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# Plastic Waste Management: Awareness & Recycling for Environmental Justice

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## Abstract

Nowadays, plastic is a substance that is transforming food preservation, transportation, healthcare, and technology. But due to its widespread use, there are now major environmental and health issues such as pollution, greenhouse gas emissions, and micro plastic contamination.

This survey research explores the dual nature of plastic, highlighting both its vital benefits and its pressing risks. It examines regional and global initiatives to lessen plastic waste, such as neighbourhood-based initiatives, state-of-the-art technologies, and legislative frameworks.

The research underscores the need for a comprehensive approach that integrates improved recycling practices, public education campaigns, and the principles of the circular economy.

The research emphasizes on finding a balance between facts, creative solutions and initiatives led by many social activists towards environmental responsibility. In this regard an attempt is made fundamentally to create awareness with global as well as Indian context statistics. Moreover the society may mitigate on the negative consequences of plastic so as to understand the dearth of worldwide concern yet leveraging its benefits for a sustainable future for now and upcoming generations. Holistically fostering innovation with sustainability, enforcing firmer regulations, and inspiring collaborative efforts between governments, industries, and citizens has become essential.

**Key Words:** Innovation, Sustainability, Progress, Recycling, Plastic

## Introduction:

The years 1901–2100 have been appropriately dubbed the "Plastics Age"[1], highlighting the revolutionary influence that plastic has had since its creation in 1907[1]. Plastic is a necessary component of modern life. It permeates every aspect of our lives, from the toothbrushes we use on a daily basis to the bottles we drink from, the devices we use, and the accessories we wear. We hardly ever go an hour without encountering plastic.

However, as we become more conscious, there have been negative effects on both the environment and our health from the increased use of plastics. Plastic contaminates our bodies, air, seas, and landscapes. Since 1945, it has grown tremendously and been deposited into the fossil record. Scientists refer to this as the beginning of the Anthropocene, or the age of humans. They found that the plastic in the strata accurately reflects the exponential increase in plastic manufacture that has occurred over the previous 70 years [2]. Because plastic is convenient and hygienic, we have been consuming more of it since the latest worldwide epidemic, COVID-19, which had the entire planet in a chokehold and at a halt. This invention has sped up plastic trash globally and stopped SUP prohibitions that were previously planned or implemented.[2]. In fact worldwide many attempts are done mainly fostering awareness campaigns by government departments, agencies, NGOs, social activist at various platforms. Eventually many efforts are experimented with technological confluences with joint efforts by many stakeholders are worth its appreciations. However innovations, promotions and sustainability will be the necessities in future endeavours.

## Objectives:

- Understanding Plastic related problems
- Analysing impact of plastic on human lives
- Figuring out correlation of plastic waste on Global Warming
- Dearth of plastic waste management recycling in current scenario
- Learning remedial efforts to solve the plastic waste problem
- Comparative analysis of various contributions towards plastic so far
- General and Technological solutions for plastic waste management
- Promotion of good use of plastic

**Data and Methodology: 3.1. Scale of the problem:**

Let's take a deep dive into the problem with some data to back it up, to really understand the scale of the problem - first, let's take a look at Sangli, the district where we reside. 9.15 metric tons of plastic garbage were created everyday on average in Sangli in 2019[3]. This translates to a yearly production of about 3,339.75 metric tons of plastic garbage. Surprisingly, a district with a population of only 502,793 generates this much waste. Let's explore Maharashtra by zooming out. Maharashtra, the state that produces the most plastic waste in India, produced an incredible 311,254 tonnes of plastic debris in 2020–21[4]. Notably, a third of this amount came from the state capital, Mumbai[4]. Let's expand out even more: what about India? India now produces a whopping 9.3 million tons of plastic waste a year[5], and 26,000 tonnes a day[6], making it the world's top producer[5]. This number more than doubles that of the country's second-largest generator of plastic garbage, highlighting the magnitude of the problem.



**Fig 1:** Plastic Waste

Broadening our view to the continent of Asia, producing 51% of the world's plastic[8], the reason behind its huge plastic waste is the imports. Up till 2017, China was the prime location for such imports, but following the plastic import ban, developing Asian countries came at the forefront of these imports instead, receiving them from Western countries[7]. Malaysia is just an example, having imported over 300 thousand metric tonnes of plastic from the European Union[7]. The global scenario is a clear indication of the increase in plastic usage over the years. We have gone from 2 million tonnes in 1970 to a mind boggling 459.75 million tonnes in 2019[9].

**Table 1:** Plastic Waste Produced

Area	Plastic Waste Produced
Sangli	3,339.75 metric tonnes
Maharashtra	311,254 metric tonnes
India	9.3 million tonnes
Asia	234.47 million tonnes
World	459.75 million tonnes

**3.2. Why is it important to address?**

The question now becomes: why is the manufacture and consumption of plastic such a crucial issue? Although a lot of the items we use on a daily basis, such as food and clothing, add to garbage, their effects are not as severe as those of plastic. The main difference is that plastic is not biodegradable, it's a synthetic, organic polymer made from fossil fuels, such as gas and petroleum [11]; it takes 20 to 500 years for it to break down, and even then, it just breaks down into ever-tinier fragments [10]. Consider this staggering figure: a total of 8.3 billion tonnes of plastic has been produced to date, with half of that amount created in just the last 13 years [10].

Macro-plastics (pieces larger than 0.5 mm) made up 88% of global plastic leakage to the environment in 2019, around 20 million metric tons, polluting all ecosystems. Effects on Health - Human blood, placentas, and a variety of foods and drinks, such as salt, beer, and tap water, have all been discovered to contain micro plastics. Numerous chemicals used in the manufacture of plastic are known carcinogens and can affect immunity, development, reproduction, and the neurological system [11]. Impact on Climate - As discussed earlier, plastic is made from fossil fuels such as gas and petroleum. The production of plastic itself, results in the release of greenhouse gases leading to climate change [11]. This brings to mind Giddens’s paradox [12], which explains why people often fail to act on problems like plastic pollution until the consequences become unavoidable—by which point, it may already be too late. Each year, around 11 million metric tons of plastic waste flow into our oceans. To put this staggering figure into perspective, that’s equivalent to roughly 60,000 Boeing 747 jumbo jets or over 1,200 metric tons entering the ocean every hour [13]. This massive pollution stems from our insatiable demand for plastic and our inability to manage waste effectively. Between 2000 and 2019, global plastic production doubled, yet 40% of plastic waste today ends up in the environment [13]. If no major changes are made, the volume of plastic in the ocean could quadruple by 2040 [13].

### 3.3. Solutions to the Plastic Problem

Plastic pollution is a worldwide problem, with millions of tons ending up in oceans and harming animals and ecosystems. It takes hundreds of years to break down, causing serious damage to nature and human health. Solving this problem needs everyone to work together.

Global efforts to tackle plastic pollution include banning single-use plastics, the UNEA’s 2021 resolution on plastic waste, the EU’s 2019 directive, and ASEAN’s framework on marine debris, all promoting sustainability through policy, awareness, and innovation [14].

**Ban on Single-Use Plastics:** A vital step toward sustainability, these bans reduce waste and protect ecosystems despite temporary inconveniences.

**UNEA Resolution, 2021:** The United Nations Environment Assembly urged global action to enhance plastic collection, promote circular economies, and raise awareness about the plastic crisis.

**EU Single-Use Plastics Directive, 2019:** The EU banned items like straws and cutlery, set consumption reduction targets, and mandated producers to cover waste management costs.

**ASEAN Marine Debris Framework, 2019:** ASEAN focused on policy, research, public awareness, and private sector collaboration to combat marine debris.

While plastic pollution is a global challenge, Asia faces a disproportionate share of the burden, with the region accounting for a significant portion of the world’s plastic waste entering oceans. Rapid urbanization, population growth, and limited waste management infrastructure have exacerbated the problem, making targeted action in Asia crucial for global progress. Governments in Southeast Asian nations have put into effect National Action Plans to address both upstream and downstream plastic waste as a result of the region’s recent spike in plastic pollution [15]. These strategies include the Extended Producer Responsibility (EPR) program, levies, plastic restrictions, and better waste management facilities. EPR mandates that businesses manage the full lifespan of their packaging, record yearly consumption, make sure waste is recycled, and fulfill reduction targets. Failure to comply can result in fines. EPR encourages intentional actions to minimize plastic waste and phase out single-use packaging, while also promoting a circular economy by holding corporations accountable. A coordinated regional effort to combat plastic pollution and promote sustainable practices is reflected in these policies.

**Table 2:** Initiatives by South Asian Countries

Asian Countries	Targets and Initiatives
Indonesia	The Presidential Decree aims to reduce marine plastic litter by 70%. Reduce Packaging waste by 30% [15].
Vietnam	50% reduction of plastic litter by 2025. EPR Rule, through Decree No. 08/2022/ND-CD [15].
Philippines	EPR Act RA 11898, enforced in 2023 [15].
Thailand	Aim to achieve 100% recycling of waste by 2027 [15].
Singapore	Mandatory Packaging Report, by 2025 [15].

As Asia works to address plastic and waste problems, India plays a key role because of its large population and fast-growing cities. India’s efforts show how big programs can make a real difference by bringing together policies, communities, and various groups to solve these issues. The Government of India has taken proactive steps to address urban sanitation and waste management through the **Swachh Bharat Mission (SBM)**, the world’s largest program of its kind. Launched in 2014, SBM emphasizes collaboration among state governments, city administrators, civil society, the private sector, and over 400 million citizens across 4,800+ cities [16].

Inspired by Mahatma Gandhi’s vision of cleanliness, SBM promotes shared responsibility for waste disposal, sustainable consumption, and anti-littering. The program has driven localized actions and stakeholder synergy, creating significant progress: door-to-door waste collection has risen from negligible levels to 94%, source segregation to 88%, and scientific waste processing to 76% [16]. To sustain this momentum, SBM emphasizes empowering local actors such as waste collectors, recyclers, and aggregators, ensuring holistic and impactful waste management. Although India has made great progress in combating plastic pollution, states such as Maharashtra are

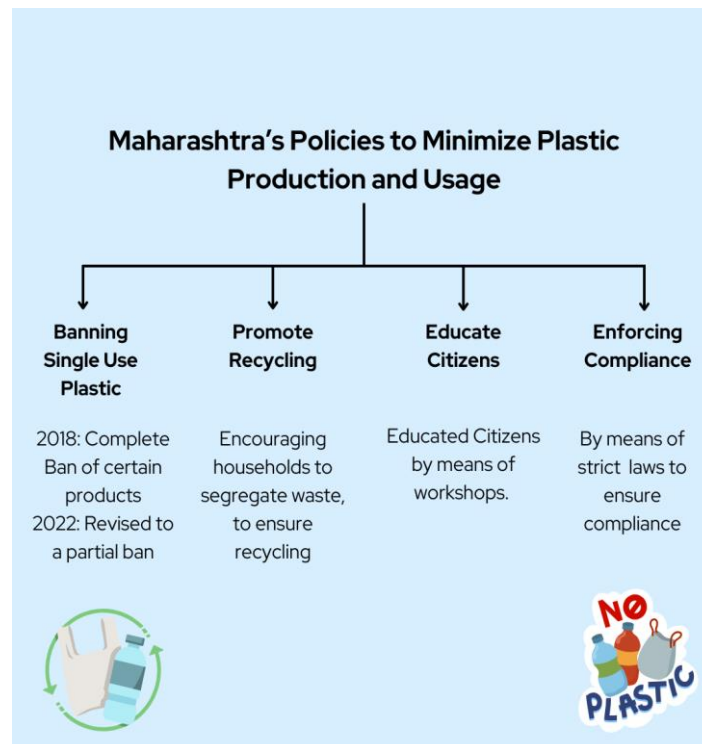
implementing focused measures to address the issue locally. Maharashtra, which is well-known for its industrial and economic activities, has taken the effort to put laws and programs into place that will lessen plastic waste and encourage sustainable behaviours. Outlawing Single-Use Polymers. To cut down on plastic waste, Maharashtra banned some single-use plastic items in 2018. Although the restriction was partially lifted in 2022 to let certain biodegradable plastic products, plastic bags smaller than 75 microns are still forbidden [17].

**Encouragement of Recycling:** To cut garbage and landfill usage, Maharashtra actively encourages localities to set up on-site composting facilities and recycling initiatives [18]. The goal of this project is to improve local sustainability and garbage management.

**Educating the Public:** To teach residents about garbage segregation, recycling, and appropriate disposal, the state hosts workshops and awareness campaigns [17]. The goal of these initiatives is to influence public opinion and provide individuals the authority to control trash in their daily lives.

**Promoting Eco-Friendly Substitutes:** Maharashtra encourages people to utilize sustainable and reusable alternatives to plastic bags, cups, and containers in order to limit their usage of plastic [17]. The state's larger objective of lowering plastic consumption includes this campaign.

**Implementing Compliance:** Maharashtra takes measures against anyone who violates its plastic prohibition in order to enforce it strictly. This entails closing businesses that don't follow the plastic restrictions, imposing environmental fines, and seizing prohibited items [19]. The state is dedicated to holding violators accountable and making sure the ban is followed.



**Fig 2: Policies in Maharashtra**

While Maharashtra has taken significant steps to combat plastic pollution, local initiatives in cities like Sangli are adding valuable contributions to the cause. These grassroots efforts, led by passionate organizations, are playing a crucial role in driving positive environmental change at the community level.

**Recycling Plastic:**

The Prithvi Zero Waste Foundation, founded by Himanshu Lele and Pawan Thombare, is committed to ensuring a landfill-free Earth[20]. They focus on recycling plastic through an in-house process, reducing waste and promoting sustainable practices within the community.

**Informative Sessions for Citizens:**

Prithvi Zero Waste Foundation organizes informative sessions for citizens to raise awareness about waste management and the importance of recycling. These sessions aim to educate the public on how they can contribute to reducing plastic waste in their daily lives.

### **Educating Young Minds:**

Prithvi Zero Waste Foundation places a strong emphasis on educating young minds, ensuring that children are aware of the environmental issues related to plastic. By making them active participants from a young age, they hope to foster a generation that is more conscious of its environmental impact.

### **Plastic Collection Drives:**

Prithvi Zero Waste Foundation also organizes plastic collection drives, "Pick Up Saturdays"[20] where volunteers collect plastic waste to ensure it gets recycled. These drives engage the community in tangible actions that contribute to the larger mission of waste reduction and sustainability.

Through their tireless work, the foundation is making a significant impact in Sangli by promoting recycling, educating the public, and actively engaging citizens in waste management practices.

## **3.4. Solutions that can be implemented (General and Technological)**

### **Strengthening Policies to Reduce Plastic Waste**

Governments worldwide can implement stricter regulations, such as banning single-use plastics, introducing plastic taxes, and incentivizing sustainable practices. For example, the European Union's Single-Use Plastics Directive sets ambitious reduction targets and bans specific harmful plastic products[21].

### **Advancing Recycling Technologies**

Modernizing recycling systems with technologies like AI-powered sorting, robotic arms, and optical recognition systems can improve recycling accuracy and efficiency. AMP Robotics, for instance, utilizes AI to sort and recycle plastics by type, reducing contamination and improving output quality[22]. Adopting Chemical Recycling and Depolymerization Chemical recycling technologies, such as depolymerization, break plastics into their original monomers for reuse. Innovations in enzymatic depolymerization have proven effective in recycling traditionally non-recyclable plastics[23].

### **Plastic-to-Fuel Conversion**

Technologies like pyrolysis convert non-recyclable plastics into fuels such as diesel or gasoline. This dual-purpose solution reduces landfill waste while addressing energy needs[24].

### **Promoting Biodegradable Plastics**

The development and adoption of biodegradable plastics, like polylactic acid (PLA), offer alternatives to petroleum-based plastics. Research shows these materials degrade more efficiently, particularly in marine environments[23].

### **Implementing Extended Producer Responsibility (EPR)**

EPR programs hold companies accountable for the lifecycle of their plastic products. By requiring producers to manage waste collection and recycling, EPR frameworks promote a circular economy. Germany's EPR system has significantly reduced plastic waste[25].

### **Smart Waste Collection Systems**

IoT-enabled smart bins equipped with sensors can optimize waste sorting and collection. For example, Bigbelly's smart bins sort waste and signal waste management services for efficient pickups[26].

### **Educating and Raising Awareness**

Public education campaigns focusing on waste segregation, recycling, and sustainable consumption can drive behavioral change. The UN Environment Programme emphasizes the importance of citizen engagement in combating plastic pollution[27].

### **Results use case:**

The Prithvi Zero Waste Foundation in Sangli has made significant progress in tackling plastic waste through innovative methods and community collaboration. Below are the key outcomes of their efforts over the past three years:

#### **1. Plastic Collection and Segregation**

The Foundation has recycled over 2,500 tonnes of plastic waste in the last three years, with an average of 70 tonnes processed monthly.

Waste is carefully segregated into categories, including meat pouches, plastic bottles, thermocol (1.5 tonnes every four months), and others. The composition of the collected waste is as follows:

- 10% PET bottles
- 20% HDPE and PP hard plastics
- 20% LDPE and PP plastic bags
- 35% Multi-Layered Plastics (MLP)
- 10% HM plastics (used in toys)
- 5% soiled waste

#### **2. Recycling and Processing**

Collected waste is baled and stored before being sent to recyclers in Malegaon, Pune, and Mumbai.

The Foundation prioritizes recycling over upcycling due to its greater practicality and environmental benefits. However, effective recycling requires a consistent input of 3–4 tonnes daily, whereas the current collection operates on a monthly cycle.

### **3. Innovative Experiments**

Projects such as using plastic to create bricks, paving blocks, furniture, and plywood have been initiated, primarily led by college students. While these innovations are promising, they remain in the experimental stage and are not yet commercially viable.

Additional ventures, like producing high-end purses from recycled plastic, show potential but are limited by high production costs and niche demand.

### **4. Community Engagement**

A network of 1,800 households actively participates in waste collection, fostering a sense of community responsibility.

Regular awareness programs and collaborations ensure public involvement in waste segregation and recycling initiatives.

Prithvi Zero Waste Foundation's focus on efficient waste segregation, partnerships with recyclers, and community-driven efforts sets a strong foundation for sustainable waste management. However, scaling operations, strengthening infrastructure, and ensuring the economic viability of new innovations are critical for further progress.

## **5. Discussions:**

### **The Hazards of Plastic**

Plastic pollution poses a severe threat to the environment, marine ecosystems, and human health. Improper disposal and the non-biodegradable nature of plastic lead to the accumulation of waste in landfills and oceans, causing harm to wildlife that ingest or get entangled in it. Microplastics have infiltrated food chains, water sources, and even the air we breathe, with potential long-term health risks. Additionally, the production and incineration of plastic contribute significantly to greenhouse gas emissions, exacerbating climate change[27].

### **The Other Side of Plastic**

Despite its environmental challenges, plastic plays a vital role in modern society. In healthcare, it is indispensable for sterile medical devices, PPE, and life-saving tools. In food packaging, plastic reduces spoilage and waste by preserving freshness and preventing contamination. Its lightweight nature makes it crucial for reducing fuel consumption in transportation, while its durability and versatility drive technological advancements, including renewable energy systems like wind turbines and solar panels[28].

### **Future Scope**

The future of plastic management requires a shift toward sustainable practices and innovations. Governments must enforce stricter policies, including bans on single-use plastics and incentives for sustainable alternatives. Investment in advanced recycling technologies, such as chemical recycling and plastic-to-fuel conversion, is essential to reduce landfill dependence. Businesses should adopt circular economy models, including Extended Producer Responsibility (EPR), to minimize plastic waste. Public awareness campaigns must educate citizens about segregation, recycling, and sustainable consumption. By fostering global collaboration and technological advancements, we can mitigate the environmental impact of plastic while retaining its societal benefits[29].

### **Conclusion:**

Plastic, while being one of humanity's most impactful innovations, presents a dual narrative of benefits and challenges. Its versatility and cost-effectiveness have revolutionized industries like healthcare, transportation, and food preservation, contributing significantly to societal advancement. However, the environmental and health hazards of mismanaged plastic waste cannot be overlooked. To navigate this complex issue, a balanced approach is required—one that embraces the utility of plastic while addressing its drawbacks. This involves fostering innovation in sustainable materials, enforcing stricter regulations, and encouraging collaborative efforts between governments, industries, and citizens. By investing in a circular economy, enhancing recycling technologies, and promoting public awareness, we can minimize the environmental impact of plastic while leveraging its advantages. The path forward lies in collective responsibility, where every stakeholder works toward a future that is both sustainable and resilient.

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### **Conflicts of Interest**

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