Review Article

A Review of Plastic Threat to Environment

ABSTRACT:

Due to low weight, great strength, and wide range of applications—all at a lower cost than other alternative materials the invention of plastics has generally been viewed as a blessing for modern living. The world purchases around one million plastic bottles every minute and uses one billion plastic bags every hour. Bangladesh is also witnessing a surge in plastic production employed in our RMG sector, the healthcare industry, and the automobile industry. Plastics are blamed for significant contamination of the air, soil, and water bodies because of their low biodegradability, excessive use, and pervasive mishandling. As a result, plastics are now found in every environmental compartment threatening biodiversity and human health also. This work overall focuses on the effect of plastic on the environment. The ultimate goal of this paper is to make researchers want to investigate Bangladesh's plastic pollution in-depth and to make relevant authorities concerned about the need to create policies and enact the necessary measures to combat plastic pollution before it's too late.

Keywords: Plastic pollution, Environment, Soil, Water, Air, Pollution.

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1. INTRODUCTION

The oceans are swimming in it, the rivers are choked with it, coastlines are collecting it, landfills are cloggh it, and ed witour trash cans are filled with it. These days, plastic is an essential part of everyday living. According to a s of decomposition of these one of the greatest hurdles to environmental conservation is the availability of plastic items. plastics make their disposal extremely hazardous to the environment [1]. That's why recently Massive quantities of plastic debris and its limited breakdown disturb the environment greatly. Every kind of plastic that people use daily ultimately ends up in the trash; tons of this waste demand vast amounts of space to be stored and cannot be recycled entirely at once [2]. Plastics are used to make a wide range of goods, and the plastics industry is growing increasingly interested in this sector. Now plastic is an essential component of modern life, and during the previous 50 years, the world's plastic production has grown significantly [3]. Conventional plastics are incredibly robust and take a long time to break down in the environment. The great threat is thatstudy, Globally, 6.5 billion tons of waste plastic and rubber are produced per year; the long rate plastics do not break down and will always remain in the environment for several years. In normal environmental conditions, polymer degradation takes hundreds of years [4]. Because plastic waste contains a lot of highly toxic trace elements in its pigment, it is harmful [5]. Therefore, it has been determined that environmental contaminants originating from synthetic plastics are a major hassle [6]. Over the last fifty years, the manufacturing of plastic has increased twentyfold. It is estimated that 9200 million metric tons (Mt) of plastic have been manufactured worldwide, of which over 6900 Mt have been landfilled or, worse, have contributed to environmental degradation. In addition, 368 million metric tons (Mt) of plastic were produced worldwide in 2019 [8], but by 20 years, that amount is expected to triple. Because most consumer plastics are made to be single-use items with little potential for recycling, global production and consumption have skyrocketed, creating previously unheard-of levels of plastic waste and pollution. Among all 9 percent of plastic garbage that has ever been recycled globally, 12 percent has been burned, and the remaining 79 percent has accumulated in natural ecosystems. In 2016, scientists, it was calculated that 19–23 Mt of plastic garbage produced worldwide found its way into aquatic environments; however, by 2030, that amount is expected to rise to 53 Mt yearly which ultimately disrupt soil or land and the aquatic continuum in various ways [7].

Bangladesh is a country that is overpopulated. Its three largest cities, Sylhet, Chittagong, and Dhaka, are all in grave danger. According to a report, Dhaka city discards roughly 14 million polybag fragments daily. The report also mentioned that one of the main reasons for the obstruction of the drainage systems in Bangladesh's urban areas during the floods that occurred in 1998 and 2008 was the use of plastic and polythene materials. Out of the top 20 countries in the world for plastic pollution, Bangladesh was ranked 10th in a recent report released by Earth Day Network (2018). Plastic contributes 800,000 tons, or eight percent, of the nation's waste, of which 200,000 tons end up in the nation's rivers and oceans [8]. Although Bangladesh, a rapidly developing country having a vast population of 166 million,has satisfactory economic growth including over three thousand small and big plastic industries at present and Bangladesh has been recognized as the 12th highest export earning sector in the fiscal year 2017-18 [9].

Furthermore, because people turned to single-use plastic out of concern for infection and the virus's spread, the arrival of COVID-19 has made the situation of plastic pollution worse. In Bangladesh, the use of single-use plastic and polythene bags increased dramatically during COVID-19. In 2020, 6,646 tons of waste were produced daily in the Dhaka metropolitan area, with plastic accounting for 10% of the total and less than half of the plastic waste is recycled, 48% ends up in landfills, and the remaining portion is either thrown in drains or rivers, or it is just thrown in other parts of the city that time [10].Bangladesh is an agriculture-based nation with 87700 km^2 of arable land. It is home to many rivers along with the country's tropical monsoon environment, which is ideal for the growth of the agricultural industry. In addition to these agricultural sectors, Bangladesh holds a 0.6% market share in the USD 570 billion global plastic industry employing over 2 million people either directly or indirectly. As Bangladesh deals with natural disasters and various forms of solid waste management, improper handling of plastics has become a major concern [11].

2. CLASSIFICATION OF PLASTIC MATERIAL

In essence, plastics are made of synthetic artificial polymers as long-chain molecules derived from petrochemicals or crude oil. Comparing plastic to many other readily available natural materials, it is more durable, lighter, and more malleable. Plastic has a wide range of uses since it rarely interacts with other materials. One such use is the packaging of food and other culinary goods. Since they are hydrophobic, plastics do not break down or decompose. Polyethene, which gained popularity after the 1960s and is a major contributor to plastic waste globally, is used to make the majority of packaging and single-use plastic bags [12]. Thermoplastics and Thermosets are two fundamental types of plastic in which

Thermoplastics can be remelted and reformed under heat, making them ideal for recycling. Examples of thermoplastics include polyethylene (PE), polypropylene (PP), PVC, polyethylene terephthalate (PET), polystyrene (PS), and polyamide (PA). Oppositely, thermosets are polymers that form stronger bonds and, as a result, cannot be remodeled or remelted, making it difficult to recycle this material. Most used thermoset plastics involve polyurethanes (PUR), unsaturated polyester, silicone, epoxy, melamine, phenolic, and acrylic resins [13].For plastic users and recyclers, a detailed classification of plastic materials was made by the Society of the Plastics Industry (SPI) in 1988. An SPI code or number is shaped into the bottom of the plastic product so that the user can easily identify their desired material. In terms of safety, plastic materials are classified into the following seven types, of which type 2, type 4, and type 5 are more compatible to use.

Type 1: Polyethylene Terephthalate (PET or PETE)

PET is an aliphatic polyester whose general chemical formula is $(C_{10}H_8O_4)n$. Because of its special qualities—such as its lightweight, toughness, high resistance to heat, grease, and oil, and low permeability to oxygen, carbon dioxide, and water—polyethylene terephthalate (PET) is the plastic used in food packaging applications that are expanding the fastest. Its polymer chain breaks down at a relatively low temperature. Although these plastics are thought to be safe in general, food and drink items can occasionally absorb flavors and odors from them. The primary drawbacks of these polymers are their oxidation susceptibility and lack of biodegradability. PET plastics are utilized in the production of numerous household items, including medicine pots, rope, clothing, and carpet fiber. This plastic istypically recycled into new products. The carpet, pillow, and sleeping bags, among other items, are made from recycled PET materials.

Type 2: High-Density Polyethylene (HDPE)

HDPE comes with an outstanding temperature range and short periods of heating with up to 248°F (120°C) or for long periods up to 230°F (110°C) are considered safe. HDPE has a low degree of branching and is not readily biodegradable. Very low water absorption. Its general formula is $(C_2H_4)n$. Other notable properties of HDPE are high stiffness, strength, toughness, resistance to chemicals and moisture, and permeability to gas Products made of High-density Polyethylene HDPE are thought to be extremely safe because they prevent chemicals from contaminating food. Due to their lightweight, extremely strong, long-lasting, weather-resistant, and impact-resistant qualities, these materials are being used more frequently these days. HDPE materials are used to make a wide range of everyday products, including soap, detergent, shampoo, oil, and milk containers. Because of health risks, it is not safe to store food or beverages in an HDPE bottle more than once. Typically, these materials are recycled to make trash cans, flower pots, and detergent bottles, among other things.

Type 3: Polyvinyl Chloride (PVC)

PVC comes in two basic forms: rigid (sometimes abbreviated as RPVC) and flexible. It is very dense compared to most plastics with a specific gravity of around 1.4). Polyvinyl Chloride has outstanding tensile strength. The formula for PVC is $(H_2C–CHCl)n$, where n represents the degree of polymerization. Other properties of PVC are abrasion-resistant, lightweight tough, and resistant to all inorganic chemicals. Polyvinyl Chloride PVC is utilized in the production of various pipes, tiles, and electronic components. PVC is replacing more conventional building materials because of its many useful qualities, including its ease of use, affordability, durability, resistance to corrosion, and ease of processing. Its main component, chlorine, makes it chemically and biologically resistant. Recycling programs typically do not accept PVC plastic.

Type 4: Low-Density Polyethylene (LDPE)

LDPE breaks down more easily than other plastics. It decomposes within 290 to 350 °C. During high-temperature processing of LDPE in the presence of air thermal oxidation occurs. LDPE is insoluble at normal temperature. It practically does not permeate in water and steam, but it has a good permeability to carbon dioxide and oxygen. The monomer of LDPE is ethylene which is the same as HDPE. Since low-density polyethylene (LDPE) is resistant to impact, moisture, and chemicals, it is regarded as a safe and healthy plastic. Due to its strength and flexibility, LDPE is now used more frequently to create a variety of everyday products, including plastic grocery bags, sandwich bags, food wraps, and beverage bottles. Since it is rarely recycled, it is preferable to reuse or repurpose it instead of discarding it after just one use.

Type 5: Polypropylene (PP)

Polypropylene is a very flexible, soft material with a relatively low melting point. It's mainly under Thermoplastic & thermoplastic materials become liquid at their melting point (roughly 130 degrees Celsius in the case of polypropylene). In a nitrogen environment, PP degrades in a single step, beginning at 300 °C and ending at 475 °C. PP can be easily copolymerized with polyethylene to combine into composite plastic. Polypropylene is highly impermeable to water. The chemical formula of PP is $(C_3H_6)n$ Strength and durability are increased by polypropylene because of its strong resistance to water, soap, detergent, acid, and bases. Because it can tolerate higher temperatures, it can be used for a variety of applications. During manufacturing, it can be made opaque, translucent, or in a variety of colors. Lunchboxes, butter receptacles, yogurt pots, sauce bottles, ketchup bottles, plastic bottle caps, and pharmaceutical packaging are among the items made with it. Occasionally, PP is recycled and used to make manhole steps, lumber, and car battery cases, among other things.

Type 6: Polystyrene (PS)

PS is a clear, amorphous, nonpolar commodity thermoplastic. It can be copolymerized with methyl methacrylate. It is insoluble in water. Polystyrene is soluble in most chlorinated and aromatic solvents, though not in alcohols. Unmodified polystyrene is clear, rigid, brittle and moderately strong. The chemical formula of PS is $(C_8H_8)n$. A thermoplastic polymer called polystyrene PS is frequently used to create rigid foam and solid plastic materials. Because this plastic release potentially harmful chemicals when heated, it is regarded as dangerous. Various everyday items like egg cartons, packing foam, plastic boxes and cutlery, tea and coffee cups, and more are made with it. It can take hundreds of years for it to decompose if it is not recycled, so recycling it is common but challenging.

Type 7: Others

The remaining types of plastic that are not covered by the first six codes are denoted by another Code 7. This category includes two well-known plastics, such as polycarbonate and bio-plastic polylactide. Typically, these kinds of plastics are not recycled. Polycarbonate, polyctide, acrylic, acrylonitrile butadiene, styrene, fiberglass, and nylon plastics are considered in this category. These plastics are used in mostly plastic CDs and DVDs, baby bottles, large water bottles with multiple-gallon capacity, medical storage containers, eyeglasses, exterior lighting fixtures etc [14].

3. WORLDWIDE PLASTIC PRODUCTION SCENARIO

An important turning point that raised the standard of living for people was the discovery of plastics. Due to their lightweight, robustness, ease of processing, cheap cost, range of applications, and resistance to corrosion by most agents, plastics have largely supplanted other materials, such as wood, metal, and ceramics, in the production of consumer goods since it’s first synthesized in the early 1900s. In addition to the previously listed advantages, research indicates that plastic-based products contribute to lower production costs across a range of human endeavors, product diversification, and global market expansion, with the packaging industry seeing the most growth and resulting in higher profits for manufacturing, chemical, and oil companies [20]. The world's population is driving up the production and consumption of plastics, and per capita income is also driving up the rate at which garbage is generated and the consumption of other items. Among other materials, plastic is thought to be the majority of hazardous waste due to its non-biodegradable nature and the ensuing impact on the ecosystem [21]. It is noted that, while taking into account the global perspective, the average per capita consumption rate of plastic is about 43 kg, with heavily populated, low-income countries being the main producers and users of this enormous number of plastics. Only the EU produced 29.1 million tons (Mt) of plastic garbage in 2018, of which 32.5% was recycled [22].

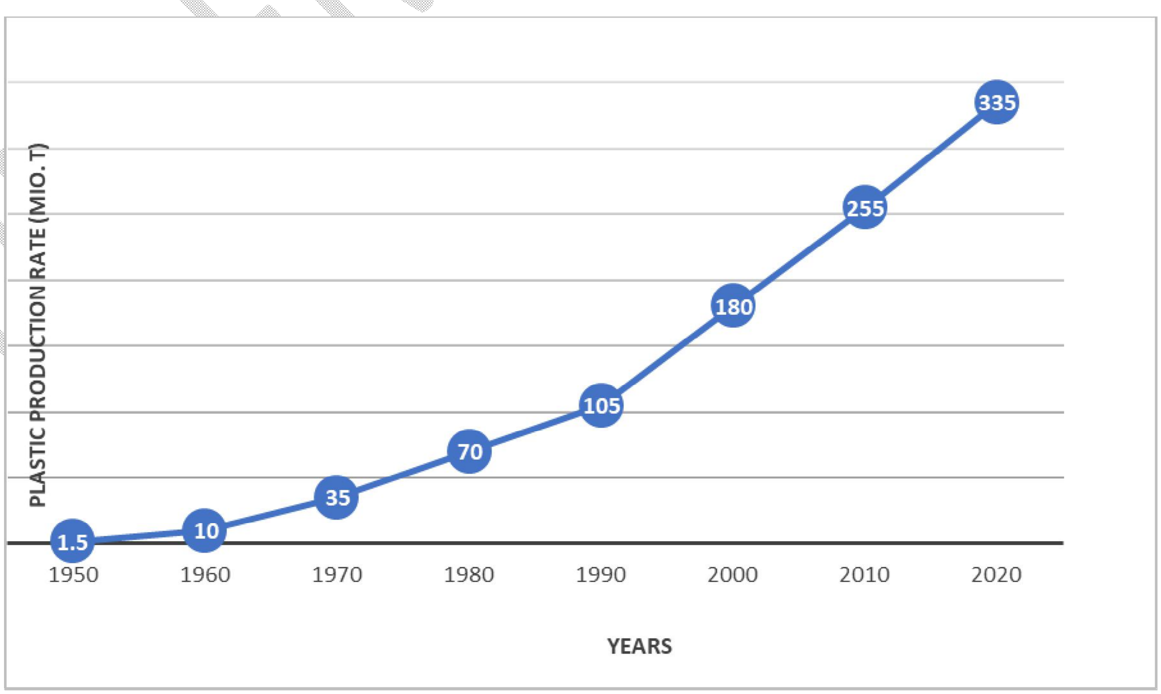

Figure 1: Plastic production rate from 1950 to 2020 globally

In 2019, the total amount of plastic production worldwide was circa 370 Mt in which Asia accounts for 51%, Europe 16%, North America 19%, Latin America 4%, Middle East and Africa accounts for 7%, Countries of the Commonwealth of Independent States (CIS) 3% [23]. According to statistics from 2015, plastic consumption amount accounted for 0.13% to 0.75% of the Asia-Pacific region's total material consumption where imported fossil fuels are used to manufacture plastic and depicts how, as per capita income rises, so does plastic usage [11].The intensifying Over the past 50 years, the plastics sector has grown. Plastic manufacturing increased throughout this time, rising from 1.5 million metric tons (Mio. t) in 1950 to around 322,00 Mio. t (figure 1), and is expected to reach over 600 million tons by 2050. From 1950 until 1990, the generation rate climbed gradually. From that point until 2020, there was a noticeable high peak. Plastic output was 105 million tons in 1990; in just ten years, it has climbed to 180 million tons, an increase of around 71%. This growth pattern is concerning. In comparison to 2014, there was a 3.4% increase in global plastic manufacturing in 2015. From 1950 to 2015 the compound Annual Growth Rate (CAGR) of plastic was about 8.6% [24].The top 10 countries in the world by production of plastic are distributed as follows namely United States (34.02 Mio. t), India (26.33 Mio. t), China (21.60 Mio. t), Brazil (10.68 Mio. t), Indonesia (9.13 Mio. t), Russia (8.47 Mio. t), Germany (6.68 Mio. t), United Kingdom (6.47 Mio. t), Mexico (5.90 Mio. t), and Japan (4.88 Mio. t) [25]. Mostly due to single-use plastics plastic waste is generated being dumped after their initial application [26].

The below figure illustrates that although the United States produces the greatest number of plastics globally, India is the nation that produces the greatest amount of plastic waste (PW), with 13 million tons (Mt). China comes in second with 12.3 Mt, followed by the Philippines (4 Mt), Brazil (3.3 Mt), Nigeria (2 Mt), Tanzania (1.7 Mt), Turkey (1.6 Mt), Egypt (1.4 Mt), Dr. Congo (1.3 Mt), and Thailand (1.3 Mt). People's living conditions improved as a result of fast urbanization and globalization, which also led to a rise in the production of plastic waste (PW).

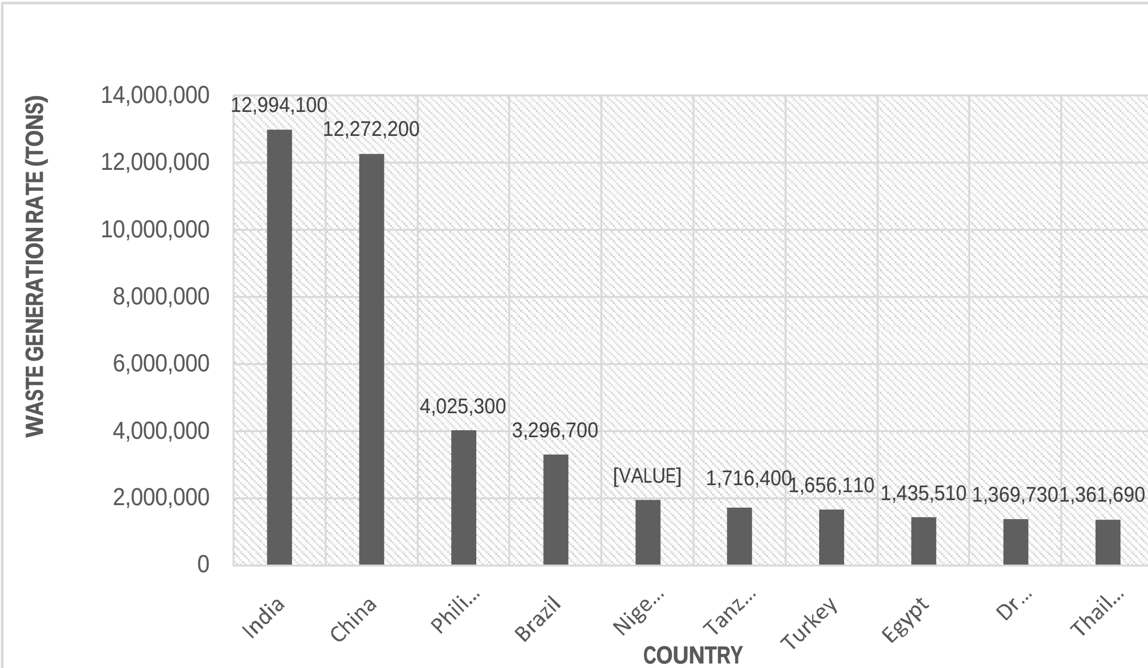

Figure 2: Ten (10) countries with the most plastic pollution

4. PLASTIC WASTE AND ENVIRONMENT

Although the broad availability of plastic products made human life easier and more intelligent, it also caused long-term environmental damage as a result of increasing trash output from overproduction and consumption. Because the most widely used plastics are disposable and non-biodegradable, they end up in landfills or the environment when left unchecked, contaminating the air, soil, and water among other environmental compartments. The irreversible use of plastic and its careless disposal have poisoned environmental bodies, endangering not only human existence but also that of other living things and ultimately putting humankind in danger. Many industries, including packaging, consumer goods and home applications, building and construction, textiles, transportation, electrical and electronic equipment, etc., use a lot of plastic materials. However, very little of the plastic material generated is recycled; the remainder is either burned or dumped in a landfill or the environment. According to recent data, of the roughly 6,300 Mt of garbage produced globally up until 2015, only about 9% was recycled, 12% was burned, and over 79% was dumped in landfills or left in their natural settings [27]. Mismanagement of plastic waste has a significant impact on soil, air, and water pollution. Intentional or inadvertent open burning of plastic waste is thought to have the greatest negative impact on air quality. In Bangladesh, burning solid waste is a common way to reduce the quantity of litter in cities and landfills. But because there was insufficient awareness and separation, plastic items were also burned in these wastes. In the winter, incinerators become more common in the communities because impoverished people burn their waste to stay warm. Among these wastes is a notable quantity of plastic waste that is carelessly discarded on the sides of roads. [9].

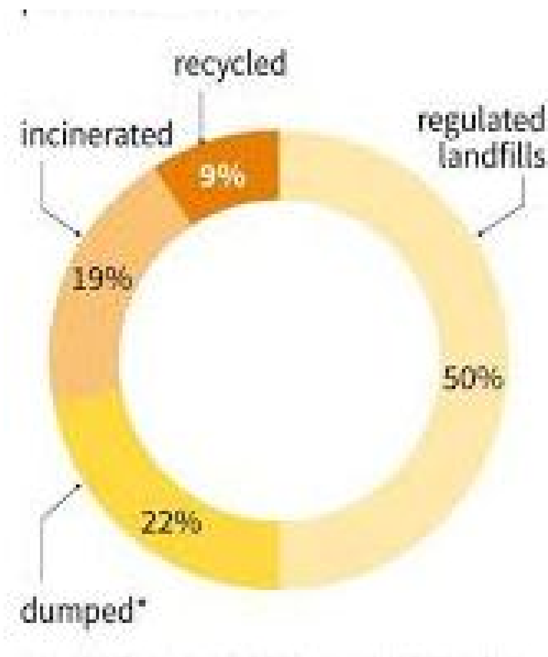

Figure 3: Fate of plastic waste in percentage

4.1. EFFECT OF PLASTIC ON SOIL

The dispersion of micro plastics damages soil aggregation ability, bulk density, water retention capacity, mineralization, stabilization, and dissolution of soil aggregates; this is expected to hurt the evolution of soil microorganisms [28]. By creating a hydrophobic barrier in the soil, MPs found in phytotoxic chemicals may negatively affect plant roots and soil fauna [29]. Furthermore, toxicity is produced by the chemical bisphenol A (BPA), which is released by plastic once it seeps into the soil [30]. Furthermore, concerning is the fact that plastic mulching, which is frequently used in agricultural fields, appears to be a major contributor to the decline of soil health, nutrition, and carbon stock and releases toxic additives that promote soil infertility.

MPs affect the bacteria in the soil, which ultimately disrupts the rates of mineralization and influences the root-colonizing by changing the pH of the soil, symbionts. Remarkably, protists possess an important function in introducing MPs into the food chain [31] and it has been found that MPs may take up protists from aquatic environments.

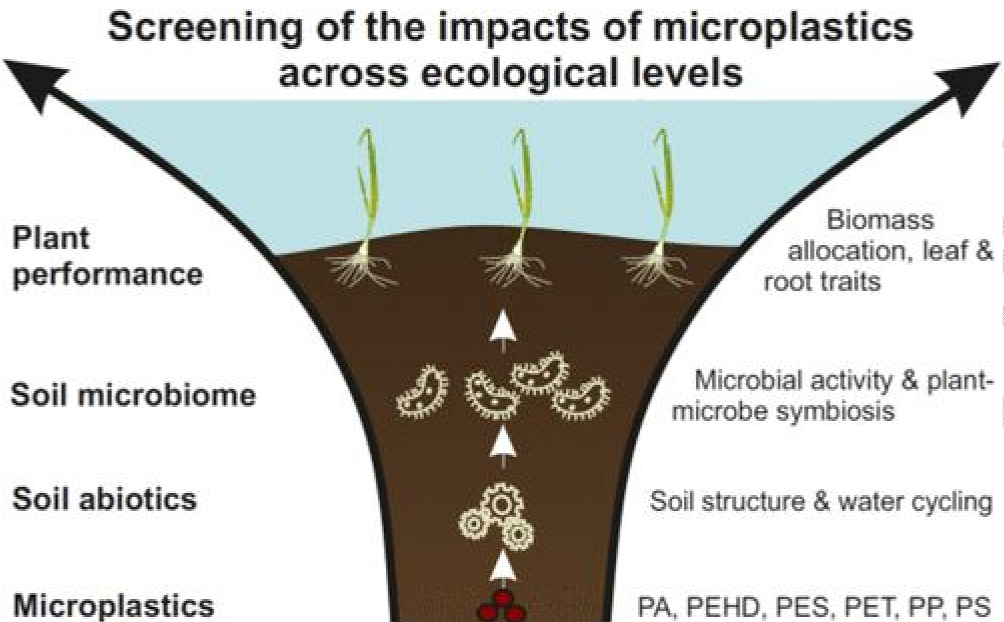

Figure 4: Impacts of microplastics in soil ecosystems

In addition to causing minor changes in bulk density, texture, and structural integrity of the soil, the transportation of MPs on agricultural soil also increases the evaporation of soil water and reduces nutrient contents through microbial immobilization. However, MPs directly harm root growth and absorption. Furthermore, MPs are quickly incorporated into various soil layers, resulting in a significant alteration of the soil's chemical composition and influencing the development of microorganisms. The health of earthworms is impacted by MPs' dispersal into deeper soil layers, which also significantly contaminates groundwater [32]. MPs can infiltrate into the soil ecosystem and accumulate in soil invertebrates, according to a previous study that found that polybrominated diphenyl ether (PBDEs), which are made from polyurethane foam (less than 75 mm), can be deposited in earthworm bodies. Therefore, it can be concluded that MPs have a significant effect on soil organisms, which in turn has an impact on the soil biota. As such, if plastic wastes pollute the soil, the production and quality of agri -products are decreased [33].

4.2. EFFECT OF PLASTIC ON WATER BODIES

Bangladesh is home to one of the greatest river networks in the world, with over 700 rivers and watercourses with tributaries totaling about 24140 km. Mishandled plastic garbage is regarded as one of the main sources of pollution among different kinds of solid waste, which is why Bangladesh is ranked 10th out of the top 20 nations in the world for mishandled plastic waste generation [34]. In the city of Dhaka, 22 out of 65 canals have been transformed into dumping zones mostly because of plastic pollution [9]. Nearly all abandoned PWs eventually find their way into aquatic bodies (ponds, lakes, rivers, and eventually the ocean) either via seeping from landfill sites or by being directly dumped. Various types of plastic accounted for between 50% and 80% of the total garbage that was collected from the ocean's surface, bottom, and coastline [35]. For instance, plastic contamination is responsible for more than 60% of the waste litter that is discovered on each of Bangladesh's four large beaches—Laboni, Inani, Ananda Bazaar, and Patenga [36]. To preserve the biodiversity in the expanding maritime tourism sector, which makes a significant contribution to the local economy, this issue needs to be addressed. Among different types of plastic litter, plastics in microform usually release hazardous organic pollutants like dichlorodiphenyltrichloroethane, polybrominated diphenyl ethers etc., that are found in water during manufacturing, consequently increasing their concentration in water [37]. Additive-free MPs have a detrimental effect on physical health over time, such as bowel obstruction, even though they are not chemically hazardous to aquatic species [38]. The following stage involves the infiltration and subsequent direct discharge of MPs that have broken down or lost size during wastewater treatment into water resources. Consequently, the following are adverse effects of MPs pollution on the environment. Low growth and variation in the species' eating habits as a result of the high number of MPs consumed [39]. If hazardous materials and additives (such as plasticizers, antioxidants, flame retardants, colors, etc.) are properly left untreated before being dumped into the marine environment, they may find their way into the body tissue of aquatic organisms [40]. Because of weathering, a longer shelf-life, and hydrophobic properties, Micro plastic's surface may absorb additional contaminants at a higher concentration. Ultimately, this allows MPs to operate as a transporter of pollutants into aquatic animals [41]. In addition to causing physical injury, ingesting tiny plastic particles can expose living things to hazardous substances in two different ways [9]. The properties of polymers are enhanced by the use of addictive chemicals, such as phthalates, as plasticizers; yet, their existence in biological organisms results in cancerous effects and disruption of the endocrine system [42]. According to Bakir et al. (2014), MPs could serve as a carrier of a variety of hydrophobic organic substances into marine organisms, rendering them more susceptible to the accumulation of persistent organic pollutants (POPs). They can spread far with other pollutants and cause problems for the aquatic ecology because of their lightweight nature [43].

4.3. EFFECT OF PLASTIC ON AIR QUALITY

The majority of standard PW management involves burning waste and operating open landfills without doing any form of sorting to separate recyclables and reusable materials, which has the worst possible impact on the environment and air quality. One popular method for treating materials with a high volume and mass of mixed plastic content is incineration or open burning. However, this method uses fossil fuels to burn the materials and releases a significant amount of greenhouse gases into the atmosphere, which can lead to air pollution and climate change (Pinto et al., 1999). The following is a summary of how plastic adulteration affects the air and surrounding environment. Burning plastic releases toxic smoke into the atmosphere, creating extremely dangerous gasses [9]. Toxic heavy metals (Cd, Pb, Cr, Ni, Cu, Zn), as well as lithophilic metals (Ca, Si, Na, Mg, Al, P, Fe), accelerate many fatal diseases in living creatures [44]. Similarly, poisonous gases are released as a result of the combustion of Plastic wastes, which are reduced to ash and ink in the form of tiny particles. Burning of the vinyl chloride releases phosgene (up to 2 mg/g Poly Vinyl Chloride) which is considered a serious health deteriorative agent while breathing. Irritation of the skin and eyes, respiratory tract infections, nervous system abnormalities, brain and gastrointestinal tract damage, and a decline in disease immunity ultimately led to cancer [45]. In addition, methane is released in huge quantities during the decomposition of landfilled plastics by a variety of microorganisms, bacteria, and flavo-bacteria (such as Pseudomonas, a well-known nylon-eating bacteria). Methane is regarded as one of the primary greenhouse gas emissions. Lead-acid and Li-ion battery boxes are occasionally burned and discarded, which spreads aqua regia from the batteries into the soil and seriously damages the soil.As a result, there is currently growing worry over the unintentional and unclassified open combustion of plastic materials and the carcinogenic spillover. Open-burning solid waste management is primarily done by local vendors or the unofficial sector in underdeveloped nations like Bangladesh; their numbers are considerable and relatively large relative to the waste management industry as a whole.

4.4. EFFECT OF PLASTIC ON MARINE LIFE

Microplastics, or particles smaller than five millimeters, are known to be a major global hazard to the marine environment. As a result, laws have been put in place to monitor and research the issue of this tiny plastic waste. These particles originate from two sources: either there is a direct release of micro- or nanosized plastics into the environment (primary microplastics), which are used for various purposes such as pre-production pellets, personal care products, cosmetics, and cleaning agents; or there is a gradual fragmentation or wear and tear of larger objects during use and after they are lost to the environment (secondary microplastics). Their low density and small size allow them to move over large distances [46]. Over 80% of all marine litter is made up of plastics. An estimated 5.25 trillion plastic waste particles are present, of which 269000 are floating and 4 billion are beneath the surface of our oceans, in microfibers per square kilometer. Ten rivers alone are responsible for 90% of the world's ocean rubbish, and up to 80% of marine pollution is caused by fertilizer, pesticides, runoff from agriculture, and untreated sewage. The pollution caused by plastic kills 100 million marine species annually [11].

Marine organisms are affected by plastic pollution due to entanglement, absorption, bioaccumulation, and changes in the integrity and function of their habitats. Although wastes made of microplastics are seen as a significant cause of entanglement, ingesting MP and macro pollutants by numerous marine species [47]. It is anticipated that every year, up to 13 million metric tons of various polymers will remain in the ocean. Plastic items that have leached phthalates and bisphenol A (BPA) are classified as implicit endocrine-dismembering agents because they can interfere with the control of hormones in both people and wildlife (Klika, 2015). Among the substances that are harmful to aquatic life include BPA, phthalates, and BFRs [11].

Table 1: Ecotoxicity of plastic waste

Item	Availability	Effect
Car Tire Rubber (CTR	Land	Harmful to the overall environment as it contains chemical substances such as carbon black, clay, silica, sulfur, etc.
Bisphenol A (BPA) and phth alates	Land and water both	Endocrine disruptive substances have the potential to alter hormone re gulation in both wildlife and people. Shows harmful effects on aquatic species also

Leachate Exposure	Water	Negative effects on a variety of organisms, including fish, photosyntheti c bacteria, and Daphnia spp., brown mussels, barnacles

Additive leaching from plastic materials is influenced by several factors, including the permeability of the polymer matrix, gaps between polymer molecules, the physical and chemical characteristics of the additives, the surrounding medium's characteristics (such as salinity, temperature, and pH), and time. This makes it more difficult to determine the precise chemical makeup of leachates, identify them, and establish a likely correlation between particular leachate constituents and the reported toxicity. However, exposure to leachate causes harm to a range of species, such as fish, photosynthetic bacteria, Daphnia species, brown mussels, and barnacle nauplii etc [48]. Aqueous leachates derived from plastic materials impact the growth of microalgae such as Raphidocelissubcapitata and Skeletonemacostatum, as well as Mytilus galloprovincialis. In addition to the everyday exposure of aquatic ecosystems to plastic trash, which has varied consequences on the health of aquatic microbes, plants, and animals, the risk of exposure to terrestrial species has also been identified [49].

4.5. EFFECT OF PLASTIC ON CLIMATE CHANGE AND GLOBAL WARMING

The most common synthetic plastic material in use worldwide, polyethylene is thought to be a substantial contributor to the production of methane gas, especiallywhen it comes into contact with sunlight [50].This form of hydrocarbon emission is determined by average molecular weight, which varies with the length of the polymer chain and, consequently, the amount of exposed branching molecules, in addition to shape and density [51].Apart from vehicle emissions, coal stockpiles, MSW disposal sites, and mines producing gas and oil are regarded as essential sources of methane production in Bangladesh.Every step of the plastic life cycle, including the extraction and transportation of raw materials, plastic manufacturing, waste treatment, and environmental release, results in greenhouse gas emissions.

The production facilities themselves are primarily responsible for controlling greenhouse gas emissions during manufacturing; these emissions are often determined by the efficiency, configuration, andequipment's service life. In addition, some unintentional impacts are also included i.e. transportation requirements, pipeline leakage, land use, and impeding forests to act as natural carbon sinks. Although recycling plastic waste energy appears to be a promising solution for managing waste plastics, it will produce a significant amount of greenhouse gas emissions. As a result of this energy conversion, burning plastic packaging waste will rank among the primary contributors to greenhouse gas emissions. Moreover, plastics that are discharged into the environment also gradually emit greenhouse gasses, and the ocean's concentration of (micro)plastics willsignificantly impair the ocean's ability to repair carbon. The present state of plastics production will result in 1.34 gigatons of greenhouse gas emissions annually by 2030 and 2.8 gigatons by 2050. This will drastically deplete the world's remaining carbon budgets, endangering the ability of the international community to prevent global temperatures from rising by more than 1.5 or even 2 degrees Celsius by the year 2100. The issue will get worse since the plastics industry intends to increase manufacturing on a big scale. According to World Economic

Forum projections, the production and consumption of plastics would increase at a 3.8% annual growth by 2030 and then decrease to a 3.5% annual rate between 2030 and 2050 [52].

Table 2: Effects of plastic waste treatment on global greenhouse gas emission

Treatment	Advantages	Disadvantages	Greenhouse gas emission
Recycling	Recycling and reusing waste plastic can both treat white pollution and save oil resources. Increased recycling can lead to negative greenhouse gas emissions by reducing raw material use and avoiding emissions from producing the same number of raw materials	Only a small percentage of "recyclable" plastic wastes are recycled into the original products, even the most easily recycled plastics. Challenges lie in the use of colorants, additives and fillers in the plastic production process, pollution from consumer use, and loss of production during recycling. Low-grade plastic waste, such as multi-layer plastic packing, is particularly difficult to separate and dispose of.	The carbon footprint of 1ton recycled PET tray containing 85% of recycled content from cradle to grave was 1.538 tons CO_2e. 3.17 million tons of plastic waste recycled in 2014 could save approximately 3.2 million tons of CO_2e, equivalent to 670,000 cars on the road in a year, and plastic packing recycling into new products could save 1.4 million tons of CO_2e.
	Incineration has recently been considered a	Greenhouse gases, usually CO_2, can be	Each ton of plastic packing waste generally contains approximately 79% combustible carbon, which will release 790 kg of carbon into

Treatment	Advantages	Disadvantages	Greenhouse gas emission
Incineration	simple solution to large-scale contamination of land-based plastics. It not only can effectively manage plastic pollution but also can provide energy and heat for use.	produced during plastic waste incineration. With this energy conversion occurring, the incineration of plastic packing waste will become one of the main sources of greenhouse gas emissions.	the atmosphere, or about 2.9 tons of CO_2.
Sanitary landfill	The sanitary landfill has the advantages of mature technology and low treatment cost, which is the main way of centralized disposal of urban plastic wastes.	The landfill refuse has not been treated innocuously. There are hidden dangers such as biogas and heavy metal pollution. Its waste leakage liquid will pollute groundwater resources for a long time	Up to now, there is no record of greenhouse gas emissions from plastic landfills. However, this does not exclude the possibility of greenhouse gas emissions from plastic landfills.
Others (open burning)	Simple treatment and low treatment cost	It has a serious impact on climate and human health since it occurs at lower temperatures and is performed without any air pollution control	Plastic packing waste can emit 2.9 million tons of greenhouse gas per ton of plastic packing waste when it is burned in the open air

Treatment	Advantages	Disadvantages	Greenhouse gas emission
		than in a waste incinerator.	

5. SCENARIO OF BANGLADESH REGARDING PLASTIC WASTE

Since Bangladesh has one of the highest densities of population in South Asia including 1265 people per square kilometer, the country generates about 87,000 t of single-use plastic waste annually, of which 86% is still dumped in landfills. Nearly 80% of total SUP waste over the country comes from municipal areas along rural areas is responsible for about 22% notable amount of single-use plastic due to rpiddvancement and agricultural sectors. Mismanaged plastic production and use in offices, business sectors, and various industries—primarily packaging—made Bangladesh one of the most plastic-polluted nations. Almost 3000 plastic manufacturing industries are located in Dhaka and Chittagong; among them, 98% belong to the Small-Medium Enterprises (SMEs) with around USD 74 million of domestic market size [53].

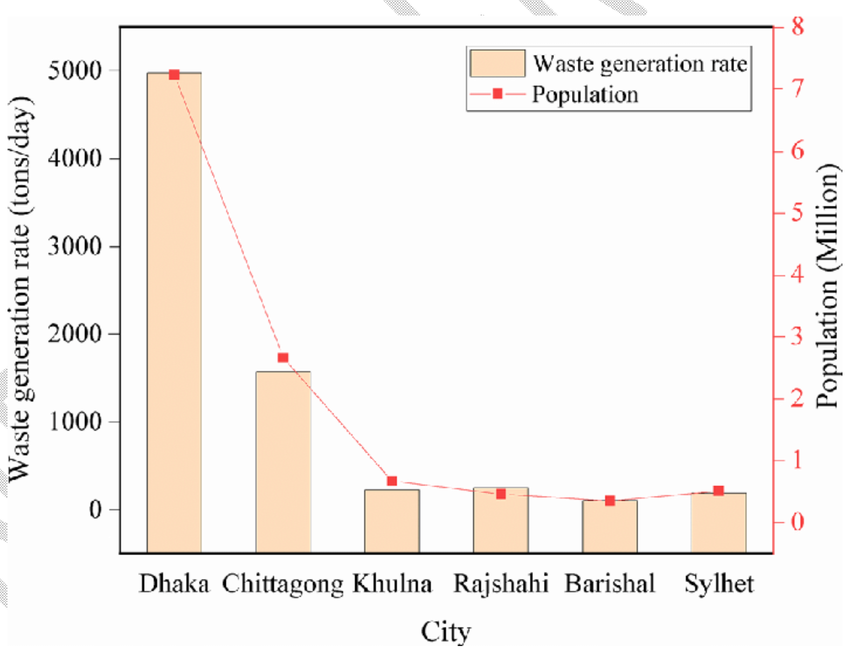

Figure 5: Different types of plastic waste generation in Bangladesh.

Notably, Bangladesh contributes nearly 8% of the world's total debris generation, producing 3000 t of PW per day. The capital city of Bangladesh, Dhaka, uses about 14 million polythene materials a day, mostly packaging bags. In addition, about 250 t of non-recyclable goods, like straws and plastic cutlery, are sold in Old Dhaka, a section of Dhaka, daily. The improper management of these waste systems frequently results in their disposal in rivers and the ocean, endangering the biodiversity of the sea. Following the flows of the three major rivers (Padma, Jamuna, and Meghna), it is estimated that 73000 tons of plastic waste are produced daily and end up in the Bay of Bengal. Polythene bags and plastic waste have been posing a serious threat to the nation's entire environmental system. Approximately 80% of Bangladeshis use plastic bags daily even though they are aware of the negative effects they have, which come from the lax enforcement of laws and regulations [11]It was estimated that the average yearly loss of revenue from tourism, aquaculture, and fisheries for Bangladesh as a result of plastic pollution was USD 11.5 million and around USD 2 million, respectively, in 2020.

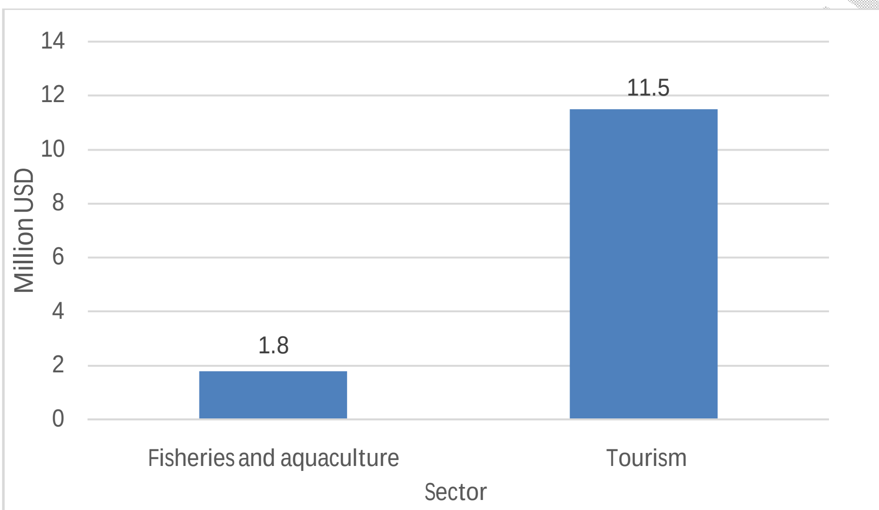

Figure 6: Average estimated annual loss in revenue as per 2020 in Bangladesh

In Bangladesh, tourism is a growing industry that was significantly affected due to the initial wave of the pandemic. However, with the progressive improvement of infrastructure, amenities, and more marketing, Bangladesh is gradually developing as an appealing tourism destination. The current size of the Bangladesh tourism economy till 2019 is BDT 500 million. Besides, Bangladesh earned USD 1157 million from the tourism sector during the 2009-2018 period. Each year, 0.55 million tourists (on average) visit Bangladesh in the same period. Moreover, it creates 2.23 million jobs each year. The travel and tourism sector contributes 4.4% of the GDP each year and this is projected to ascent to 4.7 percent in 2027 [54].

Bangladesh's tourist industry has enormous potential to not only significantly increase the GDP of the nation but also to supply employment and jobs for millions of people. Besides two of the industries in Bangladesh that are expanding the fastest are aquaculture and seafood. They have developed into significant economic drivers for the nation, serving as essential sources of revenue and food for rural communities in addition to serving as a base of operations for businesses engaged in processing, shipping, and marketing [55]. Nonetheless, mishandled garbage disposal or plastic pollution might significantly harm the tourism, fishing, and aquaculture sectors. Tourists may find coastal locations less appealing due to the ongoing buildup of plastic waste and the stench of decaying vegetation. Moreover, the growing incidence of fish polluted by microplastics could make marine life unfit for human consumption. Long-term effects on the export volume of fish could result from Bangladesh's inability to comply with partner nations' sanitary and phytosanitary (SPS) requirements. In 2020, the government's expected yearly expenditure for cleaning up plastic garbage was approximately USD 25.7 million. Furthermore, as much as 30% of the Ministry of Environment, Forests, and Climate Change's (MoEFCC) whole revised budget was allocated to the government's highest expected clean-up cost in 2020. Therefore, it is estimated that the total annual economic impact of plastic pollution in Bangladesh will be around USD 39 million [10].

6. EXISTING POLICIES IN BANGLADESH TO CONTROL PLASTIC POLLUTION

In 2002, Bangladesh implemented a ban on plastic shopping bags in compliance with the Environment Act 1995. However, the prohibition turned out to be ineffectual because of a absence of substitutes and regulatory enforcement (MoEFCC, 1995). In 2020, the High Court issued an injunction to strictly implement the national ban on plastic bags. The implementation of such enforcement measures might involve the regular monitoring of markets, the shutdown of companies producing polythene bags, and the seizure of equipment. The High Court also banned the use of single-use plastics in hotels and restaurants near beaches, including straws, cotton swabs, cutlery, bottles, food containers, and plastic plates, as well as the carrying, selling, and advertising of these items. The Mandatory Jute Packaging Act, which was introduced in 2010 and went into effect in 2013, aims to further discourage the use of plastic bags and promote alternatives. It also promotes the jute industry and lessens reliance on plastic packaging. The National 3R Strategy for Waste Management was enacted in 2010 to promote an efficient waste management system. Reducing, reusing, and recycling were the three pillars of the National 3R policy, which by 2015 called for appropriate waste management streams to reduce garbage disposal in open spaces, waterways, and flood plains. It also included clauses that mandated waste segregation at the source, promoted recycling, created a market for recyclables, and provided incentives for recycling garbage (DoE, 2010). However, practically all families do not segregate their waste due to a lack of enforcement and weak institutional infrastructure, which makes recycling a challenging work for waste pickers. Later in 2015, the Plastic Park Project was introduced which relocated old plastic factories from old Dhaka to a new location and then the Clean Dhaka Master Plan (2018-2032) was developed which aimed to prepare an integrated approach to address the growing urban population and the associated rising urban wastes under the Dhaka North City Corporation (DNCC) and Dhaka South City Corporation (DSCC). The three components of the 3R strategy are integrated into the master plan, guaranteeing appropriate waste collection, appropriate disposal and trash reduction achieved by the establishment of incineration and treatment plants. A policy known as the "National Plastic Industry Development Policy 2021 (Draft)" was introduced by the Ministry of Industries in 2020, and it emphasized the significance of lessening the environmental effects of plastic waste. This policy emphasized the need to standardize recyclable items, guarantee the quality of recycling, and reach zero waste associated with plastic and packaging by 2030 (Ministry of Industries, 2021). The guideline also highlighted how important it is to gather garbage from plastic packaging so that it can be recycled. Additionally, DNCC and Narayanganj City Corporation (NCC) are aiming to build a 42.5-megawatt (MW) waste-to-energy facility power station in DNCC and a 5MW power plant in NCC that uses incineration to convert garbage into electricity to limit the amount of landfill material. To comply with the Bangladesh Environment Protection Act of 1995, the government released the Solid Waste Management Regulations in December of 2021. The importance of the 3R strategy to lessen waste mismanagement was reiterated in the rules. The legislation also prevented the careless dumping and burning of trash and emphasized the significance of EPR, local governments, and consumers practicing waste segregation. The Eighth Five-Year Plan issued by the Bangladesh Planning Commission also includes stipulations to improve the management of solid waste in urban cities. Bangladesh's present plastic pollution regulations are both insufficient and ineffectual. Despite acknowledging the growing significance of the circular economy, Bangladesh has implemented the National 3R Strategy for Waste Management; nonetheless, it lacks a specific action plan to address the problems associated with plastic waste along its whole value chain. Additionally, there are no programs specifically addressing plastic waste in the Eighth Five-Year Plan; instead, concerns about solid waste in general are addressed. Furthermore, a sizable portion of plastic can also be found in electronic trash. As a result, legislative efforts ought to be created to allow for the easy recycling of electronic items and the safe separation of plastic components. The Ban Amendment was changed in 2019 by the Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal, which forbids the transfer of hazardous waste, including plastic garbage, to any other country from nations included in the convention's Annex VII (UNEP, 2019). According to UNEP (2019), the Ban adopted new changes to Annex II, VIII, and IX that included rules about plastic waste and were expected to take effect in 2021. Regulating the Ban Amendment to the Basel Convention and updating Bangladesh's National Report to the Basel Convention (2017) are still outstanding tasks for Bangladesh [10].

7. CONCLUSION

Plastic products can never fully decompose, and can only be reduced to smaller particles. The tiny particles also end up in the human body and incur severe health consequences. Meanwhile, burning plastic items (which is a common practice in Bangladesh) releases toxic gases and particles into the air. The Country and Climate Development Report published by the World Bank Group in 2022 says that around 32 percent of human deaths every year are associated with environmental degradation, specifically outdoor air pollution, inadequate water, sanitation, and hygiene standards, and lead exposure among adults linked with plastic pollution. The estimated annual loss for environmental health amounted to Tk 4.4 trillion in 2019. Plastic waste is also responsible for clogging drainage systems and developing breeding grounds for mosquitoes that result in incidents of vector-borne diseases such as dengue, chikungunya, and malaria. Recycling plastic waste is an economically and environmentally viable way to address plastic pollution, though the progress of this is not significant in Bangladesh. In 2020, the nation consumed 977,000 tonnes of plastic and recycled only one-third of the total. In Dhaka, around 646 tonnes of plastic waste are generated every day and only 37.2 percent is recycled. A large amount of plastic waste remains in the environment. High costs associated with recycling, lack of technology, and lack of public awareness about the consequences of plastic pollution are key factors that hinder recycling in Bangladesh. Despite our country's strides in policy and legislative arrangements, the effective implementation of the policies and laws is still a far cry. Besides the need for effective regulation and enforcement initiatives from the government, individual-level awareness is also crucial in addressing this problem. A strong focus on the circular use of plastic, based on the 3R strategy (reduce, reuse, recycle) will result positively in creating new value chains of plastic, green skills, jobs, and innovative products, while also addressing social and environmental challenges that occur due to our widespread use of plastic. More research and knowledge processes, as well as engagement of stakeholders in multisectoral actions, will driving factors in successfully curbing plastic pollution. Now is the time to act together and save our world from this impending crisis.

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