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A Review on Quantification of Plastic Waste Generation and Disposal in India

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Abstract: *Earth observed the first Plastic overshoot day on 28th July 2023 when the total amount of plastic waste on the earth exceeded the global plastic waste handling capacity. India ranks fifth in the world in plastic waste generation. As per a recent report by Earth Action, with 98.55% of waste being mismanaged, India is placed at fourth position in the mismanaged waste index (MWI). This is a cause of grave concern as the large population size, lack of awareness, unavailability of adequate waste handling infrastructure coupled with non-biodegradable nature of plastic products and harmful effects of improper waste handling poses long term risks to human life as well as other species in the environment. In this context, to understand the plastic waste management scenario in India, this review paper aims to present the trends on plastic consumption, the plastic waste generation and disposal practices and statistics in India.*

Keywords: *plastic consumption in India, Plastic waste generation in India, Plastic waste disposal practices used in India.*

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I. Introduction

The production and consumption of plastic products has exponentially increased over the last seven decades. Today, plastic is the most omnipresent and imperative material that dominates the everyday life of people around the world and has turned out to be an important and integral part of the global economy.Due to their ease of manufacturing, flexibility, durability, versatility, high strength-to-weight ratio, imperviousness to water and low cost, plastic products are used in diverse areas ranging from household needs, agriculture, construction, electrical and electronic appliances, automobile industry, medical sector, furniture and toys manufacturing to name a few. Plastic applications have become so widespread that we eat in it, sleep on it, play with it and pipe out oil and water through it. The rapid rate of development and urbanization, change in socio-economic conditions and consequently, the change in lifestyle has resulted in increased plastic waste consumption. The Covid-19 pandemic greatly added to the utilization of single use plastics (SUP).Packaging industry has seen the biggest jump in the use of this wonder material - from plastic plates, glasses, straws, water bottles, personal care products to plastic layers in wrappers for chips, biscuits, tea bags to everything that is packed for human consumption. Most of these packaging products have a short lifecycle as these are immediately discarded after the use of products, however, due to their non-biodegradable nature, plastics persists in environment for longer durations. The accumulation of plastic objects in earth's environment is termed as plastic pollution or plastic waste (PW). The entire world is grappling with the problem of PW as the whole globe is littered with this omnipresent material including the ecologically rich areas and remotest of pristine ecosystems. The linear economy model based on make-use-dispose has polluted our land and oceans. The increased use of plasticsin recent years coupled with their short lifecycle has enormously contributed to the solid waste stream. In addition to being a solid waste issue, PW is a chemical waste issues as well. Plastics release harmful chemical throughout their lifecycle polluting water, air and soil and therefore endangering human and environmental health. Plastics are accountable for 3.4% of global greenhouse gas emissions and thus have a substantial carbon footprint [].

The ubiquitous nature of this wonder material has caused ubiquitous environmental problems. Unfortunately, the properties like low cost, durability and versatility which have made plastics usable for various applications have also turned plastic into a major waste management obstacle. PW has become one of the greatest threat that our plant faces today. Despite a global recognition of this certitude, plastic production and consumption continues unabated and PW is increasingly seen in every nook and cranny of the environment.PW is choking our landfills, waterways and oceans and is causing irreversible environmental degradation. Due to lack of adequate waste management infrastructure and littering habits of populace, proper and scientific disposal of PW continues to be a major challenge. Owing to the inefficiencies in the waste collection and transit system, large amounts of PW is not able to make its way to reuse/recycling chains and therefore gets disposed of in improper, unscientific and unsafe manner. Mismanagement of PW is a serious

cause of concern in developing countries like India. More so when India ranks fifth in PW generation and fourth on mismanaged waste index [].According to a report by Earth Action, India is one of the twelve countries responsible for 52% of world's mismanaged PW [] and also accountable for 71% of mismanaged PW in Asia []. As per a joint study by FICCI and Accenture, due to the unsustainable packaging practices, India is estimated to lose plastic material value worth 133 billion dollars by 2030 out of which plastic material value worth 100 billion dollars, a whopping 75% of the value, is retrievable []. It implies that, if properly collected and recycled, the PW challenge may turn into a viable economic opportunity which will lead to job creation in addition to the main objective of environment and human health preservation. In this context, the present scenario of PW in India is reviewed in this paper.

The rest of the paper is organized as follows. Growth of plastic consumption in India is presented in section 2. Statistics on PW generation in India are discussed in section 3. Section 4 presents the PW disposal practices followed in India and Section 5 concludes the paper.

II. Plastic Consumption in India

Plastics consist of a wide range of synthetic and semi-synthetic macromolecules formed through polymerization. Plastics are malleable i.e. pressure, heat or any other type of force can be applied to macromolecules to give them a desired shape. Plastics have become an integral part of human life ranging from simplest of the products like paper clips to parts of most complex systems like airplanes. These are increasingly being used in diverse areas from packaging to hardware, healthcare to entertainment, clothing to shelter, agriculture to construction and infrastructure to communication. The expansion of industrial activities and the proliferation in urban population have led to the increased demand of plastics worldwide. In addition to this, various initiatives by Indian government like "Digital India", "Make in India" and "Skill India" have resulted in increased consumption of plastic products in India. The growth of plastics consumption over last three decades in India is presented in Figure 1.

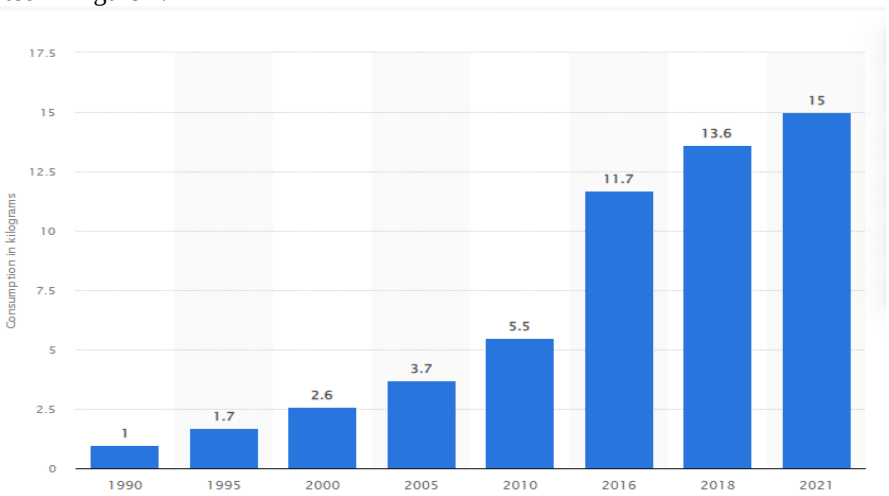

Figure 1: *Growth of plastic consumption in India over last three decades (Kilograms per capita) []*

As seen from Figure 1, the plastic consumption was 1kg per capita in 1990s and steadily increased till 2010 when it became 5.5kg per capita. The growth rate on year on year basis varied from 25%-70% with a downward consumption trajectory from 1990 to 2010. In 2014-15 various initiatives by the Indian government made plastic consumption to shoot up. In comparison to 2010, the plastic consumption increased by around 113%, i.e. it became more than doubled, in 2016 and became 11.7kg per capita. As per 2021 the per capita plastic consumption in India stands at 15kg. Though the per capita consumption in India is very low in comparison to major economies of the world. However, given the population size of our country, the total amount of plastic consumed is very high.Plastics have become versatile and imperative for economic growth in many sectors.The distribution of sector-wise plastic consumption in India is shown in Figure 2.

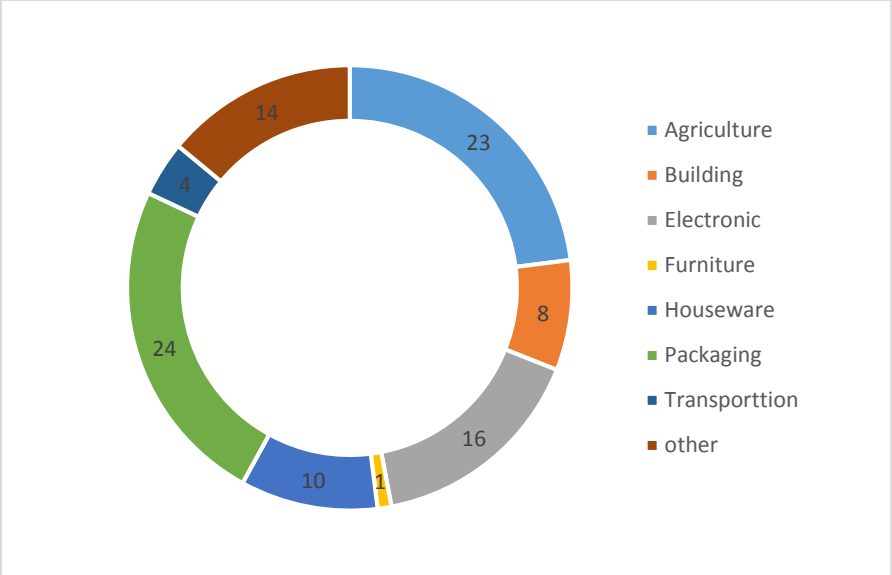

Figure 2: *Plastic consumption by various sectors in India [].*

As evident from Figure 2, packaging industry has emerged as the biggest user of plastics. From plastic plates, glasses, straws, water bottles, personal care products to plastic layers in wrappers for chips, biscuits, tea bags to everything that is packed for human consumption is wrapped using various types of plastics.

Packaging industry is closely followed by agriculture sector which consumes 23% of plastics in India. In agriculture, plastic films are used for storing the grains, animal feed and also for mulching. Plastic pipes are used in circulation irrigation systems. Plastic nets are used for creating low tunnels which, except the complexity and height, act like a greenhouse. Electrical and electronics industry occupies the third position in plastic consumption electrical wires are insulated using a type of thermoplastic named PVC and light fitting, switches and handles are made using thermoset plastics. Plastics are used as housing for various products such as desktops, laptops, keyboard mouse, fridge, TV etc. Household users of plastics make the fourth biggest segment in India which is closely followed by building and construction industry. Transportation and furniture industry also employ plastics.

III. Plastic Waste Generation in India

As observed in previous section, the consumption of plastic products in India has gone up fifteen folds in last thirty years thereby increasing the amount of plastic generated in the country. The lack of adequate infrastructure for waste management has further exacerbated the problem of plastic waste. The fragmentations in waste collection process is the root cause of inadequate waste collection coverage. Lack of proper segregation at the source results in higher generation rate for plastic waste. Single use plastics (SUP) are the biggest contributors to the PW as these products are discarded immediately after their use and become a part of solid waste stream. The growth of plastic waste in India over the last five years in shown in Figure 3 below. The PW generation details are provided by 35 states and UTs and corroborated by Central Pollution Control Board (CPCB) in their annual reports []. As seen from figure 3, the PW generation was around 15.68 Lakh Tonnes in 2016-17 which came down to around 6.6 Lakh Tonnes the very next year.

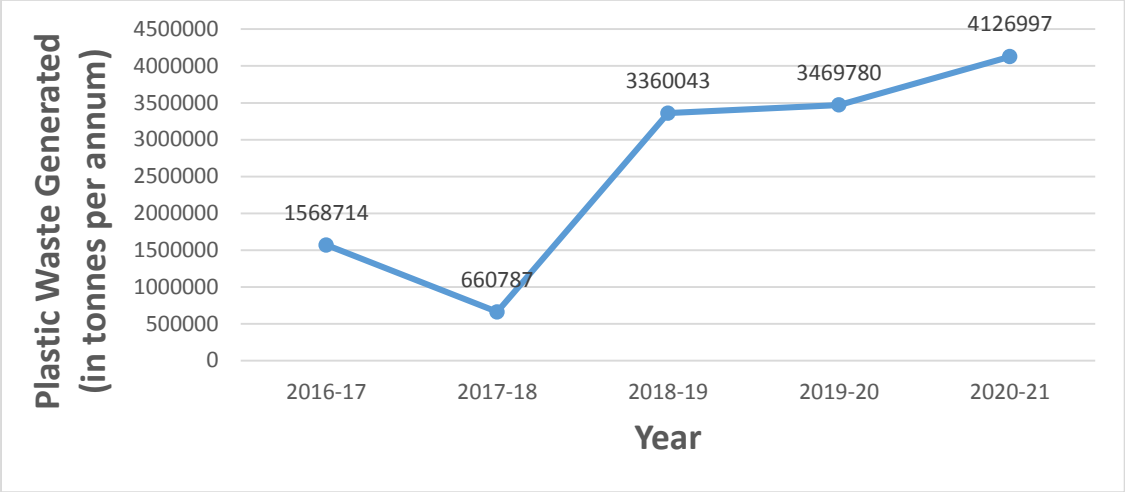

Figure 3: *Growth of plastic waste generation in India []*

Actually, it is not the reduction in quantum of waste generated but lack of data provided by states and UTs. Out of 35 states and UTs, data was provided to CPCB by 21 entities in 2016-17 and only 13 entities provided PW generation data in 2017-18.

Table 1:*State-wise and year-wise plastic waste generation in India from 2016-17 to 2020-21. []*

S. No.	States/UTs	Year				
		2016-17	**2017-18**	**2018-19**	**2019-20**	**2020-21**
	Andhra Pradesh	82863	NA	66314	46222	39626.45
	Arunachal Pradesh	NA	6	3787.37	2721	3755.9
	Assam	24030	NA	32277.87	24971	58765
	Bihar	2280	2280	68903.328	41365	74263.69
	Chhattisgarh	7300	NA	6000	32850	47450
	Goa	NA	NA	32580.52	26068	29441
	Gujarat	269294.88	269808	356873	408201	337693.96
	Haryana	23369.09	NA	68735.26	147734	185168
	Himachal Pradesh	255	NA	3672	13683	6206.78
	Jammu & Kashmir	NA	27870	34367.37	74826.33	51710.6
	Jharkhand	NA	NA	51454.53	43332	20263.45
	Karnataka	419600	NA	272776	296380	368080
	Kerala	NA	NA	133316	131400	120063.87
	Madhya Pradesh	50457.07	61037	72327.39	121079	138483.58
	Maharashtra	21420.33	NA	409630	443724	311254
	Manipur	NA	24	12453.8	8293	10303
	Meghalaya	13.265	15.096	1263	5043	
	Mizoram	NA	NA	13.306	7909	1514.51
	Nagaland	NA	14052.5	268.18	565	4785.94
	Odisha	6890.805	12092.205	90138.98	45339.4	51269.9
	Punjab	163423.4	54066.1	119414.64	92890	108332.06
	Rajasthan	NA	NA	104704.383	51966	66324.57
	Sikkim	102.7	NA	5.66	69	82.75
	Tamil Nadu	79114.792	NA	401091	431472	430107
	Telangana	NA	NA	183014.65	233655	472675
	Tripura	30	28.5	26.2	32	61.65

	Uttar Pradesh	152492.644	206733.450	254401.8	161148	375950
	Uttarakhand	NA	NA	31093	25203	18647.75
	West Bengal	NA	NA	300236.12	300236	417925
	Andaman and Nicobar	365	NA	1850	387	492.342
	Dadra and Nagar Haveli	NA	NA	1947.7	1948	4726
	Chandigarh	21516.75	12775	11715.4	6746	13107.15
	Lakshadweep	NA	NA	148	46	523.54
	Delhi NCR	232732	NA	224810	230525	345000
	Puducherry	9252.25	NA	8433	11753	12754

Since 2018-19 all the entities have presented their PW generation statistics to the CPCB. The PW has grown by almost 23% over a span of three years i.e. from 2018-19 to 2020-21. The per capita PW generation has gone up from 1.22kg in 2016-17 to 3.1kg in 2020-21 [], i.e. per capita PW generation almost tripled over a short span of five years. The state-wise breakup of plastic waste generation from 2016-17 to 2020-21 is shown in Table 1.

As seen from Table 1, in 2019-20 Maharashtra contributed 13% to the total plastic waste generated in India and was the biggest generator. With 12% contribution from each, Tamil Nadu and Gujrat second biggest PW generating states which were closely followed by Karnataka and West Bengal with each contributing 9% to the PW. Thus, more than half (55%) of the PW in India in the year 2019-20 was generated by five states. During the same period, per capita PW generation was highest in Goa followed by Delhi, Kerala, Mizoram and Gujrat.

In 2020-21, Telangna occupied the top spot in total PW generation category by adding 12% to the quantum of PW. Tamil Nadu and West Bengal contributed 10% each and occupied the second position. With 9% contribution from each state, Karnataka and Uttar Pradesh became the third largest PW generating states. Again 50% of PW came from top five generators. Delhi topped in per capita PW generation closely followed by Goa and Telangna.

This plastic waste consists of different types of plastics. Based on the properties of plastics, their applications and recyclability, plastics, consequently the plastic waste, are categorized into seven types by Plastics Industry Association (PIA) and the same categorization has been adopted by Bureau of Indian Standards (BIS) []. This classification helps to identify the basic raw material used for plastic product and to mark the product with a standard marking code so that sorting and subsequently the recycling becomes easier. The classification given by PIA is presented in Table 2 along with a few applications for each category and recyclability information and the contribution of each type of plastic in the total plastic waste generation in India is shown in Figure 4.

Table 2: *Categorization of plastics [].*

Name of Plastic	**Recyclability**	**Used for making**	**Type of Recycling**
Polyethylene Terephthalate (PET)	Widely Recycled	Water and soft drink bottles, food jars, medicine bottles, films, polyester cloth, furniture, carpets, panels	Converted back to polymer and used for making apparel
High-density Polyethylene (HDPE)	Widely Recycled	Milk pouches, shampoo bottles, carry bags, oil bottles, recycling bins, cups, detergent bottles, cutting boards	Converted to pellets and used to produce new HDPE
Polyvinyl Chloride (PVC)	Sometimes Recycled	Pipes, sheets, plastic foils, hoses, wire covers, multilayer tubes, lawn chairs, window profile, fencing	Pyrolysis, hydrolysis and heating are used to convert PVC waste into calcium chloride, hydrocarbon products and heavy metals. These are used to produce new PVC or as feed for other manufacturing processes or as fuel for energy recovery
Low-density Polyethylene (LDPE)	Sometimes Recycled	Squeeze bottles, plastic bags, trash bags, dispensing bottles, cling wrap, wash bottles	Converted to pellets and used to produce new LDPE
Polypropylene (PP)	Not Frequently Recycled	Disposable cups, yoghurt containers, toys, bottle caps, surgical tools, auto parts, straws, take away food boxes, industrial fibers, plastic furniture	Converted to pellets and used to produce new PP
Polystyrene (PS)	Not Recycled	Disposable cutlery, plates, trays, glasses, spoons, plastic forks, foams, CD covers, thermocol, cassette boxes, housing of computers, toys, hair combs, egg cartons	Not recyclable

Others (O)	Not Recycled	Thermoset plastics, nylon SMC, melamine plates, shoe soles, helmets, multilayer and laminates, Chips packets, baby feeding bottles, sachets, cigarette buds, toothpaste tubes	Not recyclable. However, multilayer packaging could be crushed and using adhesives could be turned into sheets and boards for roofing.

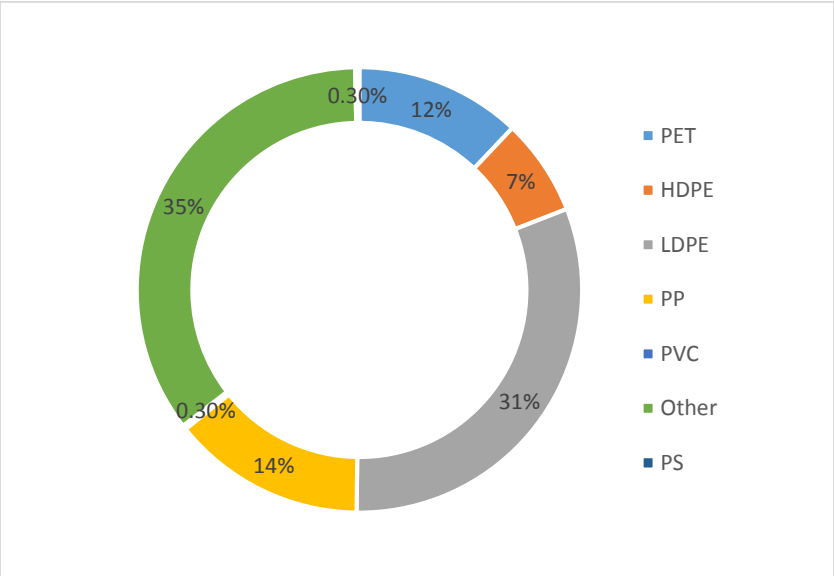

Figure 4: *Plastic waste composition in India [].*

As seen from Figure 4, "Others" category, which contains mostly non-recyclable plastic materials, is the largest contributor making up the 35% of the PW generated in India. Personal care products packaging, cigarette butts, sachets and multi-layered plastics (MLP) are included in this category []. As evident from the name itself, the MLP are made up of multiple layers of different types of plastics and sometimes paper and metal are also incorporated in the layers. Presently, the separation of layers is not commercially viable thereby making the recycling of MLP challenging [].

The next major portion of the PW is constituted by LDPE which is sometimes recycled. PP is the third largest contributor and the waste in this category is not frequently recycled. PET and HDPE contribute 12% and 7% respectively to the total amount of PW and both these categories are widely recycled. Thus, only a meagre 19% of PW is easily and frequently recyclable in India and 45% of waste is made of material which can be recycled but recycling it is not easy and therefore not widely recycled. Rest 36% of the PW is made up of plastic products which are not recycled at all.

IV. Plastic Waste Disposal in India

PW has a compound composition as it consists of different types of plastic materials and in many cases the waste plastic is combined with other types of wastes thereby making the segregation difficult. Thus, managing the PW is very complicated especially in countries like India where a major portion of collection and segregation workforce is constituted by the informal sector with multi-tier actors. This leads to obscurity in the flow of PW and it becomes difficult to trace the PW in the different waste streams. 42-86% of the waste in India is handled by the informal sector where the lack of knowledge and lack of technology driven solutions results in diversion of major chunk of waste to the landfills []. Also, the PW that reaches reuse/recycling facilities is generally contaminated thereby making the material recovery process extremely difficult and unprofitable which eventually leads to dumping of waste to the landfills.

Though India is the fifth largest PW generator in the world, the biggest concern is ineffective waste management rather than the amount of PW itself. Therefore, ensuring sufficient collection coverage, proper segregation and scientific disposal of the PW is the main focus. A total of 4953 registered units across 30 states/UTs and 823 unregistered units in 9 states/UTs are engaged with plastic/PW in India []. The distribution on these units across states/UTs is given in Table 3.

Table 3: *State-wise manufacturing/recycling capability and possible disposal methods [].*

States/UT	Registered plastic manufacturing/recycling units	Unregistered plastic manufacturing/ recycling units	Multilayer manufacturing units	Possible recycling and disposal methods involved
Andaman and Nicobar	–	–	–	Recycling, Road construction
Andhra Pradesh	Manufacturing units—131 Compostable units—1	–	–	Recycling, Road construction, Co-processing in cement kilns
Arunachal Pradesh	–	–	–	No information
Assam	Manufacturing units—18	–	5	Road construction, Co-processing in cement kilns
Bihar	Manufacturing/Recycling units—8	Producers—225 Brand owners—203 Recyclers—36	–	No information
Chandigarh	Recycling units—7	–	–	RDF processing plant
Chhattisgarh	Manufacturing units—8 Recycling units—8	–	–	Recycling, Co-processing in cement kilns, Waste-to-energy plant
Daman Diu & Dadra Nagar Haveli	343	–	–	No information
Delhi	Producers—840	–	–	Waste-to-energy plant
Goa	Manufacturing units—35 Compostable unit—1	–	1	Recycling, Co-processing in cement kilns, Sanitary landfills
Gujarat	Manufacturing/Recycling units—1027 Compostable units—12	–	10	Co-processing in cement kilns
Haryana	Manufacturing units—69 Compostable unit—1	–	28	Road construction
Himachal Pradesh	No information	24	79	Road construction, Co-processing in cement kilns, Waste-to-energy plants
Jammu & Kashmir	259	45	–	No information
Jharkhand	Manufacturing units—59	–	–	Road construction, Co-processing in cement kilns, Reverse Vending Machines
Karnataka	Manufacturing/Recycling units—163	91	–	Recycling, Co-processing plants
Kerala	Manufacturing units—1266 Producers—82 Recycling units—99 Compostable unit—1	–	–	Recycling
Lakshadweep	–	–	–	Recycling
Madhya Pradesh	Manufacturing and Recycling units—164 Compostable unit—1	–	22	Recycling, Road construction, Co-processing in cement kilns
Maharashtra	Recycling units—62 Compostable manufacturing units—6	42	–	No information
Manipur	Manufacturing units—4	–	–	No information
Meghalaya	4	–	–	Road construction
Mizoram	–	–	–	Recycling
Nagaland	Manufacturing units—4	–	–	Recycling, Road construction
Odisha	Manufacturing units—13	–	3	Co-processing in cement kilns
Punjab	Manufacturing/Recycling units—187 Compostable units—2 Material Recovery Facility—169	48	4	Recycling
Puducherry	Manufacturing/Recycling units—49 Compostable unit—1	–	4	Road construction, Co-processing in cement kilns
Rajasthan	Manufacturing units—69	–	16	No information
Sikkim	–	–	–	No information
Tamil Nadu	Manufacturing units—78 Recycling units—227	–	3	Recycling, Road construction, Co-processing in cement kilns
Telangana	Manufacturing/Recycling units—316	–	2	Recycling, Road construction, Co-processing in cement kilns
Tripura	Manufacturing units—26 Recycling units—4	–	2	No information
Uttarakhand	Manufacturing/Recycling units—33 Compostable units—2	15	28	Recycling
Uttar Pradesh	Manufacturing units—99 Recycling units—16 Compostable units—4	23	63	Road construction, Co-processing in cement kilns, Waste-to-energy plant, Production of fibers and raw materials

West Bengal	Manufacturing/Recycling units—157 Compostable unit—1	–	9	Road construction

Though it is claimed by the government that 60% of PW in India gets recycled [], based on CPCB data, a study by Center for Science and Environment (CSE) concluded that India could recycle only a meager 12% of its PW []. Furthermore, as per CSE, 20% of PW gets burnt through incineration facilities, plastic-to-fuel plants, road construction activities and cement plants and a whopping 68% of the PW in India is unaccounted for []. This unaccounted PW makes its way to landfills, is littered over land and water thereby clogging the water bodies. Like the applications of plastics, the harmful effects of PW are far and wide. PW causes soil, air, waterways and marine pollution. SUP and non-recyclable plastics are the major cause of concern as these do not fetch value and therefore not collected by the rag-pickers. To overcome this problem, w.e.f. 1st July 2022, the Indian government imposed a country wide ban on SUP items with high littering potential and low utility []. The government also issued notification to prohibit manufacture, import, sale and use of plastic carry bags thinner than 120 microns which took effect from 31st December 2022 []. However, the enforcement of the rules remained a challenge and there has been no significant improvement in the situation and the banned SUP items are still being blatantly used. Also, in the absence of proper management strategies, most of the waste in this category either gets openly burned leading to release of toxic fumes or gets openly dumped leading to choked drains and unpleasant landscapes which serve as breeding grounds for disease vectors.

V. Conclusion

India is grappling with the problem of plastic waste. In addition to the burgeoning amount of plastic waste, mismanagement of the waste is biggest challenge. Lack of awareness and strategy result in dumping of recyclable materials to the landfills which leads to the loss of revenue. The weak regulatory mechanisms and lack of strict enforcement create hindrances to proper management of waste at both industrial and individual levels. In order to handle the waste effectively and maintain traceability, better integration and regulation of formal and informal sector is important. Sustainable practices such as behavioral change to bring down the plastic consumption, availability of alternative materials, proper waste segregation and disposal, advanced recycling technologies are the need of hour to effectively handle the PW crisis in India. This calls for evidence-based strategies attuned to India's socio-economic context and their strict enforcement. Through determined and serious efforts only India will be able to protect and preserve the environment for posterity.

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