Investing in the Earth: Prevention of Single Use Plastic

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Abstract

Pollution from plastic endangers our nature, water, soils and food materials. Only 9% of the plastic waste produced worldwide so far has been recycled. The outstanding 79 percent has been collected in landfills, dumps, or the environment, with only about 12 percent being burned. There are 38 lakh tonnes of the total 95 lakh tonnes of plastic garbage produced in India each year, that go uncollected. In fact a large quantity of the Single Use Plastics (SUP), end up in dumps, rivers and even in the digestive and respiratory tracts of animals. Single-use plastics (SUP) misuse has negative effects on the environment, the economy, and human health. Several nations have launched campaigns to outlaw single-use plastics on a global scale. Based on the outcomes of this study, it is clear that stricter enforcement, increased awareness, and self-regulation as well as public pressure may prove a big help towards reducing SUP pollution.

Plastic, one of the most preferred materials in today's industrial world is posing a serious threat to the environment and consumer's health in many direct and indirect ways. Exposure to harmful chemicals during manufacturing, leaching in the stored food items while using plastic packages or chewing of plastic teethers and toys by children are linked with severe adverse health outcomes such as cancers, birth defects, impaired immunity, endocrine disruption, developmental and reproductive effects etc. Promotion of plastics substitutes and safe disposal of plastic waste requires urgent and definitive action to take care of this potential health hazard in the future.

Keywords: Plastic, Pollution, Single Use Plastic, economic and health effects, environment, plastics waste, recycling

Introduction

The term "plastic" comes from the Greek word "plastikos," which signifies that it may be moulded or formed into any shape. Plastics progressed from natural plastic materials like chewing gum to chemically adapted natural materials like nitrocellulose, natural rubber etc. and lastly as a whole synthetic molecule. Since plastic was developed in the middle of the 19th century and started to become popular in the 1970s, paper and glass have lost their primacy. Though some plastic can be moderately or entirely created from natural elements, most plastic is synthetic and is often made from petrochemicals like natural gas, oils and coal. Our daily lives depend heavily on plastic because it is a cheap manufacturing choice. It is used to preserve the food we consume, maintain the cleanliness of medical equipment, lighten cars and planes to reduce fuel use and also in greenhouse gas emissions. For hundreds of years, plastics have remained in the environment in some form or the other to jeopardize the security of our food sources, soils, water, and animals. Plastic production will probably double over the next 20 years and would grow four fold by the year 2050. This is based on current patterns.

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Microplastics, as the name implies, are tiny plastic particles. Officially, they are defined as plastics less than five millimeters (0.2 inches) in diameter—smaller in diameter than the standard pearl used in jewelry. There are two categories of microplastics: primary and secondary.
Primary microplastics are tiny particles designed for commercial use, such as cosmetics, as well as microfibers shed from clothing and other textiles, such as fishing nets. Secondary microplastics are particles that result from the breakdown of larger plastic items, such as water bottles and plastic bags and packaging. This breakdown is caused by exposure to environmental factors, mainly the sun's radiation and ocean waves.

The Everlastingness of Micro Plastics

The problem with microplastics is that—like plastic items of any size—they do not readily break down into harmless molecules. Plastics can take hundreds or thousands of years to decompose—and in the meantime, wreak havoc on the environment. On beaches, microplastics are visible as tiny multicolored plastic bits in the sand. In the oceans, microplastic pollution is often consumed by marine animals.
Most of this environmental pollution is from littering, but a majority of the littering with the result of storms, water runoff, and winds that carry plastic—both intact objects and microplastics—into our oceans. Single-use plastics—plastic items meant to be used just once and then discarded, such as a straw—are the primary source of secondary plastics in the environment.
Microplastics have been detected in marine organisms from plankton to whales, in commercial seafood, and even in drinking water. Alarmingly, standard water treatment facilities cannot remove all traces of microplastics. To further complicate matters, microplastics in the ocean can bind with other harmful chemicals before being ingested by marine organisms.
Scientists are still unsure whether consumed microplastics are harmful to human or animal health—and if so, what specific dangers they may pose. Even so, many countries are taking action to reduce microplastics in the environment. A 2017 United Nations resolution discussed microplastics and the need for regulations to reduce this hazard to our oceans, wildlife, and human health.

Plastics: Boon or Bane

The advent of fuel based plastics has revolutionized the industrial world and there is no area of manufacturing which is untouched by plastics. Convenience and cost factors have pitch forked plastics as the most preferred material of choice till recently, a rethinking about its impact on environment and sustainability is slowly putting a brake on its continued use. While cheap petroleum fuels from which most plastics are derived was once justified to introduce them in place of traditional materials like glass and metals, this plea cannot hold any more since the cost of non-renewable fossil fuels has increased several fold during the last three decades.
Research based on plastics proves their injurious nature towards human health in many direct or indirect ways. Phthalates or phthalate esters are esters of phthalic acid mainly used as plasticizers (substances added to plastics to increase their flexibility) in Poly Vinyl Chloride (PVC). PVC is a widely used material. It has extensive use in toys and other children's products such as chewy teethers, soft figures and inflatable toys. Di (2-ethylhexyl phthalate (DEHP), dibutyl phthalate (DBP), di-isononylphthalate (DINP), di-isodecyl phthalate (DIDP), benzyl - butyl - phthalate (BBP) and di-n-octyl- phthalate (DNOP) are phthalates mainly used in converting polyvinyl chloride (PVC) from a hard plastic to a flexible plastic. Phthalates tend to migrate into the air, into food and into people including babies in their mother's wombs. Phthalates can be released from soft PVC by surface contact, especially where mechanical pressure is applied e.g. during chewing of a PVC teether.

Release of phthalates during manufacture, use and disposal of PVC products, in addition to their use as additives in ink, perfumes etc. has lead to their ubiquitous distribution and abundance in the global environment.

Growing literature links many of the phthalates with a variety of adverse outcomes, including increased adiposity and insulin resistance, decreased anogenital distance in male infants, decreased levels of sex hormones, and other consequences for the human reproductive system, both for females and males, Infants and children may be especially vulnerable to the toxic effects of phthalates given their increased dosage per unit body surface area, immature metabolic system capability and developing endocrine and reproductive system.

Table 1: Types of Solid Waste

Sr. No.	Origin of Plastic	% age
1	Electricals and Electronics	5.1
2	Distribution and large industry	19.2
3	Building	5.2
4	Automotive	5.5
5	Agriculture	108

Source: https://cdn.downtoearth.org.in/image/20010731/stat1.jpg

International Legislation an Plastic like PET

Legislatures and government agencies in Australia, Canada, the European Union, and the United States have restricted or prohibited the use of phthalates in consumer products. The plastics industry generally asserts that Polyethylene terephthalate (PET) bottles are not a source of endocrine disruptors and must be distinguished from phthalate which acts as an additive and is chemically dissimilar. PET is most commonly used to make the clear plastic bottles in which bottled water is sold and as containers for soda beverages, sports drinks, and condiments such as vinegar and salad dressing.

PET bottles are also commonly used for the packaging of cosmetic products, such as shampoo, particularly when such products are sold in clear plastic bottles. Indeed, phthalates are not used as substrates or precursors in the manufacture of PET but the available research suggests that the concentration of phthalates in the contents of PET bottles varies as a function of the contents of the bottle, with phthalates leaching into lower pH products such as soda and vinegar more readily than into bottled water. Temperature also appears to influence the leaching both of phthalates and of antimony from PET, with greater leaching at higher temperatures. Lower-pH condiments such as table vinegar and salad dressing may warrant particular attention. The findings suggest that ingesting several servings of salad dressing that had been stored in a warm warehouse for a month might result in a dose of di-(2-ethylhexyl) phthalate (DEHP) on the order of several hundred micrograms, possibly reaching the reference dose limit of 20 μg/kg/day.

Table 2: Composition Household Waste in Europe

Sr. No.	Origin of Plastic	% age
1	Household Waste in Western Europe Organic Waste	34
2	Glass	9
3	Paper and board	27
4	Metals	5
5	Plastics	8
6	Miscellaneous	17

Source: https://cdn.downtoearth.org.in/image/20010731/stat1.jpg

Besides, playing an increasing role in packaging and consumer products plastics also take up a growing percentage of municipal solid waste streams and pose environmental challenges. Plastics have attracted severe criticism from the environmentalists because of its lack of biodegradability credentials.

Table 3: Composition of the Plastic Waste from Households

Sr. No.	Origin of Plastic	% age
1	Polystyrene	12.3
2	PET	8.5
3	Other	0.75
4	Polypropylene	18.5
5	HOPE	17.3
6	LOPE	23
7	PVC	10.7

Source: https://cdn.downtoearth.org.in/image/20010731/stat1.jpg

As widely known, plastic materials take about 100 to 1000 years to degrade when used in landfills besides polluting air and water around. Land availability will pose a challenge in many countries if landfill practice is continued and restrictions are now being put in place to curtail this approach. Besides, extremely thin plastic bags made from less than 20 micron thick films are choking the drains of many cities causing uncontrolled floods during rainy season. Plastics in garbage are estimated to be killing a million creatures in the sea every year. Plastic bags littering has lead to banned use of thin plastic bags by the consumer industry during retail sales of products in many countries.

Single Use Plastic (SUP)

The term "single-use plastic," sometimes known as "disposable plastic," refers to materials that are frequently used for plastic packaging and are meant to be used just once before being discarded or recycled. These SUP should only be used once; reusing them raises the risk of leaching and bacterial development; they are tough to sanitize; and appropriate cleaning calls for the use of extremely toxic chemicals. Between 26 and 36 percent of all plastic in the world has been made up of this single-use substance, which is intended for fast disposal.

Carry bags, plastic bottle caps, plastic drinking bottles, plastic sachets, food wrappers, plastic wrappers for consumer goods, straws and stirrers, multi- layer food packaging (such as chips packets), other types of plastic bags, and foam takeaway containers are common examples of avoidable or replaceable single-use plastic items. More than 400 million tonnes of plastic are thought to be created annually, and studies have shown that 79% of the plastic garbage that has ever been generated lying in dumps, landfills and the environment. Only 12% of plastic excess is burned, and only 9% is recycled. LDPE, HDPE, PET, PS, PP and EPS are the main polymers used to make single-use plastics. Plastics may be of two types i.e. Thermoplastics and Thermosets.

Worse Case Scenario of Single-Use Plastics Footprint

Single-use plastics are a glaring example of the problems with throwaway culture. Instead of investing in quality goods that will last, we often prioritize convenience over durability and consideration of long-term impacts. Our reliance on these plastics means we are accumulating waste at a staggering rate. We produce 300 million tons of plastic each year worldwide, half of which is for single-use items. That’s nearly equivalent to the weight of the entire human population.

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Reducing plastic use is the most effective means of avoiding this waste (and the impacts linked to plastic production and use). Carrying reusable bags and bottles is one great way to avoid single-use plastics in our day-to-day lives. Recycling more plastic, more frequently, reduces its footprint. Polyethylene terephthalate, one of the most commonly recycled plastics and the material that makes up most water and soda bottles, can be turned into everything from polyester fabric to automotive parts. But a whopping 91 percent of all plastic isn't recycled at all. Instead it ends up in landfills or merges in the environment. Single-use plastics in particular—especially small items like straws, bags, and cutlery—are traditionally hard to recycle because they fall into the crevices of recycling machinery and therefore are often not accepted by recycling centers.

Left alone, plastics don't really break *down*; they just break *up*. Over time, sun and heat slowly turn plastics into smaller and smaller pieces until they eventually become what are known as micro plastics. These microscopic plastic fragments, no more than 5 millimeters long, are hard to detect—and are just about everywhere. Some microplastics are even small by design, like the micro beads used in facial scrubs or the microfibers in polyester clothing. They end up in the water, eaten by wildlife, and end up being accumulated inside our bodies. Microplastics can be particularly dangerous for animals especially wildlife. They easily accumulate inside an animal's body and cause health issues, like punctured organs or fatal intestinal blockages.

Exposure to microplastics, as well as the chemicals that are added to plastics during processing, harm human health severally. Many of the chemicals in plastics are known endocrine disruptors, and research has suggested that human exposure could cause health impacts including hormonal imbalances, reproductive problems like infertility, and even cancer. The phthalate DEHP, as just one example from dozens, is often added to plastic goods like shower curtains and garden hoses to make them more flexible—but was also found to be a probable human carcinogen by the U.S. Environmental Protection Agency.

Plastic Waste: Global Scenario

More than 400 million tonnes of plastic are produced worldwide per year of these 36% are used for packaging, 16% are used in architecture and construction, 14% are used in textiles, and 10% are used in consumer and institutional goods. About 47% of the plastic garbage produced worldwide in 2015 was waste from plastic packaging, with Asia appearing to account for half of that total. When the amount of plastic surplus discarded into the ocean each and every year was considered in kilogrammes, it was exposed that the nations at fall were majorly:

Table 4: Solid Waste Generated Internationally

Sr. No.	Country	Waste Generated (in Tonnes)
1	India	126.5 million kg
2	China	nearly 70.7 million kg
3	Indonesia	56.333 million kg
4	Philippines produced	356,371 tons
5	Malaysia	73,098 tons
6	Brazil	37,799 tons
7	Vietnam	28,221 tons
8	Bangladesh	24,640 tons
9	Thailand	22,806 tons
10	Nigeria	18,640 tons

Source: Compiled by Author

Pollution from Plastic Bags

Plastic bags have been very useful since their inception in the 1960s. 2 Million Plastic Bags are used every minute around the world and up to 30 Million plastic bags enter the environment each year. Plastic bags are easily displaced by wind and can travel large distances. Unfortunately, they often end up falling into sensitive natural areas. Even using mainstream garbage disposal techniques (curbside rubbish bins and designated landfills), plastic bags still manage to make their way into water sources and natural areas. In the ocean, a floating plastic bag looks like a jellyfish (which is considered food by many different marine species). This is resulting in plastic consumption and ultimately prevents marine animals from digesting real food.

They can also get ripped apart during the sorting process at landfills. These ripped pieces are easily blown away from the site, which can lead to the death of animals living near landfills. These are just some of the many reasons why we must say no to plastic bags.

Plastic Straws as Microplastics

Why say no to plastic straws? Plastic straws are one of the worst polluters "floating around". Like plastic bags, their lightweight and durable design make the perfect combination for traveling long distances in the natural world. 500 million plastic straws are used per day in the United States alone, and they are not easy to recycle. They can also become brittle in the sun, which means that they can crack easily and split into tiny microplastics. Even when they don't break down they can be a direct threat to marine life as they attempt to eat the floating straws.

Plastic Bottles as Plastic Pollutants

A huge number of plastic bottles are used around the world each day. With clean drinking water being one of the staples of life, there is a serious lack of it. 663 million people around the world live without easy access to clean water. A decadent use and "throw-away" mentality goaded by clever advertising from large bottled water production companies has resulted in a staggering number of plastic bottles being used every second around the world.

Pollution from Plastic Containers and Cutlery

Takeaway containers are often made from "Styrofoam". This is polystyrene plastic with added air (about 95% air). This added air makes styrofoam one of the best artificial floating materials there is. Its lightweight design makes it perfect for traveling long distances in the wind and water. The base facts concerning it are:

- Styrofoam cannot be recycled. It will continue to pile up as waste.
- Styrene is *classified as a carcinogen to humans* according to the National Research Council – A study by the EPA detected Styrene in human tissue and breast milk samples.
- Styrofoam is not only terrible for the environment, but it is harmful to your health. Plastic cutlery becomes weak under UV conditions and breaks up into tiny pieces (microplastics) that are entering the food chain in the sea.

Plastic Leakage into Marine and Terrestrial Environments

Discarded plastic materials created a burgeoning pollution crisis in ecological systems soon after the production of consumer plastics began. Thompson et al. (2004) examined plankton samples that were collected regularly from various points along coastlines of the UK and Iceland dating back to the

1960s, and among the collected plankton samples found various polymers with increasing abundance over time. Among the earliest scientific accounts of a burgeoning pollution issue that would later be known to impact birds, fish, and other wildlife was that from two American marine biologists in 1972, Carpenter and Smith (1972), who documented findings of plastic in the Sargasso Sea in concentrations of approximately 3500 particles and fragments per square kilometer (km^2). Since then, studies have documented the presence of plastic debris at some of the highest points on Earth, e.g., the surface of Mount Everest at the China-Nepal border and at the lowest, within oceanic trenches

Forty years after Carpenter and Smith's findings, Eriksen et al. (2014) published an oceanic survey that estimated that 5.25 trillion plastic particles, weighing an estimated 268,940 tonnes, were floating as debris in the world's oceans, ranging from 0.33 mm to above 200 mm in size. Their expedition surveys spanned five subtropical gyres, as well as several smaller waterbodies and coastlines around the world, and their findings estimated plastic particle densities ranging between 1000 and 100,000 particles per km^2, reaching up to 890,000 particles per km^2 in the Mediterranean Sea. In the same region as Carpenter and Smith's study, plastic particle densities were most prevalent as small and large microplastics and based on the density estimates made by Eriksen et al. floating plastic debris had increased substantially. One year later, in 2015, a study estimated a much higher quantity of plastic debris present in the world's oceans, ranging from 15 to 51 trillion plastic particles on the ocean's surface, weighing between 93,000 and 236,000 metric tonnes. While further studies have proposed increasing estimates and various methodologies for measuring the amount of plastic debris in the oceans, these two examples demonstrate the challenges and diverging methods used in quantifying the presence of plastic pollution in the marine environment, using different volume and density metrics to capture the scale and character of marine plastic debris.

Pathways of Plastic Pollution

There is now a vast and growing body of literature documenting the ecological, social, and human health effects of litter and debris caused by mismanaged plastic waste leaking into the biosphere. Pathways of plastic pollution emerge from various sources on land and at sea. Sea-based sources of marine pollution emerge from commercial fishing industries, through both active fishing gear and abandoned and derelict fishing gear, caused by a lack of collection and on-land disposal protocols to retrieve gear that may continue to catch unintended species on land and at sea, entangle marine mammals, prevent mobility, and shed fragments over time through degradation. Abandoned, lost, and discarded fishing gear can cause the by-catch of unintended aquatic species when not retrieved, including aquatic species that are at risk. Estimates of land-based pollution have stated that plastics are also emitted in much greater volumes from mismanaged waste in inadequately functioning waste disposal sites, as well as via informal and uncontained dump sites. It is estimated that the most significant entry points for plastic entering waterways emerge in coastal cities and towns that are lacking in waste infrastructure or regular waste collection services, emitting an estimated 8 Mt of plastic waste into marine environments annually. If current rates of plastic production, consumption, and disposal are maintained, Borrelle et al. (2020) predict that the global quantity of plastic waste entering aquatic ecosystems could reach up to 90 Mt annually by 2030, with the highest rates from upper-middle-income and middle-income countries.

Plastic Waste Generation the Indian Scenario

The creation of polystyrene in 1957 marked a promising beginning for the Indian plastics sector. Significant advancements were made in the 1960s and 1970s, and the sector expanded and diversified quickly after that. The sector covers the entire nation, with over 2,000 exporters, over 50,000 processing facilities, and employs roughly 4 million people along the value chain. The majority of these units between 85 and 90 are small and medium-sized businesses that employ people. The amount of plastic garbage produced in India each year is 95 lakh tonnes, of which 38 lakh tonnes, or single-use plastics (SUP), are not collected and wind up in landfills, waterways, and even our animals. Every year, the ocean receives over 6 lakh tonnes of plastic trash.

Table 5: State / UT Wise Plastic Waste Generation

Sr. No.	State	Plastic Waste Generation (IN % Age)
1	Punjab	3
2	Madhya Pradesh	3
3	Kerala	4
4	Haryana	4
5	Uttar Pradesh	5
6	Delhi	7
7	Telangana	7
8	Karnataka	9
9	West Bengal	9
10	Gujarat	12
11	Tamil Nadu	12
12	Maharashtra	13

Source: https://cpcb.nic.in/uploads/plasticwaste/Annual_Report_2019-20_PWM.pdf

https://www.researchgate.net/profile/Neha-Tripathi-9/publication/333356328/figure/fig2/AS:762137056137217@1558719042170/Five-top-Plastic-Generating-States-in-India-Source-Centre-for-Science-and-Environment.png

Effects of Mismanaged Single Use Plastics

It is predicted that 2050, there will be almost 12 million metric tonnes of plastic garbage in landfills and the environment if we do not alter our consumption habits and waste disposal methods. Economic impacts: The fishing, shipping, and tourism businesses suffer financial losses. Lightweight foamed

plastics have a high transport cost to a centralized facility since they are challenging to recycle at nearby facilities. The expense of removing accumulated plastic waste from the environment is cost prohibitive. Environmental effects: It impairs streams, contaminates soil and water, and makes natural disasters worse. According to estimates, 99% of all seabirds will have consumed plastic by 2050.
Health impacts: By obstructing sewage systems and creating mosquito breeding grounds, it increases the risk of malaria transmission. If burned, it produces fumes and harmful compounds. If left in landfills it leaches contaminates into the soil and water table creating higher chances of food chain contamination.

Dealing with Plastic Wastes

Plastics in the waste stream are dealt with in any of three ways:

(i) Incineration
(ii) Burial
(iii) Recycling and reuse

Incineration is used to dispose off about 16% of all municipal wastes in developed countries burn garbage in waste-to-energy facilities that use heat energy to generate steam or electricity. As plastics are typically derived from petroleum or natural gas, they can generate almost as much energy as fuel oil, although the much higher amount of energy initially required to produce the plastic is lost. Potentially hazardous emissions from incinerating plastics include hydrogen chloride, dioxin, cadmium, and fine particulate matter. Despite strict air pollution standards in place, there is considerable public opposition to incineration.
While plastics are chemically inert certain additives to plastics in landfills tend to provoke concern as they may migrate from the plastics into the leachate. Plasticizers known as phthalates are hazardous substances and have been found in a number of leachate analyses at various concentrations. Significantly plastic wastes constitute about 10% by weight and about 20% by volume of the municipal waste stream and being essentially nondegradable, plastics eventually can consume a disproportionate amount of landfill space.
Recycling is a four-part exercise of collecting a mix of plastics at curbside or drop-off centers, sorting the plastics into six types, reclaiming the plastic by physically or chemically converting them to flakes or pellets, and then processing the flakes or pellets into a final product. One reason plastics are recycled less often than glass or metal is because the sorting step is very labor-intensive and, hence, expensive. However, the cost and accuracy of sorting are crucial elements in making plastics' recycling economically viable because each type of plastic has different performance characteristics that make it best suited for specific applications. Innovative methods for raising consumer awareness about separation of recyclable wastes from non recyclable is recently introduced in Thailand through "Waste for eggs campaign".

Plastic Recycling for Derivative Substances

The origins of the term and concept of 'recycling' are rooted within the oil processing industry, to describe the process of re-refining petroleum materials to reduce the quantity of waste. Once the term was popularly re-employed in the 1960s and 1970s, it became a descriptor for general material reuse and reclamation, and eventually became a commonplace term for the collection of separated waste streams.

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The packaging industry is dependent on extractive industries to produce steel, aluminium, glass, paper cardboard, and plastic. Metal and glass packaging materials often do not require the addition of primary materials into their recycling processes and are therefore suitable for repeated recycling that retains the original material properties intact. Plastic packaging, however, usually require the inclusion of additional primary materials to produce secondary materials . While recycling technologies have been developed to decrease the quantity of virgin resources necessary to produce packaging materials, current economic and technical dynamics are significant in shaping resource flows within the packaging industry.

The myriad types of plastics on the market with a range of chemical and physical properties inhibits the functioning of efficient plastic recycling. Additionally, recycled plastics are continually in economic competition with the virgin plastics market, which has a higher relative material efficiency as compared to secondary plastic production, due to the ongoing availability of lower-cost feedstock. Various methods are used to treat plastic waste. Two main methods of recycling are available in mechanical and chemical form. Mechanical recycling, also termed 'back-to-polymer' recycling, allows for the recovered material to be remanufactured or downgraded into a new product with a different function. Chemical recycling, also termed 'back-to-monomer' recycling, concerns the recovery of a product into its chemical constituents, permitting closed-loop recycling that maintains a material's original quality. Closed-loop recycling is possible when a resin "is returned at the end of its initial lifetime in a fit state to fulfill the service for which it was originally produced". Open-loop recycling, by contrast, remanufactures a product with a loss in physical quality and properties.

Investing in the earth – Efforts at Amelioration

The OECD (2021) distinguishes between two important factors that are relevant in defining recycling capacity, clarifying further the discrepancy between perceived and actual recyclability. A material's technical recyclability is based on the currently existing recycling technologies available, while practical recyclability is subject to greater regional differences across the world, given that each country has access to different recycling and waste management infrastructure largely shaped by available public funds, market conditions, and socio-economic determinants.

Cognizant of the many factors hindering recovery of plastics and production of secondary plastics, it has been recognized that plastic recycling produces the lowest CO_2 emissions compared to other methods of plastics production. Globally, mechanical recycling is the most available method of plastic recovery, and chemical recycling rates still remain quite low. Enkvist and Klevnäs [determined that current primary plastic production produces 5.1 tonnes of CO_2 per 1 tonne of primary plastic (both in production and embedded carbon use), compared to the production of secondary plastics via mechanical recycling, which produces 1.4 tonnes of CO_2 emissions per 1 tonne of recycled plastic. Additionally, looking forward, they projected that mechanical recycling would produce only 0.1 tonnes of CO_2 emissions per 1 tonne of secondary plastic produced, based on projections for 2050 regarding increased decarbonization in recycling technology. The recycling is summarized in table 6.

Table 6: Processes of Recycling

Sr. No.	Recycling	Description
1	Mechanical Recycling or Primary recycling	Employs the mechanical recycling process to retain original quality of material properties. Also as closed-loop recycling within a circular economy
2	Mechanical Recycling or Secondary Recycling	Employs the mechanical recycling process resulting in lower-quality material properties. Also known as downgrading in the

		circular economy
3	Chemical Recycling or Tertiary recycling	Employs the chemical recycling process to the material's chemical constituents to retain original chemical properties. Also known as depolymerization and repolymerization in a circular economy
4	Energy Recovery and Incineration or Quaternary recycling	Employs thermal recycling and energy recovery through incineration of materials. It is not considered recycling in a circular economy.

Source: Compiled by Author

Plastic Industry Regulations in India

Plastic processing and reprocessing industries are also exempted from monitoring by Pollution Control Board. With regard to safety guidelines for toys in India, Bureau of Indian Standards (BIS) has published three standards which deals with safety aspects of toys related to mechanical and physical properties, flammability requirements and migration of certain elements (limiting heavy metals in toys). None of these standards give limits for phthalates in children's toys and child care articles. The BIS guideline with regard to toy production is self regulatory and not mandatory. Toy manufacturers do not register even for the ISI mark for their products and therefore do not follow even the voluntary standards.

Regulation on Plastic Use and Disposal in India

Regulation of plastics waste, particularly manufacture and use of recycled plastics carry bags and containers is being regulated in the country as per "Recycled Plastics Manufacture and Usage Rules", 1999 and as amended in 2003. This has now been replaced by Plastic Waste (Management and Handling) Rules, 2011.

Some of the salient features of the new Rules are

- Ban on use of plastic materials in sachets for storing, packing or selling gutkha, tobacco and pan masala,
- No food stuffs will be allowed to be packet in recycled plastics or compostable plastics,
- Recycled carry bags to have specific bis standards, colour to the prescription by the bureau of indian standards (bis),
- Uniform thickness shall not be less than 40 microns in carry bags etc.

One of the major provisions under the new Rules is the explicit recognition of the rule of waste pickers. The new Rules require the municipal authority to constructively engage agencies or groups working in waste management including these waste pickers. This is the very first time that such a special dispensation has been made.

Municipal or Government authorities and NGOs may play a crucial role in recognizing and legitimizing both plastic waste recovery and trading activities and equipping them with state of art designs of waste management technology and system. Developing safe and low cost technology for which SSIs need institutional and scientific support and making mandatory of guidelines related to safety, process and product standards in consultation with plastic associations are one of the few ways. The Municipal authority under new rules is hold responsible for setting up, operationalization and coordination of the waste management system and for performing the associated functions, This will include ensuring safe collection, storage, segregation, transportation, processing and disposal of plastic waste, no damage to the environment during this process, setting up of the collection centers for plastic waste involving manufacturers, its channelization to recyclers, to create awareness among all stakeholders about their responsibilities, and to ensure that open burning of plastic waste is not permitted.

To date, research on the human health impacts of plastic has focused narrowly on specific moments in the plastic lifecycle, often on single products, processes, or exposure pathways. This approach fails to recognize that significant, complex, and intersecting human health impacts occur at every stage of the plastic lifecycle: from wellhead to refinery, from store shelves to human bodies, and from waste management to ongoing impacts of microplastics in the air, water, and soil.

Exposure to the Life Cycle of Plastics

At every stage of its lifecycle, plastic poses distinct risks to human health, arising from both exposure to plastic particles and associated chemicals. People worldwide are exposed at multiple stages of this lifecycle.

(i) Extraction and transportation of fossil feedstocks for plastic, which releases an array of toxic substances into the air and water, including those with known health impacts like cancer, neurotoxicity, reproductive and developmental toxicity, and impairment of the immune system;

(ii) Refining and production of plastic resins and additives, which releases carcinogenic and other highly toxic substances into the air, with effects including impairment of the nervous system, reproductive and developmental problems, cancer, leukemia, and genetic impacts like low birth weight;

(iii) Consumer products and packaging, which can lead to ingestion and/or inhalation of microplastic particles and hundreds of toxic substances;

(iv) Plastic waste management, especially "waste-to-energy" and other forms of incineration, releases toxic substances including heavy metals such as lead and mercury, acid gases and particulate matter, which can enter air, water, and soil causing both direct and indirect health risks for workers and nearby communities;

(v) Fragmenting and microplastics, which enter the human body directly and lead to an array of health impacts (including inflammation, genotoxicity, oxidative stress, apoptosis, and necrosis) that are linked to negative health outcomes ranging from cardiovascular disease to cancer and autoimmune conditions;

(vi) Cascading exposure as plastic degrades, which further leach toxic chemicals concentrated in plastic into the environment and human bodies; and

(vii) Ongoing environmental exposures as plastic contaminates and accumulates in food chains through agricultural soils, terrestrial and aquatic food chains, and the water supply, creating new opportunities for human exposure.

Innovatively Minimizing Single Use Plastics

- When going shopping, always carry a reusable bag.
- Buy in quantity. Avoid items that are separately packaged.
- Turn 'single-use' into 'multi-use'.
- Avoid single-use plastics such as drinking straws.

The 7 R's of maintaining Sustainability in the Environment

Here are some important questions to ask yourself before making your next purchase:

(i) Rethink – is the product really needed

(ii) Refuse – say no to single use plastic and items that are not recyclable or reusable

(iii) Reduce – limit the number of 'single-use' items that you buy

(iv) Repurpose – try upcycling your plastic
(v) Reuse – clean the plastic and use it again
(vi) Recycle – learn how to recycle plastic correctly
(vii) Remove –Prevent accumulation of trash in the environment. Every bit counts!

Steps to Reduce Plastic Waste

1. Carry cloth bags to the grocery store (or any store!).
2. Avoid beverages in plastic bottles. Glass is great.
3. Carry reusable steel or ceramic beverage container.
4. Aviod to-go coffee or hot drinks. The lid and cup will live on for over 100 years! Ask for a ceramic, reusable cup.
5. Favour farmer's market and purchase fresh fruits and veggies (not packaged in plastic).
6. Do not buy convenience foods packages in plastic.
7. Make your own bread or Buy bread from bakeries that package in paper.
8. Clean with baking soda and vinegar instead of cleaners packaged in plastic.
9. Buy laundry detergent in boxes, not liquid in plastic containers.
10. Buy farm fresh eggs in reusable paper containers.
11. Package your leftovers in steel or glassware
12. Use bar soap to wash your dishes. Stop using deodorant or antiperspirant. It's not natural to prevent yourself from sweating. Use perfume in a glass bottle if you want a nice smell.
13. Do not use air fresheners. Light a candle or incense instead.
14. If you purchase something bottled in glass, clean it and reuse it!
15. Compost trash, reduce use of plastic trash bags.
16. Line small trash bins in the house with paper bags.
17. When ordering drinks, say "no straw please!"
18. Buy toilet paper that is wrapped in paper, not plastic.
19. Don't use ziploc. Use aluminum or better waxy paper.
20. Use cloth rags for cleanly up around the house, no paper towels – reduces your trash and need for trash bags.
21. Use matches instead of plastic encased lighters.
22. Use cloth napkins. They feel nice and reduce your waste and use of plastic trash bags.
23. Bring your own bag to all stores you shop in and say "no bag needed, thanks!"
24. Put empty cardboard boxes in your car to transport heavy items to and from your car without a bag.
25. Say "paper not plastic" at the grocery store.
26. Don't use plastic chopping boards. Use wood or glass.
27. Use baby bottles made of glass.
28. Use stainless steel sippy cups for kids.
29. Use cloth based toys for your pets
30. Buy cloth diapers. Many great varieties available and better for the baby. Disposal diapers will leach toxins into the environment for centuries to come.
31. Use rechargeable batteries to reduce buying batteries packaged in plastic.
32. Make a compost heap to reduce your food waste and put it back into the earth.
33. Use a reusable cloth bag or old fashioned steel lunch box to carry your lunch to work or school.

Adopt innovative ideas to reduce your plastic footprint consciously.

Conclusion

Plastic Waste Management both in India and abroad has assumed huge significance. Innovative approaches for use of plastic substitutes under conditions of common use merits further research.

In line with the principle of 'extended producer's responsibility' the new rules for the first time in India has underlined the role of municipal bodies in not only ensuring safe collection and disposal of plastic wastes but also in engaging agencies or groups working in waste management including waste pickers.

A roadmap can be created when single-use plastics are prohibited. The transition to greener options could take some time. Circular thinking and waste administration systems can be strengthened in the interim to aid in the reduction of plastic pollution.

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