microbial soil animals are highly affected by these plastics. Other properties of soil such as compaction, Total organic carbon, soil alkalinity, electric conductivity are also changed due to the presence of plastics. Though

It's tough to mitigate the plastics spread in the soil but it's high time to reduce the amount of plastic run in the soil.

IMPACT ON HUMAN HEALTH: Plastic polymers are often perceived as inert and of minimal concern to public health; however, the additives and residual monomers present in these materials pose significant health risks. Many of these additives are recognized as potential carcinogens and endocrine disruptors. Humans are primarily exposed to these substances through ingestion, skin contact, and inhalation, with cases of dermatitis reported following contact with certain plastic additives. Microplastics, as pervasive contaminants, can bioaccumulate within the food chain when ingested by freshwater and marine organisms, thereby presenting a serious public health concern and also degrade human health due to cardiovascular diseases, chronic kidney disease, birth defects, cancer, etc.

Consumption of animals exposed to microplastics and associated additives can have harmful effects on human health. Biomonitoring studies have confirmed the persistence of plastic-derived contaminants in human tissues, highlighting their enduring presence in the population through environmental exposure. On the other hand, the growing accumulation of plastic waste poses a direct threat to human lives too. The health repercussions of plastic grocery bags are profound, spanning from emission-related ailments to fatalities. In 2005, monsoon flooding in Mumbai, India, exacerbated by plastic waste, claimed over 1,000 lives and left many injured. This underscores the severe human cost of plastic pollution. (Nkwachukwu et al., 2013). So, Plastic pollution poses significant risks to human health through various exposure pathways, including ingestion, inhalation, and dermal contact. The following table summarizes key health impacts associated with plastic exposure, along with references to relevant studies:

Table 2 Health impacts associated with plastic exposure

Health Impact	Description
Cellular Damage	Microplastics can cause oxidative stress, inflammation, and cellular toxicity, potentially leading to tissue damage. (Danopoulos et al., 2022)
Endocrine Disruption	Bisphenol A (BPA) is a carbon-based synthetic plasticizer with two unsaturated phenolic rings bridged by carbon, widely used in commercial products and known as an endocrine disruptor. Chemicals in plastics, such as bisphenol A (BPA) and phthalates, can interfere with hormone function, affecting reproduction, growth, and cognitive development. (<i>Microplastics and Human Health - Wikipedia</i> , n.d.; Nayanathara Thathsarani Pilapitiya & Ratnayake, 2024)
Reproductive Toxicity	Exposure to microplastics may decrease reproductive health, including reduced sperm quality and developmental abnormalities. (<i>Microplastics and Human Health - Wikipedia</i> , n.d.)
Respiratory Issues	Inhalation of microplastics can lead to respiratory problems, including lung inflammation and exacerbation of existing conditions like asthma. (<i>Microplastics and Human Health - Wikipedia</i> , n.d.)
Cardiovascular Effects	Microplastics have been detected in human arteries, with potential links to cardiovascular diseases such as atherosclerosis. (Campanale et al., 2020)
Carcinogenic Potential	Certain plastic additives and by-products have been associated with an increased risk of cancers, though direct links to microplastic exposure require further research. (<i>What You Need to Know About the Impact of Plastics on Human Health - Earth Day</i> , n.d.)

Immune System Effects	Microplastics may cause immunotoxicity, leading to altered immune responses and increased susceptibility to diseases.(<i>Microplastics and Human Health - Wikipedia</i> , n.d.)
Neurotoxicity	Exposure to microplastics has been linked to neurotoxic effects, potentially impacting cognitive function and behavior. Nanoplastics can cross the blood-brain barrier, potentially causing neuroinflammation and behavioral changes.(Campanale et al., 2020; <i>Microplastics and Human Health - Wikipedia</i> , n.d.)
Gastrointestinal Issues	Microplastic ingestion has been linked to gut microbiota imbalance, inflammation, and disruption of intestinal barriers.(Wright & Kelly, 2017)
Immune System Disruption	Microplastic exposure can alter immune responses, leading to heightened vulnerability to infections and autoimmune conditions.(Prata et al., 2020)

IMPACTS ON ANIMAL LIFE: The contamination of plastic waste in ecosystems poses a dual threat to wildlife and human food security, as toxic constituents from plastics can poison animals, adversely impacting their survival and indirectly affecting food supplies. Notably, large marine mammals face documented survival challenges due to the vast quantities of plastic entering oceans, with ingestion occurring more frequently than entanglement as the primary mode of exposure. Marine plastic pollution poses a grave threat to biodiversity, with over 260 species of vertebrates and invertebrates documented to ingest or become entangled in plastic waste, resulting in more than 400,000 marine mammal deaths.(Okunola A et al., 2019) Sea turtles and seabirds, often mistaking plastic bags and microplastics for prey like jellyfish or cuttlefish, are particularly vulnerable, suffering from digestive obstructions, malnutrition, starvation, and mortality due to the physical and physiological damage inflicted by ingested plastics. Plastic debris in marine ecosystems has resulted in the entanglement and subsequent fatalities of an estimated 243 species, including birds, turtles, fishes, and seals, through mechanisms such as drowning, suffocation, or increased vulnerability to predation due to immobilization. The table below shows how plastics are impacting animal species.

Table 3 Animal species affecting by plastic type (Worm et al., 2017a, 2017b)

Animal Species	Plastic type	impacts
Greater shearwater	Plastic bottle cap	Gastrointestinal blockage leading to starvation. Stomach perforation
Magellanic penguin	Fragments, line, and straws	
Green sea turtle	Plastic bags and other debris	Hindrance to hatchling movement towards the sea, exposing them to predators.
Green sea turtle	Balloons, plastic and nylon string	Impediment of hatchling movement towards the sea, increasing exposure to predators.
Dermodochelys coriacea	Plastic bags and debris	Blocked and injured cloaca impedes laying of eggs

Fish spices	Fragments and line	Ingestion of microplastics leading to physical damage and long-term health effects.
Larval perch	Microplastic particles	Delayed hatching, slowed growth, and changes in behavior
Fur seal	Plastic particles	Bioaccumulation of particulate plastic from prey fish.
Australia sea lion	Plastic fishing gear	Entanglement-caused mortality
Bivalve	Microplastic particles	Accumulation of microplastics in circulatory system
Oyster	Microplastic particles	Interference with energy uptake and reproduction
Norway lobster	Strands and particles	Ingestion and accumulation of plastics in the gut

CURRENT PLASTIC STATE OF BANGLADESH

Bangladesh being the 8th most populated country in the world, so it is obvious that the plastic consumption rate in this country is also high. As per the report of World Bank back in 2021, within 15 years Bangladesh annual per capita plastic consumption in urban areas tripled, in 2005 the rate of plastic consumption was 3 kg whereas in 2020 it became 9kg (*Meeting Bangladesh's Plastic Challenge through a Multisectoral Approach*, n.d.). No doubt the rate of this state is increasing and it can be easily assumed that within next a decade the rate of per capita plastic consumption will be 3-5 times higher than this current rate. Despite being the first nation to implement ban on plastic bags in 2002 as it were causing block in drainage and water flow system resulting in water clogging or flood. (*First Country to Ban Single-Use Plastic Bags | Guinness World Records*, n.d.)

The Mismanaged Waste Index (MWI) (The sum of uncollected and improperly managed waste, divided by the waste generated) is 98.54 which is a very high and red signal. Plastic waste is about 579.9K Tons where mismanaged waste is about 571.453K Tons thus approximately more than 90% of the plastic waste is mismanaged. The plastic consumption kg/capita/year is 3.5. (*Plastic Pollution by Country 2024*, n.d.). Hence considering 150 million of people consuming 3.5 kg of plastic annually makes it $(3.5 \times 150) = 525$ million Kg of plastic waste annually indicates how horrible the situation is. Imported plastic waste is about 2860 TONS (*Plastic Pollution by Country 2024*, n.d.). A study reveals that Bangladesh produces 3.15 to 3.84 billion single use plastics annually, most of them are plastic bottles. (YASIR WARDAD, 2024). From a study we get the data that 3000 tons of plastic garbage generated everyday in Bangladesh, everyday 14 million plastic bags are used only in Dhaka city (Muhammad Muktadirul Islam Khan, 2023) let alone the whole country, these plastic bags end up in canal, river or flows from here to there, 73,000 of plastic debris enters in ocean through rivers (Iftekhar Mahmud, 2018). This number has surely risen within these few years. The main sources of plastic waste are household, agricultural plastic waste, medical plastic waste, industries, electrical plastic waste (Kibria et al., 2023b)

FLOW OF PLASTIC WASTE IN BANGLADESH: Plastic such as polythene, plastic bags, packets of various commodities, bottles, straws, cans etc. products are the most common wastages we may found. It is found that about 45.5 billion plastic bags are used in Bangladesh each year (*'45.55 Billion Plastic Bags Used Daily' | The Daily Star*, 2023). plastic bottles used by 83.6 percent people regularly (YASIR WARDAD, 2024). These common plastics reaches to public via few ways, mostly from supermarkets. After use most of the plastics are thrown way, plastics such as water bottles, juice can, chips packet or other commodities packet mostly are thrown way to street since in most of places either

there is no waste collecting zone (dustbin) and even if it is there, or little away from the user, a number of people does not use it due to their lack of awareness about plastic and its harmful effect. Plastics used in household are thrown away to dustbin or in any open common places where the society people are also throwing away their waste. In Bangladesh, (basically in Dhaka) over a million informal waste workers (sometimes called “Tokai” in local language) play a vital role in plastic recycling, collecting and sorting waste from households, streets, and landfills. They also found in other cities of Bangladesh too. They walk through the street, field or nearer to the waste throwing zone and find out the wasted plastic. Then they sold these plastics to small shops called “Vangari” in the local language at a cheap price. Some of the people walk through the street with a van having lots of plastic wastage they have already collected besides households and ask for plastic such as bags, bottles etc. plastic wastages. They mainly buy these plastic wastages from household or grocery shops and sell them to Vangari’s with a small amount of profit. The small shops called Vangari’s collect this plastic, separate them accordingly and supply them to plastic recycling factories or other factories which need local plastic wastages. City corporation workers also assist by transporting mixed waste to landfills. The informal sector handles most of the recycling, ensuring plastic waste is reused efficiently. This process supplies raw materials for new consumer plastic products(*Meeting Bangladesh’s Plastic Challenge through a Multisectoral Approach*, n.d.)

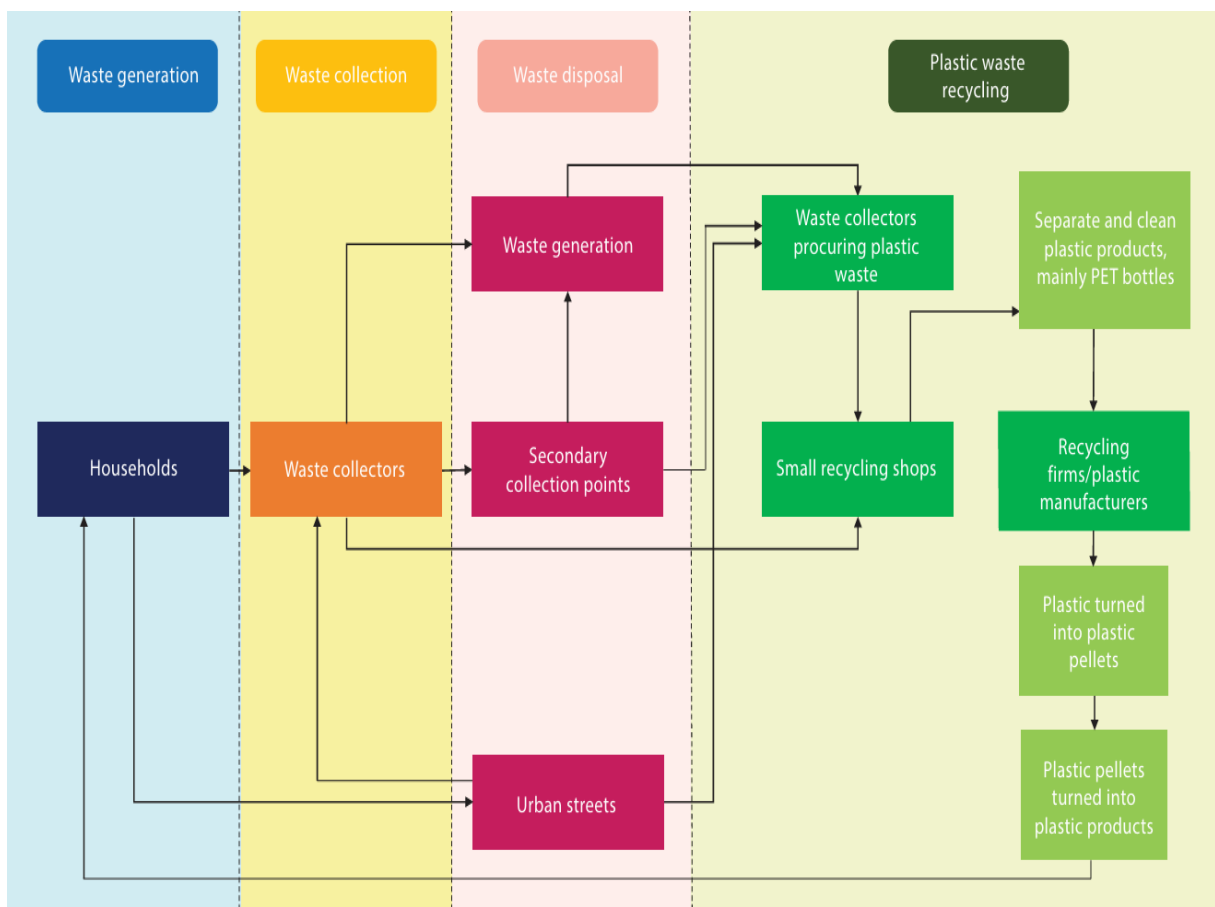


Figure 4 Waste Management and Plastic Recycling in Dhaka.(Khatun Syed Yusuf Saadat Afrin Mahbub, n.d.)

Reason behind Bangladesh failure behind reducing plastic use or generating huge amount of plastic wastage-

- Lack of alternatives, Though, there are alternatives of some regular plastic material but still there is shortness of maximum daily used plastic
- The law enforcement was very weak, even though the government implemented a ban on using plastic bags but it was not followed by even a minimum percentage of people.
- Awareness among people is one of the main reasons. To mitigate plastics people must be aware of using plastics, without awareness it is not possible to manage plastic waste management.
- Not having any proper plastic waste management system is another reason to failure

Some more reasons such as dependency on plastic material, growth of industries and their production of plastic have increased plastic production which could not be handled well.

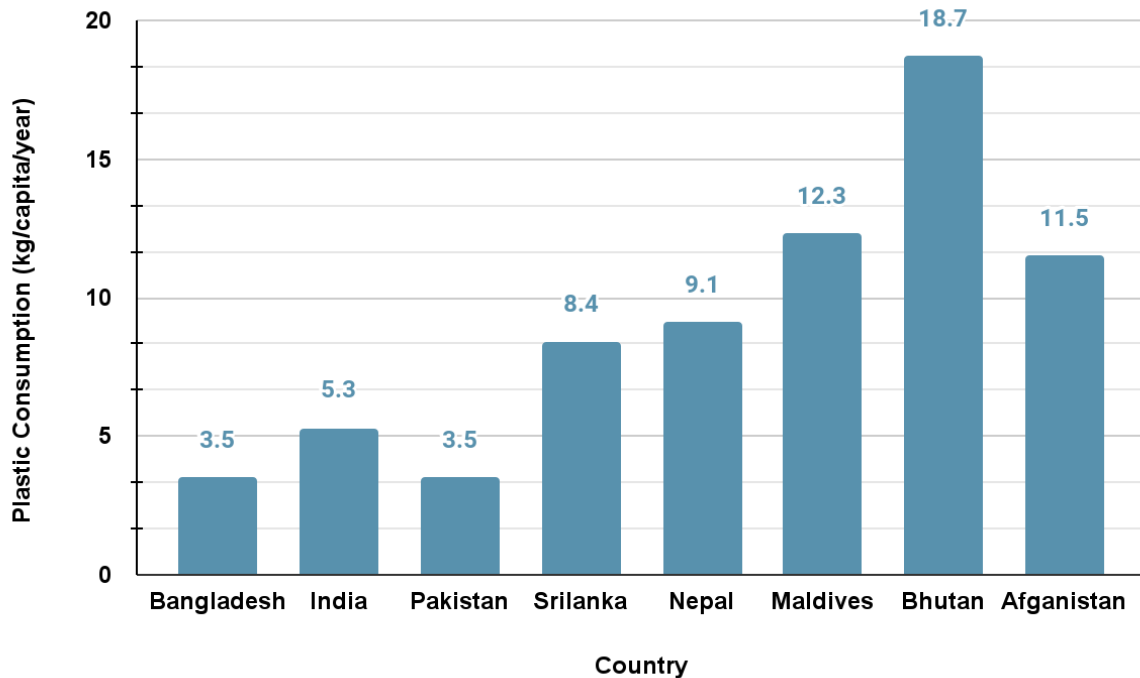


Figure 5 Comparison of Bangladesh on plastic consumption of people with other South Asian countries.(*Plastic Pollution by Country 2024*, n.d.)

The above data table on plastic consumption (Kg/capita/year) is the amount of plastic (Kg) used by people in a year. It is good to see that Bangladesh is doing good comparatively in consumption of plastic in a year compared to other South Asian Countries. For instance, we understood how emergent it is to have a proper plastic waste management system in Bangladesh as well as to recycle the plastic waste.

DIFFERENT COUNTRIES PLASTIC WASTE MANAGEMENT & RECYCLING SUCCESS

While Bangladesh does not have any proper plastic waste management system, we should look at how the other country is working towards mitigating plastic waste and recycling it.

CHINA: China is one of the countries with a huge population. It has produced the highest amount of plastic waste in the Asia Pacific region which is 55.7 million tons.(*APAC: Plastic Waste Produced by Country 2024* | Statista, n.d.). It is one of the top countries to produce single-use plastic waste. With the production of plastic waste China is becoming popular for their plastic waste management system. As per reports, the recycling value of China is about 103 billion yuan (14.42 billion U.S dollars)(*China: Value of Recycled Plastic 2023* | Statista, n.d.). Yet China is still working on how they can improve the situation and finds new way to build the recycle plastic waste industry.(Sun et al., 2022). China has been following some regulations in order to mitigate the plastic pollution control, (1) The five year plan for National Economic and Social Development of the People's Republic of China, their plan is to improve the environment quality, prompting green life and production, advancing low carbon development, reducing pollution notably, controlling environmental risks and furthermore, to meet these targets, several policies were made which encourage government and the people to be more aware about plastic waste. (2) Implementation of the ban on foreign waste importation in 2017- this was a turning point to the flow of plastic. (4) Introduction of a plastic recycling and treatment system and related policies(Liu & Liu, 2023). China banned the use of non-degradable plastic bags in shopping malls, supermarkets, pharmacies and more places in 2020. Now they have planned to ban non degradable plastic bags, disposable plastic woven bags etc. by the end of 2025(Liu & Liu, 2023). They have implemented an AI (Artificial Intelligence) system to manage their plastic waste.(*China Uses Artificial Intelligence to Sort Its Waste* | News | Eco-Business | Asia Pacific, n.d.). Using smart trash bins for particular plastic waste and rewarding the public for the use of it is another excellent idea they

have used. In fact, Shanghai, one of the cities of China, is expected to be a model of zero-waste-city around the world(*Shanghai May Become a Model for Zero-Waste Cities around the World - Focus - China Britain Business Council*, n.d.). A lot of research is going on how China can manage their plastic waste and recycle the plastic waste(PLASTIC WASTE MANAGEMENT AND BURDEN IN CHINA, 2022)

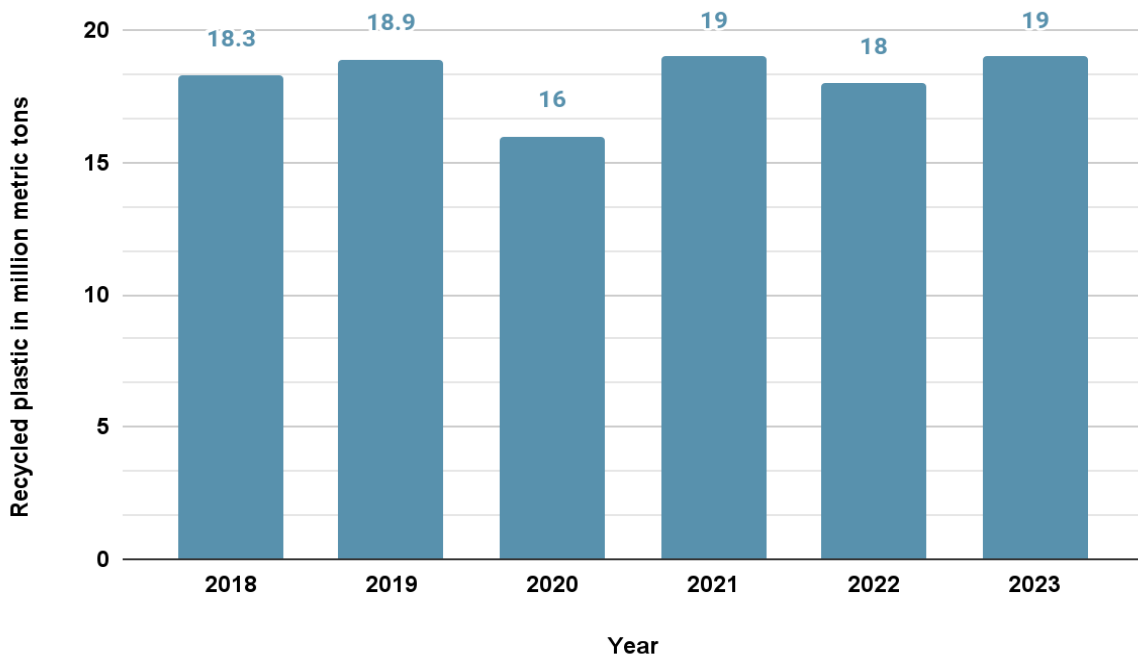


Figure 6 Recycled plastic in China (in million metric tons)(*China: Volume of Recycled Plastic 2023 | Statista*, n.d.)

The above chart shows the amount of plastic recycled by China in last few years which proves their success in plastic waste management.

RWANDA: Rwanda is a country located in East Africa. Rwanda is one of the countries, leading in the world to reduce plastic waste. In 2008, Rwanda banned the manufacture, sale and use of polythene bags(*Rwanda’s War on Plastic by Jonathan W. Rosen (Works That Work Magazine)*, n.d.). Rwanda’s capital Kigali is known as one of the cleanest cities in the world(*Umuganda: Rwanda’s Audacity of Hope to End Plastic Pollution | United Nations Development Programme*, n.d.). Mainly in 2003 Rwanda’s government understood the problem with plastic waste since it was troubling the country in many ways(*4 Countries Leading the Way in Reducing Plastic Waste - Bevi*, n.d.). The government’s and citizens’ involvement together makes the impossible possible by reducing plastic waste considerably. They have promoted eco-friendly alternatives of plastics bags such as paper bags. Except government the private company and international company also come along to mitigate the use of plastic in the country.(*Rwanda: Lessons Learnt from a Pioneer in the Fight against Plastic Pollution — Global Green Growth Institute*, n.d.)

An UNDP report says that Rwanda’s success to mitigate plastic use comes based on four things, where political will comes first, empowering communities and raising awareness are the most important things in this type of mission. To make people understand the risk of using plastic that harms the environment, health issues ease the task more. The Government of Rwanda used to organize monthly plastic collection events among the community. The investment of Rwanda’s government was heavy to mitigate plastic, they also associated with private sectors and local communities for collecting, sorting and processing of plastic waste.(*Rwanda’s Remarkable Journey: Inspiring Solutions to the Global Plastic Pollution Crisis | United Nations Development Programme*, n.d.). The table below shows how the export rate of plastic products such as (sacs, bags and cones for the conveyance or packing of goods of plastics other than ethylene polymers) has increased within 5 years (2012-2016).

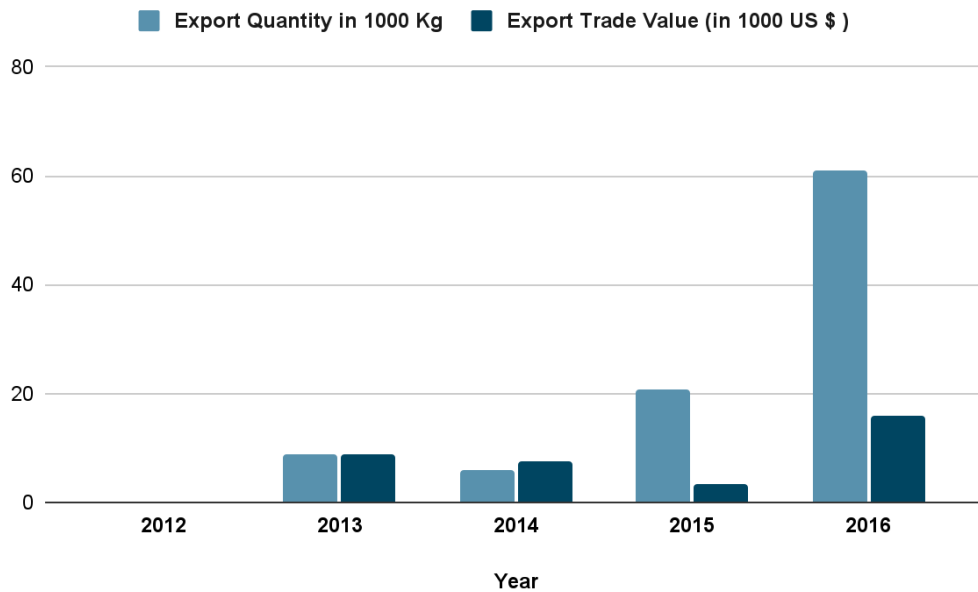


Figure 7 Exports rates of plastic product and its trade value in Rwanda(*World Integrated Trade Solution (WITS) | Data on Export, Import, Tariff, NTM, n.d.*)

SWEDEN: Sweden is one of the countries leading the world in reducing plastic and recycling of plastic. They are on a mission to turn waste into energies. As per World Population Review MWI index of Sweden is 1.49 which is very low.(*Plastic Pollution by Country 2024, n.d.*). In order to reduce plastic Swedish government put prohibition on single use plastics products such as cotton buds, straws etc. in 2022.(*Sweden Commits to Reduction of Plastic Pollution by Adopting a National Plastic Action Plan with Goals and Concrete Actions | Department of Economic and Social Affairs, n.d.*). We have found that incineration with energy recovery is the most common form of treatment for plastic waste, in 2020 more than 1.1 million tons of plastic went for energy recovery where 76K tons of plastic were recycled to fuel in the cement industry Packaging is the biggest plastic market in this country. In 2020, 220,000 tons of plastic packaging entered the Swedish market, now the Swedish government set a goal to recycle plastic packaging including PET bottles approximately 50% within 2025.(Neil Shipley, 2021). Swedish government plans to increase reusable packaging to increase about 20% within 2027.(*Sweden Commits to Reduction of Plastic Pollution by Adopting a National Plastic Action Plan with Goals and Concrete Actions | Department of Economic and Social Affairs, n.d.*). They have added tax with the using of plastic bags which results in low rate of using plastic bags.(Neil Shipley, 2021) In 2020, Construction products are the second largest area of plastic use in Sweden where only 2% of the plastic is recycled. Vehicles and tyres are another impactful field that produce plastics. The recovered plastics materials goes to incineration for energy recovery. About 65% cars tyre goes for incineration for energy recovery ,24% material are recycled. Amount of plastic in electronics is assumed to be 39,000 tons but more than half of plastic were recycled and 40% was sent to incineration for energy recovery. Again 86% PET bottles were recycled to new bottles, plastic rays, wrapping etc.15.Plastic in Sweden – facts and practical advice. In the same year 75% agricultural plastic was recycled and the rest went for incineration. Only 1% of the trash went to landfills where 52% is turned into energy and the remaining 47% of trash are recycled.(*Plastic in Sweden-Facts and Practical Advice, 2022*). By this Sweden has successfully reduce the carbon emission rate also. Childrens in Sweden are thought of plastic recycle from very beginning of their learning stage, a national day also organized to make people aware of plastic usage and recycling, Teachers are trained to teach children to understand waste policies in School. A recycling station can be found after every 300 meters nearer to any residential area, Swedish people get rewarded for using recycling machines.(Chan kim and Renee Mauborgne, n.d.). Research is still going on how they can improve their plastic waste management as well as recycling of plastic.(Milios et al., 2018). Besides their reducing plastic waste management and recycling, it's impacting environmentally by reducing greenhouse gas (GHG) emission, socially by creating few job sectors and economically also.(Davani, 2018). The graph below shows how consistent Sweden is being to their recycling plastic and forwarding towards their goal. They are on a mission to achieve approximately 50% of recycling plastic packaging including PET bottles.(Neil Shipley, 2021)

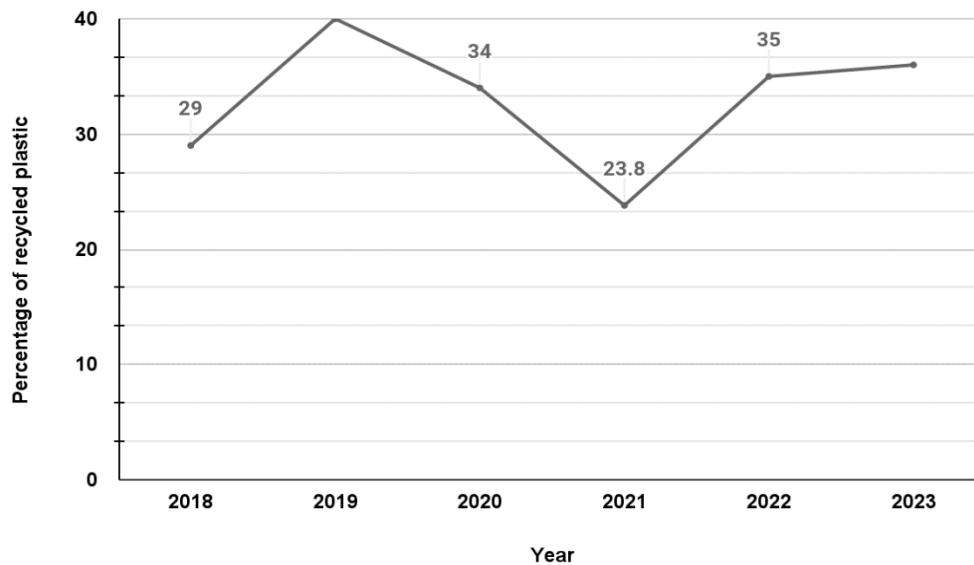


Figure 8 Rate of Recycling plastic in Sweden (2018-2023) (Graph was made by author's)

GERMANY: Germany has ranked number one in the latest plastic management index. It has scored 87.5 out of 100 in that index. (Plastics Management Index Plastics Management Index Evaluating Effective Management and Sustainable Use of Plastics Management Index, 2021). In 2021, Germany banned single use plastic. (*Plastics and Packaging Laws in Germany* | CMS Expert Guide, n.d.). The people of Germany are also now used to it and they have the alternates of regular used plastic materials. They have recycled about 99.8 % of their plastic packaging in 2021. (Plastic Packaging Recycling Rate Germany | Statista, 2024). They have followed a few strategies in order to emit plastic, at first they tried to minimize the production rate of plastic talking with its manufacturers and consumers, reusing of the plastic materials thus to decrease the production of plastic, in case it is even easy than recycling as required less energy, separation, various way for treating the plastic waste was invented to recycle the plastic, they have implemented microbial degradation, incineration types techniques to manage plastic waste. It has started to collect plastic waste through yellow containers which goes under recovering facilities. (Ramasubramanian et al., 2023). They have a 5 point plan to reduce plastic, avoiding unnecessary plastics such as avoiding unnecessary products packaging, when packaging is necessary they try to use environment friendly packaging. The government plans to increase the plastic recycling rate more, keeping plastics away from organic waste helps to recycle plastic, they have also managed to limit plastic within boundary, aiming plastic does not reach to ocean. (*Germany Unveils Plastic Reduction Plan – DW – 11/26/2018*, 2018)

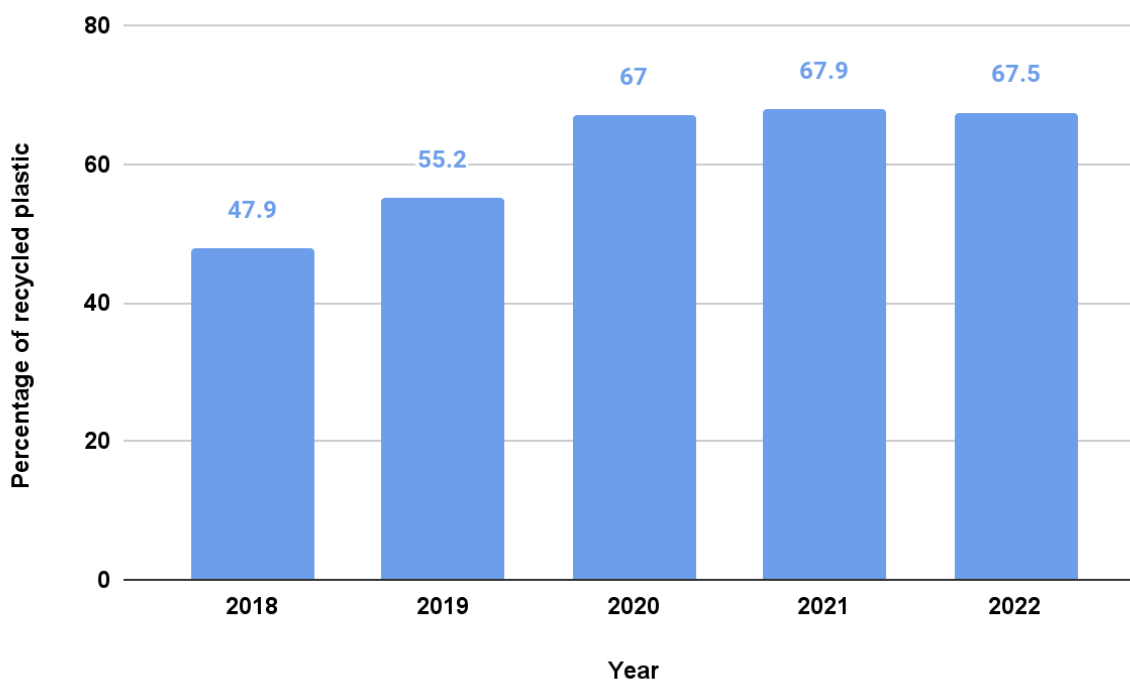


Figure 9 Percentage of recycled plastic (2018-2023) (Source: Data table made by author's)

POLICIES TAKEN BY FEW COUNTRIES TO MITIGATE PLASTIC WASTE

Laws against plastic are imperative to mitigate anthropogenic pollution that desecrates ecosystems and imperils biodiversity. Plastics exacerbate ecotoxicology, contaminating soil, water, and the food chain through microplastic proliferation. The incineration of plastics emits carcinogenic dioxins, posing deleterious health risks to humans and fauna. Economically, they inflate expenditures on waste management and degrade natural aesthetics, deterring ecotourism. Legislative interventions catalyze a paradigm shift towards sustainable alternatives, fostering environmental resilience. At present, 27 countries worldwide have opted for a plastic ban. Single-use items such as plates, cups and straws are the first products to be eliminated. Some countries even ban the use of polystyrene altogether, or limit the production volumes of plastic. Each prohibition usually entails certain exceptions.

The alarm over plastic pollution first sounded in 1997 when Charles Moore, a sailor and researcher, unveiled the Great Pacific Garbage Patch, a massive gyre where staggering amounts of plastic imperil marine ecosystems. By 2002, Bangladesh had pioneered a ban on plastic bags, spurred by their devastating role in obstructing drainage systems during catastrophic floods. In 2018, UNEP reported that 127 out of 192 nations had legislated against the burgeoning plastic bag crisis. This global response underscores the dire consequences of humanity's reliance on disposable plastics. (*Results So Far From Plastic Bag Bans - Pager Power*, n.d.)

Table 4 Existing laws, rules and goals in different country on plastic waste management

Country	Existing laws, rules and goals
Japan	The Japanese government plans to introduce mandatory plastic recycled content targets for major manufacturers, obliging them to utilize recycled plastics as part of efforts to cut plastic pollution and promote decarbonization. Law for the Control of Export, Import and Other Specified Hazardous Wastes and Other Wastes (2018) Recycling of Containers and Packaging (2000)
Bangladesh	The primary environmental legislation in this regard is the Bangladesh Environment Conservation Act, 1995 (BECA). The Jute Packaging Act, 2010 promotes the use of jute bags as an alternative to plastic bags.

	<p>In 2002, the BECA was amended to use Section 6A and ban on polyethene plastic bags (2002). (Results So Far From Plastic Bag Bans - Pager Power, n.d.)</p> <p>Every product must be packaged in jute bags, as required by the Act. For using non-biodegradable synthetics for packaging, offenders risk a maximum of one year in prison and/or a fine of BDT 50,000. (Though the law implementation was not successful.)</p> <p>Now, Bangladesh has again implement ban on plastic newly. (Bangladesh's New Government Implements Strong Measures to Eliminate Single-Use Plastic, n.d.)</p>
England	<p>From the 1st of October 2023, shops, restaurants and takeaways won't be able to supply, sell or offer certain types of single use plastic items to customers and will face possible fines and criminal charges if they don't comply with the new rules.</p>
Vietnam	<p>Decision 582/QD-TTg dated April 11, plastic bags in 2020 (In 2013 the Prime Minister approved the project on improving the environmental pollution control for the use of non-biodegradable plastic bags by 2020. The target of the Decision is to reduce 65% of comparison with 2010)</p> <p>Vietnam imposes an environmental protection tax on non-biodegradable plastic bags as one of the main instruments to reduce their use. However, the tax rate of VND 50,000/kg. The government of Vietnam has committed to banning the production and importing of plastic bags by 2026 and most single-use plastic products by 2031.</p>
Canada	<p>June 2024: Ban on the manufacture, import, and sale of six-pack.</p> <p>Canada's Federal Court overturns single-use plastic ban nation-wide - RPRA.</p> <p>In June 2022, Canada introduced the Single-use Plastics Prohibition Regulations under the Canadian Environmental Protection Act, 1999, targeting six categories of single-use plastic items: checkout bags, cutlery, foodservice ware, stir sticks, straws, and six-pack rings. (Single-Use Plastics Prohibitions Regulations Technical Guidelines - Canada.Ca, n.d.)</p> <p>The implementation timeline for these regulations is as follows: December 2022: Ban on the manufacture and import of the specified single-use plastic items. December 2023: Ban on the sale of these items.</p>

Korea	<p>Rings.</p> <ol style="list-style-type: none">1.Waste Management Act (1977, amended regularly)2.Mandatory Recycling Sorting (1991)3.Plastic Bag Ban (2019). In November 2022, the ban was expanded to convenience stores and smaller shops.4.Regulations on Single-use Plastics (2022)5.Deposit Refund System (2023) <p>Goals: Reduce plastic waste by 20% by 2025. Increase recycling rates to 70% by 2030. (<i>K-Pop's Profligate CD Output Draws Fire as South Korea Hosts Plastic Waste Talks Reuters, n.d.</i>)</p>
Malaysia	<p>In 2018, Malaysia introduced a comprehensive plan to eliminate single-use plastics by 2030. The Malaysian government has set a goal to ban plastic bags in retail businesses nationwide by 2025. (<i>Malaysia Opens Anti-Dumping Duty Probe on Plastic Imports from China, Indonesia Reuters, n.d.</i>)</p>
Thailand	<p>Single-Use Plastic Restrictions: National Parks Ban: Since April 2022, Thailand has banned single-use plastics and styrofoam containers in national parks to protect wildlife. Violators can face fines up to 100,000 baht (\$3,000)(<i>Thai National Parks Ban Single-Use Plastics, n.d.</i>)</p> <p>Extended Producer Responsibility (EPR): Thailand is developing a draft EPR law to hold producers accountable for the lifecycle of plastic products, promoting recycling and waste reduction.(<i>One Step Closer to Mandatory EPR: Thailand's New Draft EPR Law - Lorax EPI, n.d.</i>)</p> <p>Ban Implementation: Thailand will prohibit the import of plastic waste starting January 1, 2025, to prevent environmental hazards and protect public health.(<i>Thailand Bans Imports of Plastic Waste from January 1, n.d.</i>)</p> <p>The ban is being implemented in phases, with a 50% reduction in imports in 2024, leading to a complete ban in 2025.(<i>Thailand to Ban Plastic Scrap Imports in 2025, Following Multiple Other Asian Countries Waste Dive, n.d.</i>)</p>

Singapore	<p>The Zero Waste Master Plan sets a new waste reduction target for Singapore - to reduce the waste sent to Semakau Landfill each day by 30 percent by 2030.</p> <p>The mandatory bag charge covers large supermarket operators and requires that they charge at least 5c per bag, effective from July 3, 2023.</p>
Sri Lanka	<p>The National Action Plan on Plastic Waste Management 2021-2030 sets out actions that Sri Lanka needs to follow based on the principle of the 3Rs.</p> <p>This policy Plastic Bag Ban (2017), prohibits the manufacture, sale, offering, and any kind of use of high density polyethylene (HDPE) bags (“lunch sheets”) within Sri Lanka. (<i>Sri Lanka National Environmental Act - Order No. 2034/35, Plastic Bag Ban - Global Plastics Policy Centre, n.d.</i>)</p>
USA	<p>Currently, the U.S. has not placed a single-use plastic ban on a federal level, but this responsibility has been taken up by states and cities.</p> <p>San Francisco was the first city to completely ban plastic bags in 2007.</p> <p>The rest of California implemented their plastic bag ban in 2014, resulting in 70% reduction in usage of plastic bags.</p> <p>New York, banned plastic in 2020.</p> <p>The Interior Department has announced that by 2032, single-use plastic products will be phased out from national parks and public lands covering 480 million acres.</p> <p>(<i>The U.S. Progress with Single-Use Plastic Bans, n.d.</i>)</p>
India	<p>India banned the manufacture, distribution, stocking, sale and use of selected 19 single-use plastic items with effect from July 1, 2022 (<i>Ban on Single-Use Plastics in India, n.d.</i>)</p> <p>According to the Plastic Waste Management (Amendment) Rules, 2021, the minimum thickness of plastic carry bags has been increased to 120 microns effective from 1st January 2023.</p>
Rwanda	<p>Anyone who disposes of plastic carry bag waste or other single-use plastics in unauthorized areas is liable to a fine of 50,000 Rwandan francs and must remove the waste and repair any damages.</p> <p>Plastic Bag Ban (2008): In 2008, Rwanda became one of the first countries to ban the manufacture, importation, use, and sale of polyethylene bags, aiming to protect the environment and promote sustainability.</p>

	<p>(<i>Rwanda Makes Strides in Plastic Ban - Global Times</i>, n.d.)</p> <p>In 2019, Rwanda passed a transformative law that began phasing out all single-use plastics.</p>
United Arab Emirates	<p>The Environment Agency-Abu Dhabi (EAD) has unveiled a strategy to eliminate SUP from the emirate by 2021. On 30 December 2023, the Dubai Executive Council issued Decision No. 124 of 2023 to regulate the usage of single-use products in the Emirate of Dubai("Decision"),prohibits the import, sale, display for the purpose of sale, or distribution for free of the single-use plastic products. (<i>United Arab Emirates: Regulations on Single-Use Products – Environmental Sustainability in Dubai - Baker McKenzie InsightPlus</i>, n.d.)</p>
Ireland	<p>In 2002, Ireland introduced a plastic bag levy at a rate of EUR 0.15 per bag, which increased to EUR 0.22 per bag from 2007. Since July 2021, the following single use plastic items can no longer be placed on the market in Ireland: Cotton bud sticks. Cutlery.(<i>Irish Government in Single-Use Plastic Ban</i>, n.d.)</p>
France	<p>The French Packaging Law, introduced in 2022, bans plastic packaging for most fruits and vegetables starting from January 1, 2022, strengthening the AGEC Law's efforts against waste. As of January 1, 2023, on-site food services must provide food and beverages in reusable containers, and plastic containers will be banned from school canteens by January 1, 2025. France aims to achieve the phase-out of single-use plastic packaging by 2040. (<i>Plastics and Packaging Laws in France CMS Expert Guide</i>, n.d.)</p>
Sweden	<p>The Government of Sweden launched a national action plan on plastics on February 21st 2022. The action plan aims for a maximum consumption of 40 plastic bags per person per year by 2025. Plastic Bag Tax (2020-2024): In May 2020, Sweden introduced a tax of 3 kronor per single-use plastic bag. (<i>Sweden Abolishes a Tax on Single-Use Plastic Bags despite Its Proven Effectiveness</i>, n.d.)</p>
Indonesia	<p>Presidential Decree No. 83/2018: This decree introduced the National Action Plan on Marine Debris, targeting a 70% reduction in marine plastic debris by 2025.(<i>Indonesia / Towards Osaka Blue Ocean Vision</i>, n.d.)</p>

	<p>Regulation of the Minister of Environment and Forestry No. P.75/2019: The regulation mandates a producer waste reduction roadmap and bans plastic straws, bags, and polystyrene packaging by 2030.(<i>EPR Business-Indonesia</i>, n.d.)</p> <p>Planned Ban on Single-Use Plastics by 2029: Indonesia's government plans to phase out single-use plastics, including styrofoam, straws, cutlery, and bags, by 2029.(<i>Indonesian Government to Phase out Single-Use Plastics by End of 2029 The Straits Times</i>, n.d.)</p>
Nepal	<p>2011 Direct: The government issued the Plastic Bag (Regulation and Reduction) Directive in 2011, aiming to control the use of plastic bags nationwide.(Khanal, 2022)</p> <p>2015 Ban: On April 1, 2015, the Ministry of Science, Technology, and Environment announced a ban on plastic bags smaller than 20 x 35 cm and thinner than 40 microns, effective from mid-April 2015.</p> <p>Reintroduction of Ban in 2021: The Ministry of Forests and Environment reintroduced the ban on plastic bags below 40 microns by publishing a notice in the Nepal Gazette on September 15, 2021.</p> <p>Supreme Court Directive in 2022: On May 2, 2022, the Supreme Court issued an injunction order to implement the regulation of plastic bags of specified size and thickness within the valley of Kathmandu.(<i>Ban and Regulate Plastic Bags, SC Tells Govt - MyRepublica - The New York Times Partner, Latest News of Nepal in English, Latest News Articles Republica</i>, n.d.)</p>

ALTERNATIVES OF PLASTIC MATERIALS

Knowing the harmful effects of plastic materials, now it is obvious to find alternatives to plastics on the environment. An alternative which will fill up peoples' needs as well as not mischievous to the environment.

JUTE: Plastic pollution is a critical global issue, particularly due to its role in marine pollution, necessitating sustainable alternatives. Researchers and scientists are actively investigating substitutes for plastics due to their severe environmental consequences, contribution to global warming, and harmful effects on marine ecosystems. Among the potential alternatives, jute stands out as an eco-friendly and sustainable choice, providing numerous environmental benefits.

Jute, a natural fiber from the *Corchorus* plant, presents a promising substitute due to its renewable, biodegradable nature, especially in Bangladesh, a leading jute producer. Bangladesh, known for its fertile land and agricultural diversity, has a long-standing tradition of cultivating jute. Currently, the country has around 80 operational jute mills spread across different regions, and 25 state-run mills are in the process of being privatized through leasing.(Masum et al., 2024). RedQ, a Swedish company producing jute carpets and decorative items in Bangladesh, focuses on the European market, particularly Sweden. To assess consumer response, 20 jute bags were distributed in Varkaus, with feedback gathered through surveys and interviews with a superstore manager and the company owner. The findings reveal that the test group preferred jute bags over plastic, recognizing jute as an eco-

friendlier and more versatile material.(Afrin, 2011). Again, Bangladesh has developed a biodegradable poly bag made from jute cellulose, offering properties similar to bio-plastic. These bags, available in both high and low density, decompose naturally within two to three months, making them both biodegradable and compostable.(Pavel & Supinit, 2017)

ADVANTAGES OF JUTE

1. Jute plants purify the air by absorbing significant amounts of carbon dioxide and releasing large quantities of oxygen, with one hectare absorbing up to 15 tons of CO₂ and emitting 11 tons of oxygen in just 100 days.
2. Jute shopping bags help eliminate single-use plastics, reducing waste and pollution, while their fibers can be endlessly recycled for sustainable use.
3. Jute is fully biodegradable, recyclable, eco-friendly, and can be cultivated in bulk without pesticides or fertilizers because of having natural UV protection, conserving land and protecting natural habitats.
4. Jute produces 98 kg of organic mass per hectare each day, exceeding other plants, and yields 1.428 cubic meters of biogas per kg, providing a significant energy resource for rural communities.(Zakaria Ahmed, 2022).
5. The production of jute requires less energy than plastic, making it a more ecofriendly manufacturing option.
6. Unlike plastic, jute does not release harmful chemicals into the environment, ensuring it does not pose a risk to human health or wildlife.
7. Jute cultivation has minimal environmental impact, preserving natural habitats and preventing land degradation.

COMPARISION BETWEEN PLASTIC BAGS AND JUTE BAGS:

Table 5 Comparison between plastic bags and jute bags

Aspect	Plastic Bags	Jute bags
Environmental Impact	Non-biodegradable, contributes to pollution, can take up to 1000 years to decompose completely.	Biodegradable in a matter of weeks, eco-friendly
Production	Made from petroleum-based products, energy-intensive.	Made from renewable plant resources, low-energy production.
Durability	Can tear easily, single-use	Strong, durable, reusable
Carbon Footprint	High, due to petroleum extraction and processing	Low, absorbs CO ₂ during growth
Reusability	Used once and discarded, low recycling rates	Can be reused many times
Health and Safety	Can release harmful chemicals, hazardous to wildlife	Non-toxic, safe for humans and wildlife
Cost	Cheap to produce, but environmental cost is high	More expensive to produce, but cost-effective long-term
End of Life	Ends up in landfills or oceans, takes centuries to decompose	Fully biodegradable, does not pollute.

Jute as an alternative of plastic materials is even more serviceable for Bangladesh as it is one of the major jutes producing country.

Table 6 Production of jute in major jute producing countries including Bangladesh.

Year	Bangladesh	China	India	Myanmar	Nepal	Thailand
2017-18	715.33	11.50	746.68	1.26	8.01	0.57
2016-17	696.05	12.22	754	1.28	8.01	0.5
2015-16	664.89	13.44	742	1.29	8.64	0.6
2014-15	656.80	14.42	818	1.67	11.35	0.74
2013-14	665.74	17.10	837	1.02	1130	1.0
2012-13	680	193	901	3.5	10.6	1.3
2011-12	620.2	19.3	905	8.2	10.6	1.4
2010-11	587	18.8	900	12.6	13.1	1.4
2009-10	485.8	24	773.7	9.6	11.7	1.3
2008-09	408.1	26.2	785.6	14.3	11.6	1.4
2007-08	500	33	952	20.4	11.7	1.2
2006-07	533.4	31	931	46.5	12	2.3
2005-06	466	31.1	931	41	12.2	3.1
2004-05	418	32	916	35.4	11.8	16.6
2003-04	499.8	41	1000	44.1	11.9	20.4
2002-03	436.2	56	1025	58.7	11.7	27.2
2001-02	519.6	52	986	53.5	11.3	192
2000-01	448	50	873	31	14.5	19.2

The table illustrates the jute production areas (in thousand hectares) of major jute-producing countries from 2000-01 to 2017-18. It highlights Bangladesh and India as the largest contributors, with significant variations in cultivation areas over the years. Smaller contributors include China, Myanmar, Nepal, and Thailand, with their jute production areas remaining relatively stable or declining compared to the two leading nations. (Akter et al., 2020). (Akter et al., 2020). Bangladesh, the world's second-largest producer of jute, had an estimated annual production of 1.6 million tons in 2019 (FAO). Currently, about 220-245 private jute mills operate in the country, alongside 25 public jute mills transitioning to private sector leases. Between 2022-23 (up to July 2022), jute goods production reached 384.1 lakh tonnes, compared to 1,080 lakh tonnes in 2021-22. As of 2021, Bangladesh holds the position of the second-largest producer of jute, accounting for 42 percent of total worldwide production, and leading in jute exports. (*Jute Industry of Bangladesh - Wikipedia*, n.d.). Meanwhile, Indian jute exports have seen consistent growth, increasing at a CAGR of 9% between 2015-16 and 2020-21.

Table 7 Bangladesh Exports of Jute & Jute goods (US\$ million) Source: EPB DATA

Products	2016-17	2017-18	2018-19	2019-20	2020-21	2021-22
Jute & Jute goods	962.42	1025.55	816.27	882.35	1161.48	1127.63
Raw Jute (5303)	167.84	155.68	112.48	129.89	138.15	216.18
Jute Yarn & Twine (5307)	607.88	647.72	512.42	564.26	799.04	697.80
Jute Sacks & Bags (630510)	127.53	122.82	82.86	106.54	138.66	119.23
Others	59.17	99.33	108.51	81.66	85.63	94.42

The chart above highlights the steady dominance of jute yarn and twine in Bangladesh's jute exports, with significant contributions from raw jute and other jute products over the years. (JUTE AND JUTE PRODUCTS - EPB Market Intelligence Portal, n.d.)

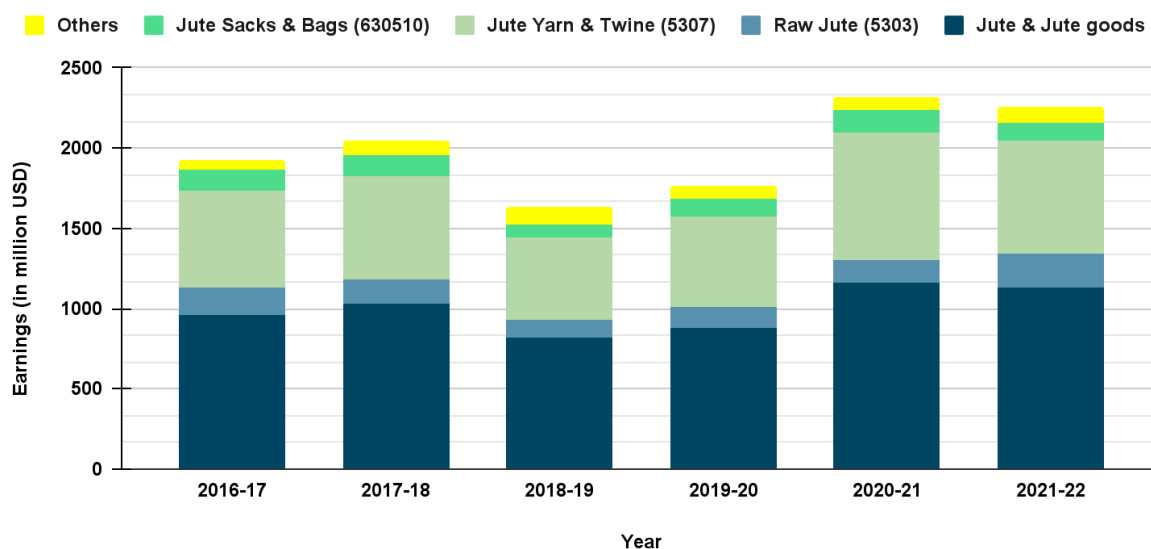


Figure 10 Export of jute and jute products by category (2016-22) (Source: Data table made by Author's)

Here is a stacked bar chart displaying the export earnings of various jute and jute products from 2016-17 to 2021-22. Each segment of the bar represents a specific category, allowing for an easy comparison of trends over the years.

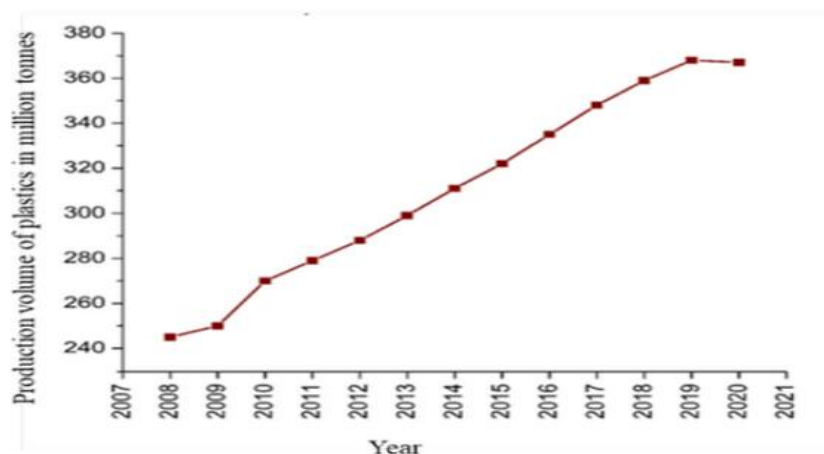


Figure 11 Global Plastics Production (Source: Statista, 2020)

Global plastic production saw a significant rise of 36% between 2010 and 2020. (Jarin & Hossain, n.d.). The data from both charts reveals that jute products have a significantly higher export value than plastic goods. This highlights the stronger international demand for jute items.

So, to conclude, Jute presents a promising alternative to plastic due to its biodegradability, sustainability, and low environmental impact. As a natural fiber, jute can reduce plastic pollution, particularly in packaging and textiles. Its growing demand aligns with global efforts to promote eco-friendly solutions and combat plastic waste.

BIOPLASTICS: Bio-plastic is one of the alternatives nowadays stakeholders are thinking about. Plastic is a type of material usually produced by Petroleum or using other natural gasses but these are not renewable products, hence production of plastic material impacting environment as well as creating a scarcity of energy source such as petroleum, natural gasses etc. On the contrary bioplastic types of material are produced by sources like plant oil, cornstarch, cellulose, potato starch etc. Moreover, these sources are renewable and easy to access.

CLASSIFICATION OF BIOPLASTIC

1. CELLULOSE: Main source of cellulose is generally wood. It is segregated from wood or trees and then heated in a digester. (*Cellulose-Based Plastics Address Need for More Sustainable Raw Materials from Food, Healthcare, Coatings and Construction*, n.d.). Thermoplastic starch, an application of cellulose, is widely used in bioplastic which is almost 50% (*What Is PLA? (Everything You Need To Know) - TWI*, n.d.). The pharmaceutical industry, some of the electronic products depend a lot on cellulose. Thus, bioplastic made from cellulose is producing a remarkable result as an alternative to plastic materials.

2. POLY LACTIC ACID (PLA): Poly Lactic Acid is a type of thermoplastic monomer. Sources of PLA are sugarcane, corn starch. It is the second most produced bioplastic. (Www et al., 2008). Materials that are produced by PLA are resins of computers, mobile phones, foil, medical implants, tins, molds, bottles etc. It produces the lowest amount of carbon-di-oxide than any other sources of bioplastic. Also, it requires less amount of ingredients compared to other bioplastic sources in the production of some specific material.

3. POLY HYDROXYBUTYRATE (PHB): PHB is another source of bioplastic which is producing materials like bank notes, car parts, ropes etc. In some case's PHB is different than other source of bioplastic since it has some extra qualities such as water insolubility, resistant to hydraulic degradation, resistance to ultraviolet lights. (Reddy et al., 2003)

4. STARCH: Starch is a polymer of cellulose which can be converted into poly lactic acid (PLA). Due to its cheapness, manufacturers value it often. Carbohydrate rich plants such as corn, potato contain huge amounts of starch thus a proper source of bioplastic (Reddy et al., 2003). Materials like straw, food packaging products, pharmaceutical industry, retail bags, plasticizers etc. can be produced from starch.

There are some more sources of bioplastic which are fossil based and biodegradable.

ADVANTAGES OF BIOPLASTICS: The prime advantage of bioplastic is that it is somewhat reducing the usage of plastics. Working as the alternative of plastic material. In 2022, amount of global production capacity was 2.2 million metric tonnes and it is expected to be 7.4 million metric tons within 2028(*Global Bioplastics Industry - Statistics & Facts | Statista*, n.d.). Except being an alternative there are more few advantages of bioplastics.

1. The environment-friendly bioplastic produces less amount of Greenhouse gases (GHG) such as carbon dioxide compared to normal plastic material(Www et al., 2008). Estimation predicting that bioplastic could reduce carbon dioxide emissions about 30%.
 2. The availability of these bioplastics is quite easy.
 3. As bioplastics are made by some renewable sources and reducing some shorts of plastic material production, nonrenewable sources such as petroleum oil, natural gases are saving highly.
 4. New entrepreneurs are coming up with the production of bioplastic material. These have created an impact in the world's economy.
 5. Required less amount of time to mixed up in the environment or soil comparing to plastics
 6. No hazard ness is there for recycling this biodegradable plastic
 7. Less harmful chemicals or additives are used in the manufacturing process of bioplastic.
- Despite having lots of advantages it also has some disadvantages as well. It cannot be recycled with other plastic materials, again it could produce toxins such as carbon-di-oxide, methanes in case of improper disposal.(Www et al., 2008)

COMPARISION BETWEEN PLASTIC AND BIOPLASTICS

Table 8 Comparision between plastic and bioplastic

Properties	Bioplastic	Regular plastic
Source	Renewable source	Nonrenewable source
Environmental behaviour	Biodegradable	Non-biodegradable, can be made biodegradable by some extra manufacturing work.
Time taken for decomposition	Less time are required since biodegradable plastics	Require huge time in some cases it crossed to thousand years to decompose
Harmful additives mixture	Less amount of chemical additive mixes in the manufacturing process	Amount of chemical additives are high as a result presence of harmful additives probability increases
Strength and Durability	Relatively have less strength and less durable	Higher strength and durability.
Circularity	Less circulate in economy, rarely used twice and then went to disposal system	More circulation in the economy loop, re-used a few times though it lost its functionality a little bit after reused.
Greenhouse gas emission	Very low	Emit considerable greenhouse gas
Use of fossil fuel gas	low	Comparatively high uses
Recycling	Less recycled	More recycled nowadays
Cost	In few cases cost is higher since no balanced production system is there,	Production Cost is balanced based on the plastic item.

though by the time the cost will decrease, in some cases cost is already low

The data table below refers to the volume of bioplastic fibers that has been produced by manufacturers in the world from 2014-2023. (*Bioplastics: Fibers Production Capacity 2023 | Statista, n.d.*)

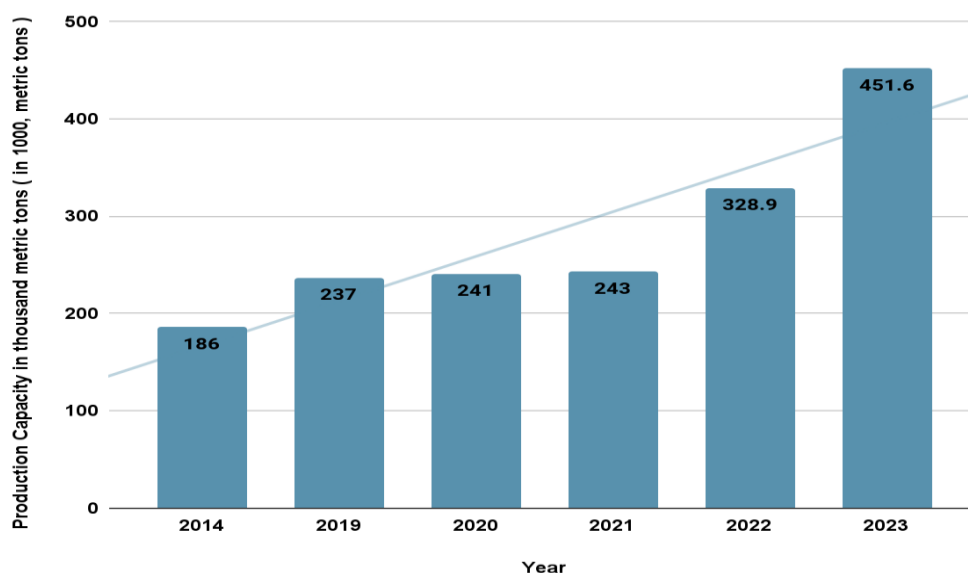


Figure 12 Volume of bioplastic fibers manufactured in the world (2014-2023) (Source: Data table made by author's)

Production capacity of bioplastic for consumers goods is also increasing even though it has decreased a little in 2023 comparing to the previous year, as in 2022 maximum bioplastic was produces for consumer goods

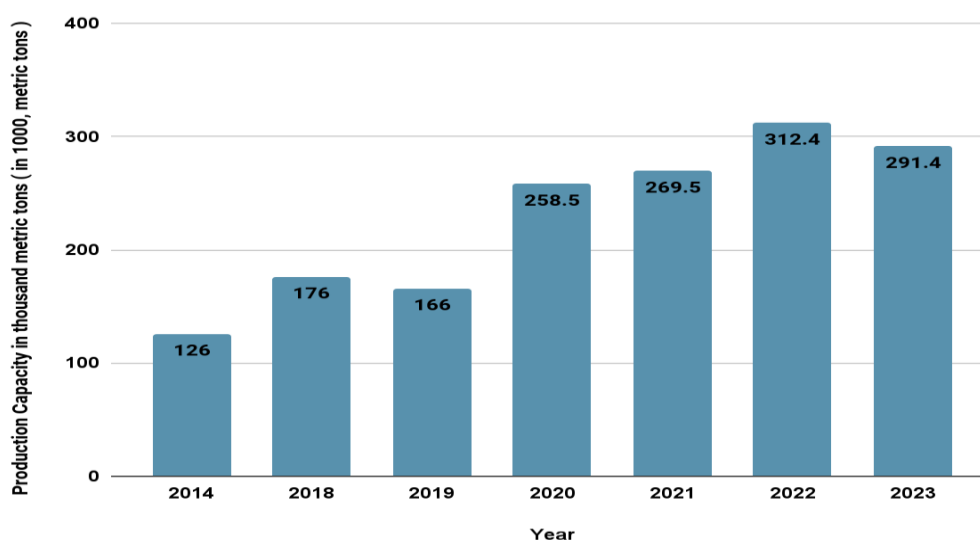


Figure 13 Production capacity of bioplastic in the world. (*Bioplastics: Consumer Goods Worldwide Production Capacity 2023 | Statista, n.d.*)

The production capacity of bioplastic in the world, in 2022 was increased to 1.8 million metric tons and it is expected to be about 7.4 million within 2028, The below chart shows the overall production capacity of bioplastic forecasting for 2023 to 2028. (*Global Bioplastic Production Capacity by Segment 2023 | Statista, n.d.*)

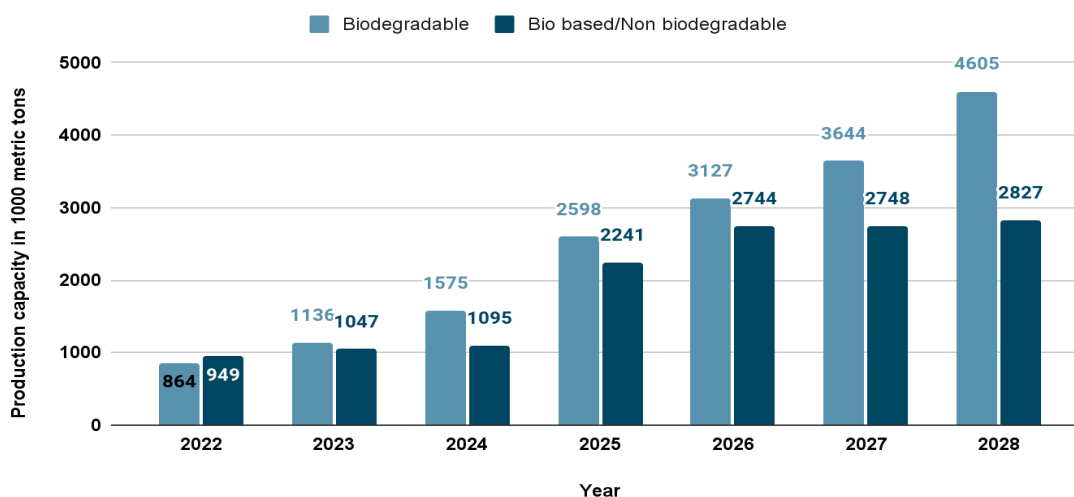


Figure 14 Individual production capacities of Bioplastic (Biodegradable and Non biodegradable)
 (Source: Data table made by Author's)

In spite of being a valuable production house of environment friendly plastic, bioplastic cannot substitute regular plastics 100%, since in many fields we need oil-based plastic material as its workability is already proven. Besides less recycling capability, low strength and durability it will take time to prove its capacity. Hence lots of research is going, on bioplastic and to make it an alternative of non-ecofriendly plastic material

OUR SUGGESTED POLICIES

Plastic has numerous harmful effects on the environment, from polluting our waterways to endangering marine life. It's an issue we can no longer overlook, and immediate steps must be taken to reduce our dependence on plastic. Simple adjustments to daily habits, like using reusable bags and water bottles, can make a difference. With combined efforts, even small actions can lead to meaningful change. Research shows that Bangladesh faces a serious threat from plastic pollution, which will worsen without urgent intervention. Unfortunately, there is still insufficient data on the amount of plastic waste produced, its disposal, and its impact on the country's environment. Although, the country has taken some measures to tackle the issue, the expected reduction in plastic usage and pollution has not been achieved. Therefore, it is recommended to implement the following steps to address this global challenge in a sustainable manner:

- Raising public awareness about the harmful effects of plastic use through media campaigns and initiatives by government and non-government organizations, encouraging reduced reliance on plastic.
- Motivating people to properly dispose of plastic waste, particularly in areas with reward-based collection systems.
- Strengthening collaboration between academic institutions and research centers to evaluate the environmental impact of plastic waste.
- Promoting research and funding for the development of cost-effective biodegradable polymers and eco-friendly packaging materials.
- Offering financial support, such as low-interest loans, tax benefits, and duty-free machinery imports, to businesses focused on producing biodegradable plastic alternatives.
- Utilizing the country's abundant jute production to create affordable eco-friendly alternatives, supported by incentives for manufacturers.
- Imposing high taxes on plastic industries, from raw material imports to product sales, to discourage plastic use by raising costs.
- Exploring sustainable alternatives in plastic manufacturing and recycling to address unemployment and promote green industries.
- Conducting further research to identify the most cost-efficient ways to produce and market jute-based products.
- Ensuring a steady supply of jute products to encourage consumers to adopt them as viable plastic substitutes.
- The government should encourage NGOs focused on humanitarian and environmental efforts to advocate for the donation of reusable plastic items.

- Involve and collaborate with key stakeholders, including retailers, consumers, industries, local authorities, manufacturers, community organizations, educational institutions, waste collectors, environmental advocates, and tourism groups, to secure widespread support.
- Evaluate the possible social, economic, and environmental consequences of the proposed measures. Consider questions like "How will this affect low-income groups?" and "What impact will these actions have on various industries and sectors?" to ensure a balanced approach.
- Focus on addressing the most harmful single-use plastics and analyze the root causes, scale, and effects of their improper disposal.
- Plastic pollution is a global issue requiring collective action and international collaboration. Developed nations should support developing countries by sharing expertise, technologies, and policies to enhance plastic waste management and promote sustainable practices.
- Avoid purchasing bottled water, as nearly 20 billion plastic bottles are discarded annually. Opt for a reusable bottle to reduce waste, save money, and potentially choose a healthier tap water option. (*Plastic Pollution Solutions - 10 Ways to Reduce Plastic Pollution*, n.d.)
- New recycling technologies are being developed that can turn plastic waste into new products. This helps to reduce the amount of plastic that ends up in landfills and oceans.
- Incorporating plastic waste (PW) in construction materials can reduce reliance on natural resources and lower costs. However, using too much PW as an aggregate can weaken the material, with a 10–15% replacement ratio being optimal for maintaining strength.
- Liquefying plastic waste (PW) offers a feasible alternative to pyrolysis, as it requires less intense processing conditions. So, the government should look into it. This method helps address the issue of excess PW more efficiently.
- Avoid products with microbeads, as they can pass through water treatment plants and harm marine life. Choose natural exfoliants like oatmeal or salt instead, and be cautious with cosmetics, as many contain microplastics.
- Implement take-back programs where consumers can return used plastic products for proper recycling or reprocessing.
- Consider natural alternatives to plastic products. For example, use a loofah instead of a plastic bath sponge or beeswax wraps instead of plastic wrap. (*How To Reduce Plastic Waste: Effective Management Strategies*, n.d.)
- Mycelium, the root system of mushrooms, can be shaped into strong, lightweight, and compostable packaging, potentially replacing plastic foam and packing peanuts. Bamboo, known for its durability and biodegradability, is also an excellent option for sustainable single-use alternatives. (*How To Reduce Plastic Waste: Effective Management Strategies*, n.d.)
- Using plastic waste in road construction is a remarkable initiative already adopted by many countries.

Table 9 Action plan for sustainable plastic management:

Action	Key Strategy/Action Details
Incentives for Alternatives	Provide national and local tax rebates, funds, and subsidies to support the development of alternative materials to plastics.
Charges for Plastics	Implement charges on plastics that have viable alternatives in stores and supermarkets.
Labeling Hazardous Materials	Set standards and policies for labeling hazardous plastic materials.
Labeling Biodegradable Materials	Establish standards and policies for labeling biodegradable materials.
Public-Private Partnerships	Develop partnerships to share technologies for minimizing plastics in products and packaging.
Access to Safe Drinking Water	Introduce infrastructure to provide access to safe drinking water in public spaces.
Waste Separation Bins	Set up bins for organic, inorganic, toxic, hazardous, biomedical, and multilayer plastic waste.
Tracking Recycling Targets	Track plastic recycling targets across the entire value chain, including recycling facilities.
3Rs Awareness Programs	Initiate national awareness programs on Reduce, Reuse, and Recycle (3Rs) and develop educational curriculum for schools and colleges.

Public-Private Partnerships	Develop partnerships to share technologies for minimizing plastics in products and packaging.
Environmental Certification	Launch certification programs for manufacturers adopting environmentally friendly practices.
Waste Diversion Targets	Set targets to divert waste from landfills through composting, recycling, and incineration.
Extended Producer Responsibility (EPR)	Ensure environmentally sound management of SUPs and other plastics through EPR.
Waste Exchange Marketplace	Create a marketplace for exchanging waste materials.
Plastic Labeling Standards	Standardize plastic product labeling to facilitate identification in the waste stream for recycling.
Reusable, Recyclable, or Compostable Packaging	Require all packaging to be reusable, recyclable, or compostable by a set deadline.
Phaseout of Problematic Packaging	Support industry-led initiatives to phase out problematic packaging materials.
Policy on Hazardous Additives	Implement policies to eliminate hazardous additives from plastic products and packaging.
Sustainable Packaging Incentives	Set incentives for brand owners, manufacturers, and importers to follow sustainable packaging guidelines.
Behavior Change Toolkits	Develop toolkits to overcome barriers to adopting plastic alternatives.
Monitoring and Revision of Targets	Revise action plan targets based on regular monitoring.
Buyback or Deposit Refund Scheme	Introduce buyback or deposit refund systems to encourage plastic recycling.
Formalized Recycling Capacity	Formalize and expand sorting and recycling capacities.
Research into Plastic Alternatives	Support research into alternatives to plastics, starting with low-density polyethylene (LDPE).
SUP Ban Strategy	Develop a strategy to ban SUP items with product chains, instruments, and timelines.
Guidelines to Minimize Packaging	Draft guidelines to reduce plastic packaging.
Consumer Campaigns	Launch campaigns to encourage reducing, reusing, and recycling plastic.
Collaboration for Policy Implementation	Collaborate with various agencies to implement policies, including Solid Waste Management Rules (SWR).
Monitoring System for Action Plan	Establish a system to monitor progress on action plan targets from a baseline.
Anti-Litter Regulations	Draft regulations to reduce plastic littering.
Pilot EPR System	Pilot EPR initiatives to enable industry co-funding for plastic waste collection and recycling.
Producer Responsibility Organizations	Establish organizations to manage producer responsibility for plastic waste.
Circular Economy Strategy	Expand the 3Rs strategy to include a circular economy by incorporating recycled content in construction, textiles, and packaging.
Plastic Material Flow Maps	Develop national maps to track plastic material flows and improve governmental capacity for circular material management.

CONCLUSION

Plastic pollution is now a headache for the world. Due to its simple manufacturing process, its production rate is increasing day by day. In addition, due to its easy availability, the use of plastic is also increasing proportionally. Moreover, the dependency on plastic products among people is also

increasing. In the last few decades there were so many objects which used to be made of wood, steel but in this decade these objects are made of plastic which has higher strength and durability similar to wood, steel etc. These plastic materials take a huge long time to decompose thus keeping harming the environment. If the consumption of plastic continues, we can assume what the future world will face seeing how plastic pollution is affecting us in today's world. Consequently, we understand how important it is to mitigate plastic.

In this review work, we have focused on the plastic pollution, how this pollution is affecting our environmental formities like soil, water, air and living beings also. The way this pollution is going, it expresses horrible scenarios in front of us. In case of Bangladesh, the overall view is even more risky. Bangladesh is in a very extreme situation in respect of its waste management system let alone plastic waste management. We have tried to review the current plastic states of Bangladesh and focus on how necessary it is to have proper waste management along with plastic waste. We review a few countries whom are doing exceptionally well with proper plastic waste management and in its recycling system hoping that Bangladesh will also introduce its proper plastic waste management by being inspired of these countries. We reviewed the policies of many countries about their plastic waste management, what laws the countries are following, and their actions on plastic waste. With respect to this we have suggested some policies that the Bangladesh government may follow to improve the current plastic pollution circumstances. This paper also has found several alternatives of plastic material, how the alternatives are being used replacing regular used plastic, comparison of alternatives of plastic versus regular used plastic.

We believe that this review paper will help its readers to have a better understanding over the importance of breaking down the plastic chain and inspire the other researchers to work on reducing plastic pollution, invention of alternatives of plastic material. We are hopeful that the policy makers of Bangladesh will make such policies that can extenuate the plastic pollution as well as increase people's awareness on plastic pollution.

REFERENCES

- 4 Countries Leading the Way in Reducing Plastic Waste - Bevi. (n.d.). Retrieved December 30, 2024, from <https://bevi.co/blog/4-countries-leading-the-way-in-reducing-plastic-waste/>
- '45.55 billion plastic bags used daily' | *The Daily Star*. (2023, June 4). <https://www.thedailystar.net/news/bangladesh/news/4555-billion-plastic-bags-used-daily-3337086>
- Accelerating reuse models to achieve a world free of plastic waste | *World Economic Forum*. (n.d.). Retrieved December 29, 2024, from <https://www.weforum.org/impact/accelerating-reuse-models-world-free-of-plastic-waste/>
- Afrin, T. (2011). *SUBSTITUTION OF PLASTIC BAG BY JUTE BAG- CASE COMPANY REDQ: Support on Sustainable Environment*. <http://www.theseus.fi/handle/10024/34170>
- Air Pollutant - an overview* | *ScienceDirect Topics*. (n.d.). Retrieved December 29, 2024, from <https://www.sciencedirect.com/topics/earth-and-planetary-sciences/air-pollutant>
- Akter, S., Sadekin, M. N., & Islam, N. (2020). Jute and Jute Products of Bangladesh: Contributions and Challenges. *Asian Business Review*, 10(3), 143–xxx. <https://doi.org/10.18034/abr.v10i3.480>
- Alimi, O. S., Farnar Budariz, J., Hernandez, L. M., & Tufenkji, N. (2018). Microplastics and Nanoplastics in Aquatic Environments: Aggregation, Deposition, and Enhanced Contaminant Transport. *Environmental Science & Technology*, 52(4), 1704–1724. <https://doi.org/10.1021/acs.est.7b05559>
- Angnunavuri, P. N., Attiogbe, F., & Mensah, B. (2023). Particulate plastics in drinking water and potential human health effects: Current knowledge for management of freshwater plastic materials in Africa. *Environmental Pollution*, 316, 120714. <https://doi.org/10.1016/j.envpol.2022.120714>

- Anunobi, T. J. (2022). Hazardous effects of plastic wastes on land biodiversity: A review. *Zoologist (The)*, 20(1), 80–86. <https://doi.org/10.4314/tzool.v20i1.10>
- APAC: plastic waste produced by country 2024 | Statista. (n.d.). Retrieved December 30, 2024, from <https://www.statista.com/statistics/1465038/apac-plastic-waste-volume-produced-by-country/>
- Atmospheric Aerosol - an overview | ScienceDirect Topics. (n.d.). Retrieved December 29, 2024, from <https://www.sciencedirect.com/topics/chemical-engineering/atmospheric-aerosol>
- Ban and regulate plastic bags, SC tells govt - myRepublica - The New York Times Partner, Latest news of Nepal in English, Latest News Articles | Republica. (n.d.). Retrieved December 30, 2024, from <https://myrepublica.nagariknetwork.com/news/ban-and-regulate-plastic-bags-sc-tells-govt>
- Ban on Single-Use Plastics in India. (n.d.). Retrieved December 30, 2024, from <https://www.cseindia.org/ban-on-single-use-plastics-in-india-11834>
- Bangladesh's new government implements strong measures to eliminate single-use plastic. (n.d.). Retrieved December 30, 2024, from <https://news.mongabay.com/2024/10/bangladeshs-new-government-implements-strong-measures-to-eliminate-single-use-plastic/>
- Barnes, D. K. A., Galgani, F., Thompson, R. C., & Barlaz, M. (2009). Accumulation and fragmentation of plastic debris in global environments. *Philosophical Transactions of the Royal Society B: Biological Sciences*, 364(1526), 1985–1998. <https://doi.org/10.1098/rstb.2008.0205>
- Bioplastics: consumer goods worldwide production capacity 2023 | Statista. (n.d.). Retrieved December 30, 2024, from <https://www.statista.com/statistics/1277064/production-capacity-of-bioplastics-worldwide-for-consumer-goods/>
- Bioplastics: fibers production capacity 2023 | Statista. (n.d.). Retrieved December 30, 2024, from <https://www.statista.com/statistics/1277077/production-capacity-of-bioplastics-worldwide-for-textiles/>
- Biassoulis, D., Babou, E., Hiskakis, M., Scarascia, G., Picuno, P., Guarde, D., & Dejean, C. (2013). Review, mapping and analysis of the agricultural plastic waste generation and consolidation in Europe. *Waste Management & Research: The Journal for a Sustainable Circular Economy*, 31(12), 1262–1278. <https://doi.org/10.1177/0734242X13507968>
- Campanale, C., Massarelli, C., Savino, I., Locaputo, V., & Uricchio, V. F. (2020). A Detailed Review Study on Potential Effects of Microplastics and Additives of Concern on Human Health. *International Journal of Environmental Research and Public Health*, 17(4), 1212. <https://doi.org/10.3390/ijerph17041212>
- Cellulose-based plastics address need for more sustainable raw materials from food, healthcare, coatings and construction. (n.d.). Retrieved December 30, 2024, from <https://www.plastemart.com/plastic-technical-articles/cellulose-based-plastics-address-need-for-more-sustainable-raw-materials-from-food-healthcare-coatings-and-construction/2356>
- Chae, Y., & An, Y.-J. (2018). Current research trends on plastic pollution and ecological impacts on the soil ecosystem: A review. *Environmental Pollution*, 240, 387–395. <https://doi.org/10.1016/j.envpol.2018.05.008>
- Chan kim and Renee Mauborgne. (n.d.). *Chan Kim & Renee Mauborgne: Authors of Blue Ocean Strategy, Beyond Disruption & Blue Ocean Shift*. Retrieved December 30, 2024, from <https://www.blueoceanstrategy.com/authors/>

- Chandegara, V., Nandasana, J. N., & Kumpavat, M. T. (2015). *Plastic Packaging Waste Impact on Climate Change and its Mitigation*. <https://www.researchgate.net/publication/284726839>
- China uses artificial intelligence to sort its waste | News | Eco-Business | Asia Pacific. (n.d.). Retrieved December 30, 2024, from <https://www.eco-business.com/news/china-uses-artificial-intelligence-to-sort-its-waste/>
- China: value of recycled plastic 2023 | Statista. (n.d.). Retrieved December 30, 2024, from <https://www.statista.com/statistics/1535004/china-value-of-recycled-plastic/>
- China: volume of recycled plastic 2023 | Statista. (n.d.). Retrieved December 30, 2024, from <https://www.statista.com/statistics/1500332/china-volume-of-recycled-plastic/>
- Chowdhury, G. W., Koldewey, H. J., Duncan, E., Napper, I. E., Niloy, Md. N. H., Nelms, S. E., Sarker, S., Bhola, S., & Nishat, B. (2021). Plastic pollution in aquatic systems in Bangladesh: A review of current knowledge. *Science of The Total Environment*, 761, 143285. <https://doi.org/10.1016/j.scitotenv.2020.143285>
- COMPREHENSIVE PRIVATE SECTOR ASSESSMENT. (2019). www.inspira-bd.com
- Cózar, A., Echevarría, F., González-Gordillo, J. I., Irigoien, X., Úbeda, B., Hernández-León, S., Palma, Á. T., Navarro, S., García-de-Lomas, J., Ruiz, A., Fernández-de-Puelles, M. L., & Duarte, C. M. (2014). Plastic debris in the open ocean. *Proceedings of the National Academy of Sciences*, 111(28), 10239–10244. <https://doi.org/10.1073/pnas.1314705111>
- Danopoulos, E., Twiddy, M., West, R., & Rotchell, J. M. (2022). A rapid review and meta-regression analyses of the toxicological impacts of microplastic exposure in human cells. *Journal of Hazardous Materials*, 427, 127861. <https://doi.org/10.1016/j.jhazmat.2021.127861>
- Davani, A. E. (2018). *Impacts of increased plastic recycling in Sweden A quantitative study of the environmental, social and economic impacts of increased plastic recycling in Sweden*.
- de Souza Machado, A. A., Lau, C. W., Till, J., Kloas, W., Lehmann, A., Becker, R., & Rillig, M. C. (2018a). Impacts of Microplastics on the Soil Biophysical Environment. *Environmental Science & Technology*, 52(17), 9656–9665. <https://doi.org/10.1021/acs.est.8b02212>
- de Souza Machado, A. A., Lau, C. W., Till, J., Kloas, W., Lehmann, A., Becker, R., & Rillig, M. C. (2018b). Impacts of Microplastics on the Soil Biophysical Environment. *Environmental Science & Technology*, 52(17), 9656–9665. <https://doi.org/10.1021/acs.est.8b02212>
- EPR | Business-Indonesia. (n.d.). Retrieved December 30, 2024, from https://business-indonesia.org/waste_management
- First country to ban single-use plastic bags | Guinness World Records. (n.d.). Retrieved December 29, 2024, from <https://www.guinnessworldrecords.com/world-records/636873-first-country-to-ban-single-use-plastic-bags>
- Gao, H., Liu, Q., Yan, C., Mancl, K., Gong, D., He, J., & Mei, X. (2022). Macro-and/or microplastics as an emerging threat effect crop growth and soil health. *Resources, Conservation and Recycling*, 186, 106549. <https://doi.org/10.1016/j.resconrec.2022.106549>
- Germany unveils plastic reduction plan – DW – 11/26/2018. (2018, November 26). <https://www.dw.com/en/germany-unveils-5-point-plan-to-reduce-plastic-waste/a-46455503>

- Global bioplastic production capacity by segment 2023* | Statista. (n.d.). Retrieved December 30, 2024, from <https://www.statista.com/statistics/678908/production-capacity-of-bioplastics-worldwide-by-market-segment/>
- Global bioplastics industry - statistics & facts* | Statista. (n.d.). Retrieved December 30, 2024, from <https://www.statista.com/topics/8744/bioplastics-industry-worldwide/>
- Global plastic production share by region 2023* | Statista. (n.d.). Retrieved December 29, 2024, from <https://www.statista.com/statistics/281126/global-plastics-production-share-of-various-countries-and-regions/>
- Global plastics production forecast 2025-2050* | Statista. (n.d.). Retrieved December 29, 2024, from <https://www.statista.com/statistics/664906/plastics-production-volume-forecast-worldwide/>
- Graf, M., Greenfield, L. M., Reay, M. K., Bargiela, R., Williams, G. B., Onyije, C., Lloyd, C. E. M., Bull, I. D., Evershed, R. P., Golyshin, P. N., Chadwick, D. R., & Jones, D. L. (2023). Increasing concentration of pure micro- and macro-LDPE and PP plastic negatively affect crop biomass, nutrient cycling, and microbial biomass. *Journal of Hazardous Materials*, 458, 131932. <https://doi.org/10.1016/j.jhazmat.2023.131932>
- Guo, J.-J., Huang, X.-P., Xiang, L., Wang, Y.-Z., Li, Y.-W., Li, H., Cai, Q.-Y., Mo, C.-H., & Wong, M.-H. (2020). Source, migration and toxicology of microplastics in soil. *Environment International*, 137, 105263. <https://doi.org/10.1016/j.envint.2019.105263>
- Hassan, H. J. A., Rasul, J., & Samin, M. (2021). Effects of Plastic Waste Materials on Geotechnical Properties of Clayey Soil. *Transportation Infrastructure Geotechnology*, 8(3), 390–413. <https://doi.org/10.1007/s40515-020-00145-4>
- He, P., Chen, L., Shao, L., Zhang, H., & Lü, F. (2019). Municipal solid waste (MSW) landfill: A source of microplastics? -Evidence of microplastics in landfill leachate. *Water Research*, 159, 38–45. <https://doi.org/10.1016/j.watres.2019.04.060>
- Hossain, M. A., Mahiuddin, S., Ahmad, A. U., & Monzurul Mamun, A. H. M. (2022). *Causes and Effects of Water Logging in Dhaka City* (pp. 153–171). https://doi.org/10.1007/978-981-16-6966-8_8
- Hossain, S., Rahman, M. A., Chowdhury, M. A., & Mohonta, S. K. (2021). Plastic pollution in Bangladesh: A review on current status emphasizing the impacts on environment and public health. In *Environmental Engineering Research* (Vol. 26, Issue 6). Korean Society of Environmental Engineers. <https://doi.org/10.4491/eer.2020.535>
- How long it takes everyday items to decompose – The Waste Management & Recycling Blog*. (n.d.). Retrieved December 29, 2024, from <https://www.forgerecycling.co.uk/blog/how-long-it-takes-everyday-items-to-decompose/>
- How To Reduce Plastic Waste: Effective Management Strategies*. (n.d.). Retrieved December 30, 2024, from <https://www.actenviro.com/plastic-waste/>
- Iftexhar Mahmud. (2018, June). *Bangladesh pours fifth largest chunk of plastic into sea* | Prothom Alo. <https://en.prothomalo.com/environment/73-thousand-tonnes-of-plastic-waste-enters-the-sea>
- Indonesia / Towards Osaka Blue Ocean Vision*. (n.d.). Retrieved December 30, 2024, from <https://g20mpl.org/partners/indonesia>
- Indonesian government to phase out single-use plastics by end of 2029* | The Straits Times. (n.d.). Retrieved December 30, 2024, from <https://www.straitstimes.com/asia/se-asia/indonesian-government-to-phase-out-single-use-plastics-by-2029>

- Irish government in single-use plastic ban.* (n.d.). Retrieved December 30, 2024, from <https://www.bbc.com/news/world-europe-46750843>
- Islam, M. R., Ruponti, S. A., Rakib, M. A., Nguyen, H. Q., & Mourshed, M. (2023). Current scenario and challenges of plastic pollution in Bangladesh: a focus on farmlands and terrestrial ecosystems. In *Frontiers of Environmental Science and Engineering* (Vol. 17, Issue 6). Higher Education Press Limited Company. <https://doi.org/10.1007/s11783-023-1666-4>
- Jarin, T. T., & Hossain, I. (n.d.). *POTENTIAL SUBSTITUTION OF PLASTICS BY JUTE PRODUCTS: A REVIEW*. <https://www.researchgate.net/publication/374546094>
- Joos, L., & De Tender, C. (2022). Soil under stress: The importance of soil life and how it is influenced by (micro)plastic pollution. *Computational and Structural Biotechnology Journal*, 20, 1554–1566. <https://doi.org/10.1016/j.csbj.2022.03.041>
- JUTE AND JUTE PRODUCTS - EPB Market Intelligence Portal.* (n.d.). Retrieved December 30, 2024, from https://epb-bangladesh-export.com/portfolio_page/jute-and-jute-products/
- Jute industry of Bangladesh - Wikipedia.* (n.d.). Retrieved December 30, 2024, from https://en.wikipedia.org/wiki/Jute_industry_of_Bangladesh
- Khanal, A. (2022). Survey on usage of single use plastic bags in Nepal. *IOP Conference Series: Earth and Environmental Science*, 1057(1), 012008. <https://doi.org/10.1088/1755-1315/1057/1/012008>
- Khatun Syed Yusuf Saadat Afrin Mahbub, F. (n.d.). *PLASTIC POLLUTION IN BANGLADESH - DRIVERS, IMPACTS, AND SOLUTIONS*. www.cpd.org.bd
- Kibria, Md. G., Masuk, N. I., Safayet, R., Nguyen, H. Q., & Mourshed, M. (2023a). Plastic Waste: Challenges and Opportunities to Mitigate Pollution and Effective Management. *International Journal of Environmental Research*, 17(1), 20. <https://doi.org/10.1007/s41742-023-00507-z>
- Kibria, Md. G., Masuk, N. I., Safayet, R., Nguyen, H. Q., & Mourshed, M. (2023b). Plastic Waste: Challenges and Opportunities to Mitigate Pollution and Effective Management. *International Journal of Environmental Research*, 17(1), 20. <https://doi.org/10.1007/s41742-023-00507-z>
- Kim, S. W., & Rillig, M. C. (2022). Research trends of microplastics in the soil environment: Comprehensive screening of effects. *Soil Ecology Letters*, 4(2), 109–118. <https://doi.org/10.1007/s42832-021-0077-3>
- K-pop's profligate CD output draws fire as South Korea hosts plastic waste talks | Reuters.* (n.d.). Retrieved December 30, 2024, from <https://www.reuters.com/sustainability/k-pops-profligate-cd-output-draws-fire-south-korea-hosts-plastic-waste-talks-2024-11-21/>
- Li, J., Zhang, K., & Zhang, H. (2018). Adsorption of antibiotics on microplastics. *Environmental Pollution*, 237, 460–467. <https://doi.org/10.1016/j.envpol.2018.02.050>
- Li, S., Ding, F., Flury, M., Wang, Z., Xu, L., Li, S., Jones, D. L., & Wang, J. (2022). Macro- and microplastic accumulation in soil after 32 years of plastic film mulching. *Environmental Pollution*, 300, 118945. <https://doi.org/10.1016/j.envpol.2022.118945>
- Liu, C., & Liu, C. (2023). Exploring Plastic-Management Policy in China: Status, Challenges and Policy Insights. *Sustainability*, 15(11), 9087. <https://doi.org/10.3390/su15119087>
- Malaysia opens anti-dumping duty probe on plastic imports from China, Indonesia | Reuters.* (n.d.). Retrieved December 30, 2024, from <https://www.reuters.com/sustainability/malaysia-opens-anti-dumping-duty-probe-plastic-imports-china-indonesia-2024-08-09/?utm>

- Maqbool, A., Soriano, M.-A., & Gómez, J. A. (2023). Macro- and micro-plastics change soil physical properties: a systematic review. *Environmental Research Letters*, 18(12), 123002. <https://doi.org/10.1088/1748-9326/ad0a1a>
- Masum, Md. M. H., Zuthi, Mst. F. R., Khan, F., Hoque, A., Pal, S. K., Emon, A. U. I., Das, S. R., Kraft, E., & Kühlewindt, S. (2024). *Challenges and Prospects for the Substitution of Plastic Products with Jute in the context of Bangladesh – A Social Study*. <https://doi.org/10.21203/rs.3.rs-5097641/v1>
- Meeting Bangladesh's Plastic Challenge through a Multisectoral Approach*. (n.d.). Retrieved December 29, 2024, from <https://www.worldbank.org/en/news/feature/2021/12/23/meeting-bangladesh-s-plastic-challenge-through-a-multisectoral-approach>
- Microplastics and human health - Wikipedia*. (n.d.). Retrieved December 29, 2024, from https://en.wikipedia.org/wiki/Microplastics_and_human_health
- Microplastics in drinking-water*. (n.d.).
- Milios, L., Esmailzadeh Davani, A., & Yu, Y. (2018). Sustainability Impact Assessment of Increased Plastic Recycling and Future Pathways of Plastic Waste Management in Sweden. *Recycling*, 3(3), 33. <https://doi.org/10.3390/recycling3030033>
- Muhammad Muktadirul Islam Khan. (2023, June 5). *The time to beat plastic pollution is now or never* | *Daily Star*. <https://www.thedailystar.net/opinion/views/news/the-time-beat-plastic-pollution-now-or-never-3337616>
- Nayanathara Thathsarani Pilapitiya, P. G. C., & Ratnayake, A. S. (2024). The world of plastic waste: A review. *Cleaner Materials*, 11, 100220. <https://doi.org/10.1016/j.clema.2024.100220>
- Neil Shipley. (2021, July 3). *Plastic Sweden – Watching the Swedes*. <https://watchingtheswedes.com/2021/07/03/plastic-sweden/>
- Ng, E.-L., Huerta Lwanga, E., Eldridge, S. M., Johnston, P., Hu, H.-W., Geissen, V., & Chen, D. (2018). An overview of microplastic and nanoplastic pollution in agroecosystems. *Science of The Total Environment*, 627, 1377–1388. <https://doi.org/10.1016/j.scitotenv.2018.01.341>
- Nkwachukwu, O., Chima, C., Ikenna, A., & Albert, L. (2013). Focus on potential environmental issues on plastic world towards a sustainable plastic recycling in developing countries. *International Journal of Industrial Chemistry*, 4(1), 34. <https://doi.org/10.1186/2228-5547-4-34>
- Okunola A, A., Kehinde I, O., Oluwaseun, A., & Olufiropo E, A. (2019). Public and Environmental Health Effects of Plastic Wastes Disposal: A Review. *Journal of Toxicology and Risk Assessment*, 5(2). <https://doi.org/10.23937/2572-4061.1510021>
- One Step Closer to Mandatory EPR: Thailand's New Draft EPR Law - Lorax EPI*. (n.d.). Retrieved December 30, 2024, from https://www.loraxcompliance.com/blog/env/2024/04/10/One_Step_Closer_to_Mandatory_EPR_Thailands_New_Draft_EPR_Law.html
- Palencia, M., Garc a Quintero, A., Chate-Galvis, N., Lerma, T. A., Anaya Tatis, L., Garc es Villegas, V., & Palencia, S. L. (2026). Microplastics & Part 1: Dynamics of pollution by microplastics. *Journal of Science with Technological Applications*, 20, 1–19. <https://doi.org/10.34294/j.jsta.26.20.115>
- Papac Zjačić, J., Vujasinović, M., Kovačić, M., Lončarić Božić, A., Kušić, H., Katančić, Z., & Hrnjak-Murgić, Z. (2023). From Macro to Micro Plastics; Influence of Photo-oxidative Degradation. *Kemija u Industriji*, 7–8. <https://doi.org/10.15255/KUI.2023.007>

- Pavel, S., & Supinit, V. (2017). Bangladesh Invented Bioplastic Jute Poly Bag and International Market Potentials. *Open Journal of Business and Management*, 05(04), 624–640. <https://doi.org/10.4236/ojbm.2017.54053>
- Plastic in Sweden-facts and practical advice*. (2022). www.naturvardsverket.se/978-91-620-7038-0
- Plastic packaging recycling rate Germany* | Statista. (2024, January 4). <https://www.statista.com/statistics/1265422/plastic-packaging-recycling-rate-germany/>
- Plastic Pollution by Country 2024*. (n.d.). Retrieved December 29, 2024, from <https://worldpopulationreview.com/country-rankings/plastic-pollution-by-country>
- Plastic Pollution Solutions - 10 Ways to Reduce Plastic Pollution*. (n.d.). Retrieved December 30, 2024, from <https://www.nrdc.org/stories/10-ways-reduce-plastic-pollution>
- PLASTIC WASTE MANAGEMENT AND BURDEN IN CHINA*. (2022). www.ipen.org
- Plastic waste: redesign and biodegradability*. (2011).
- Plastic-leakage-and-greenhouse-gas-emissions-are-increasing-OECD*. (n.d.).
- Plastics and packaging laws in France* | CMS Expert Guide. (n.d.). Retrieved December 30, 2024, from <https://cms.law/en/int/expert-guides/plastics-and-packaging-laws/france>
- Plastics and packaging laws in Germany* | CMS Expert Guide. (n.d.). Retrieved December 30, 2024, from <https://cms.law/en/int/expert-guides/plastics-and-packaging-laws/germany>
- Plastics Management Index Plastics Management Index Evaluating effective management and sustainable use of plastics Plastics Management Index*. (2021).
- Prata, J. C., da Costa, J. P., Lopes, I., Duarte, A. C., & Rocha-Santos, T. (2020). Environmental exposure to microplastics: An overview on possible human health effects. *Science of The Total Environment*, 702, 134455. <https://doi.org/10.1016/j.scitotenv.2019.134455>
- Qi, Y., Yang, X., Pelaez, A. M., Huerta Lwanga, E., Beriot, N., Gertsen, H., Garbeva, P., & Geissen, V. (2018). Macro- and micro- plastics in soil-plant system: Effects of plastic mulch film residues on wheat (*Triticum aestivum*) growth. *Science of The Total Environment*, 645, 1048–1056. <https://doi.org/10.1016/j.scitotenv.2018.07.229>
- Qian, H., Zhang, M., Liu, G., Lu, T., Qu, Q., Du, B., & Pan, X. (2018). Effects of Soil Residual Plastic Film on Soil Microbial Community Structure and Fertility. *Water, Air, & Soil Pollution*, 229(8), 261. <https://doi.org/10.1007/s11270-018-3916-9>
- Rai, P. K., Lee, J., Brown, R. J. C., & Kim, K.-H. (2021). Environmental fate, ecotoxicity biomarkers, and potential health effects of micro- and nano-scale plastic contamination. *Journal of Hazardous Materials*, 403, 123910. <https://doi.org/10.1016/j.jhazmat.2020.123910>
- Ramasubramanian, B., Tan, J., Chellappan, V., & Ramakrishna, S. (2023). Recent Advances in Extended Producer Responsibility Initiatives for Plastic Waste Management in Germany and UK. *Materials Circular Economy*, 5(1), 6. <https://doi.org/10.1007/s42824-023-00076-8>
- Reddy, C. S. K., Ghai, R., Rashmi, & Kalia, V. C. (2003). Polyhydroxyalkanoates: an overview. *Bioresource Technology*, 87(2), 137–146. [https://doi.org/10.1016/S0960-8524\(02\)00212-2](https://doi.org/10.1016/S0960-8524(02)00212-2)
- Results So Far From Plastic Bag Bans - Pager Power*. (n.d.). Retrieved December 30, 2024, from <https://www.pagerpower.com/news/results-so-far-from-plastic-bag-bans/>

- Rillig, M. C. (2012). Microplastic in Terrestrial Ecosystems and the Soil? *Environmental Science & Technology*, 46(12), 6453–6454. <https://doi.org/10.1021/es302011r>
- Rwanda: lessons learnt from a pioneer in the fight against plastic pollution — Global Green Growth Institute.* (n.d.). Retrieved December 30, 2024, from <https://gggi.org/rwanda-lessons-learnt-from-a-pioneer-in-the-fight-against-plastic-pollution/>
- Rwanda makes strides in plastic ban - Global Times.* (n.d.). Retrieved December 30, 2024, from https://www.globaltimes.cn/page/202208/1272549.shtml?utm_
- Rwanda's remarkable journey: Inspiring solutions to the global plastic pollution crisis | United Nations Development Programme.* (n.d.). Retrieved December 30, 2024, from <https://www.undp.org/rwanda/blog/rwandas-remarkable-journey-inspiring-solutions-global-plastic-pollution-crisis>
- Rwanda's War on Plastic by Jonathan W. Rosen (Works That Work magazine).* (n.d.). Retrieved December 30, 2024, from <https://worksthatwork.com/7/rwandas-war-on-plastic>
- Sarkingobir, Y., Bello, M. A., & Yabo, H. M. (2021). Harmful effects of plastics on air quality. *Academia Letters*. <https://doi.org/10.20935/al2967>
- Shanghai may become a model for zero-waste cities around the world - Focus - China Britain Business Council.* (n.d.). Retrieved December 30, 2024, from <https://focus.cbbc.org/shanghai-zero-waste/>
- Single-use Plastics Prohibitions Regulations Technical Guidelines - Canada.ca.* (n.d.). Retrieved December 30, 2024, from <https://www.canada.ca/en/environment-climate-change/services/managing-reducing-waste/reduce-plastic-waste/single-use-plastic-technical-guidance.html>
- Sri Lanka National Environmental Act - Order No. 2034/35, Plastic Bag Ban - Global Plastics Policy Centre.* (n.d.). Retrieved December 30, 2024, from <https://plasticpolicy.port.ac.uk/policy-reviews/the-sri-lanka-national-environmental-act-order-no-2034-35-plastic-bag-ban/>
- Stock, F., Kochleus, C., Spira, D., Brennholt, N., Bänisch-Baltruschat, B., Demuth, S., & Reifferscheid, G. (2020). Plastics in aquatic environments – results of an international survey. *Fundamental and Applied Limnology*, 194(1), 67–76. <https://doi.org/10.1127/fal/2019/1137>
- Sun, Y., Liu, S., Wang, P., Jian, X., Liao, X., & Chen, W. Q. (2022). China's roadmap to plastic waste management and associated economic costs. *Journal of Environmental Management*, 309, 114686. <https://doi.org/10.1016/J.JENVMAN.2022.114686>
- Sweden abolishes a tax on single-use plastic bags despite its proven effectiveness.* (n.d.). Retrieved December 30, 2024, from https://www.lemonde.fr/en/environment/article/2024/11/04/plastic-sweden-abolishes-a-tax-on-single-use-bags-despite-its-proven-effectiveness_6731564_114.html
- Sweden commits to reduction of plastic pollution by adopting a National Plastic Action plan with goals and concrete actions | Department of Economic and Social Affairs.* (n.d.). Retrieved December 30, 2024, from <https://sdgs.un.org/partnerships/sweden-commits-reduction-plastic-pollution-adopting-national-plastic-action-plan-goals>
- Thai national parks ban single-use plastics.* (n.d.). Retrieved December 30, 2024, from <https://phys.org/news/2022-04-thai-national-single-use-plastics.html>
- Thailand bans imports of plastic waste from January 1.* (n.d.). Retrieved December 30, 2024, from <https://vietnamnews.vn/world/1689364/thailand-bans-imports-of-plastic-waste-from-january-1.html>

- Thailand to ban plastic scrap imports in 2025, following multiple other Asian countries* | Waste Dive. (n.d.). Retrieved December 30, 2024, from <https://www.wastedive.com/news/thailand-scrap-ban-plastic-basel-isril/633391/>
- The U.S. Progress with Single-Use Plastic Bans*. (n.d.). Retrieved December 30, 2024, from <https://www.seasidesustainability.org/post/the-u-s-progress-with-single-use-plastic-bans>
- Umuganda: Rwanda's audacity of hope to end plastic pollution* | United Nations Development Programme. (n.d.). Retrieved December 30, 2024, from <https://www.undp.org/blog/umuganda-rwandas-audacity-hope-end-plastic-pollution>
- United Arab Emirates: Regulations on single-use products – Environmental sustainability in Dubai - Baker McKenzie InsightPlus*. (n.d.). Retrieved December 30, 2024, from https://insightplus.bakermckenzie.com/bm/environment-climate-change_1/united-arab-emirates-regulations-on-single-use-products-environmental-sustainability-in-dubai
- Vuppaladadiyam, S. S. V., Vuppaladadiyam, A. K., Sahoo, A., Urgunde, A., Murugavelh, S., Šrámek, V., Pohořelý, M., Trakal, L., Bhattacharya, S., Sarmah, A. K., Shah, K., & Pant, K. K. (2024). Waste to energy: Trending key challenges and current technologies in waste plastic management. *Science of The Total Environment*, 913, 169436. <https://doi.org/10.1016/j.scitotenv.2023.169436>
- Wan, Y., Wu, C., Xue, Q., & Hui, X. (2019). Effects of plastic contamination on water evaporation and desiccation cracking in soil. *Science of The Total Environment*, 654, 576–582. <https://doi.org/10.1016/j.scitotenv.2018.11.123>
- What is PLA? (Everything You Need To Know) - TWI*. (n.d.). Retrieved December 30, 2024, from <https://www.twi-global.com/technical-knowledge/faqs/what-is-pla>
- What You Need to Know About the Impact of Plastics on Human Health - Earth Day*. (n.d.). Retrieved December 29, 2024, from <https://www.earthday.org/what-you-need-to-know-about-the-impact-of-plastics-on-human-health/>
- World Integrated Trade Solution (WITS) | Data on Export, Import, Tariff, NTM*. (n.d.). Retrieved December 30, 2024, from <https://wits.worldbank.org/>
- World Population by Country 2024 (Live)*. (n.d.). Retrieved December 29, 2024, from <https://worldpopulationreview.com/>
- Worm, B., Lotze, H. K., Jubinville, I., Wilcox, C., & Jambeck, J. (2017a). Plastic as a Persistent Marine Pollutant. *Annual Review of Environment and Resources*, 42(1), 1–26. <https://doi.org/10.1146/annurev-environ-102016-060700>
- Worm, B., Lotze, H. K., Jubinville, I., Wilcox, C., & Jambeck, J. (2017b). Plastic as a Persistent Marine Pollutant. *Annual Review of Environment and Resources*, 42(1), 1–26. <https://doi.org/10.1146/annurev-environ-102016-060700>
- Wright, S. L., & Kelly, F. J. (2017). Plastic and Human Health: A Micro Issue? *Environmental Science & Technology*, 51(12), 6634–6647. <https://doi.org/10.1021/acs.est.7b00423>
- Www, W. :, Reddy, R. L., Reddy, V. S., & Gupta, G. A. (2008). International Journal of Emerging Technology and Advanced Engineering Study of Bio-plastics As Green & Sustainable Alternative to Plastics. In *Certified Journal* (Vol. 9001, Issue 5). www.ijetae.com
- YASIR WARDAD. (2024, December 25). *Finance News: Latest Financial News, Finance News today in Bangladesh*. <https://today.thefinancialexpress.com.bd/last-page/bd-uses-384b-plastic-bottles-a-yr-study-1735064358>
- Zakaria Ahmed. (2022, September 28). *Various Applications of Eco-friendly Jute and as an Alternative of Environmentally Hazardous Plastic - A Review*.

<https://www.envsciarch.com/volume1issue2/article/various-applications-of-eco-friendly-jute-and-as-an-alternative-of-environmentally-hazardous-plastic---a-review>

Zhang, G. S., Zhang, F. X., & Li, X. T. (2019). Effects of polyester microfibers on soil physical properties: Perception from a field and a pot experiment. *Science of The Total Environment*, 670, 1–7. <https://doi.org/10.1016/j.scitotenv.2019.03.149>