"An analysis of plastic waste scenario and its penetration rate in India & its states"

Banupriya J [a] ,Sushma R [b] , Nayan Jyoti Deka [c], Deboshmita Dey [c]

[a] *Student, Master of Technology in Environmental Engineering and Management ,*
M.S. Ramaiah University of Applied Sciences
Bengaluru, India
banupriyaj299@gmail.com
[b]*Assistant Professor, Department of Civil Engineering,*
M.S. Ramaiah University of Applied Sciences
Bengaluru, India
sushma.ce.et@msruas.ac.in
[c]*Technical Leads - Energy & Waste Management Projects ,*
VNV Advisory Services Pvt. Ltd.
Bengaluru,India

Abstract

Plastic has pervaded every part of human life due to its extraordinary properties. This results in plastic waste accumulation in every part of the world. The main purpose of this study is to make an in-depth review and analysis of the plastic waste management scenario, including the collection and recycling penetration rate obtained in India and its States. It also involves the representation of results using the GIS software.

India has a per capita plastic consumption of 13.6 Kg, which is lesser than the global average of 30Kg. The penetration rate or efficiency (percent) is provided by the Verified Carbon Standard (VCS) as the "ratio between plastic waste collection or recycling (tonnes/year) and plastic waste generation (tonnes/year) in the region". The total plastic waste generated, collected, and recycled in 2019-20 is found to be around 3469780 TPA, 2415217 TPA, and 1659283 TPA respectively. Similarly, values for each state and union territory is calculated.

Maharashtra and Gujarat are common for having the highest volume of plastic waste generated, collected, and recycled, Whereas, union territories and north-eastern states have shown consistently low volumes; mainly in Lakshadweep and Sikkim. The plastic waste penetration rate in India for collection is 69.61% and recycling is 47.82%. Many states are observed to have very poor plastic waste collection and recycling

facilities, with their penetration rates falling below the standard of 20%. Plastic waste recycled from the plastic waste collected is 68.7%.

Plastic wastes have caused worldwide Environmental and Health issues. Therefore, there is an urgent requirement for environmental laws to monitor the production, usage, and disposal of plastics.

1. Introduction

Plastic is a material that is known to offer extraordinary properties and its usage dominates modern life. However, these benefits also carry several challenges with mismanaged plastic waste that turns into plastic pollution. This results in plastic waste accumulation in every part of the world. It is estimated that the production of plastic globally crosses approximately 400 million tonnes per year. It is estimated that only 9% of this plastic is getting recycled worldwide.[1] Many global countries have predicted the consequences of using plastic in the long run and have begun to address the matter at a slower pace by adopting legal measures, and actions to dwindle the distribution and consumption of plastics.

2. Materials and Methods

The main purpose of this study is to make an in-depth review and analysis of the plastic waste management scenario and the collection and recycling penetration rate obtained in the region.

2.1. Study Area

Figure. 1 shows the study area adopted for this project i.e. India, its states, and union territories using the GIS software. Currently, there are Twenty-Eight states and eight union territories in India.

2.2. Plastic Consumption and Waste management practices

[1] https://www.downtoearth.org.in/blog/waste/plastic-waste-management-what-can-india-learn-from-other-countries-67048

A report from the Indian plastics industry has stated that the USA has the highest per capita plastic consumption of around 108 Kg followed by Europe, China, and Brazil.

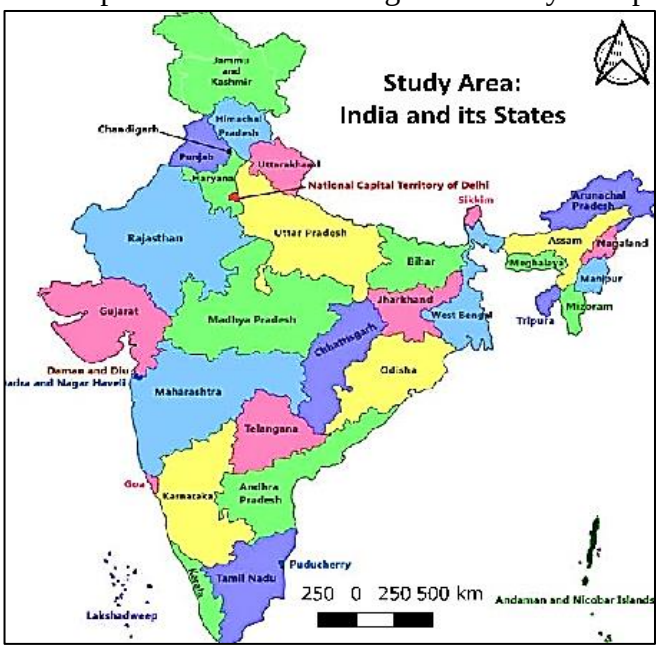

Fig.1. Study Area

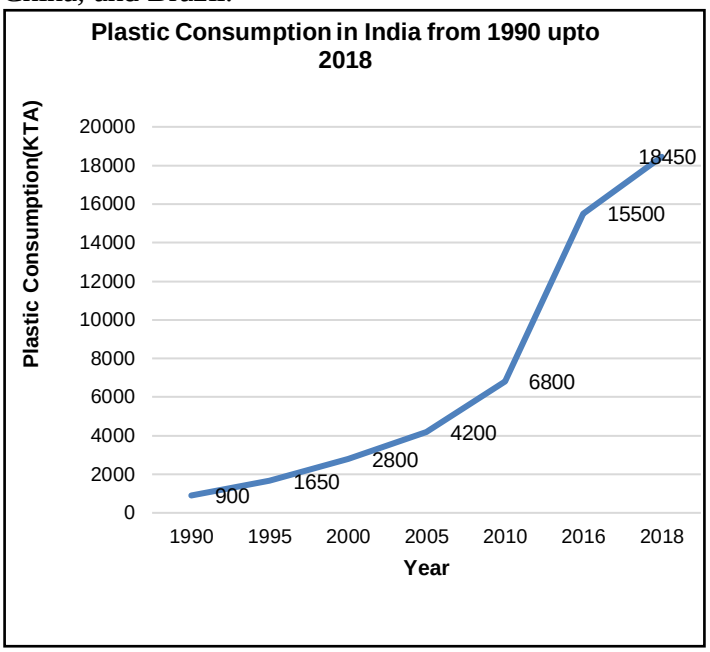

Fig.2. Plastic Consumption in India

The Indian Plastics Industry Report.in 2019 stated that India has a per capita plastic consumption of 13.6 Kg, which is lesser than the global average of 30Kg. Figure.2 shows the plastic consumption in India over two decades spanning from 1990 up to 2018.

According to the FICCI Report, Plastic consumption varies in different regions of the country. Western India accounts for almost 47% of the total consumption whereas Northern, Eastern, and Southern regions consume 23%, 21%, and 9%, respectively.

The Government of India has taken several steps to manage plastic waste in the country. It has initiated total or partial national-level bans on plastics in their jurisdictions. It has also vowed to phase out single-use plastics by 2022, which gives a much-needed impetus to help plastic waste management.

State and Union Territories are required to set-up the Plastic Waste Management (PWM) system as per the PWM Rules, 2018 in each and every Urban Local Body (ULB) and Gram Panchayat.

2.3 Penetration Rate

The penetration rate for plastic waste collection and recycling activities is given by methodologies from the Verified Carbon Standard (VCS) also known as VERRA. It is a standard for certifying, in this case, plastic waste reduction. Its newly launched plastic waste reduction program standard helps companies that have fully maximized efforts to reduce the plastic footprint of their operations to invest in projects that collect and recycle plastic waste. The organization has established methodologies that set out detailed procedures for quantifying the plastic waste reduction benefits of a project and provide guidance to help project developers determine project boundaries, set baselines, and ultimately quantify the plastic waste that was reduced or removed. This paper can be used as a baseline for projects involving India and its states as project regions. Two methodologies are adopted for this paper, namely "PWRM0001: Plastic Waste Collection Methodology" [2] & "PWRM0002: Plastic Waste Mechanical Recycling Methodology".[3] A few important guidelines mentioned in these methodologies for penetration rate are as follows;

The penetration rate (percent) is given as the "ratio between plastic waste collection or recycling (tonnes/year) and plastic waste generation (tonnes/year) in the region." If this penetration rate is below 20 percent, the region has a very poor plastic waste collection or recycling facilities. Equation (1) represents the Penetration Rate.

$$Penetration\ Rate = \frac{C}{G} \times 100 \qquad (1)$$

Where,

C = Annual plastic waste collection or recycling (tonnes/year)

G = Total generation of plastic waste (including composites), G (tonnes/year), in the region

Annual plastic waste collection or recycling in the region shall be determined, based on data from (a) publicly available information (e.g., data from governments, local authorities, and third-party studies) (b) local

[2] https://verra.org/wp-content/uploads/2021/02/PWRM0001_Plastic-Waste-Collection-Methodology-v1.0.pdf
[3] https://verra.org/plastic_methodology/pwrm0002-plastic-waste-recycling-methodology-v1-1/

authorities or independent market research (c) where such data are not available, the collection rate is determined in a credible way.

The total generation of plastic waste in the region shall be determined using (a) Publicly available information; (b) Based on population size in the region and plastic waste generation rates (kg/year per capita), or (c) where such data are not available, then the default values as stated in the methodology may be applied.

Penetration Rate is similar to efficiency; in this case efficiency of collection or recycling facilities in the region.

2.3.1. Plastic waste Generation

The plastic waste generation data for this paper is accessed from publicly available data, provided by the State pollution control boards (SPCB) to the Central pollution control board (CPCB) as per the rule of the Plastic Waste Management Rule, 2016. Figure.3 shows the plastic waste generation from 2011 up to 2020 in India. The estimated plastic waste generated in the country during 2019-20 is approximately 3469780 TPA.

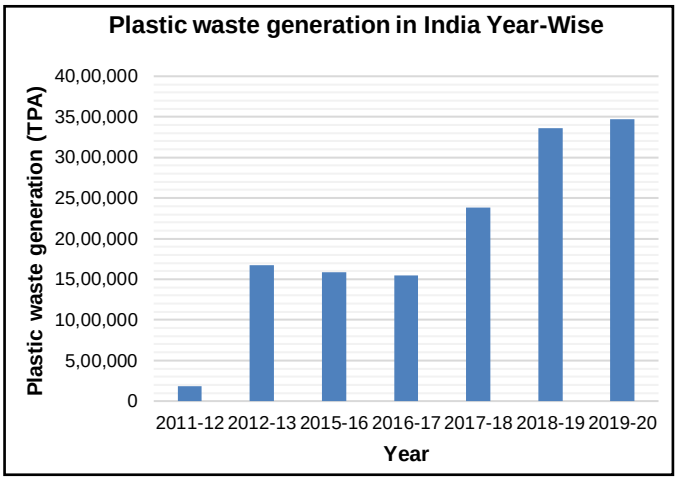

Fig.3. Plastic waste generation in India year-wise

Table 1. Shows the plastic generation in each state of India for the year 2019-20.

Table 1 : State-Wise Plastic Generation

State	Plastic Generation (TPA)	State	Plastic Generation (TPA)
Arunachal Pradesh	2721.17	Goa	26086.3
Assam	24970.88	Haryana	147733.511
Karnataka	296380	Himachal Pradesh	13,683
Manipur	8292.8	Jharkhand	43332.308
Meghalaya	5043	Tamil Nadu	431472
Mizoram	7908.6	Uttar Pradesh	161147.5
Nagaland	565	West Bengal	300236.12
Punjab	92890.17	Andhra Pradesh	46222
Rajasthan	51965.5	Maharashtra	443724
Sikkim	69.02	Chandigarh	6746.36
Tripura	32.1	Haryana	147733.511
Uttarakhand	25203.03	Lakshadweep	46
Telangana	233654.7	Jammu and Kashmir	74826.33
Bihar	4134.631	NCT of Delhi	230525
Kerala	131400	Puducherry	11753
Andaman and Nicobar Islands	386.85	Dadra Nagar Haveli and Daman & Diu	1947.7

Gujarat	408201.08	Chhattisgarh	32,850
Odisha	45339	Goa	26086.3
Madhya Pradesh	121079		

Source: CPCB Annual Plastic Waste Management Report 2019-20

2.3.2. Plastic waste collection

Plastic waste generated is collected and segregated, mainly by Urban Local Bodies (ULBs), Gram Panchayat, and other municipal organizations. The waste is mainly collected using the door-to-door waste collection method in most of the states in the country.

The data for plastic waste collection is calculated in a credible way, as stated in the VERRA methodology. The data is found in three ways;

(a) publicly available CPCB or SPCB data on plastic waste collection,

(b) a summation of collected plastic waste that is utilized for various purposes such as recycling, road construction, waste to oil and energy plants, and in cement plants for co-processing as stated in CPCB Annual Report 2019-20

(c) assumption and calculation concerning the CPCB report, estimates that collection efficiency is around 80.28% in the country.[4]

The plastic waste collection for India is taken as the summation of the data obtained for each state. The total plastic waste collected is found to be around 2415217 TPA. Table 2. Depicts the plastic waste collected in each state of India.

2.3.3. Plastic waste recycling

Plastic waste that is collected is utilized for various purposes. However, the paper's boundaries shall include the plastic waste that is sent for recycling purposes only. ULBs and Gram Panchayats collect and segregate

[4] https://www.teriin.org/sites/default/files/files/factsheet.pdf

the plastic waste and send it to the recyclers. There are 4985 registered and 823 unregistered plastic waste recyclers in the country.

The data for plastic waste recycled is calculated in a credible way as stated in the VERRA methodology. The data is found in three ways;

(a) Publicly available CPCB or SPCB data on plastic waste recycled,

(b) Four States, namely Arunachal Pradesh, Lakshadweep, Mizoram, and Sikkim have no recycling units in the state as per the CPCB Annual Report 2019-20, therefore the plastic waste recycled in these states is taken as zero

(c) Assumption and calculation concerning the CPCB report states that 60% of the total plastic waste is being recycled.[5]

The plastic waste recycled in India is taken as the summation of the data obtained for each state. The total plastic waste recycled is found to be around 1659283 TPA. Table 2. Depicts the plastic waste recycled in each state of India.

[5] https://www.teriin.org/sites/default/files/files/factsheet.pdf

Table 2: State-Wise Plastic Waste Collected and Recycled

Region	Total plastic waste Collected(TPA)	Total plastic waste Recycled(TPA)
India	2415216.63	1659282.80
Andaman and Nicobar Islands	322.40	322.40
Andhra Pradesh	37107.02	27733.2
Arunachal Pradesh	2184.56	0
Assam	20046.62	14982.528
Bihar	5300.77	5300.77
Chandigarh	11497.50	4047.816
Chhattisgarh	26371.98	19710
Dadra Nagar Haveli and Daman & Diu	1563.61	1168.62
Goa	32580.52	6057.62
Gujarat	94101.93	69079.65
Haryana	166448.45	58116.4
Himachal Pradesh	10984.71	8209.8
Jammu and Kashmir	23094.78	13546.24
Jharkhand	34787.18	25999.3848
Karnataka	122640.00	73584
Kerala	4241.80	1138.8
Lakshadweep	36.93	0
Madhya Pradesh	176875.42	74643.06
Maharashtra	273589.00	273589
Manipur	6657.46	4975.68
Meghalaya	4048.52	3025.8

Mizoram	6349.02	0
Nagaland	453.58	339
NCT of Delhi	185065.47	138315
Odisha	22198.50	22155.5
Puducherry	850.00	316
Punjab	31711.93	8621.3
Rajasthan	41717.90	31179.3
Sikkim	55.41	0
Tamil Nadu	371055.00	268575
Telangana	204086.10	68255
Tripura	28.00	19.26
Uttar Pradesh	252580.00	252580
Uttarakhand	3555.00	3555
West Bengal	241029.56	180141.672

2.4 Health and Environmental effects

Initially, plastic was assumed as harmless and inert, however, many years of plastic waste disposal has led to diverse Health and Environmental problems. Plastics have several toxic constituents among which are phthalates, poly-fluorinated chemicals, bisphenol A (BPA), brominated flame-retardants and antimony trioxide, which can leach out to have adverse effects on environmental and public health.

Environmental pollution by plastic wastes is found to be a major environmental burden causing detrimental negative effects on the aquatic and land environment and on wildlife. It also causes forms of pollution such as reduction in water percolation and normal agricultural soil aeration, which subsequently causes reduced productivity in such lands, Entanglement and death of aquatic organisms and wildlife, and also tends to block the sewage system.

Plastic waste is also harmful to Health as most of the additives present in plastics are potential endocrine disruptors and carcinogens. Dermatitis have been reported from skin contact with these plastic additives. In addition, it creates a conducive environment for breeding mosquitoes and other disease-causing vectors and also produces foul smells. Microplastics are a major contaminant that bio-accumulates in the food chain, leading to a public health risk (Alabi OA et al., 2019).

3. Results and Discussion

The results and discussion of the above sections are as given below;

India's per capita plastic consumption is estimated to be around 13.6 kilograms, which is a tenth of USA and less than a third of China's. The global average is more than 2 times of India's per capita consumption. From Figure 2. It can be seen that the plastic consumption has grown by 20 times since 1990 up to 2018.

In addition, Western India (which includes the states of Maharashtra, Gujarat, Daman and Diu & Dadra and Nagar Haveli, Madhya Pradesh and Chhattisgarh) has been the largest consumer of plastics accounting for almost 47% of the total consumption (FICCI Report). The consumption in Northern India is low in comparison to Western India primarily because of lack of availability of raw material.

During 2019-20, the average plastic waste generated in all the states is equal to 98074 TPA, which is the highest average the country had observed up to 2020.In the period Maharashtra has found to have the highest plastic waste generated closely followed by the states of Tamil Nadu and Gujarat. The lowest plastic waste generators in the country is found to be Tripura, Lakshadweep and Sikkim.

Figure 4. Shows the map depicting the average plastic waste generated using the QGIS software in all the states of India. In the last decade, the average plastic waste generation is around 2029534 TPA. The plastic waste generation has increased gradually over the years.

It can be observed from the map that, overall the states of Maharashtra has the highest plastic waste generation in the last decade, closely followed by West Bengal and Gujarat at the second and third position respectively. The Union territory of Lakshadweep occupies its position for the lowest plastic waste generated over the years accompanied by Nagaland and Sikkim at the bottom as well.

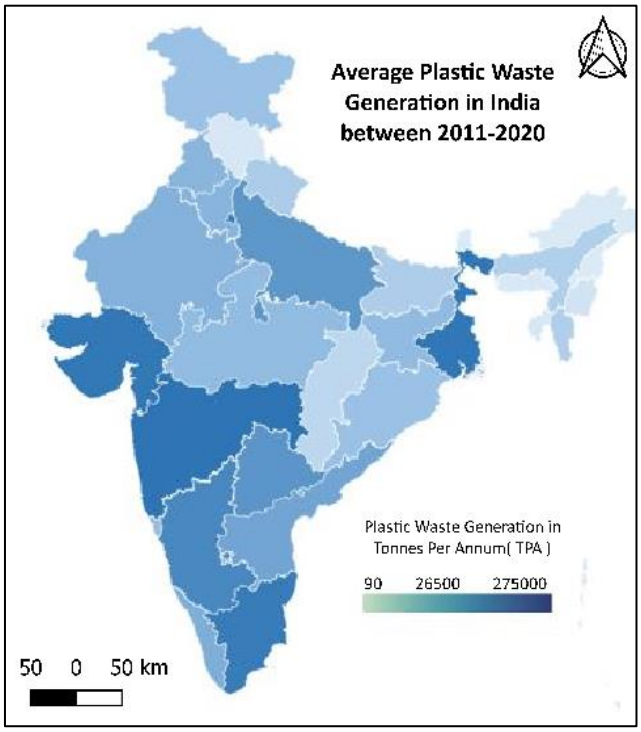

Fig.4. Average plastic waste generation from 2011-2020

The difference between the plastic waste generated between Lakshadweep and Nagaland is over 300 TPA, however when compared to other states the plastic waste generated is comparatively low.

When it comes to plastic waste collected, the average plastic waste collected in all states during 2019-20 is around 69006 TPA. In addition, it is known that a total of 3469780 TPA & 2415217 TPA of plastic waste is generated and collected respectively in the year. Therefore, 1054563 TPA of plastic waste is uncollected or unaccounted for.

The collection penetration rate found by substituting the values given in Table 1 & 2 in (1).After substitution, Figure.5 can be plotted. The penetration rate for the plastic waste collected in India is calculated to be around 69.61%. Figure.5 depicts the plastic waste penetration rate for collection activity in each state of the country using the QGIS software. Kerala, Puducherry and Uttarakhand have very low collection penetration rate.

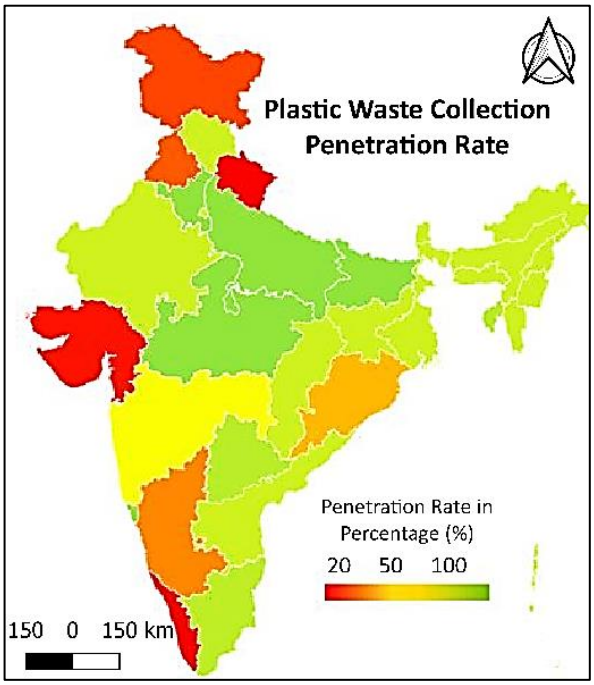

Fig.5. Plastic waste collection penetration rate

These regions have a penetration rate below the 20%, which is the required parameter for judgement as prescribed by VERRA's Plastic Methodology.

From this it, can be stated that these states have very poor plastic waste collection facilities. Chandigarh is found to have the highest collection penetration rate in the country.

The average plastic waste recycled in all states during 2019-20 is around 47408 TPA. In addition, it is known that a total of 3469780 TPA, 2415217 TPA & 1659283 TPA of plastic waste is generated, collected and recycled respectively in the year. Therefore, 755934 TPA of plastic waste collected is not recycled. In other words, 68.7 % of plastic waste collected is recycled.

If the states are individually observed, it can be stated that Arunachal Pradesh, Lakshadweep, Mizoram and Sikkim have the lowest plastic recycling volume as they have no recycling units as of 2019-2020. After that Tripura, Puducherry and Andaman & Nicobar Islands have the least recycling volume.Whereas Maharashtra,

Tamil Nadu, and Uttar Pradesh have the highest recycling volume. This does not denote that these states have poor or good waste recycling system. This is justified as these states have the lowest or highest plastic waste generation and collection as well.

The recycling penetration rate is found similar to that of the collection penetration rate by substituting the values given in Table 1 & 2 in (1).After substitution; Figure.6 is plotted using the QGIS software.

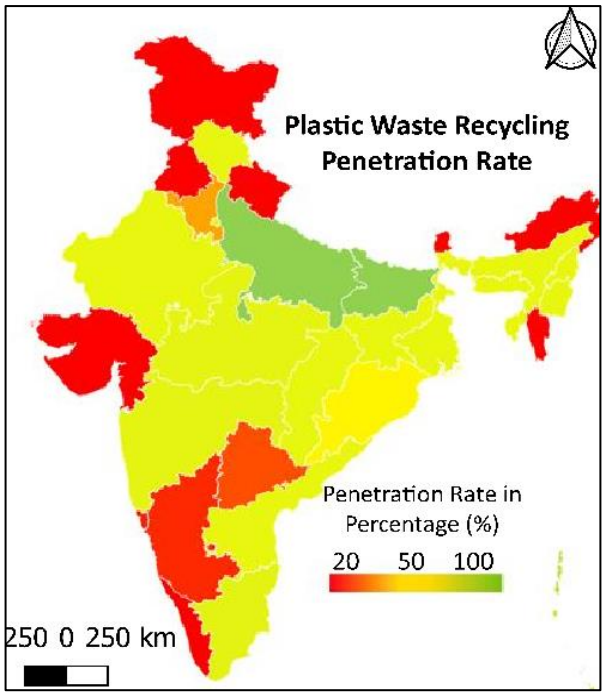

Fig.6. Plastic waste recycling penetration rate

The plastic waste recycling penetration rate for India is calculated to be around 47.82%. Figure.6 depicts the plastic waste recycling penetration rate in each state of the country. Arunachal Pradesh, Lakshadweep, Mizoram, Sikkim, Kerala, Puducherry, Punjab, Uttarakhand, Gujarat and Jammu & Kashmir have very low plastic waste recycling penetration rate. These regions have a penetration rate below the 20%, which is the required parameter for judgement as prescribed by VERRA's Plastic Methodology. From this, it can be stated that these states have very poor plastic waste recycling facilities. Uttar Pradesh is found to have the highest recycling penetration rate in the country.

4. Conclusions

It is observed that India's per capita plastic consumption has increased gradually over the years and will continue to, unless measures are taken to control and regulate its usage. Alternatives to plastic must be found and used to reduce its consumption worldwide.

The states of Maharashtra and Gujarat have topped the charts for the highest volume of plastic waste generated, collected, and recycled in the country when compared to all the states. In addition, the volume of plastic waste generated, collected, and recycled in the union territories and North-eastern states is consistently low over the years; mainly in Lakshadweep and Sikkim. This can be related to the fact that states like Maharashtra and Gujrat are well developing and with higher populations compared to North-Eastern states and Union Territories.

The Plastic waste collection Penetration rate for India in 2019-20 is around 69.61%. This shows that there is a satisfactory number of collection facilities in the country. However, when the states are observed individually, three states are found to have very poor penetration rates i.e. Below 20%. Most of the states have a good collection system, mostly lying between 60 to 80%. Though states like Maharashtra has the highest volume of plastic waste collected, it is still not acceptable as they have very high plastic waste generated and a penetration rate or collection efficiency of only 60%. Whereas, states like Lakshadweep and Sikkim have the lowest volume of plastic waste collected but have a penetration rate or collection efficiency of 80%, implying that these regions have very good number of operating collection facilities.

The Plastic waste recycled penetration rate for India in 2019-20 is at 47.82%. This shows that is very less number of recycling facilities in the country.

The low recycling rates obtained maybe be attributed to the reason that most of the collected plastic waste is sent for road construction, waste to oil and energy plants, and in cement plants for co-processing, incineration plants and landfills. This is because, there are different types of plastic and not all of them are recyclable. Based on the chemical component present in the plastic, polyethylene terephthalate (PET), High-density polyethylene (HDPE) and polystyrene plastics have been widely recycled. Polyvinyl chloride (PVC) and

low-density polyethylene (LDPE) are less likely to recycle due to their toxic chemical contents (Sanket Padgelwar et al., 2019). In India, the average plastic waste comprises mainly of HDPE and LDPE plastics at 66.91%(S.Pandey et al.,2020) However, many states have zero or very few recycling facilities, which must be improved to enhance the plastic waste management process. Overall, the plastic waste recycled from the plastic waste collected is comparatively satisfactory at 68.7%. Though states like Maharashtra and Tamil Nadu have the highest volume of plastic waste recycled, it is still not acceptable as they have very high plastic waste generated and a penetration rate or recycling efficiency of only 60%. Whereas, union territories like Andaman and Nicobar Islands have the lowest volume of plastic waste recycled but a penetration rate or recycling efficiency of 80%, implying that it has a very good number of operating recycling facilities.

Few states like Karnataka, Andhra Pradesh, Telangana, Himachal Pradesh, Punjab, Rajasthan, Uttarakhand Goa, Jharkhand, Delhi, and Madhya Pradesh have Average plastic waste generation and collection. The recycling rates are also average but require improvement.

Usage of High-density polyethylene (HDPE) and polystyrene plastic material plastics must be preferred for plastic manufacturing, as they can be easily recycled when compared to other materials.

Overall, it can be observed that Plastic consumed and Plastic Generated, Collected, and Recycled is directly proportional to the region's Development, Population, Total Area, and other Socio-economic factors.

Most states and union territories in India have imposed restrictions on the manufacture and usage of plastic bags. However, ground-level implementation must be strengthened. To achieve this, states must set-up an institutional mechanism to check the manufacture, use of plastic carry bags, and prevent littering of the same. Awareness must be spread about the various hazards of plastic waste through programmes like, lectures, film shows, interactive sessions, documentaries, workshops, and other forms of mass media.

Though plastics are very useful in daily life, its effects is a cause of public concern. Plastic wastes have caused worldwide Environmental and Health issues. Therefore, there is an urgent requirement of health authorities and government agencies to enact and enforce environmental laws to monitor the production, usage and disposal of plastics.

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