Assessment & Characterisation of Plastic Waste Generation in 60 Major Cities

CENTRAL POLLUTION CONTROL BOARD (CPCB)
Ministry of Environment, Forest & Climate Change

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FOREWORD

The increasing use of plastics products, especially carry-bags and films and its littering and open burning emitting gaseous emissions has posed serious environmental problems. The synthetic and conventional (petro-based) plastics being non-biodegradable remains in the dump-yards/landfills for several years. For management of plastics waste (PW), source segregation is necessary to ensure that collected PW is used for beneficial purposes like road construction, co-processing, conversion of plastics waste into liquid fuel, etc. To quantify the plastics waste generation, a study was undertaken through Central Institute of Plastics Engineering and Technology (CIPET), Ahmedabad for **"Assessment and Quantification of Plastics Waste Generation in 60 Cities"** during 2010-12. The study has revealed that the total plastics waste generation is 3501 tons/day ranging from approximately 3% (Chandigarh) to 12% (Surat) in Municipal solid Waste (MSW).

This report is result of hard work put in by officials of CIPET, Ahmedabad and Dr. S.K. Nigam, Additional Director, CPCB. I hope that the report will be useful for Municipal Authorities/ Urban Local Bodies for formulating action plans for plastics waste management in cities/towns.

(A.K. Mehta)

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C O N T E N T S

EXECUTIVE SUMMARY

Polymers or Plastics materials rapid growth in 1970s, 1980s and 1990s growing at the rate of 2.5 times the GDP growth in India. The demand for plastic raw material got more than doubled from 3.3 Million Metric Ton to 6.8 Million Metric Tons in 2010 attributed mainly to rapid urbanization; spread of retail chains, plastics based packaging from grocery to food & vegetable products to cosmetics & consumer items. Plastics packages have its merits but due to its non-biodegrability and improper collection system they become an eyesore alongwith Municipal Solid Waste (MSW) due to its high visibility.

As the synthetic & conventional plastics (petro-based) are non-biodegradable in nature, it remains in the dump-yards/ landfills for several years, if not collected propsly. In India, with dense population in cities & urban areas, despite of all efforts by Municipal Corporations/Local bodies, Source segregation of waste for separation of biodegradable/non-biodegradable/recyclable waste has not been effective so far & the fact is *plastics carry bags are used for packing & disposal of all kind of households, stained/soiled food or non food items & got mixed up with them. If plastics bags or packaging can be sorted or segregated from the source itself for beneficial purposes, the mixed contaminated & comingled waste would not land up at dump yards in cities.*

To assess and quantify the plastics waste generation and to reutilize the energy content of the polymer in an ecological and acceptable way, **a *Study was carried out on "Assessment and Quantification of Plastics Waste Generation in Major Cities" in collaboration with CIPET. The scope of the work comprises of assessment, quantification of plastics waste in dump sites of major 60 cities and suggesting the viable and appropriate recycling technologies (Based on "Zero" waste concept) with following Terms of References (ToR).***

1. TERMS OF REFERENCES (ToR) OF THE STUDY

- To assess the type, nature and quantum of plastics waste in the country through field survey and physical assessment at the ***MSW*** sites at 60 towns and Cities.
- Establish a Co-ordination mechanism with local Municipal/Metro corporations in identifying the dump grounds/ Localities of higher waste generation for the physical assessment/characterization of MSW as per the prescribed methodology.
- To report on the existing methodology for collection of waste by urban local bodies/Municipal bodies in different states of the country.
- To suggest the viable and appropriate recycling technologies at major cities with investment estimation for effective ***Plastics waste Management (based on " Zero Waste Concept")***
- Suggest Road Map/Recommendations for Plastics Waste Management as per the data available from the study for different towns and cities of the country.

2. OVERVIEW AND METHODOLOGY

The ASTM Method (D5231-92) method has been referred as guiding principle for assessment and quantification of plastics waste at Dump sites. Accordingly, this methodology was adopted to assess batch/samples of 1000Kg of fresh Municipal Solid waste (MSW) arriving at dumpsites on different days from different sources in vehicles like trucks/lorry. The 1000Kg of the sample is initially reduced to125 Kg by quartering technique, i.e.1000Kg are well mixed and divided into four sections where each section comprises approximately of 250 Kg, from this divided section the two opposite sections are discarded and the other two section are taken for the next quartering step. (steps illustrated in Fig 1A, 2B, 3C).

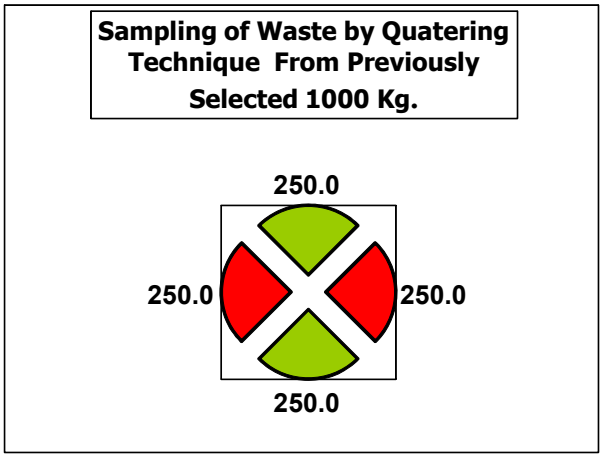


FIGURE1A: SAMPLING STEP: 1

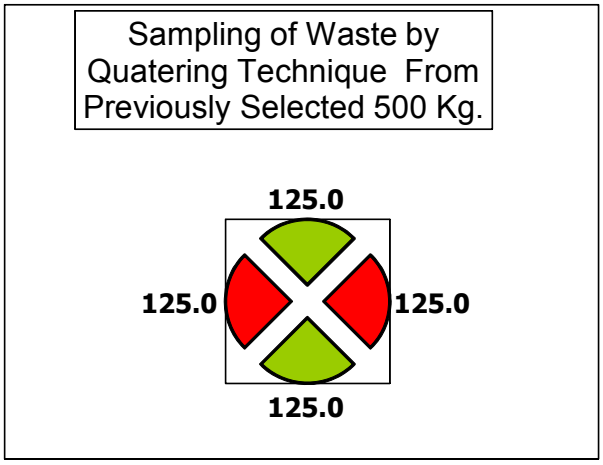


FIGURE 1B: SAMPLING STEP: 2

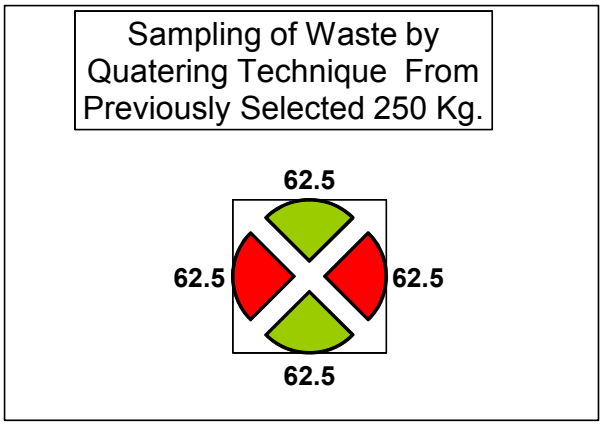


FIGURE 1B: SAMPLING STEP: 3

The plastics constitute two major categories: (i) Thermoplastics and (ii) Thermoset plastics. The plastics materials are categorized in seven types based on properties & applications. In order to make the recycling easier, the universally accepted standards has been developed to help consumers to identify and sort out the main types of plastics with marking code. The symbols defined by society of the plastic industry (SPI) USA are adopted as IS 14534:1998 of BIS are as follows:

PET

HDPE

PVC

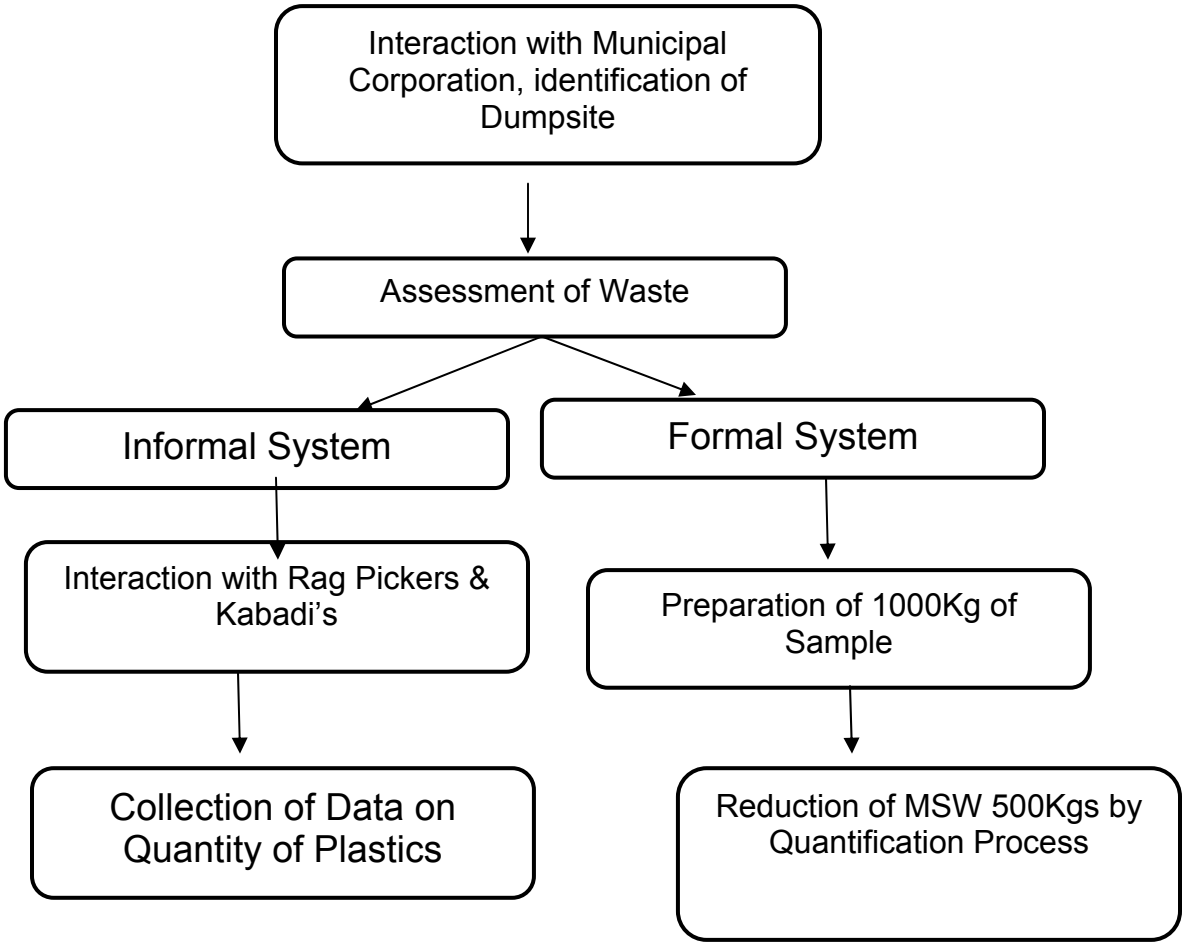
LDPE

PP

PS

OTHER

From the sampled 125Kg of Municipal Solid Waste (MSW) the various types of plastics like PET, PE Based (LDPE/HDPE), PVC, PP, PS/ OTHER has been sorted out and segregated. Finally the segregated plastics are weighed and quantified as depicted in Figure 2.



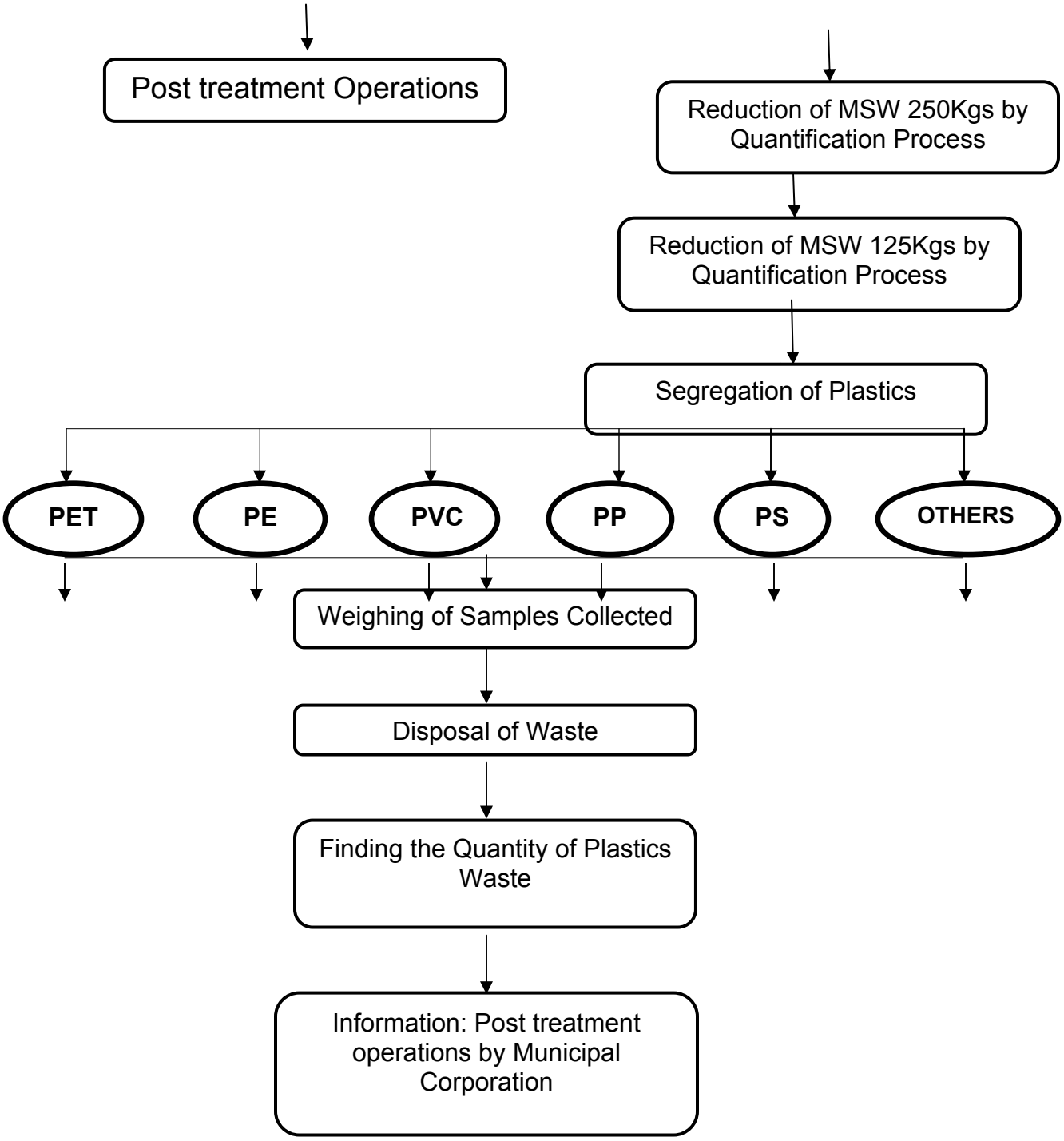


FIGURE 2: METHODOLOGY (PROCESS SEQUENCE) CHART

TABLE- A CLASSIFICATION OF PLASTICS WASTE

Sr. No	Source Code	Name of plastics	Few Applications
1.	 PET	Polyethylene Terephthalate (PET)	Drinking water Bottles, Soft drink Bottles, Food jars, Jelly pickles, Plastics Films, Sheets
2.	 &  HDPE LDPE	High Density Polyethylene (HDPE) Low Density Polyethylene (LDPE)	Plastics bags ,Food containers, woven sacks, Bottles, Plastics Toys, Milk Pouches & Shopping Bags, Metalized Pouches
3.	 PVC	Polyvinyl Chloride (PVC)	Pipes, Hoses, Sheets, Wire, cable insulations, Multilayer Tubes
4.	 PP	Polypropylene (PP)	Disposable Cups, Bottle caps, Straws,
5.	 PS	Polystyrene (PS)	Disposable Cups, glasses, Plates, spoons, trays, CD Covers, Cassette Boxes, Foams
6.	 OTHER	Thermoset, Poly Carbonate (PC), Poly urethane (PU) FRP	CD, Melamine Plates, Helmets, Shoe soles.

3. FIELD SURVEY (Field Survey Regions/ Locations)

For the assessment and quantification of plastics waste generation in India, the 60 Cities were selected in 05 regions, Northern, Southern, Eastern & Western, and Central regions.

4A. **NORTHERN REGION** comprises cities like ***Lucknow, Allahabad, Chandigarh, Delhi, Faridabad, Jammu, Srinagar, Shimla, Amritsar, Dehradun, Agra, Meerut, Varanasi, Kanpur, Patna, Ranchi, Jamshedpur, Dhanbad, Ludhiana.*** In almost all the cities the MSW generated from different sources like door to door, community bin at the street corners and from markets are collected by the municipal trucks or by the firms under contract to the government and dumped in the open dump yard. The findings of the survey are described city wise as given below.

TABLE: 01 STUDY OF LUCKNOW CITY: Plastics waste (PW) in Kg/ Metric Ton-(MT)

SERIAL OF DAYS	PET	HDPE/LDPE	PVC	PP	PS	OTHER	TOTAL
DAY 1	9.182	19.428	4.7702	13.9304	6.314	4.306	57.9306
DAY 2	3.988	36.972	3.802	6.704	0.668	3.458	55.592
DAY 3	2.448	45.732	3.146	4.144	1.38	2.254	59.104
DAY 4	3.052	41.028	4.042	6.23	0.942	4.274	59.56
DAY 5	4.394	48.162	1.422	5.512	1.136	2.31	62.936
AVERAGE	**4.6128**	**38.264**	**3.4364**	**7.3041**	**2.0882**	**3.3204**	**59.03**

In Lucknow, Dodouli Dumping yard has been selected for the assessment. The assessment revealed that average total Plastic waste generation in Lucknow at the time of study was about 59.03Kg/MT as given in Table 1. It has been worked out from the above data that about 64% of total plastics waste is generated from PE family of (HDPE/LDPE) materials. The Total MSW generated (average) in Lucknow was 1200 MT/ Day. During the period of survey, the Minimum Plastics waste generation varies from 31.06 Kg/MT to 83.18 Kg/MT on different days of the week.

TABLE: 02 STUDY OF ALLAHABAD CITY:PW (Kg/MT)

SERIAL OF DAYS	PET	HDPE/LDPE	PVC	PP	PS	OTHER	TOTAL
DAY 1	3.508	40.402	4.472	8.908	1.726	4.062	63.078
DAY 2	6.036	4.018	1.84	17.436	0	18.702	48.032
DAY 3	7.152	8.6	1.064	6.212	1.288	23.908	48.224
DAY 4	5.372	33.398	6.788	7.78	0.498	2.392	56.228
AVERAGE	**5.517**	**21.605**	**3.541**	**10.084**	**0.878**	**12.266**	**53.89**

In Allahabad, Badshi Bandh and Karamati chowki dumping grounds have been selected for the study. The data given in table 2 indicates that average Plastics-waste generation in Allahabad was about **53.89Kg/MT** out of total MSW waste of about 350 MT/day. Around 40% of total plastics waste is generated from HDPE & LDPE materials. The minimum & maximum Plastics waste generation at Allahabad have been assessed as 16.72 Kg/MT and 102.46Kg/MT respectively. The burning of MSW and plastic waste use found at the dumping ground. *No mechanism of dumping or any other post-treatment operation was found.*

TABLE: 03 STUDY OF CHANDIGARH CITY:PW(Kg/MT)

SERIAL OF DAYS	PET	HDPE/LDPE	PVC	PP	PS	OTHER	TOTAL
DAY 1	0.24	17.6	0.8	6.4	1.6	4.8	31.44
DAY 2	0.8	15.2	5.6	0.32	0.8	9.6	32.32
DAY 3	0	19.2	0.4	5.6	2.4	13.6	41.2
DAY 4	0	16.8	0.2	7.2	2	12	38.2

DAY 5	0	11.2	4	4	1.6	4	24.8
DAY 6	0	8	0	4	1.6	0	13.6
DAY 7	0	12.8	0.16	3.2	1.6	7.2	24.96
DAY 8	0.32	17.6	0	9.6	3.2	4	34.72
DAY 9	0.16	21.6	0.2	8.8	1.6	4.8	37.16
DAY 10	0.16	16	0.08	9.6	0.8	4.8	31.44
AVERAGE	**0.168**	**15.6**	**1.144**	**5.872**	**1.72**	**6.58**	**30.98**

In Chandigarh, the collection & segregation of MSW is being done by rag pickers before dumping in the open dump yard. The city corporation in association with CAW &ED society has built Sehay Saji Kaneehas to collect maximum plastic waste generated at various resident areas from different parts of the city. In addition to this, M/s Jaiprakash Associated ltd has setup a Green Tech Fuel processing plant which has capacity of 500 MT/ Day to produce a product of RDF (Refuse Derived Fuel).

Daddu Nagar site has been selected for the study. The average total Plastic waste generation in Chandigarh was found to be about 30.98Kg/MT reported in Table 3. Around 52% of total plastics wastes are generated from HDPE/LDPE materials and 23% of unclassified/other plastics waste. The Total MSW generated in this city was with an average of 264 MT/ Day. It has been reported that plastic waste generation varies from 13.60 Kg/MT to 41.60Kg/MT on different Weekdays.

TABLE: 04 STUDY OF DELHI CITY: PW(Kg/MT)

SERIAL OF DAYS	PET	HDPE/LDPE	PVC	PP	PS	OTHER	TOTAL
DAY 1	2.6026	85.245	1.205	8.381	6.757	2.946	107.138
DAY 2	5.981	79.786	1.045	3.869	7.56	1.008	99.256
DAY 3	1.94	79.56	0.852	6.72	6.42	1.192	96.684
DAY 4	3.522	75.024	1.304	2.925	9.210	3.293	95.28
DAY 5	1.416	67.349	2.632	9.33	17.221	9.298	107.253
AVERAGE	**3.175**	**77.24**	**1.447**	**6.213**	**9.650**	**3.716**	**101.44**

In Delhi, the quantity of plastic waste has been assessed as 10.14%, which comprises of 76% of HDPE/LDPE, 7% of PVC and 10% of Polystyrene material, described in Table 4. The Total MSW generated in this city was with an average of 6800 MT/ Day. During the survey on different weekdays, the minimum plastic waste generation was 87.23 Kg/MT and maximum was 118.74Kg/MT. The field survey was carried out at Gazipur, East Delhi. It has been observed no post-treatment operation for MSW is carried out in the city and 100% of MSW is dumped as land-filling. Approximately, 200-250 rag pickers were voluntarily collecting the valuable plastics waste that was generated throughout the day. Further the compost fertilizer plant having the capacity of about 500MT was established in the city, but currently the plant produces with an output of about only 200 MT. Delhi, being the capital city requires urgent attention for efforts to recycle the recyclable plastic waste such as PET, PE & PP & PVC etc. since the quantum of waste would increase further in future. With over 10% of Plastics Waste in MSW, waste management authorities/civic bodies should set-up Plastics Waste Management Cell (PWMC) exclusively to deal with plastics waste by adopting prevailing technologies.

TABLE: 05 STUDY OF FARIDABAD CITY: PW(Kg/MT)

SERIAL OF DAYS	PET	HDPE/LDPE	PVC	PP	PS	OTHER	TOTAL
DAY 1	8.736	104.054	0.32	2.36	4.3	1	120.77
DAY 2	15.368	74.4	1.648	1.144	6.984	0	99.544
DAY 3	14.444	87.65	1.656	7.79	6.996	0	118.54
AVERAGE	**12.849**	**88.701**	**1.208**	**3.765**	**6.093**	**0.333**	**112.95**

In Faridabad, the survey was conducted at Bandhwari Village, Gudam Road which has the average total MSW was around 700 MT/Day out of the average PW was generated about 112.95 Kg/MT. The classified data for different types of plastics waste is represented in Table 5. The study data revealed that about 80% of plastics waste was from HDPE/LDPE material, which is recyclable. The waste management in Faridabad is carried by M/s. A.K.Enterprise (Hanjar Bio-Tech), they have deployed rag pickers of about 150-200Nos.are employed in this treatment plant. The MSW generated in Faridabad and Gurgaon are treated in this plant. Apart from this the following post treatment plant are also currently present at Faridabad city :-

- Compost plant for fertilizer of capacity 600MT/day.
- RDF, Bricks plant of capacity 300 MT/Day
- Plastics recycling unit

TABLE: 06 STUDY OF JAMMU CITY: PW (Kg/MT)

SERIAL OF DAYS	1 PET	2 4 HDPE/LDPE	3 PVC	5 PP	6 PS	7 OTHER	TOTAL
DAY 1	1.52	29.2	14.16	19.2	4.48	9.44	78
DAY 2	3.2	21.6	1.76	23.52	7.92	34.08	92.08
DAY 3	2.56	36.88	0.64	28.00	5.92	9.76	83.76
DAY 4	0.32	16.48	0.64	12.16	8.16	9.12	46.88
DAY 5	0.96	35.68	1.76	12.32	4.8	12.64	68.16
DAY 6	1.12	41.28	3.04	27.68	4.16	8.8	86.08
DAY 7	2.56	16.32	0.96	20.32	3.52	7.2	50.88
AVERAGE	**1.7486**	**28.206**	**3.21**	**20.457**	**5.56**	**13.006**	**72.26**

The data of Bhagwati Nagar dumping ground at Jammu generate an average PW of about 72.26Kg/MT as shown in Table 6. Out of which, 66% comprise HDPE/LDPE/PP materials with a minimum plastics waste generation 46.88 Kg/MT and with maximum of 92.08Kg/MT. The Total MSW generated in this city was with an average of 300 MT/ Day. Although, the Jammu and Kashmir Government has ban on the usage of the carry bags, but still it is observed that huge quantity of plastics packaging materials are littered. Since proper dumping yard is not available, the dumping of plastic carry bag has also ban observed in Tawi River.

TABLE: 07 STUDY OF SRINAGAR CITY : PW(Kg/MT)

SERIAL OF DAYS	PET	HDPE/LDPE	PVC	PP	PS	OTHER	TOTAL
DAY 1	3.2	16.68	5.68	13.6	6.48	2.36	48
DAY 2	10.4	23.3	9.6	15.2	2.32	9.04	69.86
DAY 3	2.52	21.16	4.52	10.56	5.76	1.976	46.496
DAY 4	3.24	21.68	4.208	9.112	6.64	2.48	47.36
DAY 5	2.32	25.056	3.592	7.144	4.032	6.52	48.664
DAY 6	2.56	24.88	4.096	9.6	3.976	1.52	46.632
AVERAGE	**4.04**	**22.126**	**5.2827**	**10.869**	**4.868**	**3.9827**	**51.17**

In Srinagar, survey has been conduced at Achan Saidpura dump site. The study data shows total MSW is about 550 MT/Day of which, the total average PW is about 51.17Kg/MT. In which the types of plastics are classified and showed as 42% of HPDE/LDPE and 21% of PP waste material represented in Table 07. During the survey the minimum plastic waste generation is in 4.7 Kg/MT and maximum is 7.0 Kg/MT.

TABLE: 08 STUDY OF SIMLA CITY: PW(Kg/MT)

SERIAL OF DAYS	PET	HDPE/LDPE	PVC	PP	PS	OTHER	TOTAL
DAY 1	1.68	17.28	0.64	19.44	1.6	4.72	45.36
DAY 2	3.6	22.6	0.56	17.48	1.16	13.44	58.84
DAY 3	2.68	15.4	0.76	12.6	2.16	5.56	39.16
DAY 4	2.676	17.8	1.16	12.4	1	4.76	39.796
DAY 5	2.32	15.44	0.8	11.72	2.24	5	37.52
DAY 6	1.56	13.64	1.32	8.04	3.36	4.2	32.12
DAY 7	3.68	26.64	0.56	20.24	2.16	5.44	58.72
AVERAGE	**2.599**	**18.400**	**0.829**	**14.56**	**1.954**	**6.160**	**44.502**

In Simla, it is observed that separate system (incineration) is used for medical waste. Two types of dust bins are provided at Simla, to collect the Bio-degradable and Non-Biodegradable municipal solid waste (MSW). Survey has been conduced at Darini ka bagicha dump site. The total MSW is about 50 MT/Day out of which the total average PW is about 44.502 Kg/MT. In which the types of plastics are classified and showed the majority of 39.3% of HPDE/LDPE and 32.3% of PP waste Material as indicated in Table 08. During the survey the minimum plastic waste generation is in the range from 32.12 to 58.84 Kg/MT on few weekdays.

TABLE: 09 STUDY OF AMRITSAR CITY: PW(Kg/MT)

SERIAL OF DAYS	1 PET	2 4 HDPE/LDPE	3 PVC	5 PP	6 PS	7 OTHER	TOTAL
DAY 1	0	13.92	0.8	15.52	3.2	1.44	34.88
DAY 2	2.24	28.32	1.76	13.28	5.6	15.52	66.72
DAY 3	1.28	20	1.76	9.92	1.92	0	34.88
DAY 4	0	26.24	0	20.8	2.4	3.04	52.48
DAY 5	1.6	18.56	0.8	12.8	1.44	5.44	40.64
DAY 6	3.04	21.12	2.24	23.2	2.4	3.36	55.36
DAY 7	0.64	15.04	0	11.52	2.56	1.76	31.52
DAY 8	1.44	18.72	1.12	14.24	2.24	0.96	38.72
AVERAGE	**1.28**	**20.24**	**1.06**	**15.16**	**2.72**	**3.94**	**44.40**

In Amristar, the plastics assessment and quantification study was conducted at Bhagtawala dumping site. The findings on table 9 revealed that the total MSW generation was about 550 MT/Day. The average PW was observed as 44.40Kg/MT, the majority of plastics waste found as carry bags and packaging pouches which is of 45.5% belong to the classification of HDPE/LDPE material. The field study revealed that the minimum plastic waste generation is 31.52Kg/MT and maximum of 66.72Kg/MT

TABLE: 10 STUDY OF DEHRADUN CITY: PW(Kg/MT)

SERIAL OF DAYS	PET	HDPE/LDPE	PVC	PP	PS	OTHER	TOTAL
DAY 1	8.484	43.154	6.912	9.61	1.86	2.178	72.198
DAY 2	9.14	36.212	2.574	4.554	2.406	5.33	60.216
DAY 3	10.358	43.374	4.616	6.2	1.56	3.318	69.42
DAY 4	5.102	38.974	7.412	6.14	4.34	2.31	64.278
AVERAGE	**8.271**	**40.429**	**5.3785**	**6.626**	**2.5415**	**3.2839**	**66.53**

The field study for assessing and quantifying the plastics waste has been carried out at Sahastradhara dumping ground. The total MSW of Dehradun was about 220 MT/Day, out of which, the PW generation is 66.53Kg/MT, the majority of plastics waste was observed as carry bags, packaging pouches and multilayer films of about 61 % made up of HDPE/LDPE material. The findings of Dehradun are reported in Table 10.

TABLE: 11 STUDY OF AGRA CITY: PW(Kg/MT)

SERIAL OF DAYS	PET	HDPE/LDPE	PVC	PP	PS	OTHER	TOTAL
DAY 1	10.33	42.724	5.972	8.484	1.122	11.014	79.646
DAY 2	8.786	42.688	7.624	6.746	1.24	7.672	74.756
DAY 3	8.746	45.064	8.226	10.162	0.18	9.82	82.198
AVERAGE	**9.2873**	**43.492**	**7.274**	**8.464**	**0.8473**	**9.502**	**78.87**

In Agra, the field survey was carried out at chhalesar dumping site, where the dumping of average total MSW of about 520MT/Day.The data revealed that

about 78.87 Kg/MT of PW was generated as represented in table 11. However, 55 % plastics waste is generated from HDPE/LDPE materials consist of carry bags, household items and multilayer films. The minimum plastics waste generation is about 58.6 Kg/MT and Maximum of about 95.15 Kg/ MT.

TABLE: 12 STUDY OF MEERUT CITY: PW(Kg/MT)

SERIAL OF DAYS	1 PET	2 4 HDPE/LDPE	3 PVC	5 PP	6 PS	7 OTHER	TOTAL
DAY 1	6.49	41.106	6.924	7.114	0.658	3.588	65.88
DAY 2	6.152	42.46	6.0205	4.776	1.582	7.2485	68.24
DAY 3	4.88	42.244	3.022	5.328	0.626	6.614	62.714
DAY 4	1.552	41.218	4.612	6.758	2.484	3.402	60.026
AVERAGE	**23.26**	**23.451**	**5.569**	**3.6658**	**3.2753**	**34.715**	**64.22**

In Meerut, Lohia nagar Hapur Road, Mangat puram, Delhi Road dumping site were selected for the plastics quantification field survey. The field study provided the data, which represented an average PW of about 64.22 Kg/MT, where the total MSW generated in the city is of about 52 MT/Day. The data for segregated plastics waste is given in Table 12. The majority of plastics waste generated from HDPE/LDPE and PET has 36.5% and 36.2% respectively. Further, data revealed that the minimum quantity of plastics waste generation is about 51.37 Kg/ MT and a maximum of about 81.81 Kg/MT.

TABLE: 13 STUDY OF VARANASI CITY: PW(Kg/MT)

SERIAL OF DAYS	PET	HDPE/LDPE	PVC	PP	PS	OTHER	TOTAL
DAY 1	4.48325	28.066	15.27	6.268	0.64	4.176	58.90
DAY 2	5.712	42.898	4.108	7.384	1.434	4.135	65.670
DAY 3	4.208	37.406	4.354	3.988	1.78	3.562	55.298
DAY 4	2.844	40.164	2.586	5.936	0.54	3.53	55.6
DAY 5	12.3775	13.038	4.588	10.058	2.216	10.2	52.47
AVERAGE	**5.925**	**32.314**	**6.1812**	**6.7268**	**1.322**	**5.1205**	**57.59**

The quantity of plastics waste generated through Sheer Govardhan and Tenura Mau Dam at Varanasi are 57.59 Kg/MT. The total MSW generated at Varanasi was about 450 MT/Day. However, it has been observed that major part of value added plastics generated on HDPE/LDPE materials like carry bags, multilayer plastics etc which is about 56% given in table 13. The minimum plastics waste generated of about 23.68 Kg/MT and Maximum of about 94.44 Kg/ MT

TABLE: 14 STUDY OF KANPUR CITY: PW(Kg/MT)

SERIAL OF DAYS	PET	HDPE/LDPE	PVC	PP	PS	OTHER	TOTAL
DAY 1	4.3802	53.15	3.5102	7.0022	0.9582	2.9682	71.969
DAY 2	4.236	40.196	8.17	2.08	0.38	1.24	56.302
DAY 3	3.366	48.708	7.98	7.02	0.44	1.03	68.544
DAY 4	8.36	45.68	4.262	8.54	0.34	3.442	70.624
AVERAGE	**5.0856**	**46.934**	**5.9806**	**6.1606**	**0.5296**	**2.1701**	**66.86**

The field study at Kanpur city was conducted at Panci Bhausing dumping ground. The total MSW generated at Kanpur was about 1600 MT/Day. The average total PW generated was about 66.86 Kg/MT given in table 14, during the field survey it is observed that the majority of plastic waste generated on HDPE/LDPE materials like carry bags, bottles, and multilayer plastics. The minimum plastics waste generated of about 51.78 Kg/MT and maximum of about 94.08 Kg/ MT

TABLE: 15 STUDY OF PATNA CITY: PW(Kg/MT)

SERIAL OF DAYS	PET	HDPE/LDPE	PVC	PP	PS	OTHER	TOTAL
DAY 1	1.052	27.312	6.934	1.702	4.494	3.660	45.154
DAY 2	1.322	34.8595	0.68	8.616	1.686	3.986	51.150
DAY 3	1.426	33.25	0.596	11.458	3.042	2.126	51.898
DAY 4	1.27	35.4065	0.6135	6.084	4.216	6.016	53.606
DAY 5	1.932	38.124	1.07	4.762	3.772	10.7615	60.4215
DAY 6	1.558	45.831	0.608	9.636	6.866	6.928	71.427
DAY 7	1.672	46.564	0.42	8.988	5.008	4.444	67.096
AVERAGE	**1.4617**	**37.335**	**1.5602**	**7.3209**	**4.1549**	**5.4173**	**57.250**

In Patna, the plastics assessment and quantification study was conducted at Bairia. The findings revealed that the total MSW was about 220 MT/Day. The PW was observed as 57.25 Kg/MT, out of which the majority of plastics waste found as carry bags and packaging pouches which is of 65.15% made up of HDPE/LDPE material. The field study reveals that the minimum plastic waste generation 35.98 Kg/MT and maximum of 76.57Kg/MT. The data observed during field study are resulted in table 15.

TABLE: 16 STUDY OF RANCHI CITY: PW(Kg/MT)

SERIAL OF DAYS	PET	HDPE/LDPE	PVC	PP	PS	OTHER	TOTAL
DAY 1	0.994	35.648	0.36	7.002	3.732	9.31	57.046
DAY 2	0.702	37.4105	0.896	6.472	3.844	6.986	56.3105
DAY 3	1.024	37.95	0.438	6.28	4.842	8.266	58.8
DAY 4	0.716	40.404	1.194	6.472	5.244	6.02	60.05
DAY 5	0.68	42.546	0.436	6.542	5.89	5.358	61.452
DAY 6	0.686	43.28	0.84	5.71	3.368	6.186	60.07
DAY 7	0.656	42.088	0.89	6.46	4.332	6.226	60.652
AVERAGE	**0.7797**	**39.904**	**0.722**	**6.4197**	**4.4646**	**6.9074**	**59.20**

The quantity of plastics waste generated through Jhiri Dump site at Ranchi are 59.20 Kg/MT. The total MSW generated at Varanasi is above 140 MT/Day. Majority of the plastics waste was observed on HDPE/LDPE material which is about 67.3% given in table 16. The minimum plastics waste generation is about 48.75 Kg/MT and maximum of about 67.59 Kg/ MT.

TABLE: 17 STUDY OF JAMSHEDPUR CITY: PW(Kg/MT)

SERIAL OF DAYS	PET	HDPE/LDPE	PVC	PP	PS	OTHER	TOTAL
DAY 1	2.3725	13.95	0.65	3.688	3.806	4.554	29.020
DAY 2	1.584	18.432	0.226	2	2.476	3.87	28.59
DAY 3	1.941	19.874	0.521	2.728	2.217	3.28	30.561
DAY 4	3.070	31.943	0.487	3.890	3.933	2.693	46.017
AVERAGE	**2.242**	**21.05**	**0.471**	**3.077**	**3.108**	**3.599**	**33.55**

In Jamshedpur, the field survey was carried out at Bhuiandhri Dump site and the average PW generated about 33.55 Kg/MT. The total MSW generation at Jamshedpur is about 28 MT/Day. The actual quantity of plastic waste worked out from the survey is given in table 17. The data revealed that 6.68% of PET, 62.11% of HDPE/LDPE, 1.436 % of PVC, 9.23 % of PP, 9.23% of PS and finally 11.18% of unclassified plastics are produced. The minimum plastics waste generation was about 26.34 Kg/MT and maximum of about 50.78 Kg/ MT.

TABLE: 18 STUDY OF DHANBAD CITY: PW(Kg/MT)

SERIAL OF DAYS	1 PET	2 4 HDPE/LDPE	3 PVC	5 PP	6 PS	7 OTHER	TOTAL
DAY 1	1.068	33.64	0.76	6.366	3.232	5.726	50.792
DAY 2	0.9445	35.665	0.51	6.032	3.168	6.88	53.1995
DAY 3	0.65	36.604	0.45	4.72	2.722	4.856	50.002
DAY 4	0.606	36.15	0.367	6.847	2.974	5.004	51.948
DAY 5	0.552	35.058	0.756	4.286	3.336	6.09	50.078
DAY 6	0.518	29.42	0.47	4.826	3.286	3.9291	42.449
DAY 7	0.574	35.65	0.28	5.808	4.37	5.944	52.626
AVERAGE	**0.7018**	**34.598**	**0.5133**	**5.555**	**3.2983**	**5.4899**	**50.16**

In Dhanbad, Telipada & Matkudiya dumping yard has been selected as the study area for this project. The study revealed that average total plastic waste generation in dhanbad was about 50.16Kg/MT represented in Table 18. It has been worked out from the survey data about 69% of total plastics waste generation from HDPE/LDPE materials. The Total MSW generated in this city was with an average of 150 MT/ Day. During the survey the minimum plastic waste generation 35.98 Kg/MT and maximum of 55.75 Kg/MT.

TABLE: 19 STUDY OF LUDHIANA CITY: PW(Kg/MT)

SERIAL OF DAYS	PET	HDPE/LDPE	PVC	PP	PS	OTHER	TOTAL
DAY	0.56	34.96	1.36	9.52	1.12	3.76	51.28
DAY 2	0.16	45.68	1.36	10.16	0.24	5.6	63.2
DAY 3	1.04	60.4	0.52	17.52	1.6	4.4	85.48
DAY 4	1.2	43.12	1.28	9.44	1.92	4.48	61.44
DAY 5	0.32	32.56	4.48	9.12	0.32	7.12	53.92
DAY 6	0.00	28.72	0.56	9.76	0.72	2.64	42.4
AVERAGE	**0.547**	**40.91**	**1.593**	**10.92**	**0.987**	**4.667**	**59.62**

Total MSW that is generated in Ludhiana city was about 850 MT/Day, The data revealed that average plastics waste generation was about 59.62Kg/MT. The study indicate that 40.91Kg/MT (68.6%) plastics waste obtained from HDPE/LDPE material, the data reported in table 19. Further, it is observed that the minimum plastics waste of about 42.40 Kg/MT and a maximum of 85.48 Kg/MT.

The average total municipal solid waste generated is compared with the percentage of average plastics municipal solid waste obtained in each city is shown in Chart 1.

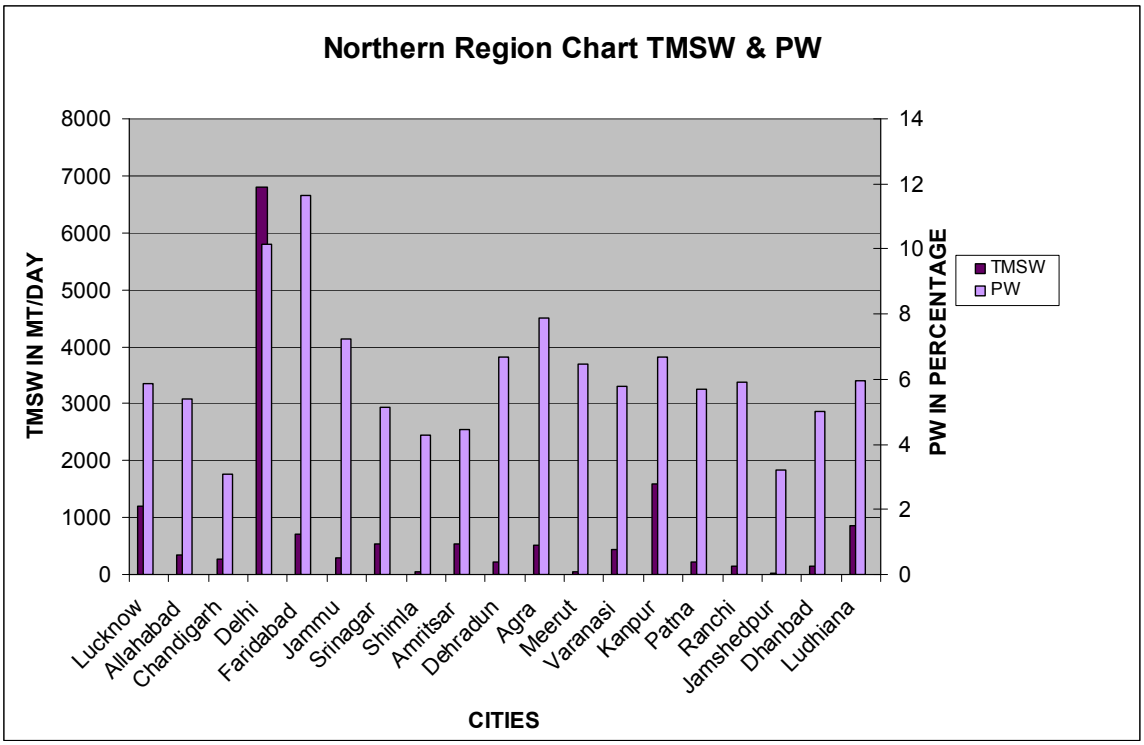


CHART 1: NORTHERN REGION
TMSW GENERATION Vs PW GENERATION

4B. SOUTHERN REGION: comprises of ***Chennai, Bangalore, Coimbatore, Kochi, Madurai, Port Blair, Thiruvananthapuram, Puducherry, Kavarati, Hyderabad, Vijayawada, Vishakhapatnam.***

TABLE: 20 STUDY OF CHENNAI CITY: PW (Kg/MT)

SERIAL OF DAYS	PET	HDPE/LDPE	PVC	PP	PS	OTHER	TOTAL
DAY 1	9.06	89.94	1.25	3.67	2.32	0.56	106.8
DAY 2	2.74	82.19	4.16	7.87	1.34	0.52	98.82
DAY 3	2.34	62.64	3.18	7.97	2.66	0.68	79.47
DAY 4	1.49	85.73	1.89	3.2	3.36	0.92	96.59
AVERAGE	**3.9075**	**80.125**	**2.62**	**5.6775**	**2.42**	**0.67**	**95.42**

In Chennai the assessment and quantification of plastics waste was conducted at Perungudi and Kodungaiyur dump sites having the total MSW of about 4500MT/Day, and the plastics were assessed as with an average of 95.42 Kg/MT. The collected MSW is directly dumped without any post treatment operation. The survey data is represented in table 20, which reveals around 84% of HDPE/LDPE waste comprising of carry bags, milk pouches and packing films. The data obtained with a minimum of 79.47Kg/MT and a maximum of 106.80Kg/MT.

TABLE: 21 STUDY OF BENGALURU CITY: PW(Kg/MT)

SERIAL OF DAYS	PET	HDPE/LDPE	PVC	PP	PS	OTHER	TOTAL
DAY 1	2.1	90.8	1	0.64	0.88	1.7	97.12
DAY 2	0.94	67.8	0.74	0.9	0.64	1.52	72.54
AVERAGE	**1.52**	**79.3**	**0.87**	**0.77**	**0.76**	**1.61**	**84.83**

Total MSW that are generated in Bangalore city was about 3700 MT/Day. The survey was conducted at Mavallipura Dumpsite which has the average PW generation of 84.83Kg/MT Shown in Table 21. Around 93% of total plastics waste generated from HDPE/LDPE/LLDPE materials with the minimum plastic waste generation of 72.54 Kg/MT and Maximum of 97.12 Kg/MT.

TABLE: 22 STUDY OF COIMBATORE CITY: PW (Kg/MT)

SERIAL OF DAYS	PET	HDPE/LDPE	PVC	PP	PS	OTHER	TOTAL
DAY 1	2.78	71.09	1.66	4.6	3.42	0.26	83.81
DAY 2	4.32	88.85	1.75	5.26	4.69	0.77	105.64
AVERAGE	**3.55**	**79.97**	**1.705**	**4.93**	**4.055**	**0.515**	**94.73**

The study has been conducted in vellalur dumpsite at Coimbatore city. The segregated plastics are given in Table 22. The total MSW in the city was about 700 MT/ Day with an average PW of 94.73 Kg/MT. The PW was obtained with a minimum of 83.18 Kg/MT and maximum of 105.64 Kg/MT.

TABLE: 23 STUDY OF KOCHI CITY: PW (Kg/MT)

SERIAL OF DAYS	PET	HDPE/LDPE	PVC	PP	PS	OTHER	TOTAL
DAY 1	11.62	40.65	0.77	3.99	1.28	0.54	58.85
DAY 2	12.22	45.42	2.29	1.19	3.79	1.99	66.9
AVERAGE	**11.92**	**43.035**	**1.53**	**2.59**	**2.535**	**1.265**	**62.88**

In Kochi, the assessment and quantification of plastics waste was conducted at Brahmapuram dump sites having the total MSW of about 150MT/Day and the plastics were assessed as with an average of 62.88 Kg/MT. The survey data is represented in table 23, which reveals the majority of plastics are PET, HDPE/LDPE. The PET is of about 18.9% comprising of water bottles and others and HDPE/LDPE is of about 68.4% which comprises of carry bags, milk pouches and Packing films. The data obtained with a minimum of 58.85 Kg/MT and a maximum of 66.90 Kg/MT. The collected MSW was directly dumped without any post treatment operation. During survey it has been observed that the plastics are segregated by the rag pickers and separated, dumped in the dump yards without any disposal system.

TABLE: 24 STUDY OF MADURAI CITY: PW (Kg/MT)

SERIAL OF DAYS	PET	HDPE/LDPE	PVC	PP	PS	OTHER	TOTAL
DAY 1	1.44	40.71	4	2.49	3.9	0.24	52.78
DAY 2	1.00	35.82	3.04	4.5	2.68	1.36	48.4
AVERAGE	**1.22**	**38.265**	**3.52**	**3.495**	**3.29**	**0.8**	**50.59**

In Madurai, the total collection of MSW was about 450 MT/Day. The quantified average plastics waste in madurai city was observed as 50.59 Kg/MT and reported in table 24. About 75% of HDPE/LDPE was observed in total PW. The data generated with a minimum plastics waste of about 48.40 Kg/MT and with a maximum plastics waste generation of about 52.78 Kg/MT.

TABLE: 25 STUDY OF PORT BLAIR CITY: PW (Kg/MT)

SERIAL OF DAYS	PET	HDPE/LDPE	PVC	PP	PS	OTHER	TOTAL
DAY 1	17	73.44	9.54	0.38	0.25	0.15	100.76
AVERAGE	**17**	**73.44**	**9.54**	**0.38**	**0.25**	**0.15**	**100.76**

Total MSW that are generated in Port Blair city was about 45 MT/Day. The survey was conducted at Brokshadbad Dumpsite which has the average PW generation of 10.07 Kg/MT. The findings during the study are reported in Table P25.The PW generated from HDPE/LDPE/LLDPE is about 73.44 Kg/MT (around 72.8%).

TABLE: 26 STUDY OF THIRUVANANTHAPURAM CITY: PW (Kg/MT)

SERIAL OF DAYS	PET	HDPE/LDPE	PVC	PP	PS	OTHER	TOTAL
DAY 1	1.86	49.67	0.62	4.11	1.37	1.52	59.15
DAY 2	4.53	35.79	2.79	4.71	1.23	12.23	61.28
AVERAGE	**3.195**	**42.73**	**1.705**	**4.41**	**1.3**	**6.875**	**60.22**

In Thiruvananthapuram, the assessment and quantification of plastics waste was conducted at Vilappilsala dump sites having the total MSW of about 250 MT/Day, and the plastics were assessed as with an average of 60.22 Kg/MT. The survey data is represented in table 26, which revealed there the majority of plastics in HDPE/LDPE which is about 71%. Comprising of carry bags, milk pouches and Packing films. The data obtained with a minimum PW of 59.15 Kg/MT and a maximum of 61.28 Kg/MT.

TABLE: 27 STUDY OF PUDUCHERRY CITY: PW(Kg/MT)

SERIAL OF DAYS	PET	HDPE/LDPE	PVC	PP	PS	OTHER	TOTAL
DAY 1	4.28	91.56	2.44	4.96	5.64	0.62	109.5
DAY 2	4	85.52	2.24	4.06	3.6	0.4	99.82
AVERAGE	**4.14**	**88.54**	**2.34**	**4.51**	**4.62**	**0.51**	**104.66**

In Puducherry, Karuvadikuppam dumping yard has been selected as the study area for this project. The study revealed that average total Plastic waste generation in Puducherry was about 104.66Kg/MT represented in Table 27. It has been worked out from the survey data about 84.5% of total plastics waste is generated from HDPE/LDPE materials. The Total MSW generated in this city was with an average of 250 MT/ Day. During the survey the minimum plastic waste generation 99.82 Kg/MT and maximum of 109.50 Kg/MT

TABLE: 28 STUDY OF KAVARATTI CITY : PW(Kg/MT)

SERIAL OF DAYS	PET	HDPE/LDPE	PVC	PP	PS	OTHER	TOTAL
DAY 1&2	23.5	74.75	4.5	18.83	1	0.417	123
DAY 3	20.13	77.63	5.625	14.87	0.475	0.125	118.85
AVERAGE	**21.815**	**76.19**	**5.063**	**16.85**	**0.738**	**0.271**	**120.92**

In Kavaratti , the survey was conducted at Common Depository Place which has the average total MSW generation was around 24 MT/Day out of the average PW was generated about 120.92 Kg/MT. The data which are classified according to the codes of plastics, represented in the table 28. The data showed that the HDPE/LDPE plastics having the code of 2 &4 has the majority of about 62.55%.The field study obtained with a minimum figure of average PW of 111.50 Kg/MT and a maximum of 139.50 Kg/MT. An incinerator of 50 Kg capacity installed for burning of plastic waste, near to the dump site.

TABLE: 29 STUDY OF HYDERABAD CITY: PW(Kg/MT)

SERIAL OF DAYS	PET	HDPE/LDPE	PVC	PP	PS	OTHER	TOTAL
DAY 1	4.975	22.103	1.650	5.075	0	3.000	36.81
DAY 2	7.05	39.35	5.85	4.575	0	8.135	64.96
DAY 3	3.975	25.475	2.225	2.1	0	3.95	37.73
DAY 4	4.9	32.8	3.95	2.825	0	5.875	50.35
AVERAGE	**5.225**	**29.932**	**3.4188**	**3.6438**	**0**	**5.24**	**47.46**

In Hyderabad, the survey was conducted at Jawaharnagar dumpsite, which has the average total MSW generation was around 4200 MT/Day out of the average PW was generated about 47.46Kg/MT. The classified data for different types of plastics waste are represented in Table 29. From the study data it has been observed about 63.21% of PW was obtained from the recycling codes of 2 and 4 which is of HDPE/LDPE Material.

In Hyderabad, the MSW collected from various locations of city are transported to Jawaharnagar dumpsite where 50 families of rag pickers are living nearby dumpsite and segregating the PW and selling to the reprocessors.

TABLE: 30 STUDY OF VIJAYAWADA CITY: PW(Kg/MT)

SERIAL OF DAYS	1 PET	2 4 HDPE/LDPE	3 PVC	5 PP	6 PS	7 OTHER	TOTAL
DAY 1	4.432	52.148	3.264	5.044	1.188	0.2	66.276
DAY 2	2.584	61.416	1.128	12.932	4.488	2.112	84.66
DAY 3	4.996	52.352	2.844	5.352	1.728	0.4	67.672
AVERAGE	**4.004**	**55.305**	**2.412**	**7.776**	**2.468**	**0.904**	**72.87**

In Vijayawada, the survey was conducted at Pathapadu Pit No.10, which has the average total MSW generation was around 600 MT/Day out of the average PW was generated about 72.87 Kg/MT. The classified data for different types of plastics waste is represented in Table 30. From the study data it has been worked that about 76% of PW was obtained from the recycling codes of 2 & 4 which is of HDPE/LDPE Material. The waste was collected at the transfer stations located at sinshnagar , Where about 100 Nos. of Ragpickers picks valuable plastics and then the MSW is dumped in the dump yard and about 20 vermiculture plants are there which uses wet waste. In addition to that a fuel gas Plant (Bio-Gas) operated by M/S. Shivram Energy system Pvt. Ltd is present near to the dumpsite which is currently not working.

TABLE: 31 STUDY OF VISHAKHAPATTNAM CITY:PW(Kg/MT)

SERIAL OF DAYS	PET	HDPE/LDPE	PVC	PP	PS	OTHER	TOTAL
DAY 1	2.32	69.52	2.368	14.32	2.288	0.896	91.712
DAY 2	3.08	74.768	2.08	15.28	3.656	0.56	99.424
DAY 3	1.536	71.84	1.12	10.48	0.64	0.744	86.36
DAY 4	6.584	66.144	0.432	7.48	3.192	0	83.832
AVERAGE	**3.38**	**70.568**	**1.5**	**11.89**	**2.444**	**0.55**	**90.33**

The study data on Kapuluppada dumping ground of Vishakapattnam generated an average PW of about 90.33 Kg/MT. The data is shown in table 31; Out of about 78% comprise HDPE/LDPE materials with a minimum plastics waste generation 83.83 Kg/MT and with maximum of 99.42 Kg/MT. The Total MSW generated in this city was with an average of 334 MT/ Day. Near by dumpsite M/S. Marine Eco-Industries is operating, where they collect and treat the medical waste. The average total municipal solid waste generated is compared with the percentage of average plastics municipal solid waste obtained in each city is shown in Chart 2.

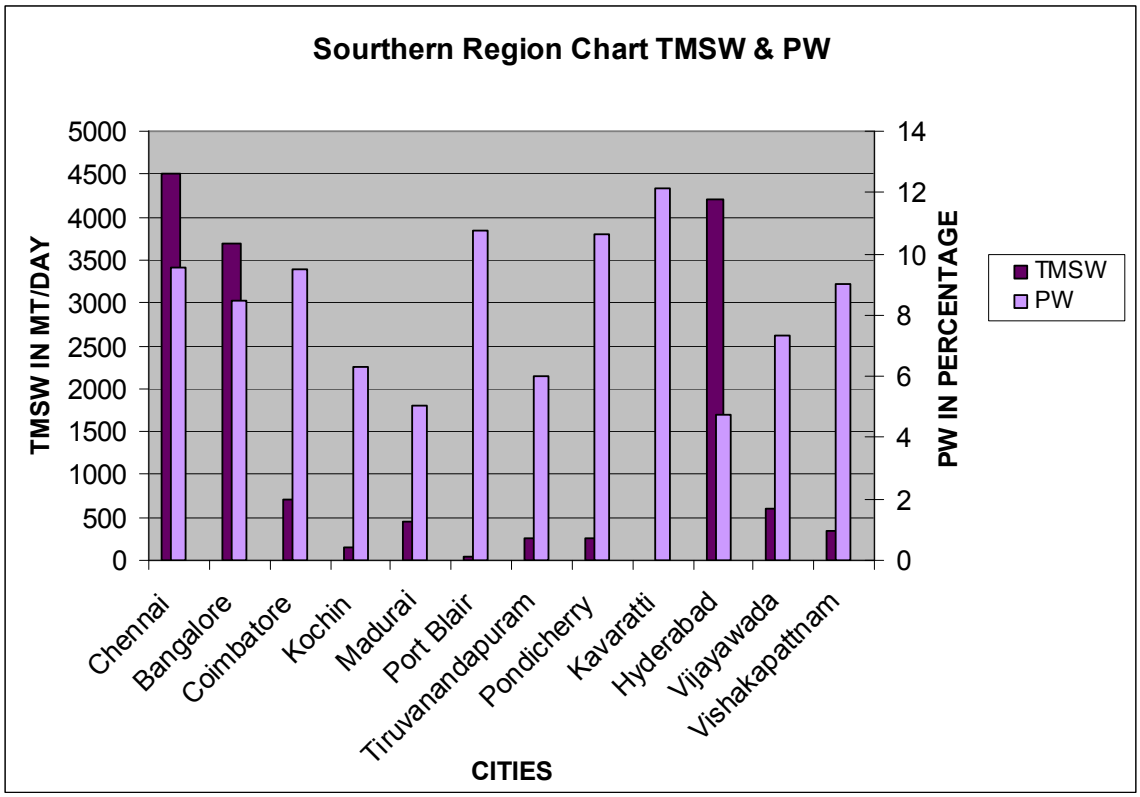


CHART 2: SOURTHERN REGION

TMSW GENERATION Vs PW GENERATION

4C. Western Region: The cities selected to carry out assessment and quantification of Plastics waste in the western region of the country are Ahmedabad, Daman, Dwaraka, Gandhinagar, Mumbai, Nashik, Panjim, Pune, Rajkot, Silvassa, Surat, Vadodara, & Jaipur

TABLE: 32 STUDY OF AHMEDABAD CITY: PW (Kg/MT)

SERIAL OF DAYS	1 PET	2 4 HDPE/LDPE	3 PVC	5 PP	6 PS	7 OTHER	TOTAL
DAY 1	1.344	82.752	1.648	9.792	0.496	0	96.032
DAY 2	0	102.08	0	3.712	8.32	0	114.112
AVERAGE	**0.672**	**92.416**	**0.824**	**6.752**	**4.408**	**0**	**105.07**

The field study in Ahmadabad was carried out in co-operation with Ahmedabad Municipal Corporation (AMC) in the place of Pirana dump site where the total MSW is dumped @ 2300 MT/Day. The survey reported an average PW of about 105.07 Kg/Tons, shown in Table 32 in which 92.416 Kg/MT (88%) belongs to code of 2 and 4, i.e. HDPE/LDPE Plastics waste comprises of carry bags, milk pouches, packing items etc. The study revealed that the average PW produced with a minimum and maximum of 96.032 Kg/MT and 114.11 Kg/MT respectively. During the study it is observed that Organic waste is treated separately to manufacture organic fertilizer. Refused Derived Fuel –RDF is also manufactured in nearby plant & supplies to local industries. GAS based power plant is also situated at site which helps to reduce the total quantity of Municipal solid waste generated. RDF plants nearer to the dumpsite which is operated by M/S. EXCEL under contract. Composting is done to promote derivation of organic manure from waste and to reduce the quantity of waste going to landfill site and also to help agricultural production; Waste to RDF (Refuse Derived Fuel) Plant by UPL DJAI Power Ltd. This RDF is used in Boiler for substitute for Coal, Lignite, Wood, Oil etc.

TABLE: 33 STUDY OF DAMAN CITY: PW (Kg/MT)

SERIAL OF DAYS	PET	HDPE/LDPE	PVC	PP	PS	OTHER	TOTAL
DAY 1	0	27.28	0.112	0	13.44	9.856	50.688
DAY 2	0.664	34.12	1.112	6.152	0.372	2.816	45.236
DAY 3	1.168	39.2	0	0.84	1.56	0.424	43.192
AVERAGE	**0.611**	**33.53**	**0.408**	**2.331**	**5.124**	**4.365**	**46.37**

In Daman, the field study on quantification of plastics waste was carried at the back side of fort. The PW obtained during the survey was about 46.37 Kg/MT where the TMSW generated @ 25 MT/Day the data's shown in table 33.

It is observed during the study that the plastics waste littered more in the city and only few number of collection points are available in the city and there is no proper dumping ground available in the city, at present the TMSW generated in the city are dumped at fort back side. The study reported that the HDPE/LDPE plastics had more quantity of packing items which was about 75%.

TABLE: 34 STUDY OF DWARKA CITY:PW (Kg/MT)

SERIAL OF DAYS	PET	HDPE/LDPE	PVC	PP	PS	OTHER	TOTAL
DAY 1	16.59	48	5.2	3.15	9.01	13.3	95.25
DAY 2 & 3	8.23	43.63	2.13	3.68	7.44	3.71	66.32
AVERAGE	**12.403**	**45.813**	**3.6667**	**3.3973**	**8.384**	**8.52**	**80.79**

In Dwarka, the study was carried out at Old Charakala Road (Vermi Plant Compost) where the TMSW are dumped and they are used at vermin compost plant. The Data obtained during the study are represented in Table 34**.** The Total Municipal waste generated was about 18 MT/Day out of which the PW generated was about 80.79 Kg/MT (8.07%). It is observed that lot of plastics films, carry bags littered on the main roads, streets of the city.

TABLE: 35 STUDY OF GANDHINAGAR CITY: PW (Kg/MT)

SERIAL OF DAYS	PET	HDPE/LDPE	PVC	PP	PS	OTHER	TOTAL
DAY 1	0.76	55.34	1.802	3.02	4.16	0.12	65.20
DAY 2	0.87	35.21	0.68	0.506	0.331	0.91	38.50
DAY 3	0.675	24.51	0.35	1.05	13.54	0.35	40.48
AVERAGE	**0.77**	**38.35**	**0.944**	**1.525**	**6.010**	**0.460**	**48.06**

In Gandhinagar, the dumpsite located in Sector 28, Opp to Electronic Park City, The average PW generated in Gandhinagar was about 48.06 Kg/MT. The MSW of the Data obtained during the study is represented in Table 35**.** The Total Municipal waste generated was about 97 MT/Day. The data obtained with the minimum PW of about 28.14Kg/MT and the maximum PW of about 65.20 Kg/MT. The field study report shows that, the MSW is directly dumped in the dumping yard without any post treatment operations. The maximum PW obtained as HDPE/LDPE waste like Carry bags, Packing Pouches etc.

TABLE: 36 STUDY OF MUMBAI CITY: PW (Kg/MT)

SERIAL OF DAYS	1 PET	2 4 HDPE/LDPE	3 PVC	5 PP	6 PS	7 OTHER	TOTAL
DAY 1	6.234	37.65	2.32	9.984	0.832	4.548	61.57
DAY 2	3.45	54.34	3.23	5.78	2.63	4.72	74.15
DAY 3	2.79	69.39	0.79	1.49	2.17	2.24	78.89
DAY 4	3.17	30.31	1.425	0.61	0.235	0.43	36.18
DAY 5	2.68	28.08	3.324	2.816	4.88	13.01	54.8
DAY 6	2.776	60.17	2.252	1.328	1.82	2.94	71.29
AVERAGE	**3.517**	**46.6517**	**2.224**	**3.668**	**2.095**	**4.648**	**62.813**

The field study in Mumbai was carried out in two dumpsite located at Mulund and Deoner. The MSW Collected at Deoner Dumpsite was three times more than than Mulund Dumpsite. The Average PW studied at the both dumpsites is reported in the Table 36. The Total Municipal solid waste collected at both the dumpsites was about 6500 MT/Day. The average PW generated was about 62.81 Kg/MT. The dumpsite was observed with huge nos. of Rag pickers who collects the valuable plastics waste like Polybags, PET Bottles, Sacks, Milk Pouches, rubber & Foam slippers etc, and it's observed that Metalized pouches were not collected by rag pickers.

TABLE: 37 STUDY OF NASIK CITY PW (Kg/MT)

SERIAL OF DAYS	1 PET	2 4 HDPE/LDPE	3 PVC	5 PP	6 PS	7 OTHER	TOTAL
DAY 1	1.108	47.00	0.648	5.244	2.396	0	56.39
DAY 2 & 3	1.349	50.25	0.355	4.24	3.77	0.075	60.04
AVERAGE	**1.229**	**48.625**	**0.502**	**4.742**	**3.083**	**0.038**	**58.22**

In Nasik, the survey was conducted at Patharadi, which has the average total MSW generation was around 350 MT/Day out of the average PW was generated about 58.22 Kg/MT. The classified data for different types of Plastics waste are represented in Table 37. From the study data it has been worked that about 83.57% of PW was obtained from the recycling codes of 2 and 4 which is of HDPE/LDPE Material.

In dumpsite of Nashik, the following post treatment plants are present (1) Inert Processing unit (2) Bio Gas Plant unit (3) Pre sorting unit (4) Dead Animal Incineration unit (5) Refused Derived Fuel unit (RDF) (6) Compost Manure Unit (Finished product unit) the MSW collected from various location of city post treated and corresponding outputs are produced.

TABLE: 38 STUDY OF PANJIM CITY PW (Kg/MT)

SERIAL OF DAYS	1 PET	2 4 HDPE/LDPE	3 PVC	5 PP	6 PS	7 OTHER	TOTAL
DAY 1	1.6	20.22	1.92	12.16	0.64	2.56	39.1
DAY 2	1.44	23.04	2.32	7.76	7.04	4	45.6
DAY 3	4.32	31.76	4.544	1.92	3.52	3.36	49.424
AVERAGE	**2.453**	**25.01**	**2.928**	**7.28**	**3.733**	**3.31**	**44.71**

In Panjim, the field study on quantification of plastics waste was carried at the Animal welfare centre. The PW obtained during the survey was about 44.71 Kg/MT where the TMSW generated @ 25 MT/Day. The data obtained on the segregated plastics are given in table 38. The majority of Plastics waste obtained as Poly bags, Packaging plastics the average of about 55.9%.The average PW resulted with a minimum of about 39.1Kg/MT and a Maximum of about 49.42 Kg/MT. In Panjim, the Bio-Compost Plants are present, almost all the municipal solid waste generated in the city are treated after the completed segregated of plastics and manure is produced as final product.

TABLE: 39 STUDY OF PUNE CITY PW (Kg/MT)

SERIAL OF DAYS	PET	HDPE/LDPE	PVC	PP	PS	OTHER	TOTAL
DAY 1	0.4	76.348	0.48	2.852	1.12	0	81.2
DAY 2	1	78.804	0	0.36	1.992	0	82.156
DAY 3	0.72	74.416	0.956	1.304	1.796	0.08	79.272
DAY 4	0	67.76	0	1.088	0.4	0	69.248
AVERAGE	**0.530**	**74.332**	**0.359**	**1.404**	**1.327**	**0.020**	**77.969**

In Pune, Fursangi Processing Plant, (Hanjar Bio-Tech Energy Ltd.) have been selected as the study area for this project. The study revealed that average total Plastic waste generation in Pune was about 77.96 Kg/MT represented in Table 39. It has been worked out from the survey data about 95% of total plastics waste is generated from HDPE/LDPE materials. The Total MSW generated in this city was with an average of 1300 MT/ Day. During the survey the Minimum Plastic waste, generation is about 69.25 Kg/MT and Maximum of 91.09 Kg/MT. Waste Collected from 85 wards of Pune city from various location are transferred to 4 transfer stations located at different locations, Finally the MSW are transported To Fursungi Processing Plant Operated by Hanjar Bio-Tech Energy Ltd. supplied to vermi-compost plants-12 Nos. Currently, no dumping of waste is done, all MSW are post treated, at Fursungi Processing Plant and produce products like Plastics to Diesel, Plastics Recycled Granules, Sand, Refused Derived Fuel, Compost Fertilizers.

TABLE: 40 STUDY OF RAJKOT CITY PW (Kg/MT)

SERIAL OF DAYS	PET	HDPE/LDPE	PVC	PP	PS	OTHER	TOTAL
DAY 1	8.1045	50.556	4.48	1.888	1.952	2.333	69.31
DAY 2	7.856	33.952	0.848	0.976	0.828	24.132	68.592
DAY 3	6.984	44.22	.332	0.664	3.66	9.076	69.936
AVERAGE	**7.648**	**42.91**	**3.553**	**1.176**	**2.147**	**11.85**	**69.28**

In Rajkot, the survey was conducted at 100 Ft Road & 80 Ft Road Dumpsites, which has the average total MSW generation, was around 230 MT/Day out of the average PW was generated about 69.28 Kg/Day. The data for different types of Plastics waste are represented in Table 40. From the study data it has been worked that about 62.06% of PW was obtained from the recycling codes of 2 & 4 which is of HDPE/LDPE Material. At dumpsite of Rajkot, the MSW collected from various locations of city are transported to three different stations where PW is segregated. The remaining MSW is finally transported to the dumpsite ground.

TABLE: 41 STUDY OF SILVASSA CITY PW (Kg/MT)

SERIAL OF DAYS	PET	HDPE/LDPE	PVC	PP	PS	OTHER	TOTAL
DAY 1	3.24	52.75	9.448	0.412	1.64	4.88	72.36
DAY 2	1.944	34.288	0.728	0.224	10.064	0.928	48.17
DAY 3	11.136	47.94	0	0	3.712	0	62.79
AVERAGE	**5.440**	**44.993**	**3.392**	**0.212**	**5.139**	**1.936**	**61.107**

In Silvassa, the field study on quantification of plastics waste was carried at the khadoli Village. The PW obtained during the survey was about 61.12 Kg/MT

where the TMSW generated @ 35 MT/Day. The data obtained is reported in table 41. There is no proper dumping ground available in the city, at present the TMSW generated in the city collected zone wise and dumped at khadoli Village. The study reported that the HDPE/LDPE plastics had more quantity of packing items which was about 73.3%. The study data revealed that the average PW with a minimum figure of 31.94 Kg/MT and maximum of 79.45 Kg/ MT.

TABLE: 42 STUDY OF SURAT CITY PW (Kg/MT)

SERIAL OF DAYS	PET	HDPE/LDPE	PVC	PP	PS	OTHER	TOTAL
DAY 1	0.887	131.67	1.524	0.678	1.622	2.3974	138.773
DAY 2	2.326	116.68	0.953	0.744	1.496	2.7288	124.920
DAY 3	0.561	105.07	0.246	0.628	1.066	2.798	110.3598
AVERAGE	**1.258**	**117.8**	**0.908**	**0.683**	**1.397**	**2.644**	**124.68**

In Surat, the survey was conducted at varachha and Anjana sites, which has the average total MSW generation, was around 1200 MT/Day out of the average PW was generated about 124.68Kg/MT (12.46%). The classified data for different types of Plastics waste is represented in Table 42. From the study data it shows that about 94.44% of PW was obtained from the recycling codes of 2 and 4 which is of HDPE/LDPE Material. The Municipal Corporation has six different transportation sites, where the MSW are collected from different zones and the Plastics and foot wears are segregated before dumping in the dumping ground. The Municipal Corporation has recruited rag pickers on each transportation site for the segregation of value added plastics and other materials. As per information received from Surat Municipal Corporation, the primary segregation of Plastic waste is carried out by the waste collection and secondary segregation is done at the transportation site. Finally the remaining MSW are dump at the dumping ground.

TABLE: 43 STUDY OF VADODARA CITY PW (Kg/MT)

SERIAL OF DAYS	PET	HDPE/LDPE	PVC	PP	PS	OTHER	TOTAL
DAY 1	0	48.90	1.69	0.565	2.97	1.13	55.26
DAY 2	0.27	30.11	0.97	0.64	4.78	6.13	42.89
DAY 3	0.988	28.096	2.64	0.704	3.90	2.584	38.912
AVERAGE	**0.42**	**35.70**	**1.76**	**0.64**	**3.883**	**3.280**	**45.69**

The field study in Vadodara was carried out at Makarpura Tarsali Bye Pass NH.8 where the total MSW is dumped @ 600 MT/Day. The survey reported an average PW of about 45.69 Kg/Tons, shown in Table 43 in which 36.65 Kg/MT (79%) belongs to code of 2 and 4, i.e. HDPE/LDPE Plastics waste comprises of carry bags, Milk Pouches, Packing items etc. The study revealed that the average PW produced with a minimum and maximum of 33.22 Kg/MT and 67.57 Kg/MT respectively.

TABLE: 44 STUDY OF JAIPUR CITY PW (Kg/MT)

SERIAL OF DAYS	PET	HDPE/LDPE	PVC	PP	PS	OTHER	TOTAL
DAY 1	3.349	31.83	6.043	9.56	9.26	11.75	71.79
DAY 2	0.89	37.11	0.320	7.632	3.059	8.552	57.56
DAY 3	0.440	19.00	0.357	3.827	2.045	9.555	35.226
DAY 4	0.699	15.49	1.059	4.280	0.683	5.091	27.307
DAY 5	4.600	16.259	3.765	16.288	3.579	14.109	58.600
DAY 6	1.560	16.083	7.309	15.133	2.240	8.755	51.080
AVERAGE	**1.922**	**22.63**	**3.142**	**9.45**	**3.479**	**9.635**	**50.26**

In Jaipur , the survey was conducted at Meena Transport Site which has the average total MSW generation was around 310 MT/Day out of the average PW was generated about 50.26 Kg/MT. The data which are classified according to the codes of plastics, represented in the table 44. The data shows that the HDPE/LDPE plastics having the code of 2 &4 has the majority of about 46%. The field study obtained with a minimum figure of average PW of 17.68 Kg/MT and a maximum of 79.78 Kg/MT. Scrap dealers collect the material of plastic which can be recycled like LDPE, PP but the coloured PET bottles are left over in the dumping site. It is observed that there is No post treatment Plant in Jaipur City. The average total municipal solid waste generated is compared with the percentage of average plastics municipal solid waste obtained in each city is shown in Chart 3.

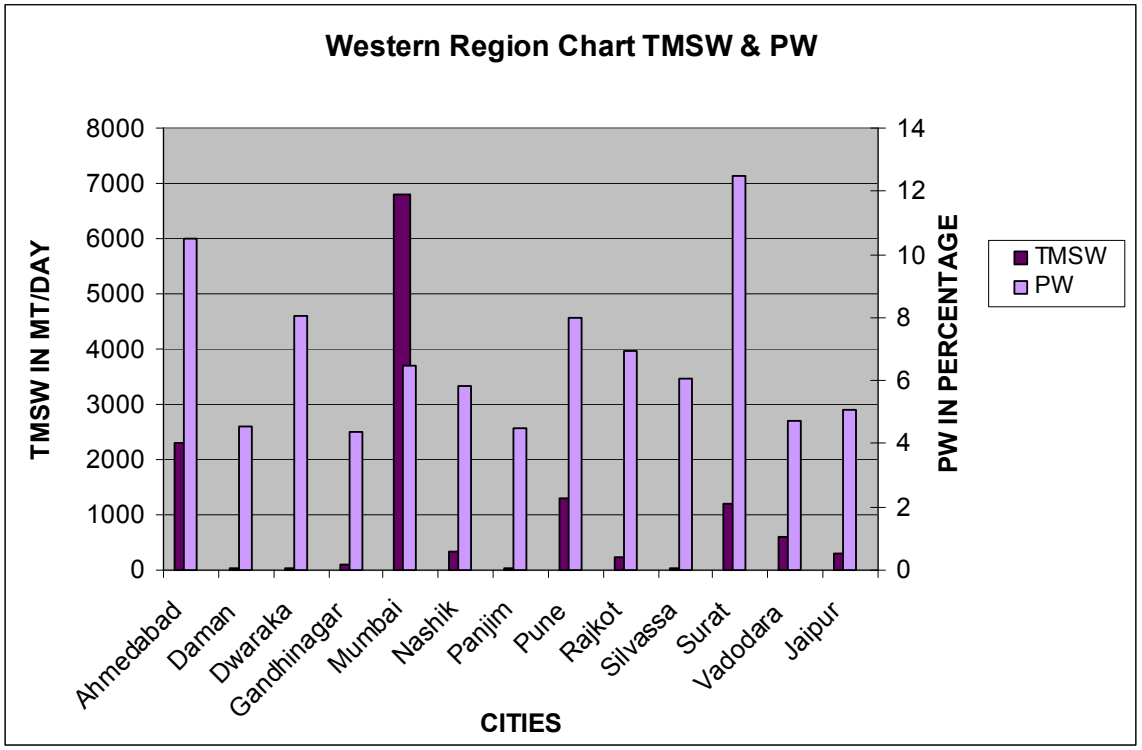


CHART 3: WESTERN REGION

TMSW GENERATION Vs PW GENERATION

4D. In the EASTERN REGION of the country, the cities selected to carry out assessment and quantification of Plastics waste are Asansol, Bhubaneswar,

Kolkata, Guwahati, Imphal, Gangtok, Aizwal, Itanagar, Kohima, Shillong and Agartala.

TABLE: 45 STUDY OF ASANSOL CITY PW (Kg/MT)

SERIAL OF DAYS	PET	HDPE/LDPE	PVC	PP	PS	OTHER	TOTAL
DAY 1	7.451	34.98	4.032	7.124	6.8	2.952	63.34
DAY 2	2.712	36.66	11.675	3.491	3.738	2.52	60.80
DAY 3	3.954	33.87	5.544	2.52	4.99	5.28	56.16
AVERAGE	**4.706**	**35.17**	**7.084**	**4.378**	**5.176**	**3.584**	**60.09**

The Assessment and Quantification of plastics waste at Asansol was carried out at Kalpahari**,** where the average TMSW generated at the rate of 210 MT/Day the majority of plastics reported as HDPE, LDPE and PVC. Ethylene based plastics obtained about 58.95%, Vinyl based plastics obtained about 12.5%. The total average PW obtained about 60.09 Kg/MT with the Minimum average PW of about 42.10 Kg/MT and Maximum of about 82.19 Kg/MT. The data obtained during the survey are depicted in table 45. The solid waste management and waste disposal has been put up effectively as a project by west Bengal state government for the following five regions that includes Asansol and its adjoining areas Raniganj, Durgapur, Asansol, Kulti and Tamulia. Each of these has their own treatment plants where they segregate the biodegradable, non-Biodegradable and recyclable waste.

TABLE: 46 STUDY OF BHUBANESWAR CITY PW (Kg/MT)

SERIAL OF DAYS	PET	HDPE/LDPE	PVC	PP	PS	OTHER	TOTAL
DAY 1	21.701	30.68	3.72	7.43	8.72	6.64	78.89
DAY 2	25.01	29.26	5.46	4.328	5.18	6.74	75.99
DAY 3	28.95	23.31	6.32	5.67	2.47	3.73	70.45
DAY 4	23.71	25.96	4.87	10.49	3.36	3.23	71.62
DAY 5	31.91	34.056	9.94	10.25	3.95	11.90	102.00
AVERAGE	**26.26**	**28.65**	**6.061**	**7.64**	**4.74**	**6.45**	**79.79**

The study data on bhuasuni dumping ground of Bhubaneswar generated an average PW of about 79.79Kg/MT. Out of about 36% comprise HDPE/LDPE and 32.9% PET plastic waste with a minimum plastics waste generation 67.30 Kg/MT and with maximum of 111.82 Kg/MT. The Total MSW generated in this city was with an average of 400 MT/ Day. The generated data is shown in Table 46. In Bhubaneswar the waste from the dumping ground is sent to ACC Cement kilns for utilization of plastics as fuel in cement kilns. But the company is situated at Bargadh i.e. about 500 km far from city. A parallel level of recycling unit is operated in and around Malisahi Basti. It has been observed that hundred of wholesale dealers, rag pickers and garbage lifters for sorting, segregating and cleaning the waste for further recycling process.

TABLE: 47 STUDY OF KOLKATTA CITY PW (Kg/MT)

SERIAL OF DAYS	PET	HDPE/LDPE	PVC	PP	PS	OTHER	TOTAL
DAY 1	1.760	99.97	3.333	2.587	4.480	4.000	116.13
DAY 2	2.4	78.36	1.4	1.52	4.2	0.24	88.12
DAY 3	1.27	86.03	3.39	1.39	2.80	1.20	96.07
DAY 4	2.533	143.013	1.867	2.533	6.347	4.720	161.013
DAY 5	1.23	99.32	2.27	1.88	2.10	2.99	109.79
AVERAGE	**1.797**	**102.98**	**2.526**	**2.015**	**3.97**	**2.8**	**116.09**

In Kolkata, the assessment and quantification of plastics waste was conducted at dump site located at Dhapa Check Post, Near Science City having the total MSW of about 3670 MT/Day, and the plastics municipal solid waste were assessed as with an average of 116.09 Kg/MT. The survey data is represented in table 47, which reveals that the majority of plastics in HDPE/LDPE which is about 88.7%, comprising of carry bags, milk pouches and Packing films. The data obtained with a minimum PW of 78.40 Kg/MT and a maximum of 177.60 Kg/MT.

TABLE: 48 STUDY OF GUWAHATI CITY PW (Kg/MT)

SERIAL OF DAYS	1 PET	2 4 HDPE/LDPE	3 PVC	5 PP	6 PS	7 OTHER	TOTAL
DAY 1	8.8	29.28	0.808	6.48	1.4	1.2	47.97
DAY 2	3.392	29.52	0.00	1.64	3.208	2.32	40.08
DAY 3	10.88	22.13	2.48	1.68	1.52	6.33	45.02
DAY 4	13.84	32.04	1.12	1.6	6.64	1.02	56.26
DAY 5	6.392	34.14	2.18	2.98	4.12	2.34	52.15
DAY 6	7.102	39.59	3.02	4.13	3.18	2.96	59.98
DAY 7	7.392	34.12	0.00	2.8	4.102	2.62	51.034
AVERAGE	**8.257**	**31.54**	**1.373**	**3.044**	**3.45**	**2.68**	**50.36**

Total MSW that are generated in Guwahati city was about 204 MT/Day. The survey was conducted at Boragoan Dumpsite which has the average PW generation of 50.36 Kg/MT. Around 62.6 % of total plastics waste is generated from HDPE/LDPE/LLDPE. The average PW obtained with the Minimum of 40.08 Kg/MT and Maximum of 59.98 Kg/MT. The classified average PW is given in Table 48. In Borogaon dumpsite extreme segregation is done and plastics are taken out from the municipal solid waste by the rag pickers. The plastics like PET bottles, HDPE containers, bottle closures, PP disposable items , CD's, packaging plastics usually of thickness more than 40 microns are picked up, cleaned and in bulk is sold to scrap dealers. More concern is about metalized plastics which are not picked up and can be seen all round the dumpsites. The Assam Gas Cracker Project is going to come up 2011-2012. Due to this many downstream plastics industries are expected to come up. In Guwahati CIPET PWMC is working in full swing with the vision to give complete solution for the disposal of waste plastics. Other concerns like M/S. Jagriti industries are also working towards recycling of

plastics waste. In Guwahati a compost manufacturing plant is also erected at the dumpsite.

TABLE: 49 STUDY OF IMPHAL CITY PW (Kg/MT)

SERIAL OF DAYS	1 PET	2 4 HDPE/LDPE	3 PVC	5 PP	6 PS	7 OTHER	TOTAL
DAY 1	10.85	33.13	1	3.37	7.21	2.94	58.5
DAY 2	10	30.79	0.9	5.445	1.2	0.67	49.005
DAY 3	11.67	25.36	2.33	2.28	1.02	2.34	45
DAY 4	14.34	29.96	1.32	1.4	4.39	1.38	52.79
AVERAGE	**11.715**	**29.81**	**1.3875**	**3.1238**	**3.455**	**1.8325**	**51.32**

In Imphal, the plastics assessment and quantification study was conducted at Lamphel,. The finding reveals that total MSW was about 120 MT/Day. The PW was observed as 51.32 Kg/MT out of the majority of Plastics waste found as carry bags and packaging pouches which is of 58.45% belong to the HDPE/LDPE material. The field study reveals that the Minimum Plastic waste generation 45.00 Kg/MT and Maximum of 58.50 Kg/MT. The study data on quantification of plastics waste is reported in Table 49. The contribution of plastics waste towards the total solid waste generated is no more negligible. Any programme like awareness programme regarding recycling and environment can go a long way in sustaining the presence of plastics in this beautiful region.

TABLE: 50 STUDY OF GANGTOK CITY PW (Kg/MT)

SERIAL OF DAYS	1 PET	2 4 HDPE/LDPE	3 PVC	5 PP	6 PS	7 OTHER	TOTAL
DAY 1	19.925	16.68	7.06	24.66	5.56	4.54	78.42
DAY 2	19.43	26.08	9.945	28.00	4.00	7.115	94.56
DAY 3	16.00	29.45	11.5	26.67	6.50	8.12	98.25
DAY 4	21.00	22.23	8.00	26.00	4.555	5.005	86.79
AVERAGE	**19.09**	**23.61**	**9.126**	**26.33**	**5.154**	**6.195**	**89.51**

The MSW generated in Gangtok was about 26 MT/Day. The study data on Lower Martham dumping ground of Gangtok generated an average PW of about 89.51 Kg/MT. Out of about 26.33% comprise PP waste consisting of Wheel covers, Woven Sacks, Electrical Items Covers, Box Container Disposable Cups, 23.61% of HDPE/LDPE waste consists of Polybags, Packing Items etc, 19.09% of PET Bottles. The survey data resulted with a minimum plastics waste generation 78.43 Kg/MT and maximum of 98.25 Kg/MT. The data of the field study on plastics quantification is shown in table 50. The Sikkim Government has banned the carry bags but still it is observed that the quantities of plastics packaging materials are littered in Gangtok. At Lower Martham Dumpsite, two types of MSW waste is collected namely dry and wet waste. The extreme segregation is done at the dumpsite and all types of plastics waste is sold to the scrap dealers of Silliguri. Compost treatment plant is not in working condition nearer to dumpsite.

TABLE: 51 STUDY OF AIZWAL CITY PW (Kg/MT)

SERIAL OF DAYS	PET	HDPE/LDPE	PVC	PP	PS	OTHER	TOTAL
DAY 1	20.025	15.02	5.085	26.06	6.27	7.115	79.575
DAY 2	15.025	17.11	11.575	15.21	10.27	9.615	78.805
DAY 3	15.52	14.52	8.59	18.56	9.92	9.695	76.805
DAY 4	10.025	22.52	5.085	28.575	8.77	7.745	82.72
AVERAGE	**15.15**	**17.30**	**7.589**	**22.10**	**8.807**	**8.543**	**79.48**

In Aizawal, the field survey was carried out at Tuirial dumping site, where the dumping of average total MSW of about 107 MT/Day. The data reveals that about 79.48 Kg/MT of PW was generated represented in table 51. However 21.6% plastics waste is generated from HDPE/LDPE materials consists of carry bags, household Items & multilayer films, 19.04% plastics waste is generated from PET. The minimum plastics waste generated of about 76.81 Kg/MT and Maximum of about 82.72 Kg/ MT.

TABLE: 52 STUDY OF ITANAGAR CITY PW (Kg/MT)

SERIAL OF DAYS	PET	HDPE/LDPE	PVC	PP	PS	OTHER	TOTAL
DAY 1	14.02	30.2	0.27	3.11	4.39	2.16	54.15
DAY 2	12.89	30.27	1.02	3.12	3.96	1.02	52.28
DAY 3	11.86	33.06	0.96	2.06	5.12	1.06	54.12
AVERAGE	**12.923**	**31.177**	**0.75**	**2.7633**	**4.49**	**1.4133**	**53.52**

Karsengsa Place has been selected as study area. The average total Plastic waste generation in Itanagar was found about 53.52 Kg/MT reported in Table 52.

Around 59.3% of total plastics waste is generated from HDPE/LDPE materials. The Total MSW generated in this city was with an average of 102 MT/Day. During the survey the minimum plastic waste generation 52.28 Kg/MT and maximum of 54.15 Kg/MT.

TABLE: 53 STUDY OF KOHIMA CITY PW (Kg/MT)

SERIAL OF DAYS	PET	HDPE/LDPE	PVC	PP	PS	OTHER	TOTAL
DAY 1	10.5	30.24	0.67	2.5	4.5	10.65	59.06
DAY 2	9.23	32.3	2.5	3.08	0.39	2.5	50
DAY 3	10.75	21	0	12	2.09	1.83	47.67
DAY 4	6	27.7	2.3	1.4	2.76	3.62	43.78
AVERAGE	**9.12**	**27.81**	**1.3675**	**4.745**	**2.435**	**4.65**	**50.13**

The quantification of plastics waste carried out at Kohima Dumping ground, the study revealed that average total plastic waste generation in Kohima was about 50.13 Kg/MT shown in Table 53. Around 55.4% of total plastics waste is generated from HDPE/LDPE materials. The Total MSW generated in this city was with an average of 45 MT/ Day. During the survey the minimum Plastic waste generation 43.78 Kg/MT and Maximum of 59.06 Kg/MT.

TABLE: 54 STUDY OF SHILLONG CITY PW (Kg/MT)

SERIAL OF DAYS	PET	HDPE/LDPE	PVC	PP	PS	OTHER	TOTAL
DAY 1	11.87	31.1	0	2.2	8.14	3.1	56.41
DAY 2	9.97	33.3	0.98	1.1	5.2	2.01	52.56
DAY 3	14.66	29.53	1.92	2.12	4.02	2.52	54.77
DAY 4	8.23	33.12	3.11	2.33	4.98	1.93	53.7
AVERAGE	**11.18**	**31.76**	**1.50**	**1.93**	**5.585**	**2.39**	**54.36**

In Shillong, the assessment and quantification of plastics waste was conducted at Borapani dump site having the total MSW of about 97 MT/Day, and the plastics was assessed as with an average of 54.36 Kg/MT. The survey data is represented in table 54, which shows that majority of plastics are PET, HDPE/LDPE. The PET is of about 20.57% comprising of water bottles & Medical bottles and HDPE/LDPE is of about 58.43% which comprises of carry bags, milk pouches and Packing films. The data obtained with a minimum of 52.56 Kg/MT and a maximum of 56.41 Kg/MT. The collected MSW was directly dumped without any post treatment operation. During survey it is observed that the plastics are segregated by the rag pickers and separated dumped in the dump yards without any post operations.

TABLE: 55 STUDY OF AGARTALA CITY PW (Kg/MT)

SERIAL OF DAYS	PET	HDPE/LDPE	PVC	PP	PS	OTHER	TOTAL
DAY 1	3.915	40.5	1.91	1.91	1.165	6.05	55.45
DAY 2	0.00	60.55	0	0.55	3.50	1.8	66.4
DAY 3	2.72	43.96	0.72	.96	0.32	2.52	52.2
DAY 4	3.365	41.8	1.355	2.41	0.87	4.615	54.415
AVERAGE	**2.5**	**46.703**	**0.995**	**1.701**	**1.46**	**3.75**	**57.13**

In Agartala, the dumping site was selected for the plastics quantification field survey, which is located Happania. The field study provided the data, which represented an average PW of about 57.13 Kg/MT, where the total MSW generated in the city is of about 102 MT/Day. The data of segregated plastics waste is given in Table 55. The majority of plastics waste generated from HDPE/LDPE and Unclassified plastics has 81.7% and 6.56% respectively. Further it revealed from data, that the minimum quantity of plastics waste generation is about 52.20 Kg/ MT and a maximum of about 66.40 Kg/MT. The segregation of plastics waste is done at the dumpsite. Other degradable MSW is utilized in compost plant which is installed at the dumpsites and operated by M/S. Prayag group with municipal corporation Agartala. The segregated PW is sent to Kolkata. The Agartala Municipal Corporation has provided bins of three colours to many residential areas for collection of different types of waste, so that plastics may be reduced at the dumpsite. As the people are not properly aware, the practice of separation of degradable and Non-degradable is not practiced. Hence some awareness programme may also help to resolve the issue of waste plastics in Agartala.

The average total municipal solid waste generated is compared with the percentage of average plastics municipal solid waste obtained in each city is shown in Chart 4.

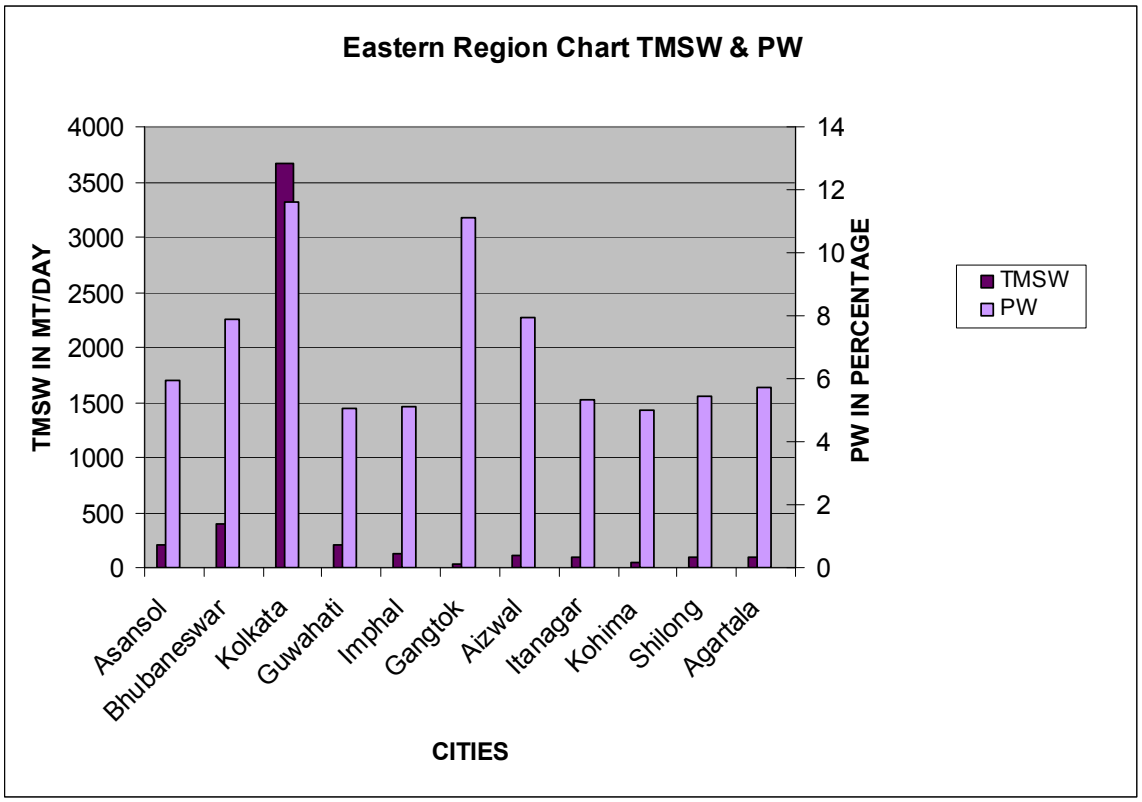


CHART 4: EASTERN REGION
MSW GENERATION Vs PW GENERATION

4E. In the CENTRAL REGION of the country, the cities selected to carry out assessment and quantification of plastics waste are Bhopal, Jabalpur, Nagpur, Raipur, Indore

TABLE: 56 STUDY OF BHOPAL CITY PW (Kg/MT)

SERIAL OF DAYS	PET	HDPE/LDPE	PVC	PP	PS	OTHER	TOTAL
DAY 1	0.68	39.07	2	14.4	1.12	0.52	57.79
DAY 2	0.416	45.872	0.68	16.832	0.2	1.04	65.04
DAY 3	0.072	32.008	1.384	32.624	0	0.76	66.848
DAY 4	0.144	61.944	4.048	12.68	2.04	0.712	81.568
DAY 5	0	41.76	3.632	11.72	1.24	0.12	58.472
AVERAGE	**0.2624**	**45.131**	**2.3488**	**17.651**	**0.92**	**0.6304**	**65.94**

In Bhopal, the average quantity of plastic waste has been assessed as 65.94 Kg/MT, which comprises of 68.44% of HDPE/LDPE, 26.76% of PP and 3.56% of PVC material, described in Table 56. The field survey was carried out at Bhanpur dumpsite where the TMSW dumped at the rate of 350 MT/Day. It has been observed that no post-treatment operation for MSW is done in the city and 100% of MSW is dumped as land-filling. The Bhopal Municipal Corporation and MPPCB stabilized compact packer for the welfare of rag pickers. Approximately 250 Rag pickers collects the valuable plastics waste generated though out the day.

TABLE: 57 STUDY OF JABALPUR CITY PW (Kg/MT)

SERIAL OF DAYS	PET	HDPE/LDPE	PVC	PP	PS	OTHER	TOTAL
DAY 1	0.304	44.23	2.88	10.88	1.72	1.34	61.35
DAY 2	0.1824	39.90	1.44	9.568	0.793	0.712	52.59
DAY 3	0.648	51.28	1.92	4.80	1.248	1.84	61.736
DAY 4	0.00	47.51	2.912	4.80	0.72	4.32	60.26
DAY 5	0.00	28.33	0.76	2.017	0.443	1.877	33.42
DAY 6	0.00	41.79	4.72	3.6	1.08	2.36	53.55
DAY 7	0.32	30.8	1.2	4.32	0.824	1.872	39.336
AVERAGE	**0.207**	**40.55**	**2.261**	**5.713**	**0.975**	**2.045**	**51.75**

In Jabalpur, the dumping site was selected for the plastics quantification field survey, which is located at Rental. The field study provided the data, which represented an average PW of about 51.75 Kg/MT, where the total MSW generated in the city is of about 400 MT/Day. The data for segregated plastics waste is given in Table 57. Further it revealed from the data, that the minimum quantity of plastics waste generation is about 33.42 Kg/ MT and a maximum of about 61.74 Kg/MT.

TABLE: 58 STUDY OF INDORE CITY PW (Kg/MT)

SERIAL OF DAYS	PET	HDPE/LDPE	PVC	PP	PS	OTHER	TOTAL
DAY 1	2.552	43.2	0.92	24.46	3.968	3.064	78.168
DAY 2	2.08	48.8	0.8	18.88	2.4	4.4	77.36
DAY 3	3.024	38.08	1.04	30.05	5.536	1.728	79.46
DAY 4	1.128	33.52	12.95	27.39	2.112	8.00	85.104
DAY 5	15.84	39.016	3.84	38.51	18.16	4.784	120.15
AVERAGE	**4.924**	**40.52**	**3.91**	**27.86**	**6.44**	**4.39**	**88.05**

In Indore, the field study on quantification of plastics waste was carried at Devgudariya Trenching ground Nemavar road. The PW obtained during the survey was about 88.05 Kg/MT where the TMSW generated @ 720 MT/Day. The data obtained is resulted in table 58. There is no post treatment operations are performed in indore city. The study reported that the HDPE/LDPE & PP consumptions are more yields about 46.1% and 31.64% respectively. The study data revealed that the average PW resulted with a minimum figure of 77.36 Kg/MT and maximum figure of 120.15 Kg/ MT.

TABLE: 59 STUDY OF NAGPUR CITY PW (Kg/MT)

SERIAL OF DAYS	PET	HDPE/LDPE	PVC	PP	PS	OTHER	TOTAL
DAY 1	6.272	53.96	1.00	8.464	7.152	0.616	77.46
DAY 2	4.80	52.16	2.64	9.56	4.24	0.472	73.87
DAY 3	0.00	66.00	1.456	5.28	3.20	0.96	76.89
DAY 4	1.632	43.2.	11.52	7.44	6.96	0.72	71.47
DAY 5	5.28	44.16	5.968	6.352	3.544	2.40	67.70
DAY 6	1.96	47.18	4.192	7.616	6.80	1.68	69.42
DAY 7	2.40	42.40	01.88	4.656	4.248	2.496	58.08
AVERAGE	**3.19**	**49.87**	**4.09**	**7.05**	**5.16**	**1.33**	**70.70**

In Nagpur, Municipal Corporation and State Pollution control Board jointly stabilized composite fertilizer Plant which is operated by M/S. Hanjar Bio-Tech Ltd. Further a plant operated by GIL for compacting the old municipal waste.The quantification of plastics waste survey was conducted bhadewadi dumping yard The Nagpur city collects the average MSW of about 650MT/Day, Out of that 70.70 Kg/MT was produced as average PW. The data resulted during the study is given in Table 59. The data shows the minimum PW of about 58.08 Kg/ MT and the maximum of about 77.46 Kg/MT.

TABLE: 60 STUDY OF RAIPUR CITY PW (Kg/MT)

SERIAL OF DAYS	PET	HDPE/LDPE	PVC	PP	PS	OTHER	TOTAL
DAY 1	1.496	106.1	4.624	34.8	6.328	2.97	156.3
DAY 2	1.728	88.384	7.104	46.8	8.048	1.04	153.1
DAY 3	1.264	123.8	2.152	22.84	4.608	4.91	159.56
DAY 4	2.52	45.68	3.768	25.9	2.744	1.112	81.73
DAY 5	2.04	22.93	0.528	51.78	3.904	0.184	81.37
DAY 6	2.04	19.31	0.68	17.31	4.56	2.45	46.34
DAY 7	1.376	14.26	2.776	37.01	5.66	2.98	64.06
AVERAGE	**1.78**	**60.06**	**3.09**	**33.78**	**5.12**	**2.23**	**106.07**

In Raipur, the plastics assessment and quantification study was conducted at Sarona, Ring road No.1, near Kharun River, The findings revealed that the total MSW was about 224 MT/Day. The PW was observed as 106.07 Kg/MT out of the majority of plastics waste found as carry bags and packaging pouches which is of 56.62% belongs to the classification of HDPE/LDPE material. The field study reveals that the minimum plastic waste generation is about 46.34 Kg/MT and maximum of 159.56 Kg/MT. The study data on quantification of plastics waste is reported in Table 60. The average total municipal solid waste generated is compared with the percentage of average plastics municipal solid waste obtained in each city is shown in Chart 5.

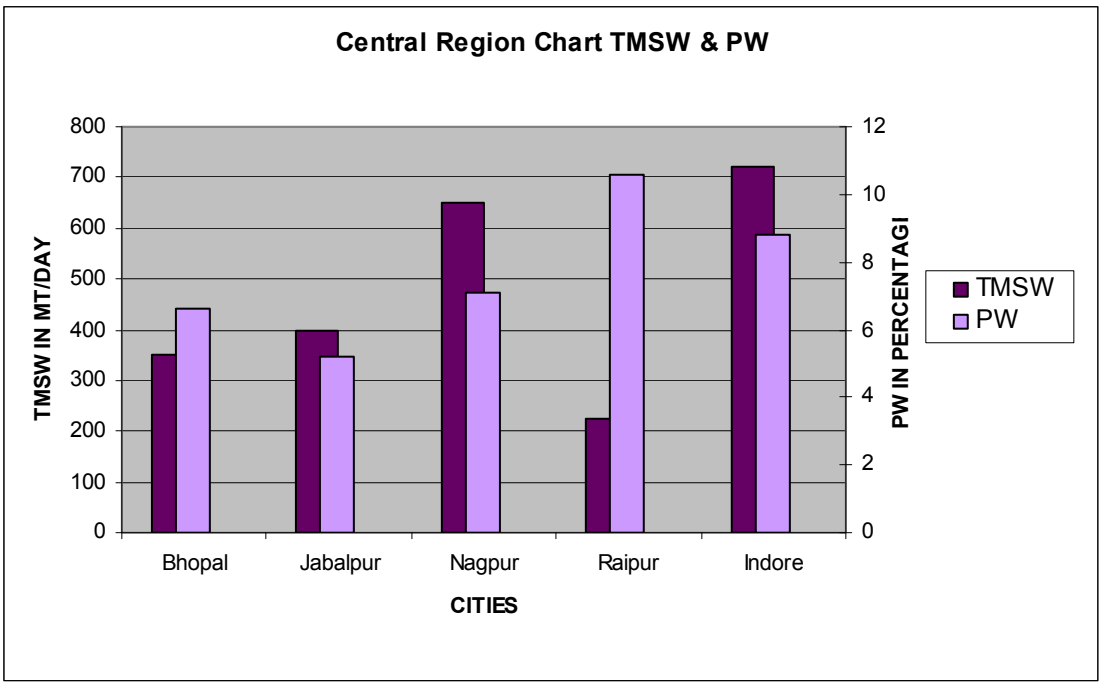


CHART 5: CENTRAL REGION
TMSW GENERATION Vs PW GENERATION

CONSOLIDATED CHART FOR TOTAL MSW and PW GENERATED AT 60 MAJOR CITIES OF INDIA

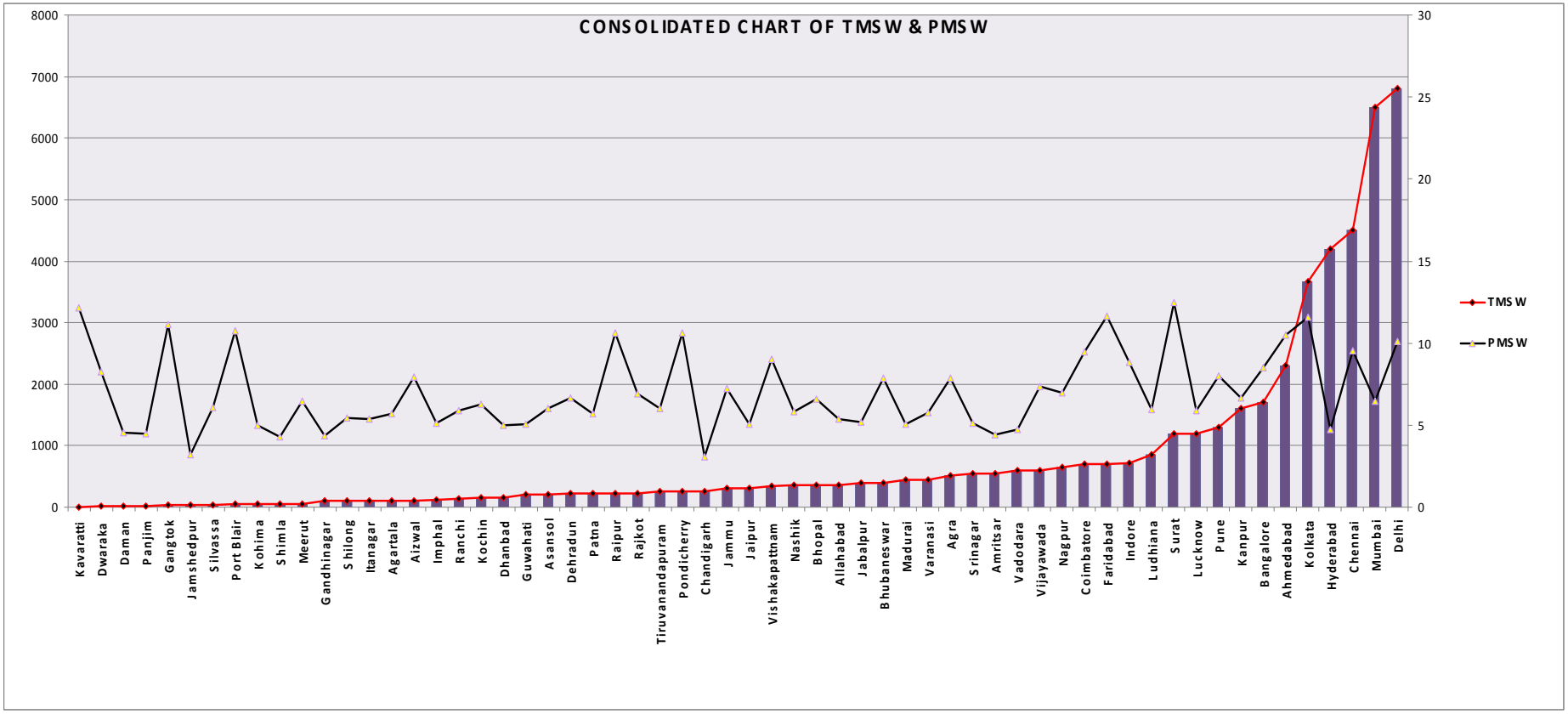


CHART 6: MSW GENERATION Vs PW GENERATION OF 60 CITIES

5. CURRENT INDIAN SCENARIO FOR COLLECTION, TRANSPORTATION AND DISPOSAL OF PLASTIC WASTE

The study observed that, the main practice used for waste collection is that the municipal and hired vehicles operated in various zones of the city on daily basis to collect the waste from the community bins. In this system, residents deposit their waste into the nearest community bins located at street corners at specific intervals. Waste generated in households is generally accumulated in small containers (often plastic buckets) and then disposed of into community bins. The waste is loaded into the vehicles from the community bins and finally, the waste is transferred to the disposal site. Before unloading the waste that is collected from the community bin, the vehicles were weighed on the weigh bridge located near the disposal site or in other areas. The weighing exercise was carried out on major cities and the daily waste quantity was computed and waste generation in kg/capital/day was calculated based on the urban population.

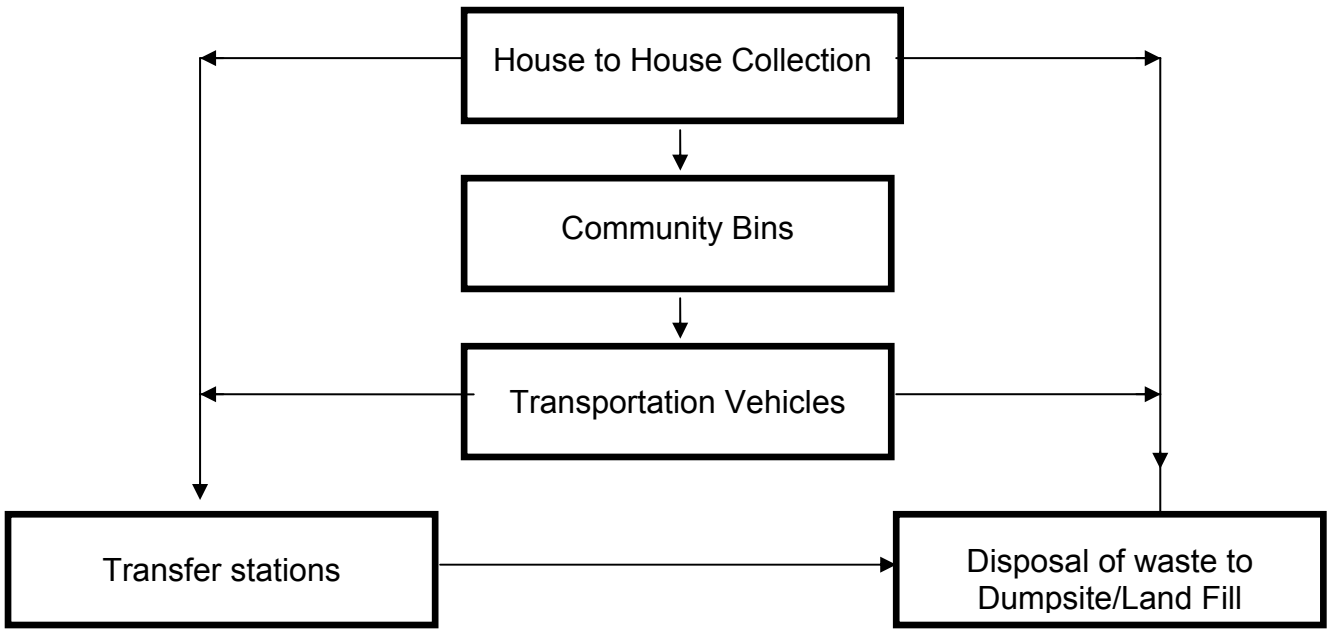
HOUSE-TO-HOUSE COLLECTION SYSTEM

House-to-house collection is system is adapted in few cities. In those cities that use house-to-house collection the waste that are collected from houses, offices, small shops and small markets. Here people are required to deposit their wastes in communal containers/ community bins (stationary or haul types), from which it is collected by municipal crews, handcarts and tricycles are used for waste collection from individual houses at a specific time in the morning, when residents deposit the stored waste into the handcarts. The waste in the handcarts is either transferred to community bins or directly transferred to vehicles going to the disposal site. Few cities like Kanpur, Ahmedabad, Hyderabad, Chennai, Surat, Nashik, Panjim, Vijayawada, Vishakapattnam, Nagpur and Pondicherry has implemented house to house collection system. This collection method will be promoted as an improvement to the existing system in various cities and towns.

TRANSFER STATIONS SYSTEM

The cities like Hyderabad, Thiruvananthapuram, Surat, Vadodara, Rajkot and Panjim have established transfer stations systems. Transfer refers to the movement of waste or materials from collection points to disposal sites. Transportation of waste from collection point to disposal sites is carried out by using different types of vehicles depending on the distances to be covered by them. Larger vehicles carry the waste from the collection points to the disposal sites. Comparatively small vehicles discharge waste at transfer stations where the wastes are loaded into larger vehicles for transportation to the disposal sites. In metro cities transfer stations located at different places to support intermediate transfer of waste from the surrounding areas up to the dumping grounds. Transfer stations are centralized facilities where waste is unloaded from smaller collection vehicles and re-loaded into larger vehicles.

CHART 7: COLLECTION & TRANSPORTATION OF MSW CAN BE SCHEMATICALLY SHOWN AS



TREATMENT AND DISPOSAL

There is no processing of waste being done in most of the cities. The entire waste, which is collected, is taken for dumping to the disposal site. At present there is no sanitary landfill site in most of the cities. The disposal is carried out following the method of crude dumping where the waste is neither spread nor covered. In some

areas the garbage waste is recklessly burnt in open dump yards placed on the main highway road.

Land filling of mixed waste like non-biodegradable, inert waste and other waste that are not suitable either for recycling or for biological processing is dumped together with recyclable material. Waste processing facilities are not available with proper capacity except few cities.

WASTES PROCESSING BY ENERGY RECOVERY OR COMPOSTING

In Metro cities like Kanpur, Bangalore, Hyderabad, Ahmedabad and Kolkata, Solid Waste processing plants established near the dump site to produce Refuse Derived Fuels (RDF) plant (Energy recovery) by some of the private agencies, which involves the mechanical processing of household waste using screens, shredders and separators to recover recyclable materials and to produce a combustible product. This system involve the removal of inert and compostable materials followed by pulverization to produce a feedstock which can be incinerated in power stations, pyrolysis and gasification systems, co-incinerated in other industrial combustion processes or fluidized bed plant. In cities like Delhi, Hyderabad, Pune the vermi- composting practices has been adapted. Vermi-compost is the degraded organic matter (cast or excreta) by worm activity, and the process of converting organic fraction of the MSW into vermi-compost. The conversion of solid waste into vermi-compost is done with Low cost solution which improves the soil fertility, resulting in better agricultural yield in the region.

But plastics waste were found to be simply dumped in most of the dumpsites & forming “Hill like” structures in Dump ground, which one may call as “Plastics Hill”. On the positive note, most of these waste of Plastics Hill can be recycled provided there is an organized, scientific Framework in the form of an “Industry” which not only converts these waste into value added granules or products but also clears out the “so-called” plastics explosion in cities.

RECYCLING OF PLASTIC WASTE- TYPES & AVAILABLE OPTIONS:

The recycling of plastics is possible through different methods the polymers have become increasingly multi-component through the use of multi-layers, laminates and composites. Many polymers are rarely additive free, normally they contain additives,

formulates and modifiers such as fillers, pigments, antioxidants and flame-retardants, hence it pose difficulties in processing.

Recycling is the process of transforming materials into secondary resources for manufacturing mew products. The waste recycling leads to less utilization of raw materials, saves on landfill space, reduces the amount of energy required to manufacture new products.

The methodologies for recycling of plastics waste are classified as follows:

1. Primary Recycling (Conversion of waste plastics into products having performance level comparable to that of original products made from virgin plastics).
2. Secondary Recycling (Conversion of waste plastics into products having less demanding performance requirements than the original material).
3. Tertiary Recycling (The process for producing chemicals/fuels/ Similar Products from waste plastics).
4. Quaternary Recycling (The process for recovering energy from waste plastics by incineration).

1. Mechanical Recycling

Mechanical recycling involves processing of waste into a product which characteristics similar to those of original product. This process involves the following steps.

1. Collection and Segregation:

   The plastics materials has varying density, hence they are segregated/separated by floatation process.
2. Cleaning and Drying:

   The post consumer plastics waste requires proper cleaning and drying.
3. Sizing :

   The cleaned plastics waste products should be sized; the dried flakes are fed into an extruder where they are heated to melting state and forced through the die converting into a continuous polymer product or strands.
4. Pelletizing :

   The strands are cooled by water and cut into pellets, which produces reprocess granules.

5. Fabrication into end product :

Reprocessed granules used as raw materials for producing end products.

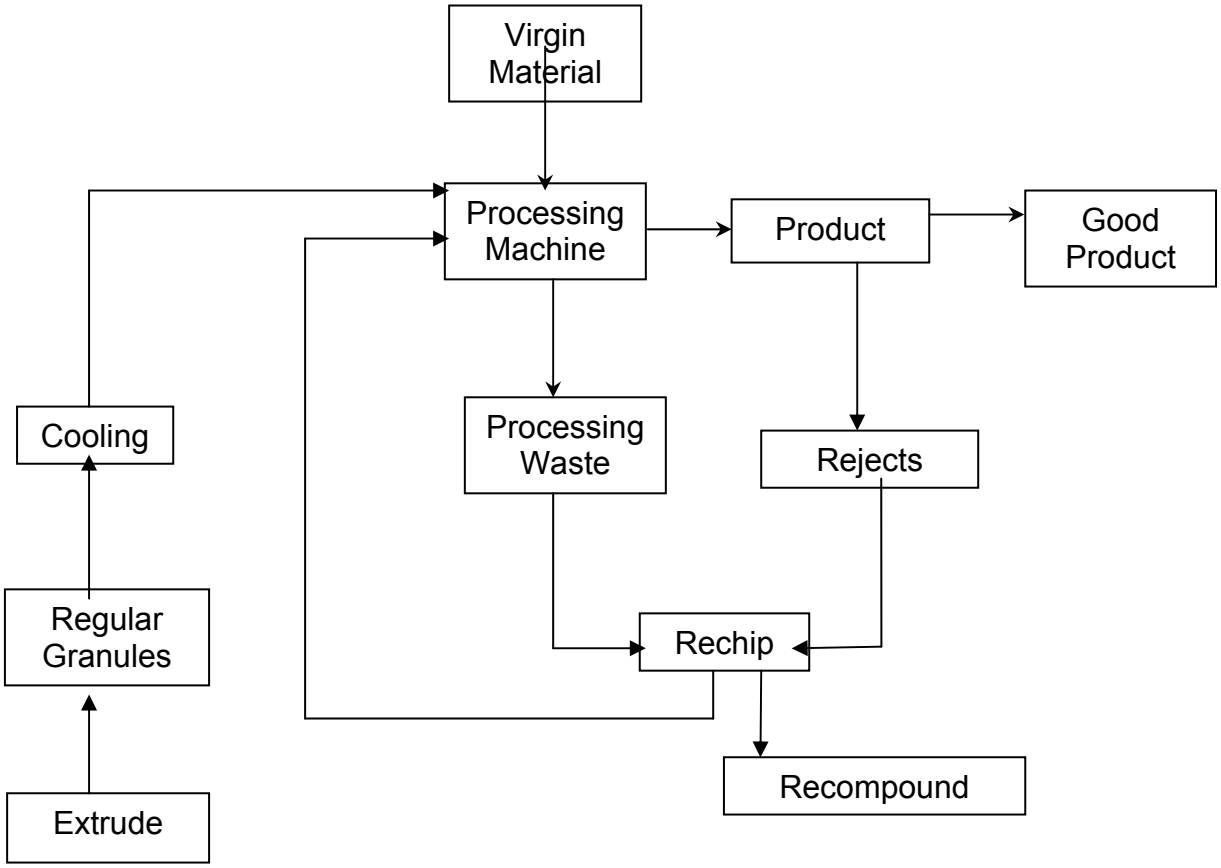


CHART 8: FLOW CHART FOR MECHANICAL RECYCLING

1. Chemical Recycling

Chemical or Feed stock recycling is a process, in which a plastic or polymer is broken down into its basic components/constituents i.e. Monomer. This process is called depolymerization. The monomers may be used as raw materials for manufacturing a new polymer. The types of Chemical recycling processes are,

Pyrolysis This technology is used for Extracting Fuel from the Non-Recyclable plastics. Pyrolysis is the chemical decomposition of condensed substances that occurs spontaneously at high enough temperatures.

Pyrolysis is a special case of thermolysis and is most commonly used for organic materials, being then one of the processes involved in charring. The pyrolysis of wood, which starts at 200-300 °C (390-570 °F), occurs for example in fires or when

vegetation comes into contact with lava in volcanic eruptions. In general, pyrolysis of organic substances produces gas and liquid products and leaves a solid residue richer in carbon content. Extreme pyrolysis, which leaves mostly carbon as the residue, is called carbonization.

Pyrolysis differs from other high-temperature processes like combustion and hydrolysis in that it does not involve reactions with oxygen, water, or any other reagents. However, the term has also been applied to the decomposition of organic material in the presence of superheated water or steam (hydrous pyrolysis), for example in the steam cracking of oil.
Anhydrous pyrolysis can also be used to produce liquid fuel similar to diesel from plastic and rubber waste.

Pyrolysis is a process of thermal degradation in the absence of oxygen. Plastic/Rubber waste is treated in a cylindrical chamber at temperature of 370 °- 420 °C. Specially developed Catalyst gently cracks the Polymer and converts plastics/ Rubber into Gas. Majority of gas gets condensed into Fuel and no condensed gas is either stored or re-used for Heating.

The essential steps in the Pyrolysis process involves:

- Elimination of Moisture by Pre-drying the material
- Indirect heating the plastic / Rubber with gradual increase in temperature.
- Converting the plastics/Rubber to gas with the help of catalytic converter.
- Careful condensation and Fractionation of pyrolysis vapours to produce fuel.

Input Material

Mixed Plastic Scrap in any form /Rigid/Film
Carry bags (even less than 20 microns) / oven sacks
Mono /Multilayer pouches and sachets
PU Foam /EPS/FRP
All kinds of Rubber Waste
Tyre scrap from Bi-cycles to Heavy Vehicles
Cable husk / Carpets / Shoe soles etc…

Output Material

Fuel Oil

Carbon Black Ash (option to convert into activated Carbon)

INPUT / OUTPUT	PLASTICS	RUBBERS
Light oil	60-65%	40-45%
Heavy oil	10-15%	10-15%
Gas	20%	20%
Ash content	5%	25%

TABLE: B PERCENTAGE OF INPUT AND OUTPUTS

Product and its application:

Furnace Oil also known as Fuel Oil or Bunker Oil. It is an industrial fuel used in generation of electricity and heat in many manufacturing units. It is majorly used in Power, Fertilizer and Steel manufacturing units in India. It is traded on major commodity exchanger

Hydrogenation:

An important method of chemical recycling is hydrolysis. The breaking down of plastics into their constituent raw materials by hydrolysis is of course, possible if the plastic contains that groups which can be hydrolyzed. Since hydrolysis is the reverse of condensation, it is clear that plastics which can be hydrolyzed are all those made by condensation. Whether hydrolysis is practical or not is solely a question for the reaction conditions.

The polycondensation products which also include plastics produced by polyaddition, encompass such as polyamides, polyesters, polycarbonates, polyureas and polyurethanes. Hydrolysis involves the specific reaction of the water molecule at the point of linkage with the starting materials (this is the reverse of the reaction that produced the polymer originally), so that the starting materials used

originally are recovered directly. The groups of plastics mentioned above as being hydrolysable are all resistant to hydrolysis under normal conditions use. Hydrolysis must be induced under extreme conditions.Moreover, hydrogenation promotes the removal of hetro atoms, such as Chlorine (Cl), Nitrogen (N), Sulphur (S) in the form of volatile compounds.

Gasification:

Gasification is a recycling method where plastics are processed into gases such as carbon monoxide (CO), Hydrogen (H2) and Hydrogen chloride. These gases are then used as the chemical raw material for the production of chemicals such as methanol and ammonia. Almost all types of plastics, including those containing chlorine can be recycled under the gasification method. However, the profitability of a gasification process largely depends on the value and application of synthesis gas. The gases can be used for synthesis of various chemicals such as methanol, ammonia or acetic acid.

3. Incineration

Incineration is the term used for the combustion and reduction to an inert residue of any combustible waste. Incineration can be used as a means of plastic waste disposal and incinerators may be used to produce steam for domestic heating and the generation of electricity. In the incinerator the combustion takes place at high temperature (around 7000°C) in the presence of the requisite amount of oxygen. Since the plastics present in waste consists mainly of carbon and hydrogen, the product obtained after combustion should consist mainly of carbon dioxide and water.

Incineration is not usually favored as a method of disposal because of very high capital, maintenance and operating costs, unreliability and adverse environmental impact. Problems are added when incineration is combined with generation of steam and the output to be controlled to suit customer demand.

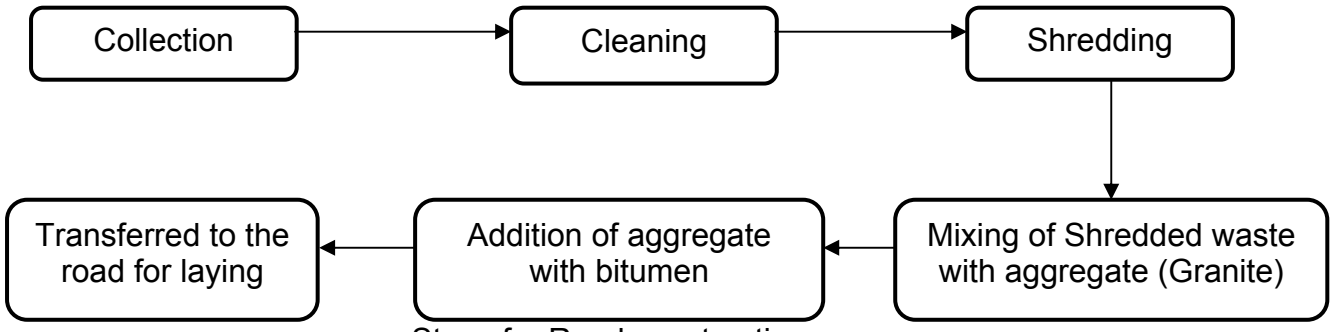
PVC has received considerable criticism since HCI gas is evolved on combustion for long term use, the incineration may be a favored and economical method to dispose of all the plastics exclusive of PVC from the incinerator to safeguard it from the

problems associated with evolution of HCl, the other plastics could be readily utilized as high energy fuel, because they have considerably high caloric value.

UTILIZATION OF PLASTICS WASTE IN DIFFERENT FIELDS

A. Road Construction

The plastic waste (Bags, Cups, Thermocloe) made out of PE, PP, & PS are separated, cleaned and shredded into small pieces by passing through 4.35mm sieve. The aggregate (granite) is heated to 170 C in the mini hot mix plant and shredded plastic waste is added, it's get softened and coated over the aggregate. Immediately the hot bitumen of 160 C is added and mixed well. As the polymer and the bitumen are in the molten state they get mixed and the blend is formed at the surface of the aggregate. The mixture is transferred to the road for laying.



Steps for Road construction

Wet Process

Blending of plastic waste by direct mixing of shredded polymer with hot bitumen at 160◦C. Mixing of higher percentage of polymer is difficult, because of difference in viscosities of molten polymer and bitumen. Powerful mechanical stirrer required for effective mixing. Also required addition of stabilizers and proper cooling

Dry Process

Waste polymer is added on the hot aggregate (170◦C).The polymer gets coated over the aggregate uniformly. The bitumen is added; mixing of bitumen with polymer takes place at the surface of the aggregate around 155-163◦C. With the increase in surface area of contact, mixing of polymer with bitumen is better. Hence, blend with better binding property is formed.

B. Cement Kilns

The recycling of plastics waste for recovery of energy is the use of plastics waste as an alternative to fusible fuel in Cement Kilns. Any material having calorific value of at least 2,500 kcals are accepted as an alternative fuel in cement kilns, provided it is available at a cost less than the normal fossil fuel: plastics waste, which have quite high calorific values, offer a viable alternative fuel. As Cement Kilns are operated at a very high temperature in the range of 1500°C or more. *Use of plastics Waste in Cement Kilns* of generation of any toxic emission due to the burning of plastics waste. In fact, Cement Kilns can be utilized for burning of some hazardous waste and for recovering precious energy out of it for production of cement. Energy Recovery depends on the types of plastics waste and the relative ease / difficulty in total or partial segregation from other plastics and / or other waste materials. Mechanical recycling includes a wide variety of processing techniques and a broad range of processing methods. Pure grade production scrap may only have to be reground and reprocessed, mixed plastics have to be mechanically separated and, if contaminated, also adequately washed and cleaned. All these steps increase the cost depending on the degree of contamination. After collection of the portions that can be recycled by mechanical recycling, there remain numerous very small, heavily contaminated articles, multi layered composites or cross-linked products, which are mostly unattended and are allowed to remain in the waste stream causing solid waste problem. The best way of reutilizing these portions is to properly incinerate them instead of dumping them diffusely on landfills. This recovers their calorific values and at the same time disposes of the waste without causing any environmental hazards. The unattended plastics waste in the Municipal solid waste stream through co-processing in Cement Kilns (Energy Recovery) using in Blast Furnaces and conversion of all types of mixed plastics waste into Industrial Fuel.

6. FINDINGS ON RECYCLABLE & NON RECYCLABLE CONTENTS:

The present study on Assessment and quantification of plastics waste generation in MSW in 60 major cities of India suggests that out of total plastics Waste, thermoplastics content is about 94% (RECYCLABLE) and rest 06% belong to family

of others including thermoset plastics (Non-Recyclable) The consolidated details of classification of different constituents of plastics waste are tabled below:

TABLE: C Consolidated PERCENTAGE OF CLASSIFIED PLASTICS WASTE

S.NO	CODES	DESCRIPTION	TOTAL PERCENTAGE OBTAINED
1	1	PET	8.66
2	2 4	HDPE/LDPE	66.91
3	3	PVC	4.14
4	5	PP	9.9
5	6	PS	4.77
6	7	OTHERS	6.43

The above data reveals that the Polyethylene Terephthalate (PET) corresponds to the identification code "1" is about 8.66% (5.69 Kg/MT), High density Polyethylene/Low density Polyethylene (HDPE/LDPE) Corresponds to the identification code "2 & 4" is about 66.91% (43.94Kg/MT), Polyvinyl Chloride (PVC) Corresponds to the identification code "3" is about 4.14% (2.72 Kg/MT), Polypropylene (PP) corresponds to the identification code "5" is about 9.90% (6.50Kg/MT), Polystyrene (PS) Corresponds to the identification code "6" is about 4.77% (3.13 Kg/MT) and other unclassified plastics/ Non-Recycling plastics/ Rubbers etc having the identification code "7" obtained about 6.43% (4.22 Kg/MT).

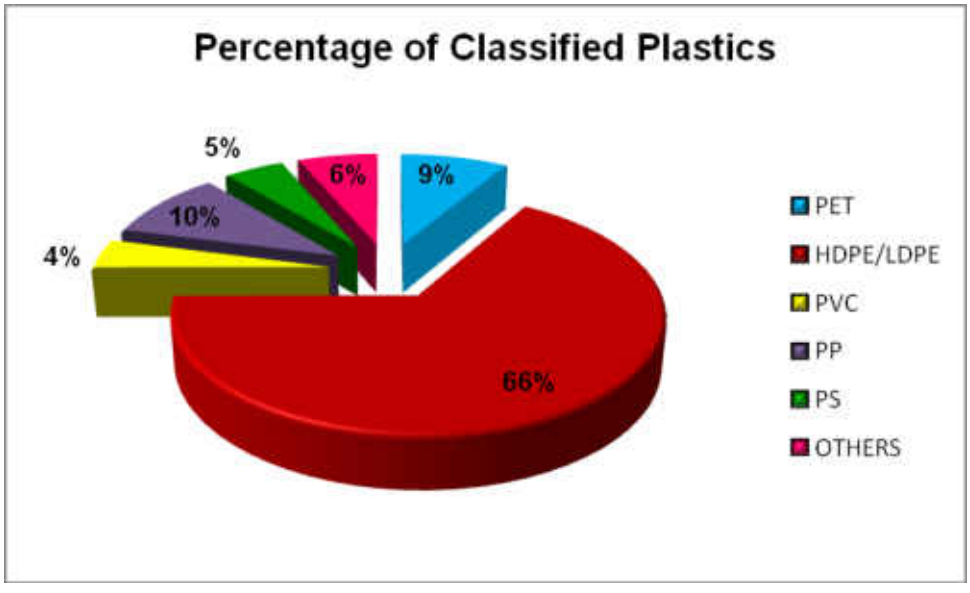


CHART 9: PERCENTAGE OF CLASSIFIED PLASTICS WASTE

The data indicates that the majority of the plastics waste (PW) obtained about 66% generated by HDPE/LPDE materials which is of mixed plastic wastes like Polybags, Multilayer pouches used for packing food items, Ghutkas etc. The households are the biggest source of plastics waste.

The mechanical recycling requires extensive sorting is necessary to separate the packaging waste and the isolation of pure plastics was found to be too difficult.

The containers, films and other oversized items which consist of Polyethylene, Polypropylene and Polystyrene can undergo mechanical recycling. But the mixed plastics, any blended material or other multilayer films should be prepared for chemical or feedstock recycling. In the chemical recycling process, contamination and heterogeneity are not a problem. The multilayer components which consists of 2-3 layers of different plastics, will find difficult on the mechanical recycling. Hence the monomer recovery makes logistics and economic sense for the multilayer pouches which are littered in more quantity and keep piling up on garbage leads unhygienic condition. It is also observed that these multilayer/ Metalized pouched are not lifted by the rag pickers, because collecting them is not profitable and non-recyclable hence thrown/dumped in the dumpsite.

7. ANALYSIS OF SAMPLES

GARBAGE SAMPLING AND ANALYSIS

The chemical and physical characteristics of garbage were analyzed for confirming the plastics waste materials. The samples were collected from the fresh MSW of dump ground analyzed by using Differential Scanning Calorimeter (DSC) make of Perkin Elmer. The samples are tested as per ASTM D: 3417, the temperature rise of 20° C/ min with the supply of nitrogen is maintained. The results obtained are depicted in (**Figure -3A, 3B, 3C, 3D, 3E)** The other plastic waste consist of thermoplastics like Poly Carbonate (PC), Poly urethane (PU), Nylon and thermosets

like Melamine formaldehyde (MF), Phenolics (PF) or (phenol formaldehydes), Urea-formaldehyde (UF) , Fibre reinforced plastics (FRP) which are not recyclable.

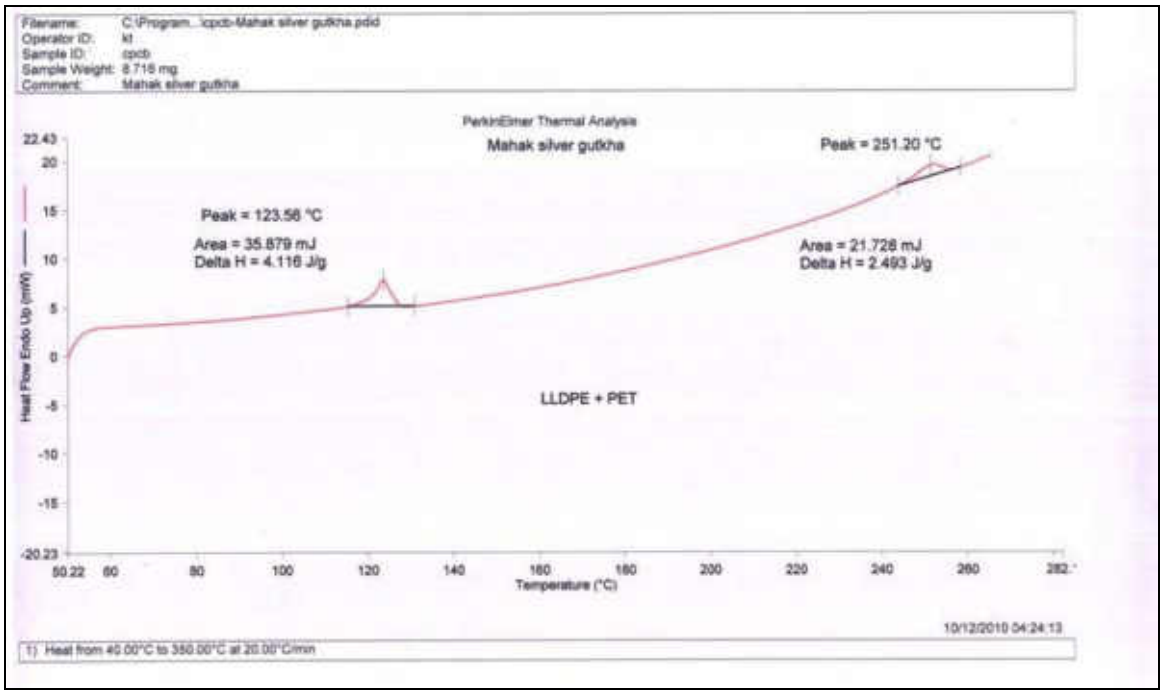


FIGURE 3A: ANALYSIS GRAPH: MAHAK SILVER GUTHKA

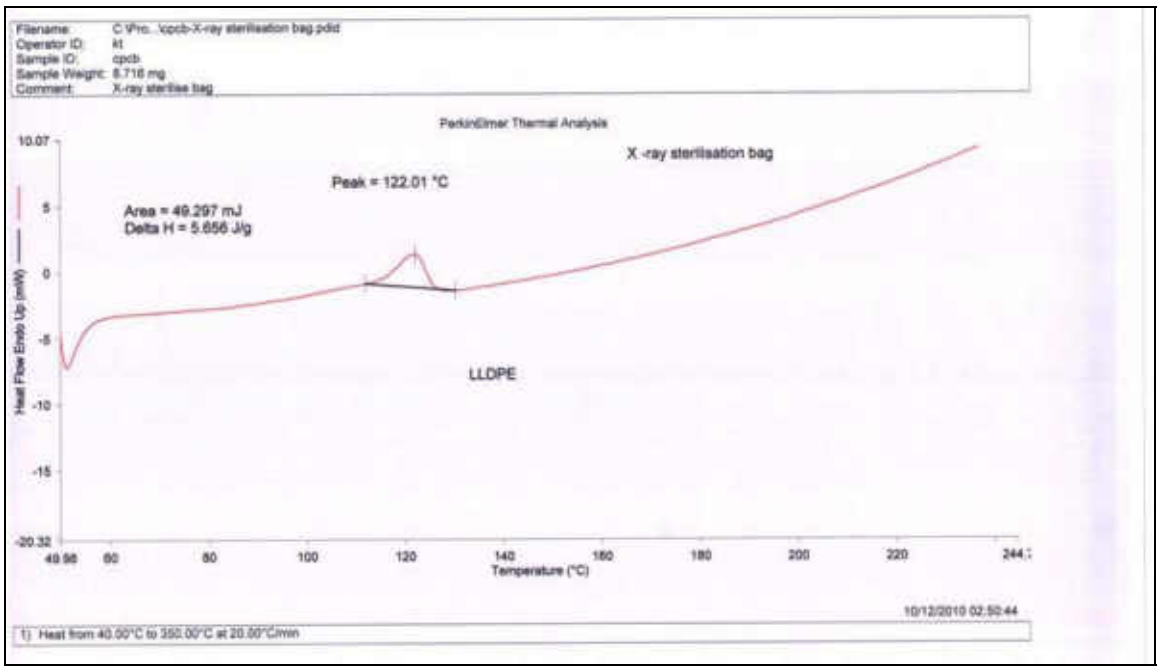


FIGURE 3B: ANALYSIS GRAPH: X-RAY STERILISATION BAG

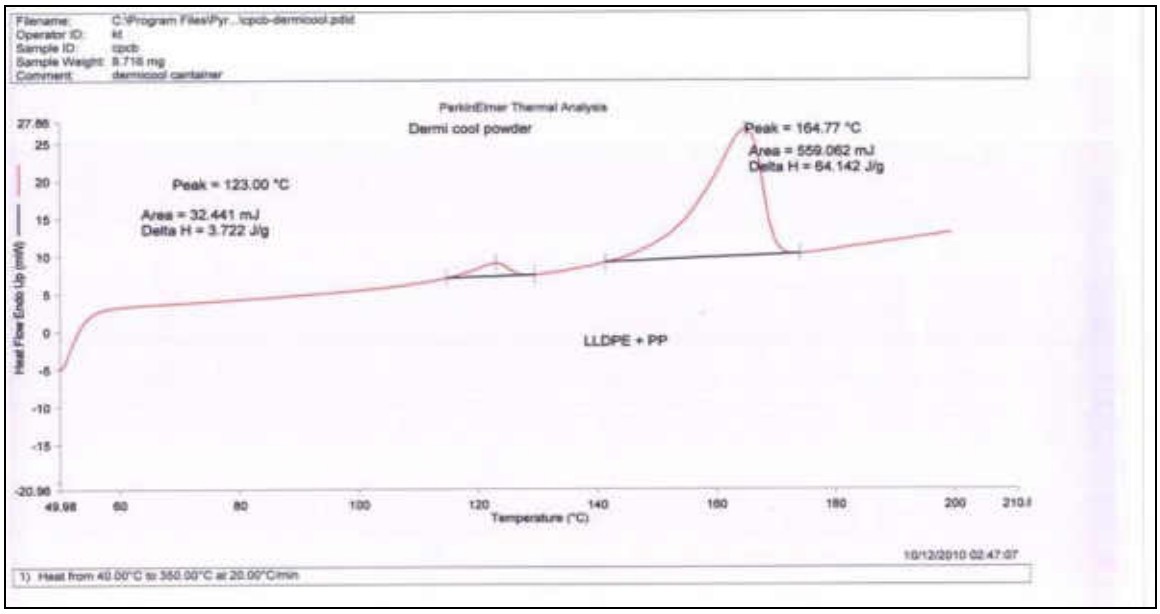


FIGURE 3C: ANALYSIS GRAPH: DERMI COOL POWDER

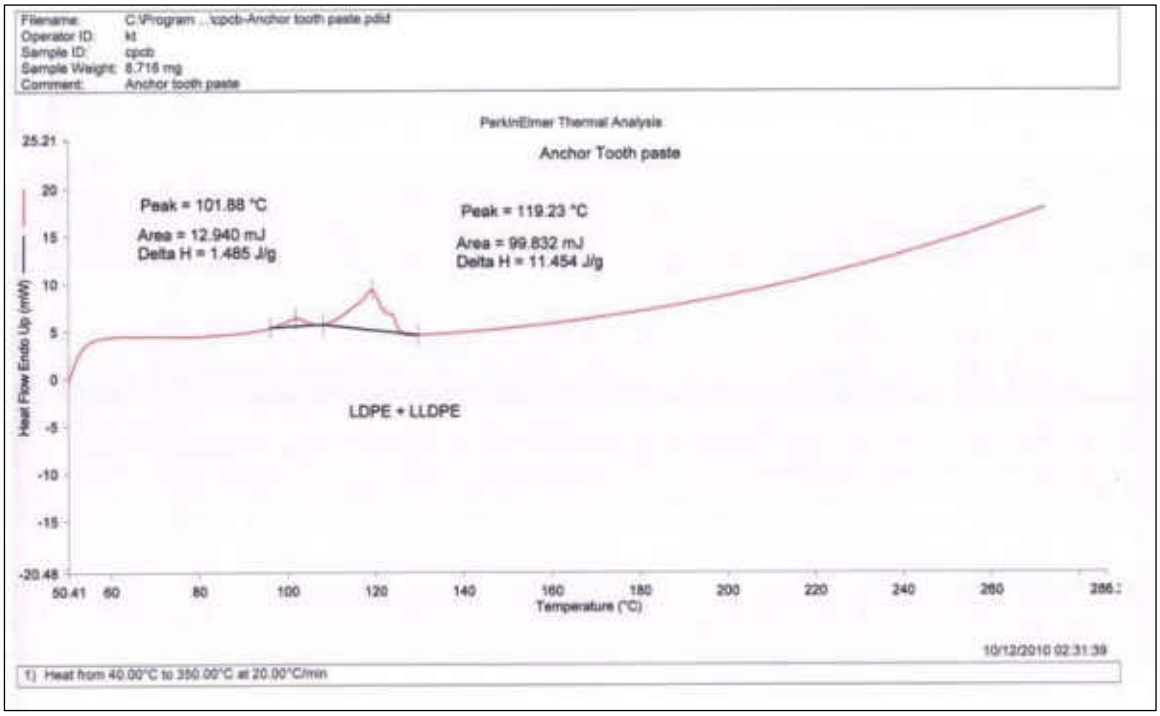


FIGURE 3D: ANALYSIS GRAPH: ANCHOR TOOTH PASTE

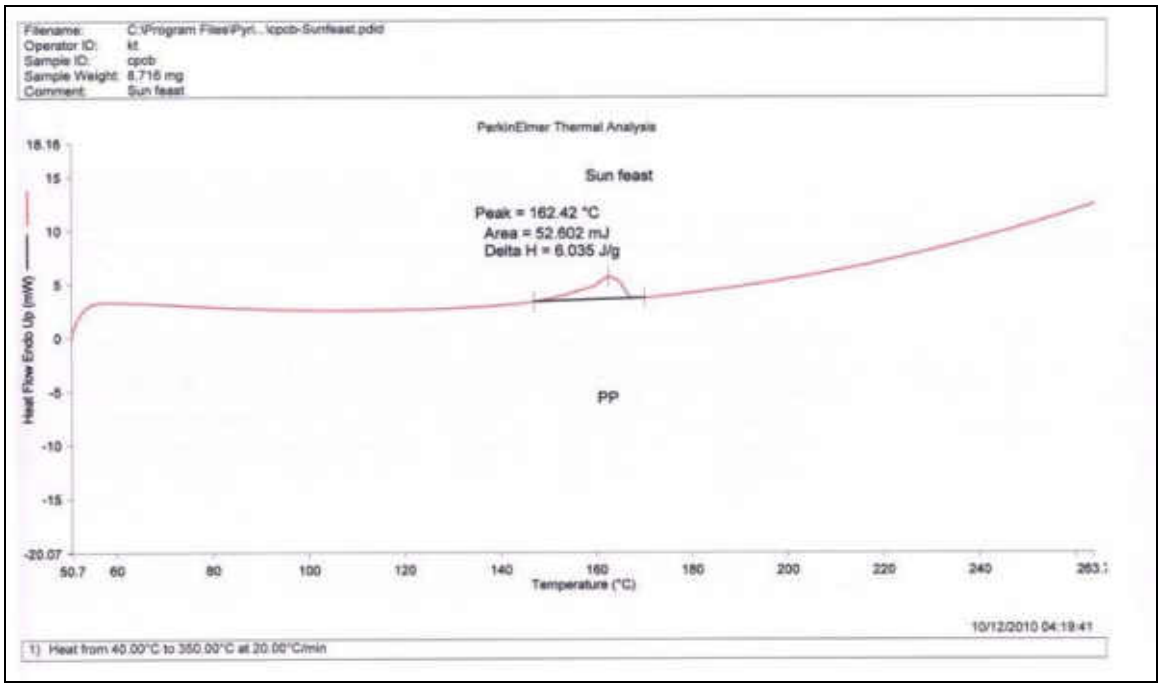


FIGURE 3E: ANALYSIS GRAPH: SUN FEAST PACK


PLASTICS WASTE ASSESSMENT AT THIRUVANANTHAPURAM


PLASTICS WASTE ASSESSMENT AT PUDUCHERRY


PLASTICS WASTE ASSESSMENT AT HYDERABAD

8. **CONCLUSION & RECOMMENDATIONS:** Based on the field study by CIPET & CPCB team at 60 cities, plastics waste (PW) content –Minimum & Maximum % during different weekdays. Also,an average value of PW content % has been worked out, taking into consideration the consolidated data of all week days of the study in different cities. The final summary of data is tabulated as follows:

S. No.	Name of City	Total Municipal Solid Waste (Tonnes per day)	Plastic Waste (Percentage of Municipal Solid Waste)	Plastic Waste (Tonnes per day)
		2010-11	2010-11	2010-11
1.	Kavaratti	2	12.09	0.24
2.	Dwarka	18	8.08	1.45
3.	Daman	25	4.64	1.16
4.	Panjim	25	4.47	1.12
5.	Gangtok	26	8.95	2.33
6.	Jamshedpur	28	3.36	0.94
7.	Silvassa	35	6.11	2.14
8.	Port Blair	45	10.07	4.53
9.	Kohima	45	5.01	2.26
10.	Shimla	50	4.45	2.23
11.	Meerut	52	6.42	3.34
12.	Gandhinagar	97	4.81	4.66
13.	Shillong	97	5.44	5.27
14.	Itanagar	102	5.35	5.46
15.	Agartala	102	5.71	5.83
16.	Aizwal	107	7.95	8.50
17.	Imphal	120	5.13	6.16
18.	Ranchi	140	5.92	8.29
19.	Kochi	150	6.29	9.43
20.	Dhanbad	150	5.02	7.52
21.	Guwahati	204	5.04	10.27
22.	Asansol	210	6.01	12.62
23.	Dehradun	220	6.67	14.66

24.	Patna	220	5.73	12.60
25.	Raipur	224	10.61	23.76
26.	Rajkot	230	6.93	15.93
27.	Thiruvanandapuram	250	6.02	15.06
28.	Pondicherry	250	10.46	26.15
29.	Chandigarh	264	3.10	8.18
30.	Jammu	300	7.23	21.68
31.	Jaipur	310	5.03	15.58
32.	Vishakhapatnam	334	9.03	30.17
33.	Nashik	350	5.82	20.38
34.	Bhopal	350	6.59	23.08
35.	Allahabad	350	5.39	18.86
36.	Jabalpur	400	5.18	20.70
37.	Bhubaneswar	400	7.98	31.92
38.	Madurai	450	5.06	22.77
39.	Varansi	450	5.76	25.92
40.	Agra	520	7.86	40.89
41.	Srinagar	550	5.12	28.14
42.	Amritsar	550	4.44	24.42
43.	Vadodara	600	4.57	27.41
44.	Vijayawada	600	7.29	43.72
45.	Nagpur	650	7.07	45.96
46.	Coimbatore	700	9.47	66.31
47.	Faridabad	700	11.29	79.03
48.	Indore	720	8.81	63.40
49.	Ludhiana	850	5.96	50.68

50.	Surat	1200	12.47	149.62
51.	Lucknow	1200	5.90	70.84
52.	Pune	1300	7.80	101.35
53.	Kanpur	1600	6.67	106.66
54.	Ahmedabad	2300	10.50	241.50
55.	Kolkata	3670	11.60	425.72
56.	Bangalore	3700	8.48	313.87
57.	Hyderabad	4200	4.75	199.33
58.	Chennai	4500	9.54	429.39
59.	Mumbai	6500	6.28	408.27
60.	Delhi	6800	10.14	689.52
	Total MSW	**50592**		
	Average PW generation		**6.92**	**4059.18**

The total MSW generated in 60 cities was about 50592 MT/Day out of which the average plastics Municipal solid waste generated was about 6.92 Kg/MT i.e. an average of about 6.92% of Plastics municipal solid waste is generated. The number of cities that ranges from 0-5%, 5-10% and more than 10% are listed in the following Table D.

TABLE D: RANGE OF PW GENERTION

SR.NO	DESCRIPTION	NO.OF CITIES
1.	0-5% PW	09
2	5-10% PW	42
3	>10% PW	09

Study team is of the opinion that 20 cities where plastics waste (PW) content is more than 7.5 %,(*Delhi, Chennai, Bangalore, Kolkata, Ahmadabad, Pune, Surat, Indore,*

Faridabad, Coimbatore, Agra, Bhubaneswar, Visakhapatnam, Rajkot, Raipur, Aizwal, Portblair, Gangtok, Kavarati, Dwarka) there is an urgent need to establish Waste recycling or treatment centre adjacent /nearby dumpsites involving Municipal Corporations & private recyclers in PPP mode.

As per the field study, it is assessed that majority of plastics waste content (about 66%) belong to HDPE/LPDE or PP materials which are of mixed plastic waste like Polybags, Multilayer pouches used for packing food items, etc. & their source is mainly from households /residential localities, Apartments etc.

The mechanical recycling of these wastes is feasible provided extensive sorting & separation, cleaning of waste are done effectively before putting into mechanical recycling by which granules/pellets can be produced. The containers, films and other oversized items which consist of Polyethylene, Polypropylene and Polystyrene can also undergo mechanical recycling in a better manner. There are few Mechanical recycling plant manufacturer in developed countries like Germany, Italy, France etc. who claim to have developed expertise in converting multilayer packaging waste into granules effectively.

It is recommended that to begin with, at least in 20 cities (mentioned above, where PW content is more than 7.5%), municipality/civic authority should take the responsibility for setting up mechanical waste recycling plant nearer to each dumpsite and engage agencies or groups working in waste management including rag pickers and ensure that open burning of plastic waste is not permitted. These 20 cities must have plastics Waste Management Cell (PWMC) to take initiative & act upon to set up Mechanical Recycling Plant.

9. Suggested Action Plan & Guidelines for Plastic Waste Management:

Plastic are non-biodegradable, synthetic polymers derived primarily from petro-fossil feedstock and made-up of long chain hydrocarbons with additives and can be moulded into finished products excluding compostable plastic or polymer confirming IS/ISO 17088:2008. These polymers are broken in presence of suitable catalyst, into monomers such as ethylene, propylene, vinyl, styrene and benzene. These monomers are then chemically polymerised into different categories of plastics.

9.1 Categories of Plastics : The main category of plastics include :

A. **Recyclable Plastics** (Thermoplastics): PET, HDLE, LDPE, PP, PVC, PS etc.

B. **Non-Recyclable Plastic** (Thermoset & others): Multilayer & Laminated plastics, PUF, Bakelite, Polycarbonate, Melamine, Nylon etc.

1) As per BIS Codification in Rule 8 (b) Plastic Waste (Management and Handling) (Amendment) Rules, 2011, there are seven categories of plastics:

S.No.	Symbol	Scientific Name	Used in
1.		Polyethylene Terephthalate	Water Bottles, PET Bottles etc.
2.		High Density Polyethylene	Milk/detergent Bags, Carry bags, Container etc.
3.		Polyvinyl Chloride	Cables, Pipes, Floorings etc.
4.		Low Density Polyethylene	Carry bags, films
5.		Polypropylene	Medicine bottles, cereal liners, Packaging films etc.
6.		Polystyrene	Foam Packaging, Tea cups, Ice cream cups etc.
7.		Others	Thermoset plastics, Multilayer & Laminated Plastics, PUF Bakelite, Polycarbonate, Melamine, Nylon etc.

9.2 Usage of Plastic and Plastic Waste:

Plastic products have become an integral part in everybody's daily life. Its production crosses the 150 million tons per year globally and in India, approximately 8 Million tonnes plastic products are consumed every year (2008). It has broad range of application in films, wrapping materials, shopping and garbage bags, fluid containers, clothing, toys, household and industrial products, and building materials. Once plastic is discarded, and remain on landscape for several years. Mostly, plastic waste are recyclable but, recycled products are more harmful to the environment as thus contains additives and colours. The recycling of a virgin plastic material can be done 2-3 times only, because after every recycling, the plastic material deteriorates due to thermal pressure and its life span is reduced. Hence recycling is not a safer and permanent solution for plastic waste disposal. It is estimated that approximately 70% of plastic packaging products are converted into plastic waste in a short span. Approximately 5.0 million tons per annum (TPA) plastic waste is generated in country, which amounts to 15342 tons per day (TPD).

9.3 Environmental issues on disposal of plastic waste :

Indiscriminate littering and unorganised recycling/reprocessing and non-biodegradability of plastic water raises the several environmental issues, it include;

- Release of fugitive emissions during polymerization process.
- Release of harmful gases such as Carbon Monoxide, Formaldehyde etc. during product manufacturing.
- Land become infertile due to indiscriminate plastic waste disposal.
- Release of toxic emissions such as Carbon Monoxide, Chlorine, Hydrochloric Acid, Dioxin, Furans, Amines, Nitrides, Styrene, Benzene, 1,3 –butadiene, CCl4 and Acetaldehyde on burning of plastics waste including polyvinyl chloride (PVC)
- Leaching of toxic metals into underground water such as Lead and Cadmium pigments due to indiscriminate dumping of plastic waste on land.
- Multilayer, metalised pouches and other thermoset plastic pose disposal problems.

- Sub-standard plastic carry bags, thin packaging films etc. pose problem in collection and recycling and reuse.
- Indiscriminate and littered plastic waste pose anaesthetic look and choke the drain.
- Soiled and mixed plastics waste interferes its beneficial utilisation.
- Unsound of plastic waste and running of recycling industries in non-conforming areas release fugitive emissions.

9.4 Technologies for Plastic Waste Management (PWM):

It has been observed that disposal of plastic waste is a serious concern due to improper collection and segregation system. However, a few technologies have been developed to minimize its adverse effect on the environment. Currently Worldwide accepted technology used for the plastic disposal in incineration, though it is not preferred option in India because it releases toxic gases like chlorinated dioxins and furans, raising several environmental issues. CPCB put efforts to consolidate innovative technical options for safer disposal of plastic waste these are described in the following paragraphs. It is worth to note that before adopting any technology, it is necessary to the description of technologies are mentioned below:

9.4.1 Utilisation of Plastic Waste in Road Construction:

(i) Description of road laying process;

The process of road laying using waste plastic is designed and the technique is being implanted successfully for the construction of flexible roads at various places in India. A brief description of the process mentioned in the **Table 1.**

Table 1: Protocol for description of road laying process

S.No.	Description	Executing Agency
1.	Collection and segregation of plastic waste (Expect chlorinated/brominated plastic waste)	Municipal Corporation, Nagar Parishad & Nagar and Gram Panchayat
2.	Transportation and storage of plastic waste	Municipal Corporation, Nagar Parishad & Nagar and Gram Panchayat
3.	Cleaning and sun drying of plastic waste	Municipal Body or PWD
4.	Shredding of plastic waste (2 to 4 MM size)	Municipal Body or PWD
5.	Heating of stone aggregate (160°c-170°c)	Municipal Body or PWD
6.	Adding of shredded plastic waste (5 to 10% w/w for 30 to 40 seconds)	Municipal Body or PWD
7.	Coated aggregate is mixed with hot bitumen (Temp. 155 °c to 163 °c)	Municipal Body or PWD
8.	The mix-plastic aggregate bitumen mix (130-140 °c) The mix can be used for road laying	

(ii) Advantages of polymer-Bitumen Roads:

- **Stripping and pothole formation**: Bitumen film is often stripped off the aggregates because of the penetration of water, which results in pothole formation. This is accelerated during the movement of vehicle. When polymer is coated over aggregate, the coating reduces its affinity for water due to non-wetting nature of the polymer and this resists the penetration of water. Hence the penetration of water is reduced which resists stripping and hence no pothole formation takes place on these roads.
- **Leaching:** Polymer will not leach out of the bitumen layer, even after laying the road using waste plastics-bitumen aggregate mix.
- **Effect of Bleeding:** Waste polymer-bitumen blend shows higher softening temperature. This increase will reduce the bleeding of bitumen during the summers.
- **Effect of Fly Ash:** Roads made from plastic-bitumen mix inhibits leaching of toxic compounds into soil.

9.4.2 Co-processing of plastic waste as Alternative Fuel and Raw Material (AFR) in cement kilns and power plants:

Co-processing refers to the use of waste materials in industry process such as cement and power stations or any other large combustion plants. Co-processing indicate substitution of primary fuel raw material by waste, recovering industry and material from waste. Waste material such as plastic waste used for co-processing are referred to as alternative fuels and raw material (AFR). Co-processing of plastic waste offers advantages for cement industry as well as for the Municipal Authorities responsible for waste management. In other hand, cement producers or power plants can save fossil fuel and raw material consumption, contributing more eco-efficient production. In addition, one of the advantage recovery method used in existing facility, eliminating the need to invest on other plastic waste practices and to secure land filling. The protocol for Co-processing of plastic waste is given at Table 2.

Table 2 : Protocol for Co-processing of plastic waste

S.No.	Item	Description	Action to be taken by
1.	Collection of plastics waste	Concerned Municipal Authority should create a system for collection of plastics waste from dustbin/Dhallaos through Public Private Partnership (PPP) mode on any other feasible method.	Municipal Corporation, Nagar Nigam, Nagar Parishad & Cantonment Boards.
2.	Segregation & Pre-processing of plastic waste	Collected plastic can be reprocessed/sorted for recyclable and non-recyclable. The Non-recyclable plastic waste will be transported to nearest cement kilns and power plant for co-processing by concerned Municipal Authority in consultation with concerned State Pollution Control Board (SPCB)/Pollution Control Board(PCC).	Municipal Corporation, Nagar Nigam, Nagar Parishad & Cantonment Boards.
3.	Identification of cement factory	Mapping of cement kilns and power plant for accepting co-processing of plastic waste in same State or neighbouring State. An agreement shall be signed between Municipal Corporations and Cement kilns.	State Pollution Control Boards & Pollution Control Committees and Municipal Bodies
4.	Modification for feeding plastic waste (PW) in cement kilns.	Cement industry/power plant to set-up storage facility, shredder, conveyor-belt, one hopper, one winch-machine and one double-flap damper.	Concerned Cement industries/power plant
5.	Setting-up of laboratory for plastics waste analysis	Cement industry/power plant shall set-up a minimum lab facility to analyses plastics waste before sending for co-processing. The instrumentation include Thermo-Gravimetric Analyser, Bomb-Calorimeter and C, H, N & S analyser.	Concerned Cement industries/power plant
6.	Monitoring of emission by cement industry/SPCBs	Cement industry/power plant shall monitor the stack emission in respect of routine parameters and hazardous air pollutants (HAPs).	Concerned Cement industries/power plant
7.	Forwarding progress Report to CPCB	Forwarding quarterly progress report of Co-processing of plastic waste to CPCB.	SPCBs/PCCs and Cement industries/power plant

9.4.3 Conversion of plastic waste into liquid RDF (oil):

Firstly, plastic waste is segregated mechanically from municipal solid waste (MSW). This method is not full-proof, as alongwith plastic waste, other lighter material is also segregated. Therefore, the segregated plastic waste is again sent through conveyer belt fixed with optical segregation device for 100% source segregation of plastic waste. Then, the mixed plastic waste is converted into the more useable i.e. Liquid RDF through catalytic pyrolysis. The process is termed random Depolymerisation as the degradation of bonds to break down into monomers occurs randomly. This process is utilized for the degradation of plastic to lower hydrocarbons. The random Depolymerisation is carried out in a specially designed Reactor, in absence of oxygen and in the presence of certain catalytic additives. The maximum reaction temperature is 350 °C. The entire feed material is converted into either of the products: Liquid RDF, gases and some sludge. There is no effluent generated in the process and the unused hot air from the reactor is released through chimney Steps involved in conversion of plastic waste into fuel RDF (Fuel) are given below :

- Mechanical segregation of plastic waste from mixed MSW dumpyard/storage;
- Transportation of Segregated plastic waste through conveyor belt for optical segregation;
- Optical segregation of plastic waste (only HD, LD, PP and multilayer packagings except PVC;
- Shredding of plastic waste and dislodging dust and impurities;
- Transportation of bsegregated (100% plastic waste) into feeding hopper (reactor);
- Feeding of plastic waste into reactor for random depolymerisation in prtesence of additives;
- Collection of liquid RDF (Fuel);
- Collection of rejects and solid waste (charcoal).
- Process flow diagram is shown at **Annexure-1**

Observations:

The quantity of plastic waste from MSW is approximately 4% and various depending on plastic waste content (quantity and concentration) in MSW sample. The catalyst added whereby the pyrolysis requires less energy and results in the formation of more branch hydrocarbons. The products of the process is reused as fuel in the process thus making the process economically viable and also help in minimising air pollution. The Oil (liquid RDF) has properties similar to LDO and can be safely used as an alternative to LDO in industries the conserving the already depleting natural resources. The by-products from the process like sludge and gas can be reused. The sludge can be reused as fuel in cement industries while the gas reused in the system as a fuel.

9.4.4 Plasma Pyrolysis Technology (PPT)

Plasma Pyrolysis is a state of the art technology, which integrates the thermo-chemical properties of plasma with the pyrolysis process. The intense and versatile heat generation capabilities of Plasma Pyrolysis Technology enable it to dispose of all types of plastic waste including polymeric, biomedical and hazardous waste in a safe and reliable manner. Pyrolysis is the thermal disintegration of carbonaceous material in oxygen-starved atmosphere. When optimized, the most likely compounds formed are methane, carbon monoxide, hydrogen carbon dioxide and water molecules. In plasma pyrolysis, firstly the plastics waste is fed into the primary chamber at 850 °C through a feeder. The waste material dissociates into carbon monoxide, hydrogen, methane, higher hydrocarbon etc. Induced draft fan drains the pyrolysis gases as well as plastics waste into the secondary chamber where these gases are combusted in the presence of excess air. The inflammable gases are ignited with high voltage spark. The secondary chamber temperature is maintained at 1050 °C. The hydrocarbon, CO and hydrogen are combusted into safe carbon dioxide and water. The process conditions are maintained such that it eliminates the possibility of formation of toxic dioxins and furans molecules (in case of chlorinated waste). The conversion of organic waste into non-toxic gases (CO_2, H_2O) is more than 99%. The extreme conditions of plasma kill stable bacteria such as bacillus stereo-thermophilus and bacillus subtilis immediately. Segregation of the waste is

not necessary, as the very high temperature ensure treatment of all types of waste without discrimination.

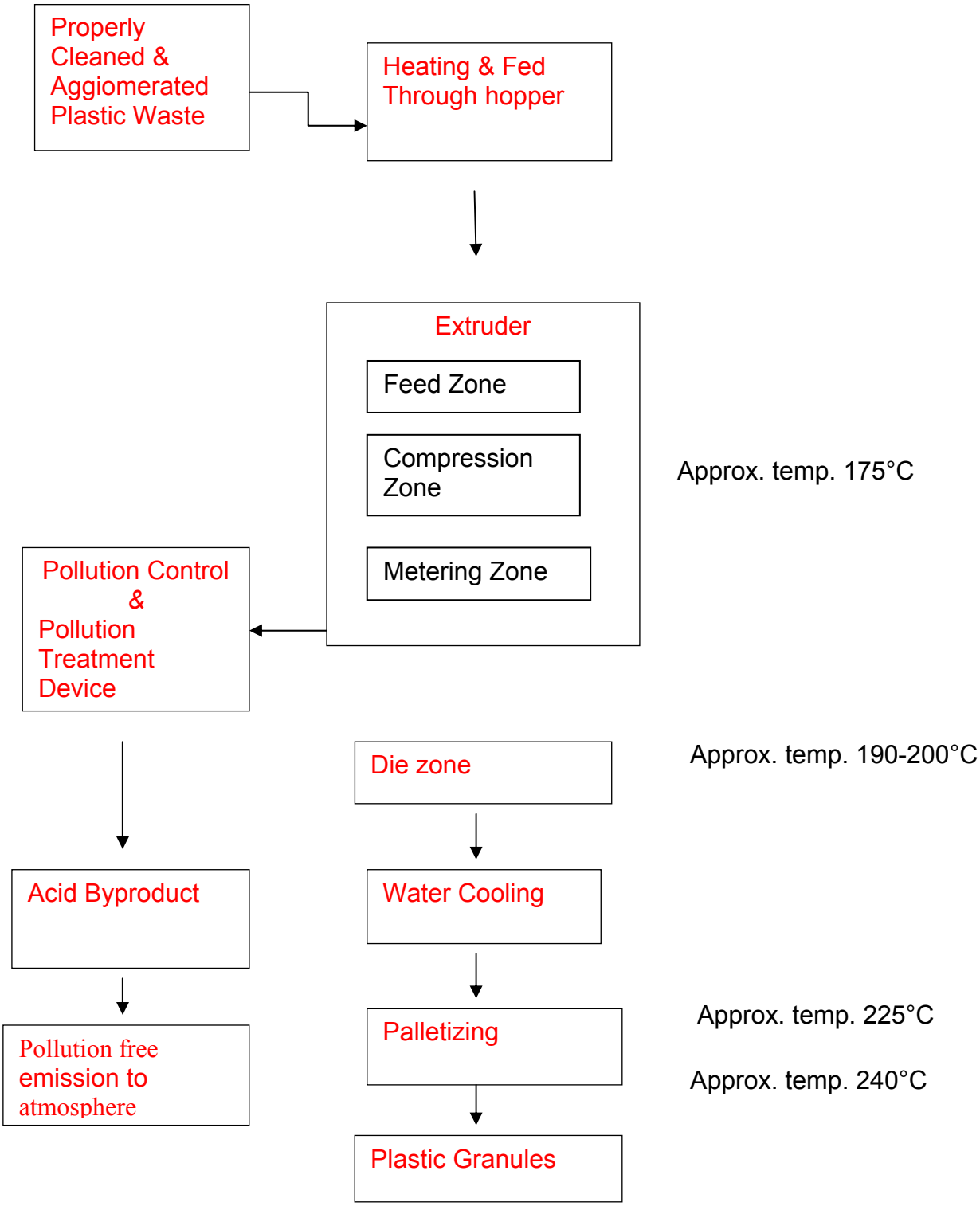
Environment Related Observations

Stack emission monitoring of different categories plastic waste such as 100% Polyethylene Waste 80% polyethylene + 20% PVC waste was carried out by VIMTA Lab. It has been observed that the emission of toxic pollutants such as dioxins and furans from the plasma pyrolysis system developed by FCIPT is lower than the norms set for incinerator.

9.4.5 Recycling of plastic through environmentally sound manner:

The main goal for developing green recycling of waste plastic was to design an extruder, which would have “Zero Significant Adverse Environmental Impact “. This has been achieved by assigning right motor of minimum capacity, selecting optimum L/D ratio, heat sealing and right temperature for the processes and trapping all the emission in pollution control gadget and treating the pollutant to produce byproducts. The extrusion & palletisation processes have been redesigned to make the pollution from the process to a minimum level and as a result to enhance the efficiency of the process. The details of process Flow Chart is given below:

Process Flow-chart of the "Green Recycling Process" – The Pilot Plant



3.0 Action Plan for PWM:

A time-bound action points as per the provisions of Rule 6 of Plastic Waste (Management & Handling) (Amendment) Rules, 2011 is mentioned at table: 3 below:-

Table 3 : Time Bound Action Plan for PWM

S. No.	Action Points	Time Required	Infrastructure Requirement	Implementing Authority
1.	Setting-up of plastic waste system such as Safe, collection, storage, segregation	Within 6 months	Establishment of separate bin	Concerned Municipal Authority such as Municipal Cooperation, Municipal Council, Nagar or Gram Panchayat.
2.	Safe, collection, storage, segregation	Immediate	Segregation of plastic waste from Municipal Solid Waste (MSW)	Concerned Municipal Authority such as Municipal Cooperation, Municipal Council, Nagar or Gram Panchayat
3.	Transportation, processing and disposal of plastic waste	Immediate	Transportation of segregated plastic waste to disposal site	Concerned Municipal Authority such as Municipal Cooperation, Municipal Council, Nagar or Gram Panchayat
4.	Create awareness among all stakeholders about their responsibilities including house holders or owners or occupiers	Within 6 months	• Mobile vans • Newspapers ads • Television • FM Radio	Concerned Municipal Authority such as Municipal Cooperation, Municipal Council, Nagar or Gram Panchayat
5.	Engage agencies or groups working in waste management	Within one year	Visiting to successful waste management sites such as Kanpur, Gwalior, Surat, Rajkot etc.	Concerned Municipal Authority such as Municipal Cooperation, Municipal Council, Nagar or Gram Panchayat
6.	Ensure that open burning of plastic waste is not permitted	Immediate	Constitution of Vigilance Squad	Concerned Municipal Authority such as Municipal Cooperation, Municipal Council, Nagar or Gram Panchayat

Annexure -I

Process flow diagram for production of Liquid RDF from waste plastic