PROMOTION OF COUNTER MEASURES AGAINST MARINE PLASTIC LITTER IN SOUTH EAST ASIA AND INDIA

REPORT

Plastic Leakage Scenarios for Selected Locations in Identified Cities / Study Area

UN environment programme

Counter MEASURE FOR PLASTIC FREE RIVERS

National Productivity Council

Table of Contents

Executive Summary **7**

1.0 Introduction 7

2.0 Objective 7

3.0 Approach & Methodology 7

4.0 Agra 8

Chapter 1: Introduction & Background **12**

1.0 Introduction & Background 12

1.1 OBJECTIVE 12

1.2 SCOPE OF WORK (SOW) 12

1.3 Approach & Methodology 13

1.4 FORMAT OF THE REPORT 18

Chapter 2: Summary Report Haridwar **19**

2.0 Introduction 20

2.1 Geography & Climate 20

2.1.1 Physiography 20

2.1.2 Climate 22

2.2 Demography & Land Use 22

2.3 Municipal Solid Waste and Plastic Waste Management at Haridwar 23

2.4 Identification of Hotspots 27

2.5 Cleanup Activities & Macro Plastic Assessment Studies in Haridwar 31

2.6 Conclusion 32

Chapter 3: Summary Report Agra **35**

3.0 Introduction 36

3.1 Demography & Land Use 36

3.2 Solid and Plastic Waste Generation 37

3.3 Municipal Solid Waste & Plastic Management in Agra 38

3.4 Identification of Hotspots 39

3.5 Clean up Activities & Macro Plastic Assessment Studies 42

3.6 Micro plastic Survey 43

3.7 Conclusions 44
3.8 Plastic Waste Leakage Pathway and Scenario 45

Chapter 4: Summary Report Prayagraj 47
4.0 Introduction 48
4.2 Demography & Land Use 49
4.3 Municipal Solid waste & Plastic Management in Prayagraj 50
4.4 Identification of Hotspots 52
4.5 Clean up Activities & Macro Plastic Assessment Studies 54
4.6 Micro plastic Survey 56
4.7 Conclusions 57
4.8 Plastic Waste Leakage Pathway and Scenario 58

Chapter 5: Summary Report Mumbai 59
5.1 Introduction 60
5.2 Geography & Climate 60
5.2.1 Physiography 60
5.2.2 Climate 61
5.3 Demography & Land Use 61
5.4 Municipal Solid Waste and Plastic Waste Management at Mumbai 64
5.5 Identification of Hotspots 65
5.6 Clean up Activities & Macro Plastic Assessment Studies in Mumbai 69
5.7 Conclusion 70

List of Tables

Table 1: Correlation between Macroplastic & Microplastic Source in Agra **10**
Table 1.1: Classification of Hotspots **14**
Table 2.1: Demographic and Administrative Profile of Haridwar **22**
Table 2.2: Plastic Waste generation and leakage in Haridwar **25**
Table 3.1: Major Polymers found in Micro plastic Study **44**
Table 4.1: (a) Major Polymers found in Micro plastic Study **56**
Table 4.1: (b) Major Polymers found in Micro plastic Study **57**
Table 5.1: Summary of estimates pertaining to waste generation **64**

List of Figures

Figure1: Prominent plastic categories observed during cleanups in Agra 9
Figure 2: Plastic leakage vulnerable areas identified using fuzzy logic approach 9
Figure 3: Field Reconnaissance & Verification 10
Figure 1.1: Conceptual Plastic Value Chain showing LCA application to Material Flow Analysis (MFA) 14
Figure 2.1: Municipal Boundaries of Haridwar City 20
Figure 2.2: Contour and Drainage Map of Haridwar 21
Figure 2.3: Demographic, Administrative and Land Use Map of Haridwar 23
Figure 2.4: Ward Wise Plastic Waste Generation Map 26
Figure 2.5: Waste accumulated on river bank at slum area in Haridwar 27
Figure 2.6: Plastic Leakage Vulnerable Areas identified using Fuzzy Logic Approach 28
Figure 2.7: Location of Probable Hotspots in Haridwar 29
Figure 2.8: Drains and Sources of Plastic Leakage 29
Figure 2.9: Field Reconnaissance& Verification 30
Figure 2.10: Captured in January,2020 31
Figure 2.11: Captured in March,2020 31
Figure 2.12: Breakup of plastic items in numbers 32
Figure 2.13: Breakup plastic items in terms of weight 32
Figure 15: Flow Diagram of Plastic Waste Generation and Leakages 34
Figure 3.1: Demographic, Administrative and Land Use Map of Agra 37
Figure 3.2: Ward wise Plastic waste generation map of Agra 38
Figure 3.3: Plastic Leakage Vulnerable Areas identified using Fuzzy Logic Approach 40
Figure 3.4: Location of Probable Hotspots 40
Figure 3.5: Untapped Drains Source of Plastic Leakage 41
Figure 3.6: Field Reconnaissance& Verification 42
Figure 3.7: Breakup of plastic items in numbers 43
Figure 3.8: Breakup plastic items in terms of weight 43
Figure 4.1: Prayagraj (previously known as Allahabad) 49
Figure 4.2: Demographic, Administrative and Land Use Map of Prayagraj 50
Figure 4.3: Ward wise Plastic waste generation map of Prayagraj 52
Figure 4.4: Mixed plastic waste, multilayered plastic waste found at Baswar Dump Site 52
Figure 4.5: Plastic Leakage Vulnerable Areas identified using Fuzzy Logic Approach 53
Figure 4.6: Map showing surveyed points at Prayagraj 53
Figure 4.7: Hotspots identified at Prayagraj 54
Figure 4.8: Field Reconnaissance& Verification 54
Figure 4.9: Breakup of plastic items in numbers 55
Figure 4.9: Breakup plastic items in terms of weight 56
Figure 5.1: Mumbai Map 60
Figure 5.2: Wards & Village wise slum cluster map of Greater Mumbai. 62
Figure 5.3: Demographic, Administrative and Land Use Map of Mumbai 63
Figure 5.4: Cluster Wise Plastic Waste Generation Map 65

Figure 5.5: Plastic Leakage Vulnerable Areas identified using Fuzzy Logic Approach 67
Figure 5.6: Location of Probable Hotspots in Mumbai 68
Figure 5.7: Field Reconnaissance& Verification 69
Figure 5.8: Breakup of plastic items in numbers.....70
Figure 5.9: Breakup of plastic items in terms of weight 70

Executive Summary

1.0 Introduction

Humanity has long used the ocean to dispose of goods and materials regarded as waste, either directly or indirectly (e.g. via run-off, wind etc.). Since the 1950s, when large-scale production of plastics began, an increasing proportion of solid waste in the ocean has consisted of this material, representing up to 80% of marine litter. This is a result of both land-based and sea-based human activities. Plastic litter is most obvious on shorelines, where litter accumulates due to current, wave and wind action, river outflows and by direct littering at the coast. Major sources or 'leakage' points include poorly managed solid and liquid waste on land, through either direct entry or via rivers, activities on the shoreline, shipping and fisheries and many other. However, 'Plastic' covers a very wide range of compositions and properties. Size, shape and composition all influence the distribution, fate and effects in the environment and need to be accounted for where possible. Monitoring the marine environment for the presence of plastic litter is a necessary part of assessing the extent and possible impact of marine litter, devising possible mitigation methods to reduce inputs, and evaluating the effectiveness of such measures. However, it is important to use consistent and reliable methods of sampling and sample characterization (e.g. number, size, shape, mass and type of material) to gain greatest benefit. Promotion of Counter Measures against Marine Litter and Plastic Pollution in South East Asia and India has been conceptualized to develop knowledgebase for plastic pollution and its leakage into riverine and marine ecosystem. The India components involve a number of activities in The Ganges Basin and Mumbai to address the riverine and marine ecosystem. Since the river Ganges has been cited in literature as the major carrier of plastics into its ecosystem, three cities Haridwar, Agra and Prayagraj in the basin have been selected for carrying out the activities related to the assessment of plastic pollution and marine litter. The report describes the objective, scope of work (SOW), methodology of one of the major activities (Activity–B), "Identification of Plastic Leakage Scenarios (sources and pathways of major plastic leakage) in Identified Cities" in India.

2.0 Objective

The objective of this activity is to assess the on land plastic waste management in the four cities, identify the major hotspots, which serve as source to plastic leakage scenario into the riverine and marine ecosystem. This will assist to identify specific countermeasures, which can tackle and address plastic pollution both in the short and long term. The basic approach is used to achieve these objective includes the understanding of the concept of hotspotting and defining the leakage pathways. This approach is supported by usage of a number of techniques and the tools in achieving the desired outcome.

3.0 Approach & Methodology

To date there is no common methodology to either measure (through field studies) or assess (through modeling) plastic flow for a country. However, an effort has been made to develop this methodology in a city's context. Literature cotes that a hotspot is defined when its threshold contributes 10% of the total impact. But there is no precise agreed upon level.

Therefore, two approaches may be used to identify the hotspots.

1st Approach: A hotspot shall always be a percentage greater than if the impacts were evenly distributed across life cycle stages. For example, if there are 5 life cycle stages, a hotspot should not be defined lower than 20% of the impact category, and if there are 7 stages, it should not be lower than 14%.

2nd Approach: Where the hotspot has been identified based on qualitative information, it will not be possible to identify a hotspot with quantitative precision. Therefore, the analysis should be confident that the majority of impacts (i.e., over 50%) are covered. Clear boundaries are essential to ensure that appropriate information is obtained and used within the analysis.

A combination of hybrid MFA-LCA when applied in sub-national geographical areas (city) will assist in identification and classification of hotspots. The study boundary may include different stages where input-output analysis can be carried out within the city boundary. A number of **tools/ techniques both quantitative and qualitative** can be used to determine the geographical locations, vulnerable areas and input output analysis covering each stage or a combination of stages or complete plastic value chain. **Some of these tools/ techniques include: Reconnaissance Survey, Perception Survey, GIS Technique and Fuzzy Approach, waste management data templates, input-output tables, Macroplastic Clean up Technique** and **Microplastic Survey & Assessment. 'Heat Maps' were developed, which provide an overview of the hotspots identified in the study, the issues or impact categories associated with them and their location in the economy, sector, product lifecycle or value chain. Types of hotspots identified included, Plastic Value Chain hotspots, Plastic Leakage Source Hotspots, Plastic Accumulation Source Hotspots and Plastic Application Hotspots.**

4.0 Agra

Agra is geographically located at 27°12' North latitudes and 78°12' East longitudes. The city of Agra is situated on the Western Bank of river Yamuna at about 200 Kms from Delhi in the state of Uttar Pradesh. It falls in Great Indo-Gangetic Plain region and its strata consist of mainly sandy soil. The ground water level varies generally 6 to 8m below ground level. The altitude varies from RL 150 m to 170m above mean sea level. The city stretches for about 9.0 kms along the Yamuna River. Agra is a centre for shoe industry as well as a major tourist destination.

Agra has a population of almost 1.77 million. The total area of the city is 126.15 sq. km. Every year Agra attracts a huge number of tourists as it is amply from the numerous historical monuments in and around the city. Agra also houses one of the '7 Wonders of the World' i.e., Taj Mahal. The primary data from Agra Nagar Nigam indicates that the total municipal solid waste generation in the city are about **850-870 metric tonnes per day.** This is based on per capita generation of 400 gm with collection efficiency 91 %. Therefore, an average value of ***~866* metric tonnes per day** of municipal solid waste has been considered to know about the plastic leakage scenario in Agra.). However, only 2 to 3 % waste is collected from the slum. The high value recyclables solids are extracted by the rag pickers from the transfer stations. Out of this 4-5% of high value plastic is taken away by the rag pickers and 80-90 tonnes of flow plastic in dry waste reaches to MRF facility. Thus 80-100 TPD of plastic is attempted to bring back into the value chain. The remaining 10-30 tones per day plastic is directly disposed,

open burned or littered into streets, drains etc. finally its way into the land and river ecosystem by various means. The remaining solid waste is transferred or dumped to Kuberpur dump site. As reported average 700 to 750 tons mixed MSW is being dumped at the site on daily basis. From the field study we were informed that presently around 22 % of plastic waste was found in mixed waste that dump in Kuberpur dumpsite. These include single use plastics and polythene carry bags.

Though waste generation is low in slums, it's littering into drainage and banks of water bodies are rampant. Slums which are in close vicinity of the river are more likely to contribute to the plastic pollution. Therefore, the drainage and water bodies serve as carrier of plastic waste to the river. Industrial waste consists of thin white plastic covers for covering Petha boxes that are littered in significant amount after single use and thrown in drain (nallah) and nearby secondary collection points. The synthetic leather and rubber trimming from footwear industry also accounted for the plastic pollution. It was also observed that accumulated waste at open dump or dustbins was burnt in order to reduce the volume when it remains unattended for several days. Macroplastic Cleanup activities were carried out at two hot spots of plastic litter in Agra (i.e., Hathi Ghat and Pohiya ghat). Cleanup at Hathi Ghat is carried twice in a gap of around three months to validate that it is a hotspot and a potential source of leakage into the river. The prominent plastic categories observed **(Figure 1)** during cleanups in Agra are Polythene bags, multilayer plastic bags, plastics pouches used for water and milk, mono layer plastics, disposable plastic cups and glasses, woven bags and others. **Figure 2** depicts the plastic leakage vulnerable areas identified using fuzzy logic approach. **Figure 3** shows the field reconnaissance & verification of the hotspots in the city.

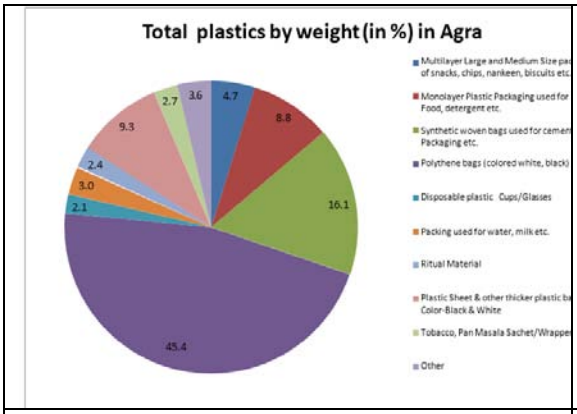


Figure 1: Prominent plastic categories observed during cleanups in Agra

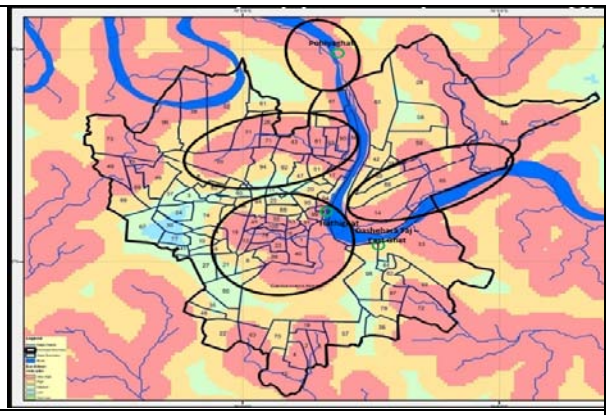


Figure 2: Plastic leakage vulnerable areas identified using fuzzy logic approach

Figure 3: Field Reconnaissance & Verification

Microplastic sampling and analysis was also undertaken in Yamuna River in Agra (near Dussehra Ghat). Microplastic sampling indicated presence of polymers that are likely present in Multilayers packaging and Tobacco, Pan Masala sachet (EVOH, PVAL, PE,PP,PVC, PET), thermo packaging material (Polyamide), thin polybags and plastic bags (LDPE, HDPE). Overall, 47 types of polymers are found in the microplastic sample and most of them are below 300 µm. Major polymers found in the microplastic sample comprise of Polyacetylene, EVOH, Polyisoprene, PVC, PVAL, Polyamide, polyethylene (LDPE, HDPE), polyester, etc. Further, based on macroplastic assessment studies, land based waste sources have been correlated with microplastic survey as depicted below in **Table 1.**

Table 1: Correlation between Macroplastic & Microplastic Source in Agra

Types of Plastic found in Macroplastic assessment study in Agra	**Total plastics by count (in %)**	**Possible microplastic polymer source**
Multilayer Large and Medium Size packets of snacks, chips, namkeen, biscuits etc.	12	EVOH, PVAL, EVA, PVC, Polyimide, PP, LDPE, Polyacrylamide, Acronitrile film, PE/PP, Polyester film, HDPE, Poly ethylene oxide
Monolayer Plastic Packaging used for food, detergent etc.	4	Polyethylene, polypropolyene
Synthetic woven bags used for cement packaging etc.	2	Polyester
Polythene bags (colored white, black)	62	Polyethylene
Disposable plasti c Cups/Glasses, take away food containers	3	Polyamide, Styrene/Isoprene, PIP, PES, Polyester film, HDPE, Styrene/Butadiene, Styrene/Maleic anhydride
Packing used for water, milk etc.	5	Polyethylene
Ritual Material	2	Polyethylene, PP, PIS
Plastic Sheet & other thicker plastic bags. Color-Black & White	2	Polyethylene
Tobacco, Pan Masala Sachet/Wrappers	2	EVOH, PVAL,PET, Polyethylene, PVC, PS, PVDC

Major hotspots have been identified, which trigger plastic leakage into river Yamuna through carriers like air, drains and run off. These include all the four types of hotspots. These include: (i) Plastic Value chain hotspots like plastics processed in leather factories; (ii) Plastic Leakage Source Hotspots in major wards in the city; (iii) Plastic Accumulation Hotspots in major drains of the city; and (iv) Plastic Application Hotspots considering poly bags found in macroplastic as well as microplastic. Massive amount of plastic was observed to be littered during the field study at various locations in Agra. Littering ranges 10% to 25% against 2% assumed in major studies carried abroad. Therefore, littering is one of the major reasons for the plastic not being collected and brought back into the value chain. However, majority of the waste categories found during Clean Up include plastic bags, Multi layer packaging, Plastic Sheet & other thicker plastic bags in black & white color, water pouches, Packaging Material e.g. Tobacco sachets, Biscuit packets, Surf excel, Rusks etc. as perclean up report. The findings of micro plastic survey confirm the findings of on land survey.

Chapter 1: Introduction & Background

1.0 Introduction & Background

Promotion of Counter Measures against Marine Litter and Plastic Pollution in South East Asia and India has been conceptualized to develop knowledgebase for plastic pollution and its leakage into riverine and marine ecosystem. The India components involve a number of activities in The Ganges Basin and Mumbai to address the riverine and marine ecosystem. Since the river Ganges has been cited in literature as the major carrier of plastics into its ecosystem, three cities Haridwar, Agra and Prayagraj in the basin have been selected for carrying out the activities related to assessment of plastic pollution and marine litter. The following sections describe objective, scope of work (SOW), methodology of one of the major activities (Activity–B), "Identification of Plastic Leakage Scenarios (sources and pathways of major plastic leakage) in Identified Cities" in India.

1.1 OBJECTIVE

The objective of this activity is to assess the on land plastic waste management in the four cities, identify the major hotspots, which serve as source to plastic leakage scenario into the riverine and marine ecosystem. This will assist to identify specific countermeasures, which can tackle and address plastic pollution both in the short and long term.

1.2 SCOPE OF WORK (SOW)

The detailed SOW of this activity has been summarized in seven tasks, which need to be completed.

Task–B1: Selection of key assessment methodologies: Identification and deliberations on nature of methods that have been or are being utilized for plastic flux assessments in water bodies, and developing a suitable plan for estimating macro plastic flux in channels; techniques for capturing plastics and assessing the composition for further reflection on leakage scenario. Focus on macroplastics of sizes above 2.5 cm and who due to buoyancy properties are floating in the water surface layers.

Task–B2: Collection of data through survey and interviews at different locations: Selection of a set of monitoring sites and undertaking survey of a sample set of areas / dumpsites and water body boundaries where plastic is found and have likelihood of reaching water bodies (River/drain) during rains/ floods etc., as well. Collection of information on meteorological data and hydrological data of selected water bodies (including channels / rivers etc.) to reflect on plastics flows and related variations.

Task–B3: Collection and analysis of samples during clean up: Application of suitable technique after exploration & feasibility to collect floating debris samples at outfalls to rivers and one major drain during clean up drives.

Task–B4: Sampling and analysis of data collected: Analysis of collected floating debris / macro litter and identification of the plastics captured therein in a set of samples. The study

shall be undertaken to achieve, collect & analyze of 12 to 14 samples covering major rivers or drain in total across the four cities (Agra, Haridwar, Allahabad & Mumbai).

Task–B5: Assessment of the sources and pathways of major plastic leakage through agreed upon methodologies: Reflecting on sources and pathways of major plastic leakage using GIS mapping of the drainage pattern and the proximities to plastic waste dumps and hotspots.

Hotspot identification: GIS layers of Sewer network, storm water drainage, land-use/cover, locations of solid waste dump sites, etc of the city shall be overlaid. Based on this locations of hotspots for example at the dumpsites, at the outfall to river (sewer line as well as storm water drain) shall be made.

Characterization of plastic debris: Sampled plastics waste will be characterized by mass and type identified. Statistics on plastic composition, size, volume and identity can be drawn for identifiable plastics.

Task–B6: Two consultation workshops: Undertaking two consultation workshops and deliberating findings and obtaining inputs for taking forward the study. These workshops are proposed in Delhi or Mumbai in Consultation with UNEP.

Task–B7: Collection of visual records of the current status of plastic pollution: Collating pictures (where feasible video clips) and documenting aspects / features pertaining to visual records created including those that may be geo tagged.

1.3 Approach & Methodology

The basic approach adopted to complete the above tasks includes understanding of the concept of hotspotting and defining the leakage pathways. This approach is supported by usage of a number of techniques and the tools in achieving the desired outcome.

Conceptual Understanding of Hotspotting

Hotspot is a life cycle stage, process or elementary flow which accounts for a significant proportion of the impact of the functional unit, where the functional unit is a measure of the function of the studied system to which inputs and outputs can be related.

Life Cycle Assessment (LCA) provides information on the relationship between a specified functional unit and specified environmental impacts. In case of plastics, the conceptual LCA when applied to the material flow as shown in **Figure 1.1** can be used to define this relationship, where inputs and outputs at each stage can be related to environmental impacts. However, the study boundary will vary in a geographical context. For example, in a city's context it can include all the stages or some of the stages prior to distribution, but will include distribution and post distribution stage as highlighted by the dotted line.

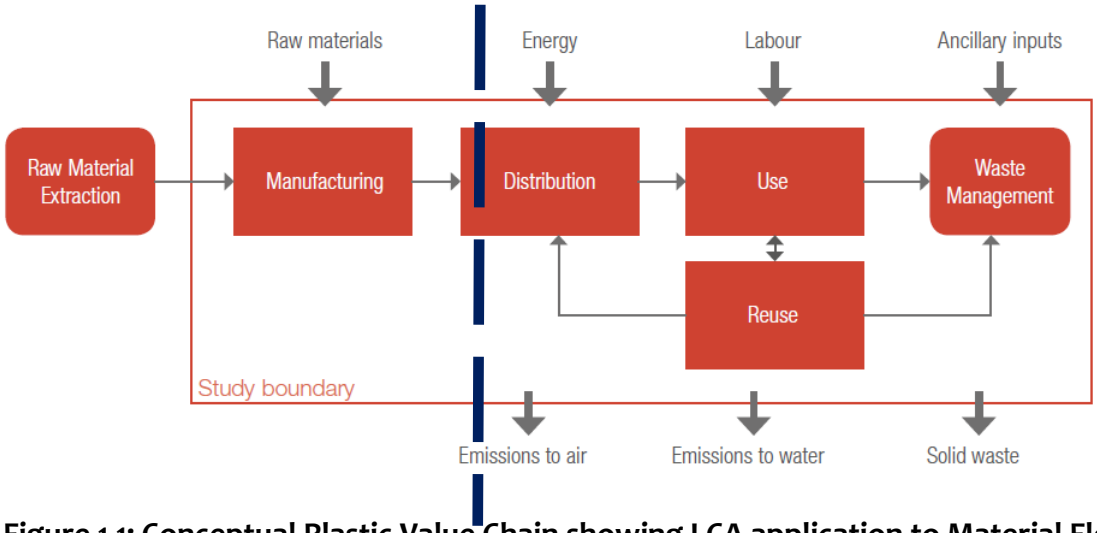


Figure 1.1: Conceptual Plastic Value Chain showing LCA application to Material Flow Analysis (MFA)

Since in case of plastic, there is no specific methodology defined so far to assess the environmental impacts, therefore, the ultimate goal is to get an approximate understanding of where significant impacts occur. So hotspots analysis shall consider all the geographies in which impacts occur. A comprehensive assessment of the relevant geographies will also help to establish the broader socio-political context in which the hotspots analysis is being conducted. **Therefore, a combination of hybrid MFA-LCA when applied in sub-national geographical areas (city) will assist in identification and classification of hotspots. The study boundary may include different stages where input-output analysis can be carried out within the city boundary. The classification and definition of the hotspots based on this understanding is given in Table 1.1. It covers all the stages i.e., production, consumption (Use & Reuse) and waste management as shown in Figure 1.1.**

Table 1.1: Classification of Hotspots

Hotspot	Definition	Note
1. Plastic value chain hotspot	Plastic value chain hotspot includes attributes of the plastic value chain in the region, including elements of plastic production, conversion, trade, use or disposal. Such attributes may be related to domestic, commercial or industrial activities. Plastic value chain hotspots are not related to any specific plastic application or product but can often be related to a plastic type (e.g., a polymer) or an industry. **This will include all the stages shown within the study area given in Figure 1.**	Examples include rates of plastic production or trade, key industries that drive plastic production or use, or inadequate infrastructure for appropriate disposal.
2. Plastic leakage source hotspot	Plastic leakage source hotspot is the high-risk source of plastic waste to be leaked to waterways connecting to the ocean which is	These hotspots are based on criteria including population density, waste generation rate, percentage of plastic in the

Hotspot	Definition	Note
	identified through an optional analysis, relying on GIS tools, and allowing to identify the locations of highest leakage within country. The hotspots mainly consist of localities or watersheds.	waste-stream, waste collection rate, MWI, distance to shore, catchment run-off, slope and wind patterns. Examples also include Illegal dumpsites and littering sports as well as the area where waste collection service is not provided and slum.
3. Plastic accumulation hotspot	Plastic accumulation hotspot is wastes accumulated at the artificial barriers and topographic barriers in waterways and rivers locally and regionally. **This hotspot assists in identification of plastic items getting leaked into carrier (water) and identification of plastic leakage source hotspots while tracking it back to the source. It will assist the practitioner to correlate the plastic waste to loss rate and leakage rate into carrier medium.**	The location of accumulation should be • Artificial barriers, Dam • Topographic barriers in waterways and rivers
4. Plastic application hotspot	Plastic application hotspot is related to a plastic application or an activity related to the plastic application. Plastic application refers to a product or packaging partially or completely made of plastic. For Example: A "hotspot" as defined in this category can be a product category with high environmental impact in multiple impact categories **e.g. PET cans and PE bags. Generally this hotspot assists the decision maker for prioritizing actions related to polymer**	• Common examples of applications include straws, grocery bags, plastic beverage containers, fishing nets, etc. • Common examples of activities related to applications include driving a car (leading to tyre abrasion) or on-the-go eating (potentially leading to littering).

Conceptual Approach for Hotspot & Plastic Leakage Pathway Analysis

To date there is no common methodology to either measure (through field studies) or assess (through modelling) plastic flow for a country. However, an effort has been made to develop this methodology in a city's context. Literature cotes that a hotspot is defined when its threshold contributes 10% of the total impact. But there is no precise agreed upon level. **Therefore, two approaches may be used to identify the hotspots.**

1st Approach: A hotspot shall always be a percentage greater than if the impacts were evenly distributed across life cycle stages. For example, if there are 5 life cycle stages, a hotspot should not be defined lower than 20% of the impact category, and if there are 7 stages, it should not be lower than 14%.

2nd Approach: Where the hotspot has been identified based on qualitative information, it will not be possible to identify a hotspot with quantitative precision. Therefore, the analysis should be confident that the majority of impacts (i.e., over 50%) are covered. Clear boundaries are essential to ensure that appropriate information is obtained and used within the analysis.

In majority of countries, where input output data related to each of the stages shown in Figure 1 are not available, use of second approach is the most preferred option.

A number of **tools/techniques both quantitative and qualitative** can be used to determine the geographical locations, vulnerable areas and input output analysis covering each stage or a combination of stages or complete plastic value chain shown in Figure 1. **Some of these tools/techniques include:**

Reconnaissance Survey: The first step to carry out data collection is to carry out field reconnaissance survey using GPS in the identified geographical area e.g. city/ watershed and identify the physical features/benchmarks in the city's context. A photographic technique using 360 degrees camera, still photography can be used for reconnaissance survey.

Perception Survey: Different stakeholders e.g. Policy & Regulatory bodies, Institutions, businesses and communities mapped as per **Figure 1** can be surveyed using a number of tools like questionnaire, focused group discussions, workshops/conferences to identify hotspots and leakage pathways. This technique covers the complete plastic value chain and different stages or combination of stages as well. **It can capture all types of hotspots identified in Table 1.1. This technique has been extensive used in Indian component of the project.**

GIS Technique and Fuzzy Approach: Develop layers of physical features (slope, contour, rivers, drainage etc.) as well as human interventions (land use, demography, socio-economic layers, points of interests, commercial, agriculture, industrial areas etc.) using Geographical Information Systems (GIS). Use the fuzzy approach, an analytical tool by overlaying these layers to identify the vulnerable areas consisting of different hotspots, which may contribute to plastic leakage into river through carrier/medium like drains and air. **'Heat Maps' will provide an overview of the hotspots identified in the study, the issues or impact categories associated with them and their location in the economy, sector, product lifecycle or value chain. This technique gives lots of information on plastic value chain hotspots, plastic leakage source hotspots and plastic accumulation spots as well as assists in development of risk maps of the geographical area.**

Macroplastic Clean up Technique: Macroplastic clean up technique gives information about major polymers, plastic products as well as unmanaged waste (Qualitative and Quantitative), which is getting leaked into the environment from the technosphere.

Microplastic Survey & Assessment: Microplastic survey and assessment technique gives information about major polymers, plastic products as well as unmanaged waste both

qualitative and quantitative to some extent, which finds its way through leakage pathway into the environment (water) from the technosphere.

Economic Data Templates: Market/sales data can be helpful in establishing the quantities of goods and services that could be considered in defining a functional unit, and identifying subsequent data needs (e.g., Bill of Materials, purchasing data) to identify impacts from a life cycle perspective. Sector economic data may be available at the level of an organisation, trade association, region or nation through information collected by businesses, associations and national statistics bodies. **This will assist in establishing production and consumption material flow trends as well as analysis across the plastic value chain.**

Waste Management Data Templates: This will cater to the data related to waste generation, collection, transportation, treatment and disposal. This will also give information related to money flow related to waste management.

Input-Output Tables: At each stage or a combination of stages, material flow, money flow and their linkages to environment can be established using Economic Data templates versus Waste Management Data templates. Environmentally extended input output information can be used to identify hotspots and causal links through a supply chain.

Ranking Technique: Some form of ranking or points system can be used to convert the qualitative information into a quantitative metric to arrive at environmental impact. Assessment of plastic usage, waste or recycling rates, with little focus on circularity can be used synergistically to identify the best scenarios in terms of reducing environmental impacts while aiming to maximise circularity.

Hotspot analysis is an iterative approach. Steps naturally form a sequence; there will be a need to revisit steps in the process to refine the analysis as it develops. All the techniques or a combination of techniques can be used to identify hotspots and leakage scenarios. Depending upon the number of impact categories selected, the number of hotspots may vary. Consideration should be given to how these can be most effectively used to develop counter measures and communicated with stakeholders identified at the same time. Various steps involved in identification of hotspots, leakage pathways and counter measures are given below.

1. Carry out the reconnaissance survey and perception survey to identify all types of tentative hotspots (Value Chain, Leakage Source, Accumulation and Application Hotspots)
2. Develop GIS layers and use Fuzzy approach to identify the leakage vulnerability of the study area
3. Identify the "**Plastic leakage source hotspot**"
4. Identify the "**Plastic accumulation hotspot**" with "**Plastic application hotspot**"
5. Merge other layers and data (e.g. river network, littering spot) and including "**Plastic Value Chain, Plastic leakage source** & **Accumulation Hotspots** and physically verify the pathway visually as predicted by GIS & Fuzzy Logic approach
6. Estimate amount of plastic loss to the environment and leakage to the waterway (in municipal level) by using input/ output analysis
7. Target the identified and verified hotspots and develop countermeasure.

1.4 FORMAT OF THE REPORT

One of the expected outcome of this activity is development of a report "Plastic leakage scenarios for selected locations in identified cities / study area". The **Plastic Leakage Assessment Report describing the expected outcome** has been compiled in **five chapters and three annexure**. The table of contents of each chapter is given below.

Chapter 1 Introduction and Background: Introduction; Objective of the Study as per ToR; Scope of Work (SoW) as per SSFA; Approach and Methodology; Format of the Report.

Chapter 2 Summary Report Plastic Leakage in Haridwar: This chapter describes the summary of the findings of the plastic leakage into The Ganges in Haridwar. It consists of the description of basic physiography, drainage, administrative structure of the city followed by Solid and Plastic Waste management in Haridwar. Further, predictive analysis based on hotspotting and plastic leakage pathway into the river has also been described.

Chapter 3 Summary Report Plastic Leakage in Agra: This chapter describes the summary of the findings of the plastic leakage into The Yamuna in Agra. It consists of the description of basic physiography, drainage, administrative structure of the city followed by Solid and Plastic Waste management in Agra. Further, predictive analysis based on hotspotting and plastic leakage pathway into the river has also been described.

Chapter 4 Summary Report Plastic Leakage in Prayagraj: This chapter describes the summary of the findings of the plastic leakage into The Ganges in Prayagraj. It consists of the description of basic physiography, drainage, administrative structure of the city followed by Solid and Plastic Waste management in Prayagraj. Further, predictive analysis based on hotspotting and plastic leakage pathway into the river has also been described.

Chapter 5 Summary Report Plastic Leakage in Mumbai: This chapter describes the summary of the findings of the plastic leakage into The Arabian Sea in Mumbai. It consists of the description of basic physiography, drainage, administrative structure of the city followed by Solid and Plastic Waste management in Mumbai. Further, predictive analysis based on hotspotting and plastic leakage pathway into the sea has also been described.

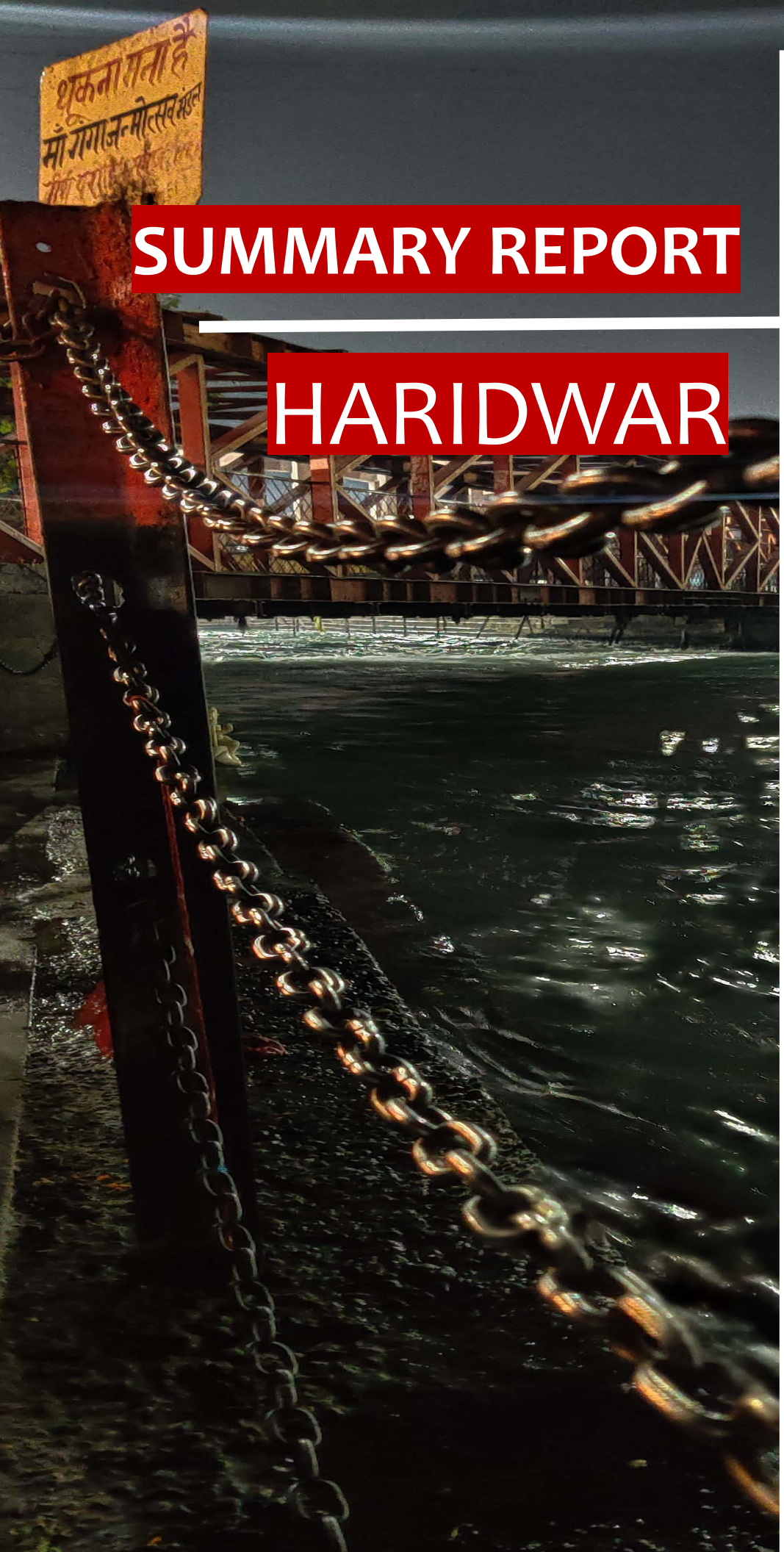
Annexure 1: Detailed City Reports of Haridwar, Agra, Prayagraj and Mumbai.

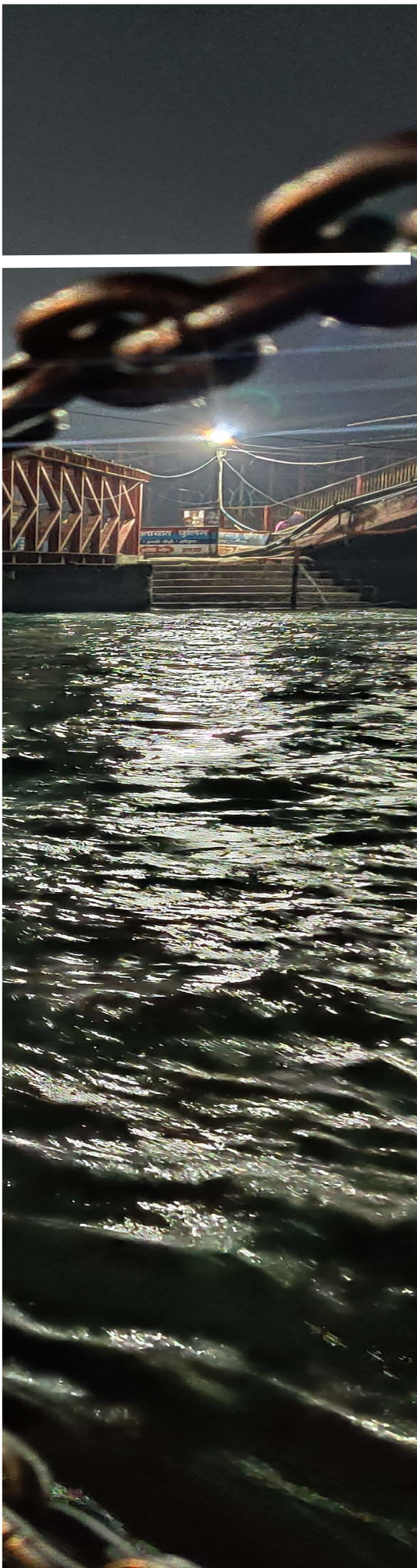
Annexure 2: Macroplastic Assessment Clean up Assessment Methodology and findings of cleanups

Annexure 3: Microplastic Assessment Methodology and findings of microplastic assessment

SUMMARY REPORT

HARIDWAR





Chapter 2: Summary Report Haridwar

2.0 Introduction

Haridwar, is a city which falls in Uttarakhand state in India. It is located at latitude 29° 58' in the North and longitude 78°10' in the East. Haridwar is situated along Delhi-Niti Pass (DN Road) which starts from Delhi and passes through Meerut, Muzzafarnagar, Roorkee, Haridwar and goes till India-Tibet Boundary. It is the second largest city in the state and the district headquarter of the Haridwar district. Haridwar is regarded as a holy place for Hindus, hosting important religious events and serving as a gateway to several prominent places of worship. Most significant of the events is the Kumbha Mela, which is celebrated every 12 years in Haridwar. During the Haridwar Kumbh Mela, millions of pilgrims, devotees, and tourists congregate in Haridwar to perform ritualistic bathing on the banks of the river Ganges. However, during festive periods such as Kavad Mela, Somvati Amavasya Mela, Shivaratri, Ganga bath, Baisakhi (April–August), numbers increases (around 5–6 million). **Figure 2.1** shows the municipal boundary of the city.

Figure 2.1: Municipal Boundaries of Haridwar City

Source: Google Maps

2.1 Geography & Climate

2.1.1 PHYSIOGRAPHY

The city is situated along the bank of Ganga River in the upstream at an altitude of 314 metres from the sea level, between Shivalik Hills in the North and Northeast and the Ganges River in the South. On the left side of the town is Chandi devi hill on which

a temple dedicated to Goddess Chandi is situated; on the right is Mansa Devi temple. Geologically, Shivaliks are separated by the Himalayas by a continuous reverse fault and fall in three main divisions, the upper Shivalik, middle Shivalik and the lower Shivalik. The Shivalik are mostly composed of sandstone and conglomerates. The river Ganga flows in a series of channels separated from each other called aits, most of which are well wooded. Other minor seasonal streams are Ranipur Rao, Pathri Rao, Rawii Rao, Harnaui Rao, Begam Nadi etc. The contour and drainage map of the city is shown in **Figure 2.2**. The contour and the major drainage pattern along with the river flow indicates that it emerges from the north, moves towards south west and then changes to east direction. The major part of the city is on the right bank (Eastern side) of the Ganga and has grown beyond the river on the western side as well. There are nineteen major storm water drains with a total length of about 17.9 km draining into Ganga. These include Pandewala, Kasa Nala, Shiv Mandir Nala, Latowali Nala, Jagjeetpur Nala, Avas Vikas Nala, Dev Pura Nala, Mayapur Nala, Lalita Rao Nala, Kusha Ghat Nala, Nago Ki haveli Nala, Nai Sota, Kangra Mandir Nala, Karanwal Nala, Karoli Nala, Bhimgoda Nala, Sapt Sarovar Nala and Lok Nath Nala. Practically the whole town, wherever roads or brick paved lanes/paths exist, have some kind of side drains leading to storm water drains, except in slums or some parts of peripheral areas. These drains are silted and carry a lot of waste into the river.

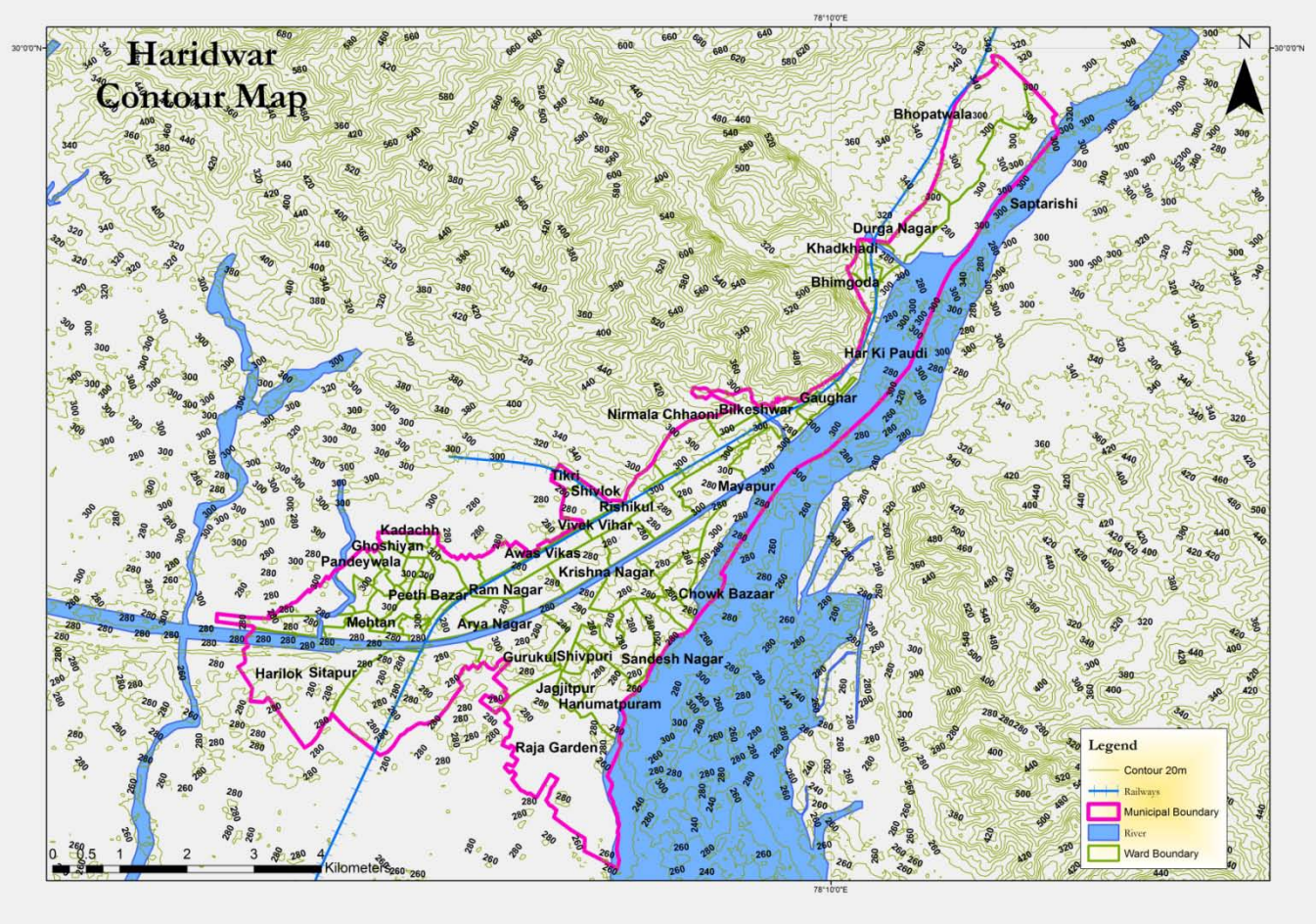


Figure 2.2: Contour and Drainage Map of Haridwar

Source: NPC team

2.1.2 CLIMATE

The city experiences three seasons, summer, rainy and the winter. The summer season starts from April till June, the rainy season from July to September while winter season starts from October and ends in February. The general characteristics of climate of this region are:

- **Temperature:** Hot during summers, cool to cold during winters and warm humid during Monsoon season. Annual maximum temperature is 30 to 42 degree Celsius. Annual minimum winter temperature ranges from 4 to 14 degree Celsius.

- **Humidity:** During rainy season humidity ranges from 70 percent to 85 percent while during summer season it ranges from 40 percent to 60 percent. During winter season it is about 25 percent approximately.

- **Wind:** The most probable wind direction is West, Northwest and Southwest. Summer is characterized by hot dust raising winds with velocities going up to 15 km/hour. Atmosphere is dusty In May/June.

2.2 Demography & Land Use

As per Census 2011, Haridwar has a population of 229,000. The population of Haridwar has maintained an upward trend with a few kinks in some decades. In the recent decades, as is observed, the decadal rate of growth gradually dropped down from 45.71% in 1981 to 16.00 % in 2001, the later being far below the national average. The average household size is about 5.4 persons. The demographic and administrative profile of Haridwar is given below in **Table 2.1**.

Table 2.1: Demographic and Administrative Profile of Haridwar

City Population 2011	2,29,000
floating population	6,93,000
slum population	86,880
Peak season floating population	50,00,000-60,00,000
Number of wards	60
Number of households	41335

There are 41,335 households falling in 60 wards in Haridwar. Slum population in Haridwar is 86,848. Average household size for slum households, as found from the baseline survey, is 7.1. The slums on encroached land and on the hill slope are generally worse in comparison to other slums. Of the below poverty line (BPL) population, 15 percent households and 10 percent of the poor do not have any legal rights of the land. In the absence of ownership of land and clear policy to address

their problems, the poor suffer from many inadequacies in terms of access to basic services like water supply and sanitation, and infrastructure. Land availability is a major constraint in the slums. On an average 20 percent of all the families in the slums stays with some other family. The city receives 0.6 million floating population. At the height of festivals, it can receive 5 to 6 million of floating population putting a pressure on city services. **Figure 2.3** shows the land use plan as per the approved master plan 2025. This would be utilized for urban activities, including housing, commerce, industries, tourism, community services, transport, parks, amusement and entertainment centers, parks and parking spaces. Demographic pattern tally with land use pattern of the city with majority population residing in the eastern area. Land use pattern also indicates that residential area as well as the eastern part of the city is a major area of consumption as well as generator of bulk of solid waste within the municipal limits.

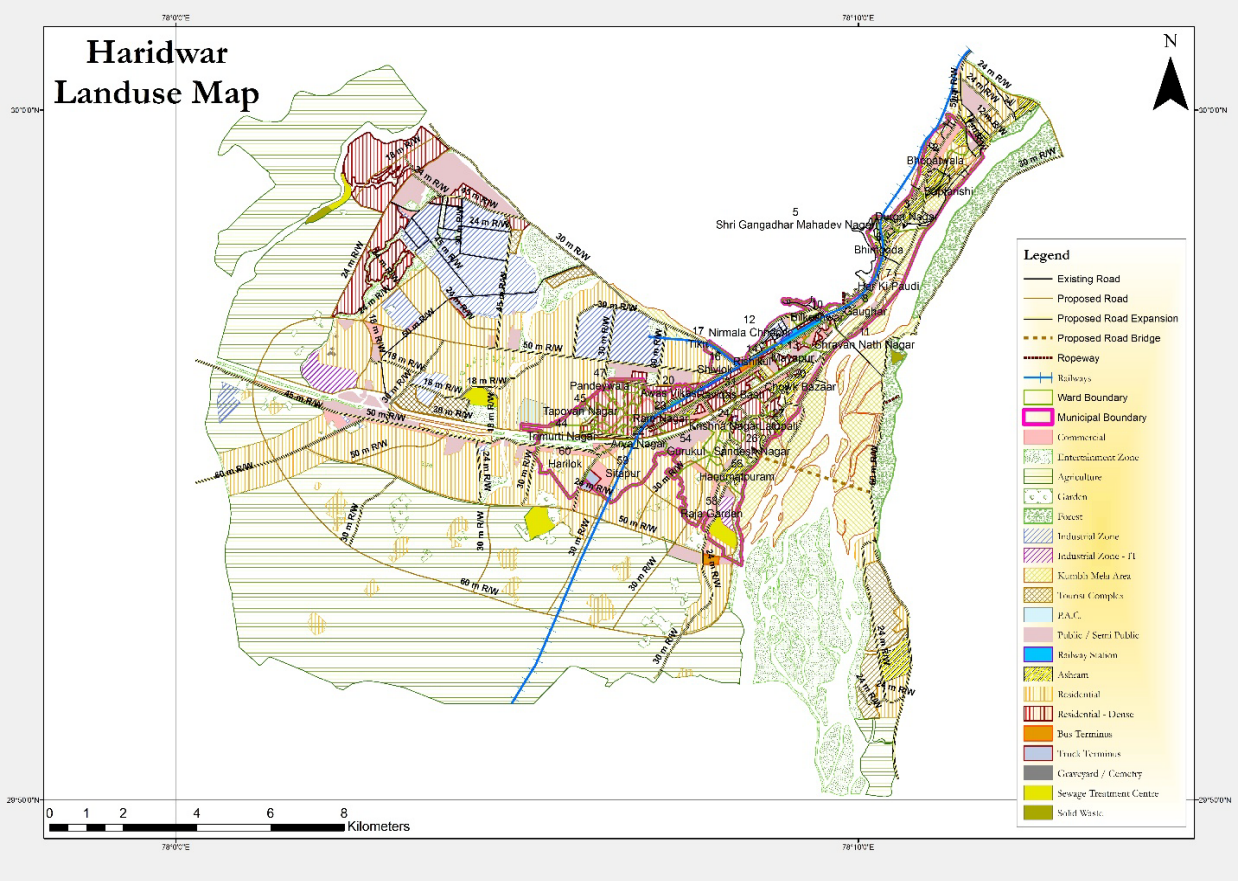


Figure 2.3: Demographic, Administrative and Land Use Map of Haridwar

2.3 Municipal Solid Waste and Plastic Waste Management at Haridwar

Waste generation in the city is average 312 Tonne per day which may vary depending upon the floating population. Most of the waste generated comprises of food and other discarded waste such as paper, plastic, glass, metal, packaging material etc. M/s KRL Waste Management Pvt. Ltd. is engaged by

Municipal Corporation for waste collection, transport, storage, and treatment & disposal. Features of waste management in Haridwar are given below.

- Presently segregation of waste at source is not followed and the commingled waste collected comprises of food and other discarded waste such as paper, plastic, glass, metal, packaging material etc. is incoming ate waste treatment plant.
- Waste is collected from about 52 wards out of the total 60 wards. About 8 wards are newly added and so the waste collection efficiency is 86%. In addition to this the waste generated from the slum population in Haridwar city is also not collected.
- The biggest challenge with respect to solid waste management in Haridwar city is that the total capacity of waste treatment plant capacity is only **150 metric tons per day**. However the total waste collected by M/s KRL is about 312 TPD (tons per day). 162 tons of waste per day is dumped at trenching ground without any treatment.
- 8 tons of plastic waste (comprising of mainly MLPs) segregated from150 TPD of mixed waste (treated at the plant) is sent to the Cement Industry as Refuse derived fuel. The percentage of plastic waste in mixed waste is estimated as (8/150) = 5.3%
- In addition to M/s KRL's services, M/s Akansha Enterprises under Namami Gange Program of Government of India ensures maintenance of cleanliness of 72 nos. of Ghats at Haridwar (In Haridwar city, water from river Ganga is diverted through a channel which flows in the city and then joins back the river. Along this channel bank at several points, arrangements are made for devotees to perform religious rites. These points are called Ghats). Around 12 tons per day of waste which mainly comprises of waste cloths, silt, poly bags, packaging waste, flowers, fruits, vegetables etc is generated from these Ghats. People also visit these Ghats to perform last rites of their family member, friends, etc as per Hindu religion and leave behind their clothes on the Ghat (which get accumulated). The waste collected from these Ghats is also transferred to the trenching ground without any treatment.
- Street sweeping is carried out manually and waste collected is transported to the treatment plant. Street litter comprises of multilayer plastic packages, colored poly bags, synthetic bags, silt etc.

This results in generation of additional 500–600 MT of waste (considering 100 gm waste generation per capita per day) during the month of July.

Total Plastic generation as estimated from data collected from various stakeholders as well as literature review is depicted below in **Table 2.2.**

Table 2.2: Plastic Waste generation and leakage in Haridwar

	Quantity in TPD	Remarks
Lean Period		
Total plastic waste generation	23 - 25.4	1. **Min value:** 393 TPD mixed waste collected by KRL (from 52 wards out of total 60 wards) + from Ghat +floating population during lean season +plastic waste collected by rag pickers @40% of total waste collected by them i.e 6TPD 2. **Max value:** waste collected by KRL + waste collected from Ghat+ Waste generated from slum + floating population amounting to 436 TPD 3. Plastic in mixed waste is 5.3%
Plastic leakage	2.1 - 2.739	1. **Min Value:** untreated plastic waste in trenching (15 TPD) may be leaking to environment @5% i.e 0.5 TPD + plastic waste from slum i.e 1.6 TPD is also leaking into environment 2. **Max Value:** In addition to Min value, waste not collected from 8 wards at present @ 13 TPD having 5.3% plastic i.e 0.689 TPD
Peak season (Month of July)		
Total plastic waste generation	49 - 57	1. **Min value (additional plastic waste generation during peak season):** 50 lakh population generating mixed waste @100gmper capita per day which has 5.3% plastic 2. **Max value (additional plastic waste generation during peak season):** 60 lakh population generating mixed waste @100gmper capita per day which has 5.3% plastic 3. Total plastic waste = plastic waste during lean period+ Peak season
Plastic leakage	3.7 - 4.4	1. **Min value:** 5.3% of untreated waste amounting to 500+286 during normal which is leaked @ 5% 2. **Max value:** Additional leakage from slum @ 0.689 TPD

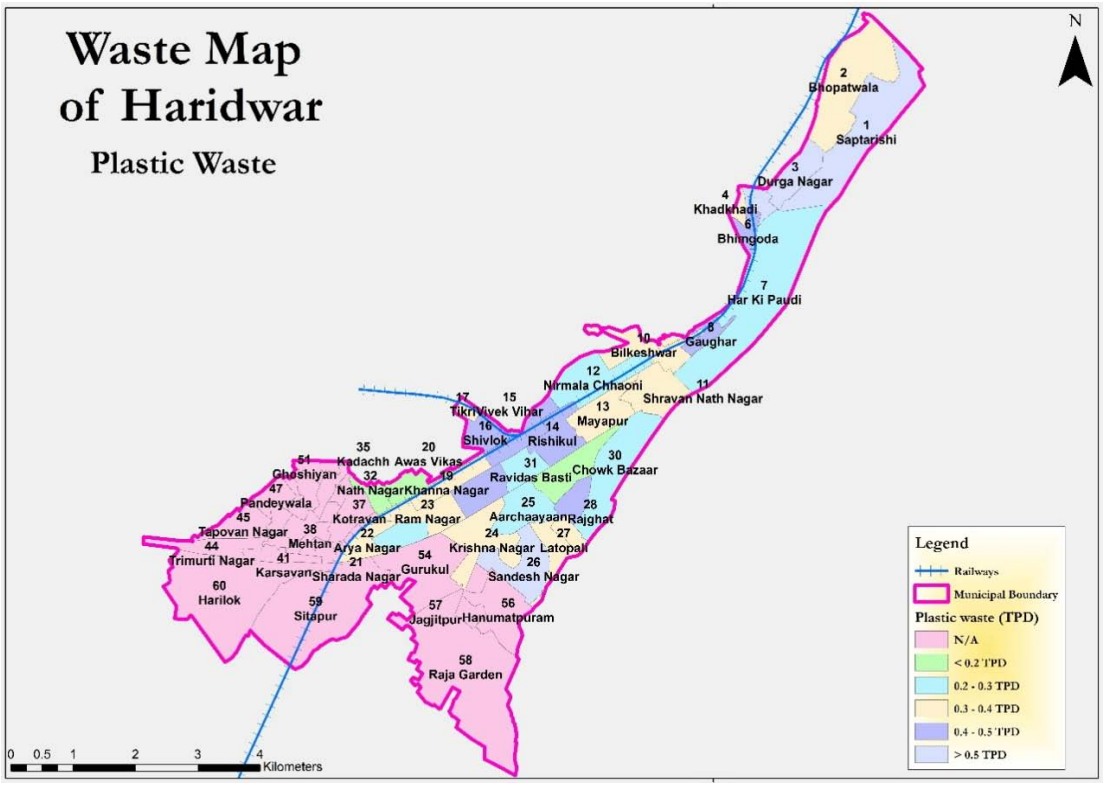
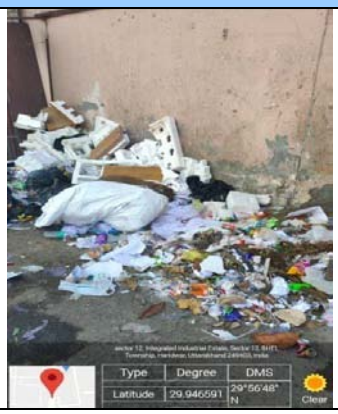


Figure 2.4: Ward Wise Plastic Waste Generation Map

Plastic waste is generated from different sources are as given below:

Sources	Types of Plastic Waste	
Household	multiplayer plastic packages, polythene bags, cardboard, Plastic packets of detergent, clothes, luggage bags, milk pouches, etc	
Market	Poly bags, polyesters/synthetic bags, packaging waste	

Sources	Types of Plastic Waste	
Commercial areas	polythene, paper cups, cans, Aluminium silver foil, black polythene, thermocol Transparent polythene, black polythene, Nylon sacks, thermocol, cardboards are in significant quantity and synthetic ropes, multilayer packaging, pet bottles, hard plastic.	

Slums which are in close vicinity of the river are more likely to contribute to the plastic pollution. Therefore, the drainage and water bodies serve as carrier of plastic waste to the river as shown in **Figure 2.5** below.

Figure 2.5: Waste accumulated on river bank at slum area in Haridwar

2.4 Identification of Hotspots

A step wise approach has been adopted to identify the hotspots, which serve as source of plastic leakage into the river. This is based on IUCN's approach for defining the plastic leakage as a function of loss rate and leakage rate. The various steps include identification of vulnerable areas using fuzzy logic approach adopted by GIC, AIT Thailand **(Figure 2.6)** and identification of leakage points **(Figure 2.7 & Figure 2.8)** followed by field reconnaissance & verification **(Figure 2.9)** and cleanup activities. During the field survey at Haridwar, littering

of solid waste comprising majority of plastic waste was observed in abundance. This was followed by discussion with HNN, which suggested hotspots, which were in line with predicted vulnerable areas.

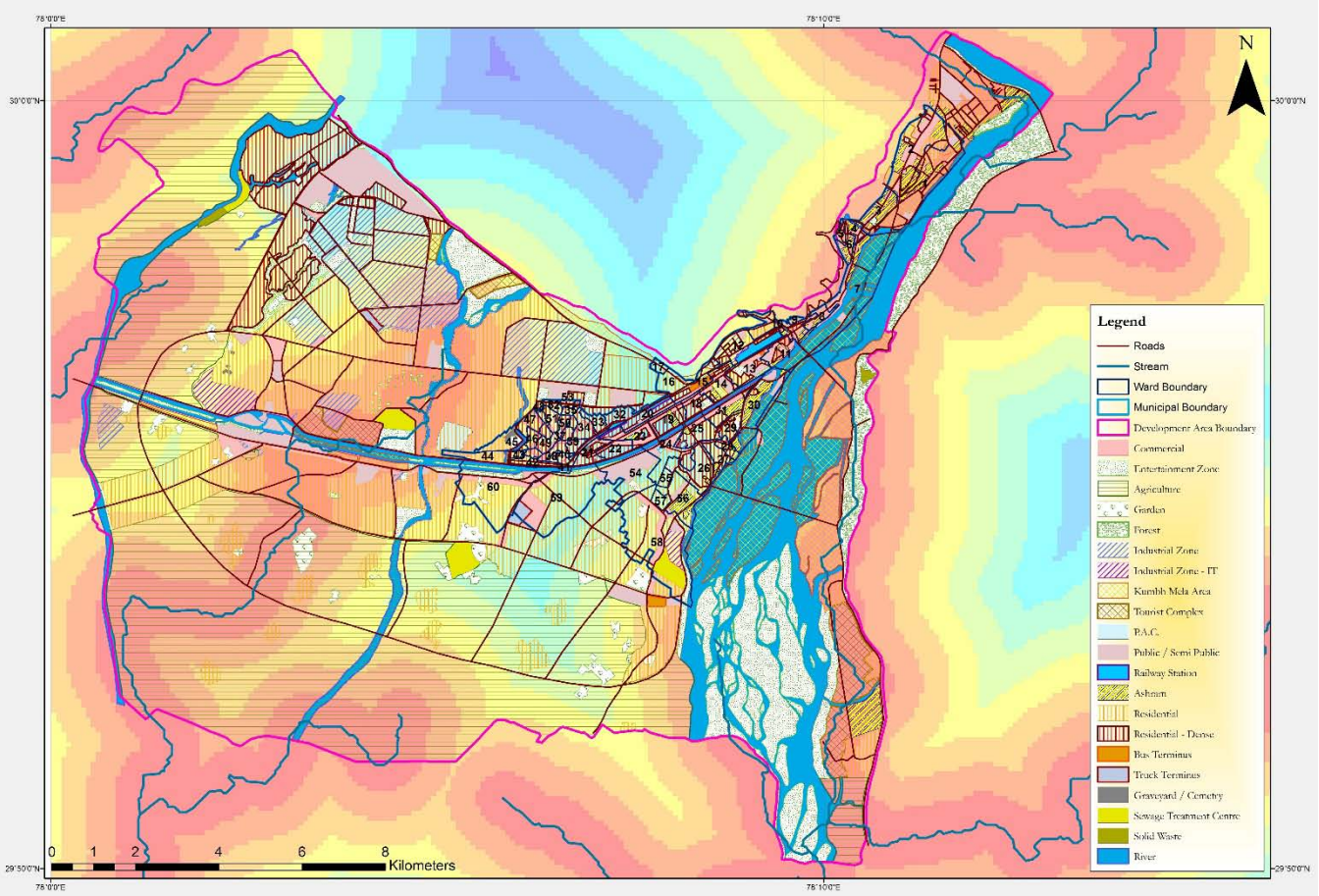


Figure 2.6: Plastic Leakage Vulnerable Areas identified using Fuzzy Logic Approach

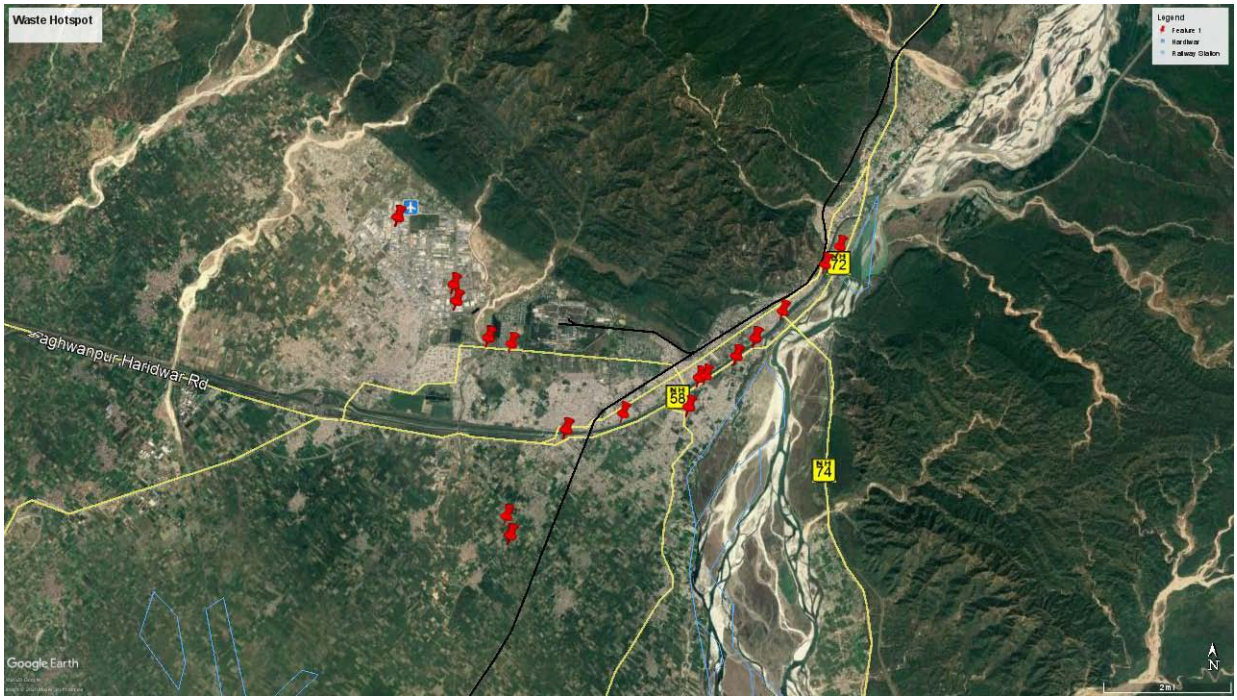


Figure 2.7: Location of Probable Hotspots in Haridwar

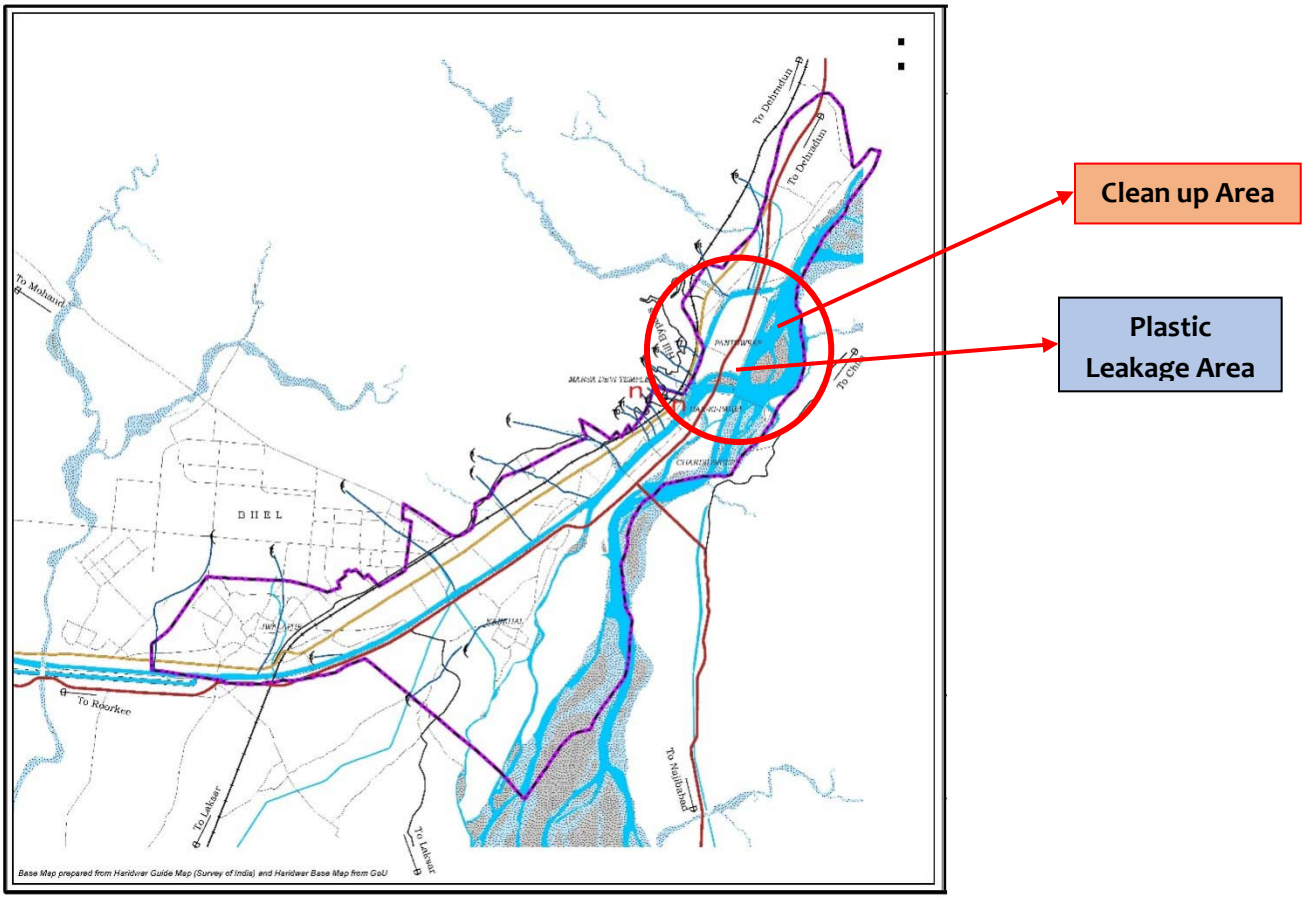


Figure 2.8: Drains and Sources of Plastic Leakage

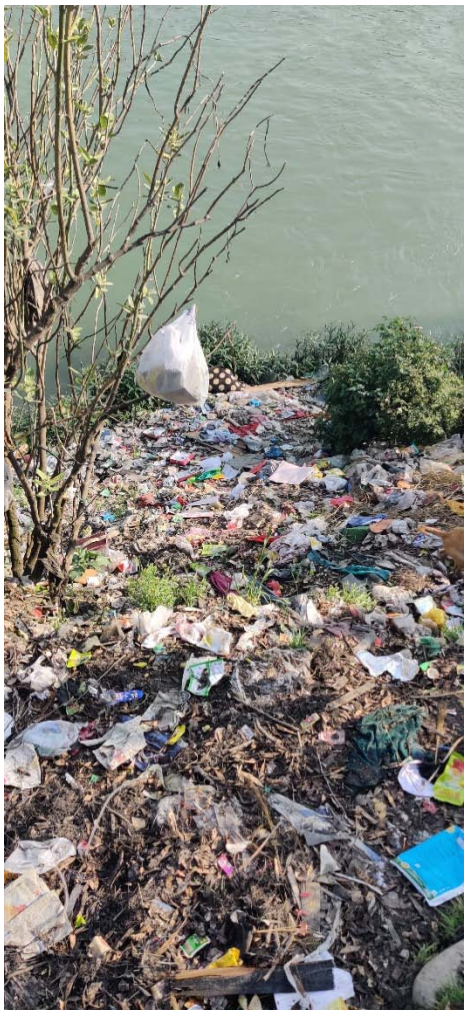
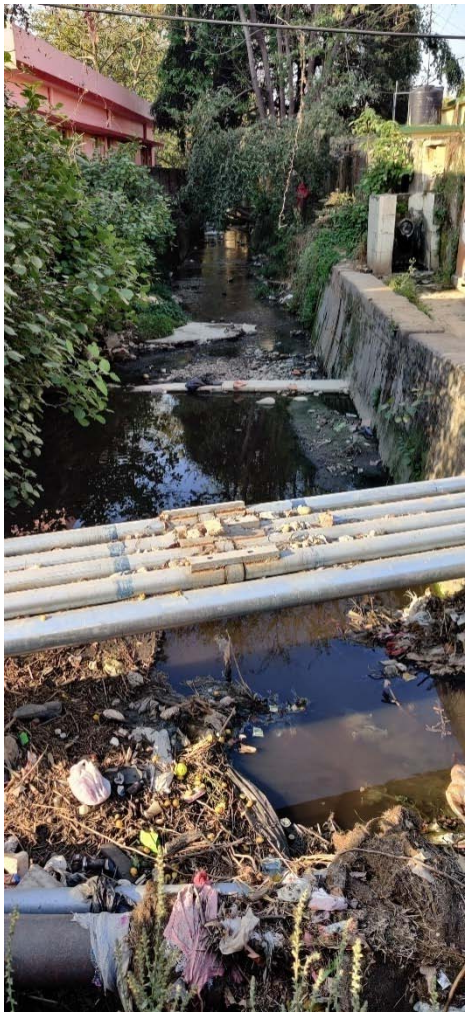




Figure 2.9: Field Reconnaissance& Verification

2.5 Cleanup Activities & Macro Plastic Assessment Studies in Haridwar

Clean up activities were undertaken at Vishnu Ghat and Pant deep Parking near Har ki Pauri in Haridwar. The accumulation of waste again within a period of two months at Pant deep Parking validated the identification of the hotspots as shown in **Figure 2.10 & Figure 2.11.** The following charts **(Figure 2.12 & Figure 2.13)** depict the prominent plastic wastes in Haridwar, both on the basis of count and on the basis of weight. **Figure 13** indicates that maximum number of prominent plastic waste in decreasing order are Polythene carry bags, multilayer packaging packets, HDPE pipes, tubes & trays, disposal plastic cutlery, garments/textile packaging materials, metallic foil disposable plates and bowls having plastic lamination, packaging used for water/milk, plastic bottle caps and others. In terms of weight polythene bags contributes the maximum followed by multilayer packaging packets, garments/textile packaging materials, HDPE pipes, tubes & trays and many others.

Figure 2.10: Captured in January,2020

Figure 2.11: Captured in March,2020

The following charts depict the prominent plastic wastes in Haridwar, on the basis on count and on the basis of weight.

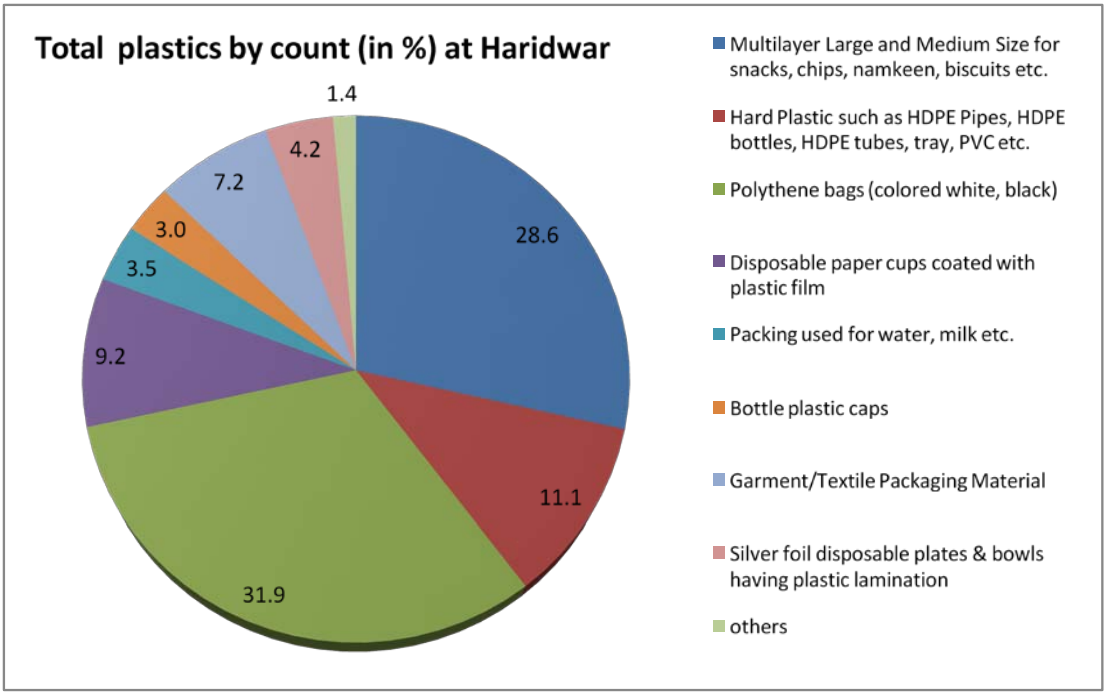


Figure 2.12: Breakup of plastic items in numbers

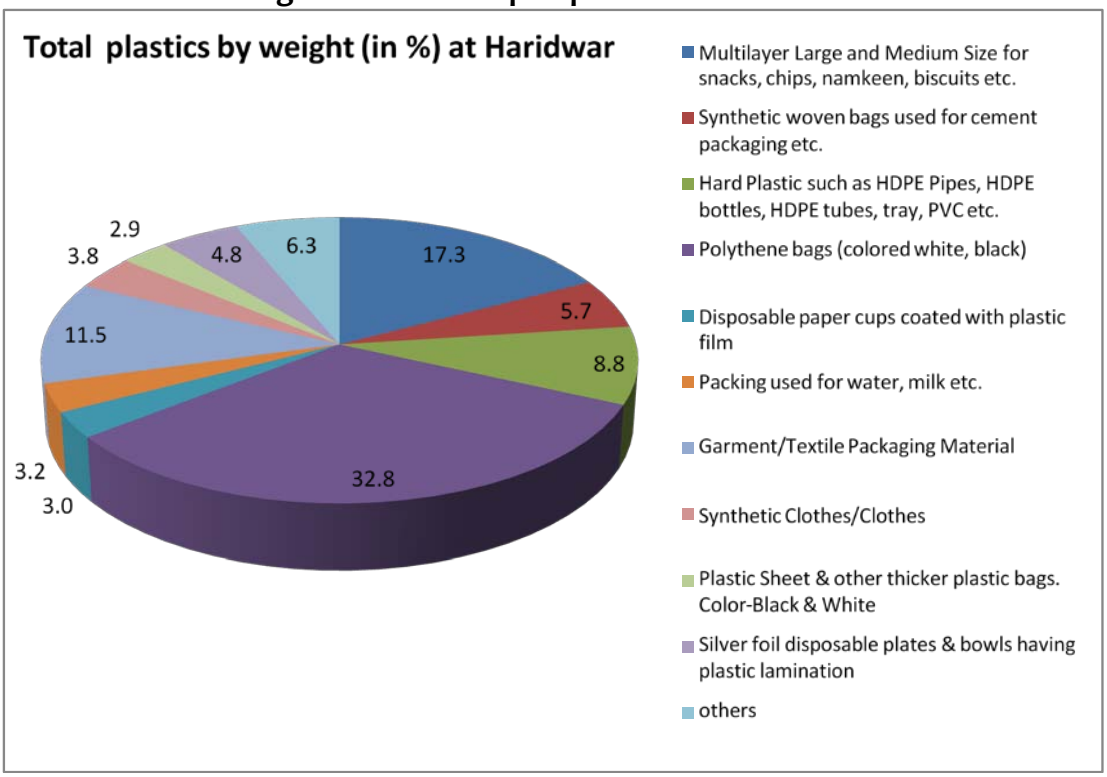


Figure 2.13: Breakup plastic items in terms of weight

2.6 Conclusion

Major hotspots have been identified, which trigger plastic leakage into river Ganga through carriers like air, drains and run off. These include all the four types of hotspots. These include: (i) Plastic Value chain hotspots like plastics

waste generated in Slum Areas and industrial areas; (ii) Plastic Leakage Source Hotspots in major wards in the city; (iii) Plastic Accumulation Hotspots in major untapped drains of the city; Plastic generated on Ghats on peak seasons and (iv) Plastic Application Hotspot like Polythene bags and MLPs. The major hotspots (accumulating points of waste) in Haridwar includes: Transfer station (locally called Dhalos), Street litter in market, Open spaces in residential areas where daily door to door waste collection is not there, Slum areas, Barriers in open drains/Ganga Channel and Banks of Ganga Channel (called Ghats in India). Routes of leakage from accumulating points to open drains happen via wind, from barriers by opening of Gates to release excess water during monsoon season. From Channel, drain, plastic is transported to river Ganga. Massive amount of plastic was observed to be littered during the field study at various locations in Haridwar. Majority of vacant lands are found as illegal dumping points created by local public. Littering ranges 10% to 25% against 2% assumed in major studies carried abroad. Therefore, littering is one of the major reasons for the plastic not being collected and brought back into the value chain. However, majority of the waste categories found during Clean Up include polythene bags, Multi-layer packaging, HDPE pipes, disposable plates & glasses, synthetic clothes, water pouches, milk pouches, Aluminium Plates & bowls used for food packaging, plastic sheets, Packaging Material e.g. Tobacco sachets, Biscuit packets, Surf excel, Rusks etc. as per clean up report. A schematic diagram representing the leakage pathway has been described in **Figure 2.14** below.

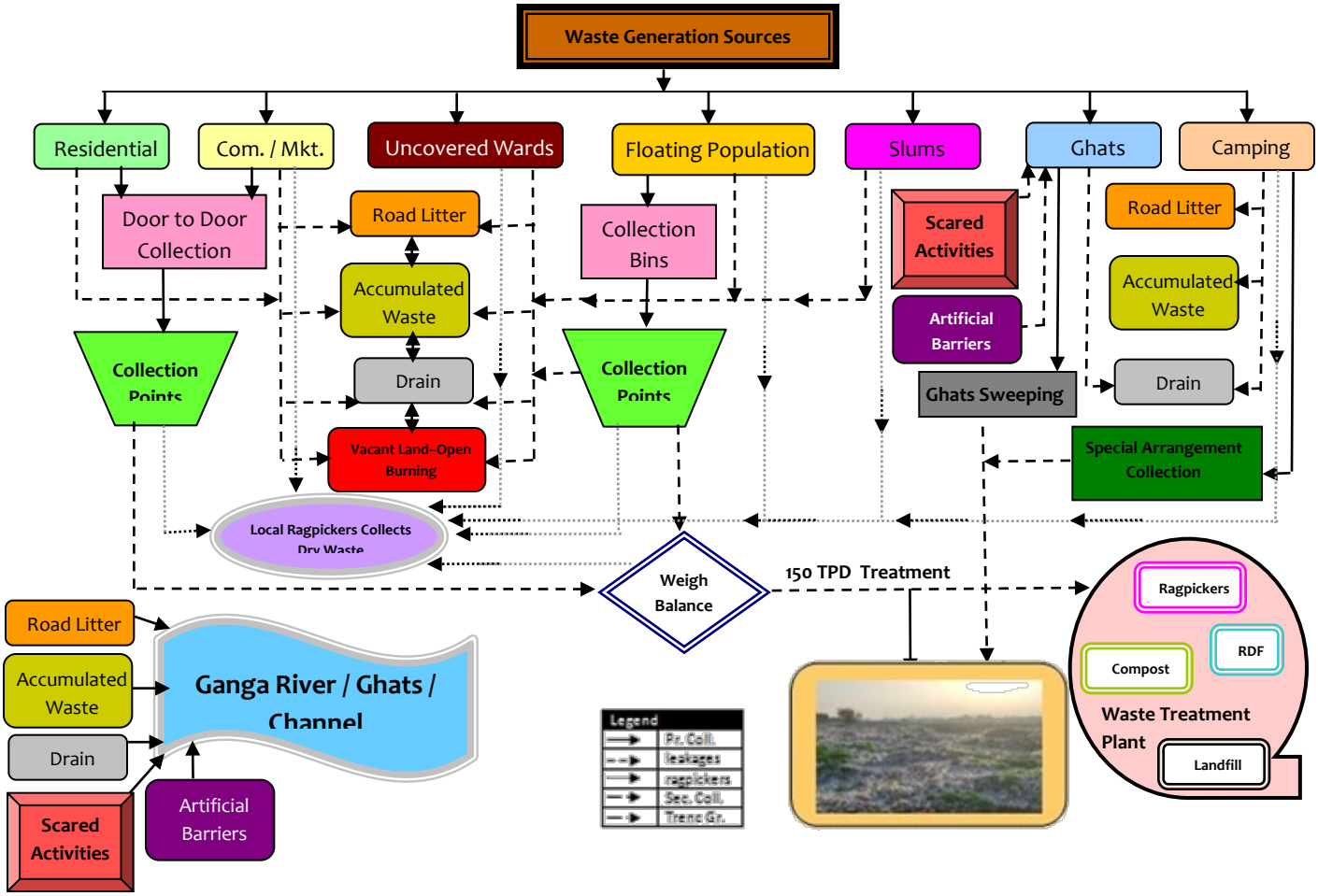
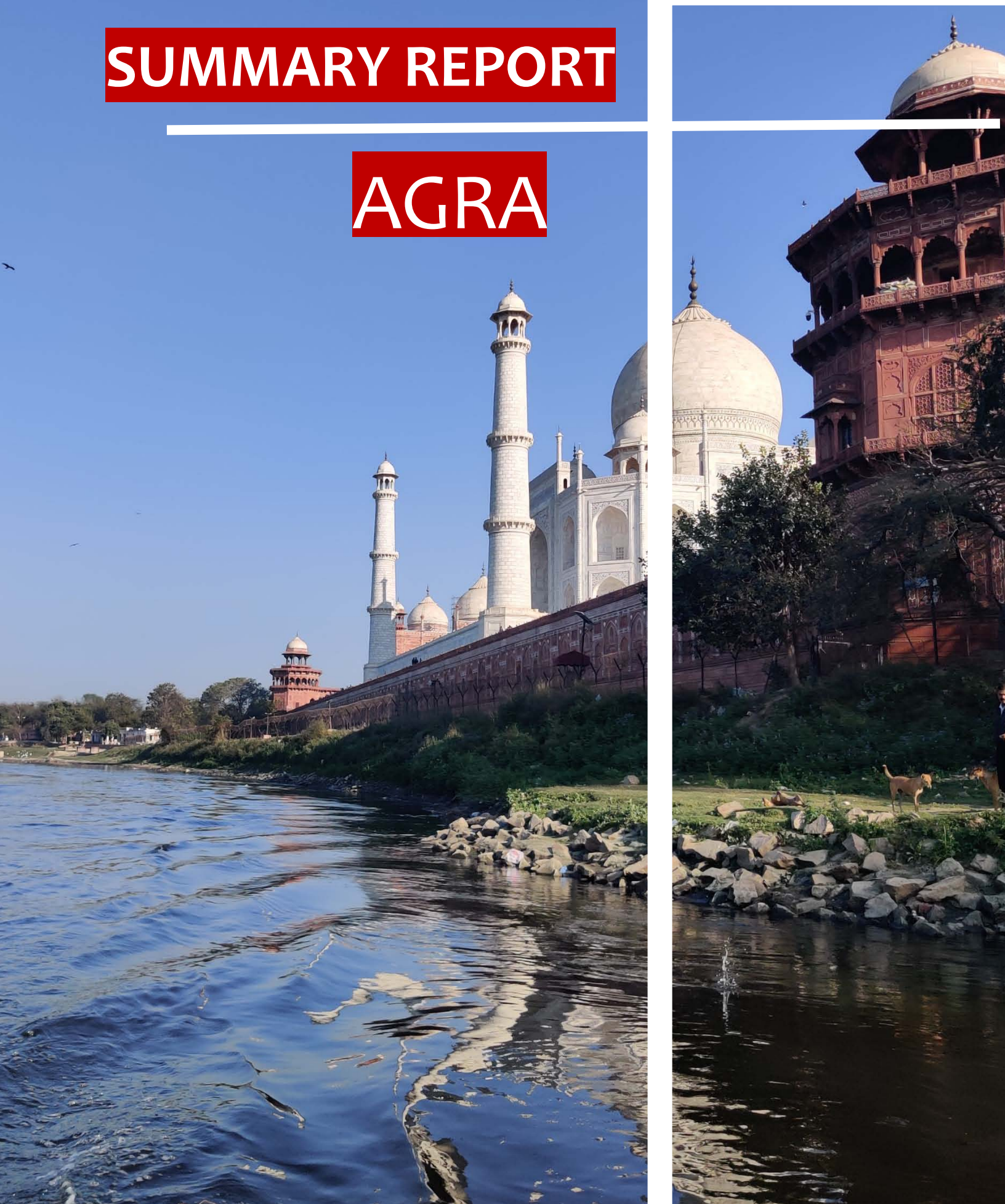


Figure 15: Flow Diagram of Plastic Waste Generation and Leakages

SUMMARY REPORT

AGRA



Chapter 3: Summary Report Agra

3.0 Introduction

Agra is geographically located at 27°12' North latitude and 78°12' East longitude. The city is situated on the Western Bank of river Yamuna at about 200 Kms from Delhi in the state of Uttar Pradesh. It is a Class I town, municipality and administrative headquarters of Agra District and falls under Agra division of Uttar Pradesh. The climate of Agra is extreme and tropical in nature. The temperature drops to 3°C in winter and rises to 47°C in summer. The city experiences three seasons, the summer, rainy and winter seasons. The summer season starts from April and ends in June, the rainy season starts from June and ends in September with an annual rainfall of 686 mm while winter starts in November and lasts till February. Agra has an extremely strategic location on the confluence of three distinct geo-physical regions namely the plain of Uttar Pradesh, the plateau of Madhya Pradesh and the desert of Rajasthan. It falls in Great Indo-Gangetic Plain region and its strata consist of mainly sandy soil. The ground water level varies generally 6 to 8m below ground level. The altitude varies from RL 150 m to 170m above mean sea level. The city stretches for about 9.0 kms along the Yamuna River. The contour and the major drainage pattern along with the river flow indicate west to east direction. The major part of the city is on the Western side of Yamuna and has grown beyond the river on the eastern side and is called the Trans Yamuna area while the original part is called as CIS Yamuna. Being centrally located on the national map, Agra forms an important regional urban Centre and a prominent tourist destination of India.

3.1 Demography & Land Use

Agra has a population of 1.77 million with about 264,053 households located in 100 wards in 4 zones. Agra receives about 391037 floating population annually. The city has 417 slums constituting about 56% of the city population. Demographic trends indicate that Hariparwat, Lohamandi, Cantonment and Tajganj zones on the western side of the river are densely populated while Chatta zone is an upcoming area. Figure 3.1 shows the land use plan for an area of20036.97 Ha as per the approved master plan period of 2001-2021. This would be utilized for urban activities, including housing, commerce, industries, tourism, community services, transport, parks, amusement and entertainment centers, parks and parking spaces. About 50 per cent of area is for residential use and about 2percent for commercial use. Demographic pattern tally with land use pattern of the city with majority population residing in the western area. Land use pattern also indicates that residential area as well as the western part of the city is a major area of consumption as well as generator of bulk of solid waste within the municipal limits.

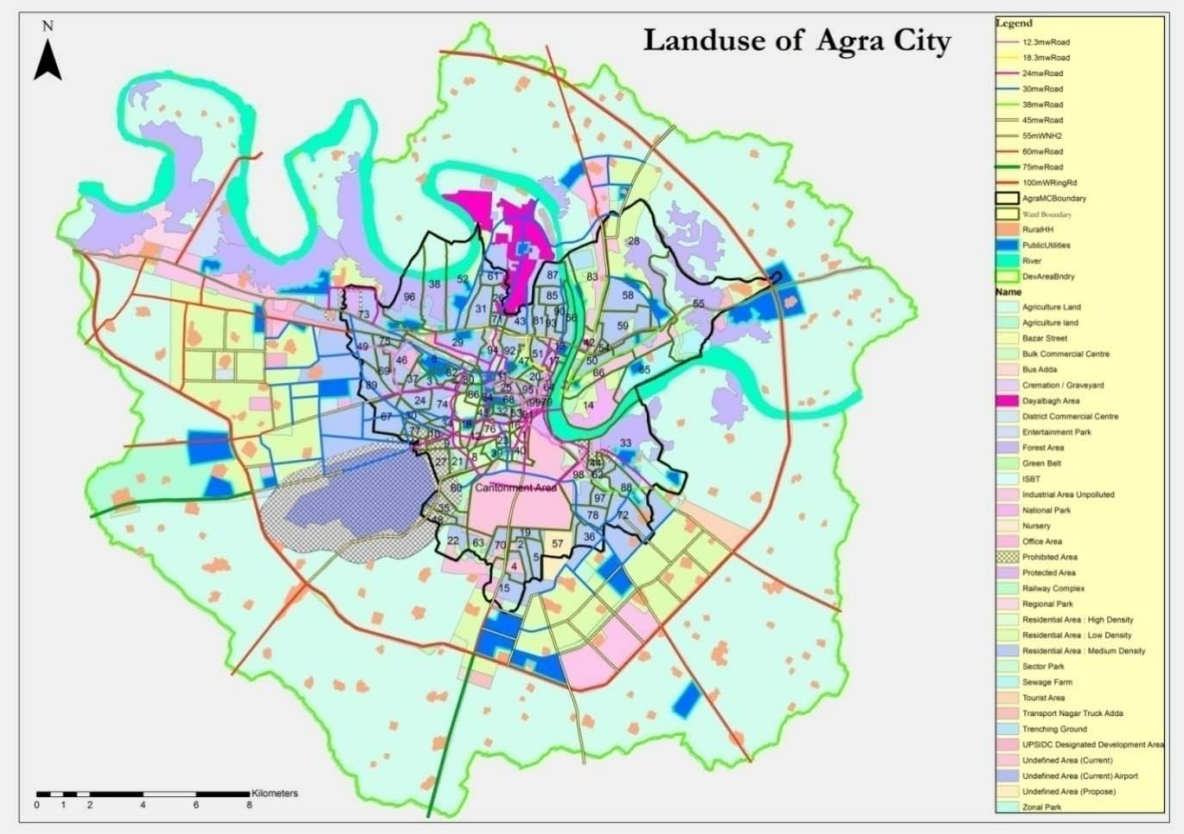


Figure 3.1: Demographic, Administrative and Land Use Map of Agra

Source: Amit Jain, NPC team

3.2 Solid and Plastic Waste Generation

The growing population along with rising tourist inflow leads to higher consumption and waste generation in the city. The primary data from Agra Nagar Nigam indicates that the total municipal solid waste generation in the city is about 850-870 metric tones per day. This is based on per capita generation of 400 gm with collection efficiency 91%. Therefore, an average value of ~866metrictonnesperday of municipal solid waste from various sources like households, commercial, market and street sweeping etc. has been considered to know about the plastic leakage scenario in Agra. Household waste constitutes 69% of the total waste generation in the city. The household waste is generated from a number of sources which include household (kitchen and yard) as well as items of daily consumption e.g. plastics.

Generally, household waste constitutes Black Polythene, Single Use Plastic Carry Bags, Maggie Pouches and single use plastic carry bags etc. Estimated total plastic waste generated is 110-130 TPD by the urban section of the city while slums generate about 9-13 TPD. Hence a total estimated 100-130 TPD of plastic waste is generated by the city per day. Generally, market waste constitute disposable cups & plate, plastic straw, white plastic carry bags, chips & confectionery packet, milk pouches etc. Post-consumer

product such as detergent bottles, beverage bottles, cleansing product bottle etc. are found in the commercial waste. Industrial Waste contributes 2% to the total waste generation and includes mainly, plastic waste, textile rejects, footwear rejects, foams, tobacco sachets etc. There are various small scale and cottage industries in Agra city. Based on field observations about these industries, the plastic waste is primarily generated from Petha (local sweet) and Footwear unit. Petha units are mostly located at Noori Darwaza and Raja Mandi. Around 84 MT/day of mixed waste is generated from street sweeping. It also includes tobacco sachets, plastic bottles and chips packets. **Figure 3.2** shows ward wise plastic waste generation map of Agra.

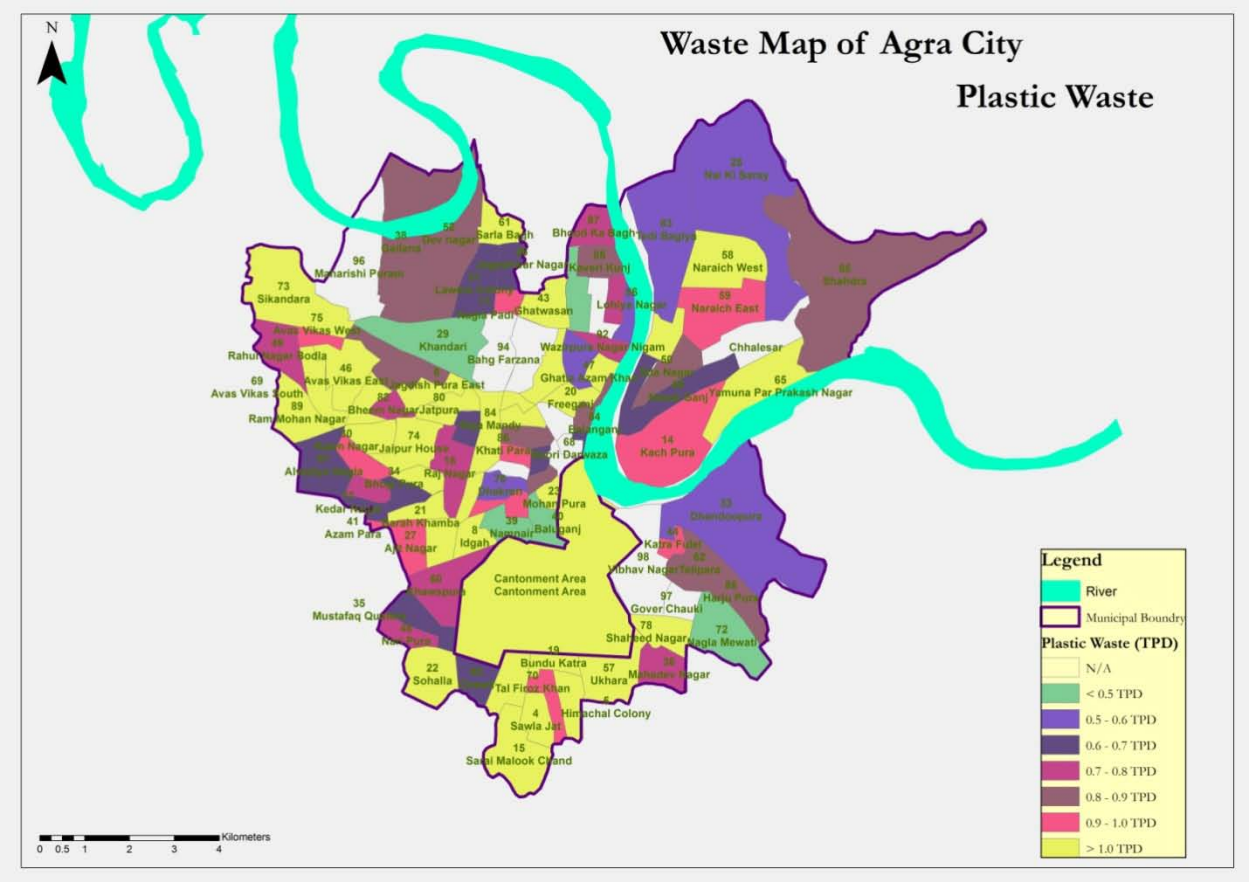


Figure 3.2: Ward wise Plastic waste generation map of Agra

Source: Amit Jain, NPC team

3.3 Municipal Solid Waste & Plastic Management in Agra

Agra Nagar Nigam (ANN) is responsible for the management of solid waste generated by the city. As in any other city SWM in Agra also functions on these pillars viz., Collection, Transportation, and Processing & Disposal. The waste is collected door to door by ANN with 91 % efficiency and transferred to community bins/depots/transfer stations. Until recently, all domestic and trade waste was being discharged on the streets or in street bins, and street sweeping was the principal method of waste collection. With the introduction of door to-

door collection systems in many urban areas, there is a sizeable reduction in the quantity of waste littering on the streets.). However, only 2 to 3 % waste is collected from the slum. The high value recyclables solids are extracted by the rag pickers from the transfer stations. Out of this 4-5% of high value plastic is taken away by the rag pickers and 80-90 tonnes of flow plastic in dry waste reaches to MRF facility. Thus 80-100 TPD of plastic is attempted to bring back into the value chain. The remaining 10-3- tones per day plastic is directly disposed, open burned or littered into streets, drains etc. finally its way into the land and river ecosystem by various means. The remaining solid waste is transferred or dumped to Kuberpur dump site. As reported average 700 to 750 tons mixed MSW is being dumped at the site on daily basis. From the field study we were informed that presently around 22 % of plastic waste was found in mixed waste that dump in Kuberpur dumpsite. These include single use plastics and polythene carry bags.

Though waste generation is low in slums, it's littering into drainage and banks of water bodies are rampant. Slums which are in close vicinity of the river are more likely to contribute to the plastic pollution. Therefore, the drainage and water bodies serve as carrier of plastic waste to the river. Industrial waste consists of thin white plastic covers for covering Petha boxes that are littered in significant amount after single use and thrown in drain (nallah) and nearby secondary collection points. The synthetic leather and rubber trimming from footwear industry also accounted for the plastic pollution. It was also observed that accumulated waste at open dump or dustbins was burnt in order to reduce the volume when it remains unattended for several days.

3.4 Identification of Hotspots

A step wise approach has been adopted to identify the hotspots, which serve as source of plastic leakage into the river. This is based on IUCN's approach for defining the plastic leakage as a function of loss rate and leakage rate. The various steps include identification of vulnerable areas using fuzzy logic approach adopted by GIC, AIT Thailand **(Figure 3.3)** and identification of leakage points **(Figure 3.4 & Figure 3.5)** followed by field reconnaissance & verification **(Figure 3.6)** and cleanup activities. During the field survey at Agra, littering of solid waste comprising majority of plastic waste was observed in abundance. This was followed by discussion with ANN, which suggested hotspots, which were in line with predicted vulnerable areas.

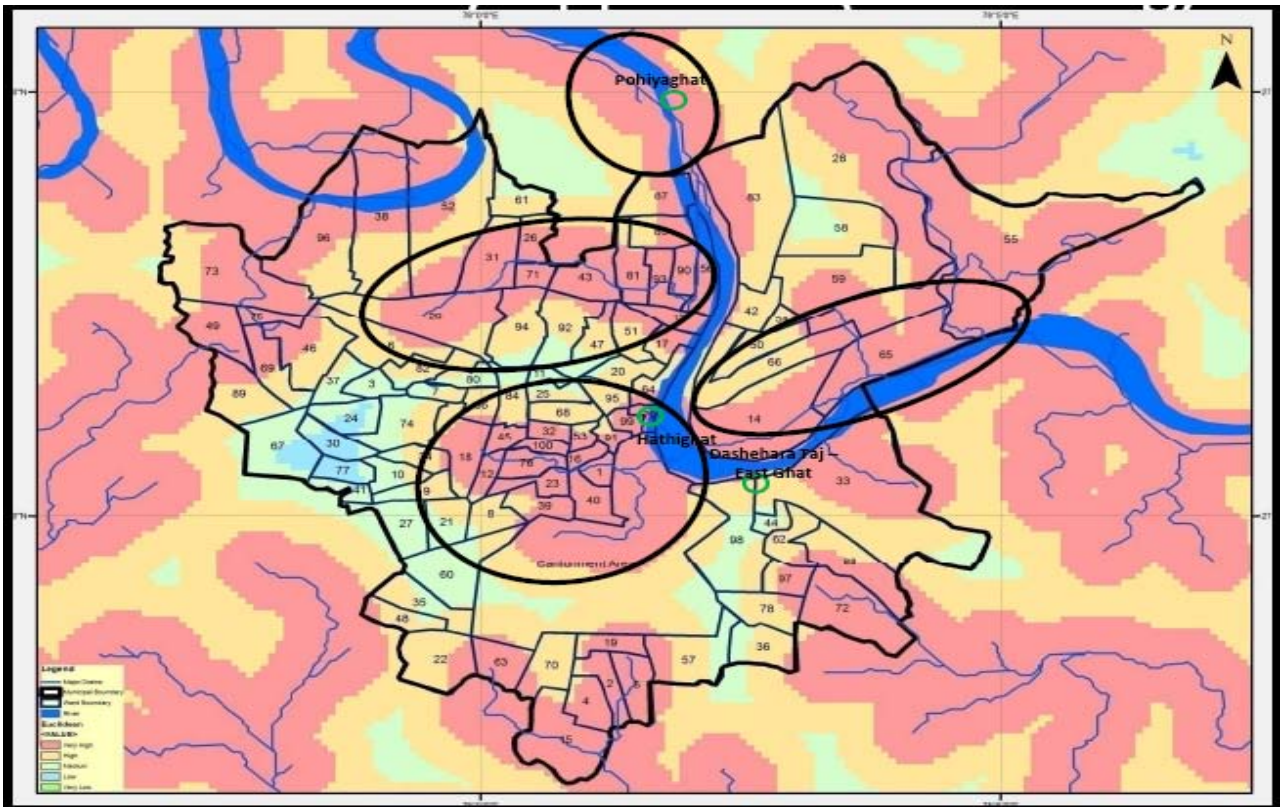


Figure 3.3: Plastic Leakage Vulnerable Areas identified using Fuzzy Logic Approach

Source: Amit Jain, NPC team

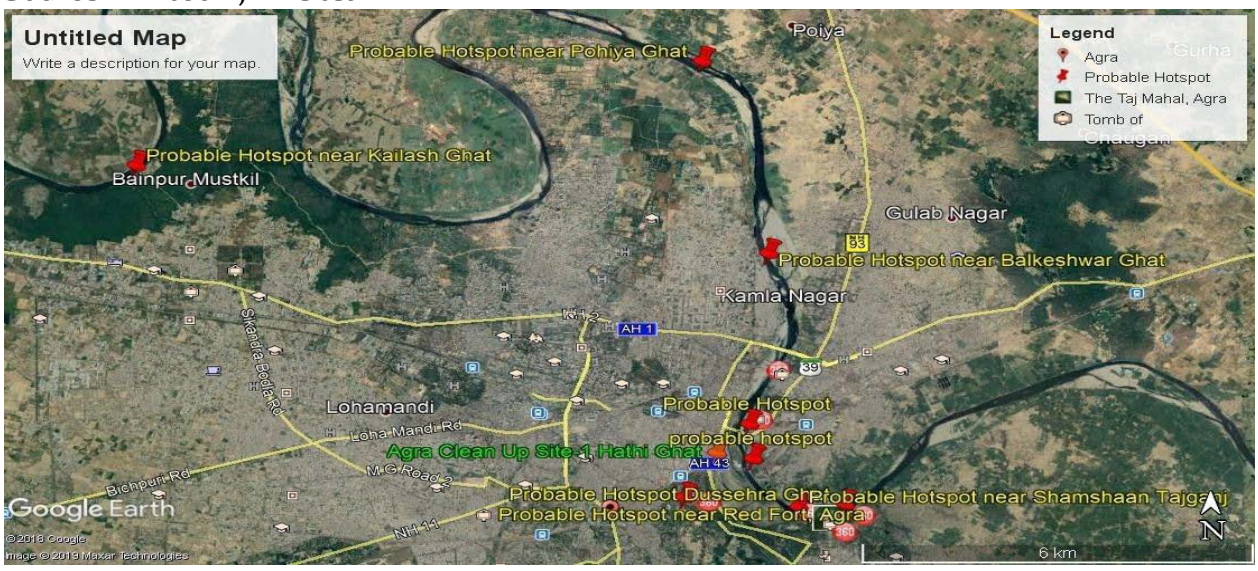
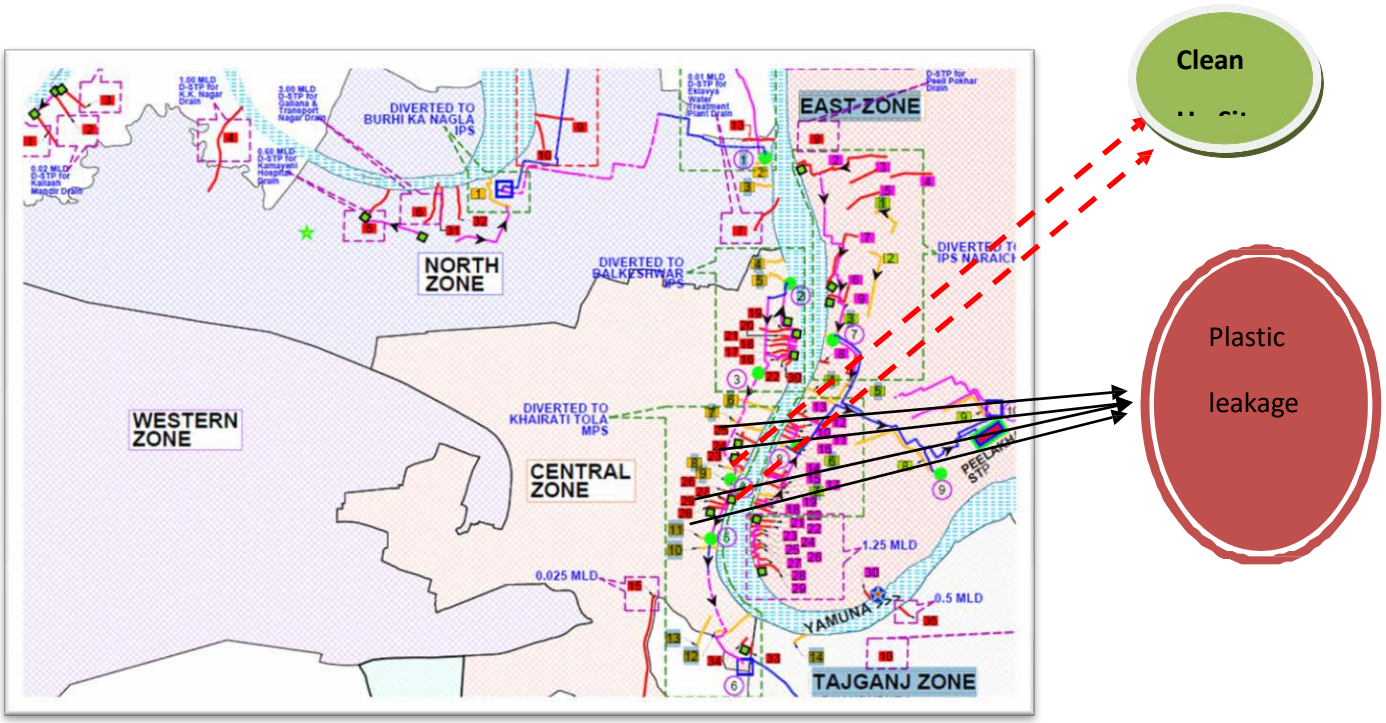


Figure 3.4: Location of Probable Hotspots

Source: NPC team



The red dots depict the untapped open drains locations which are plastic leakage

Figure 3.5: Untapped Drains Source of Plastic Leakage

Source: NPC team

Figure 3.6: Field Reconnaissance& Verification

Source: Amit Jain, NPC team

3.5 Clean up Activities & Macro Plastic Assessment Studies

Clean up activities were undertaken at Hathi Ghat, Pohiyaghat & again at Hathi Ghat after a gap of three months. The accumulation of waste again within a period of three months at Hathi ghat validated the identification of the hotspots. The following charts **(Figure 3.7 & Figure 3.8)** depict the prominent plastic wastes in Agra, on the basis of count and on the basis of weight. **Figure 3.7** indicates that maximum number of plastic waste in decreasing order are Polythene bags, multilayer plastic bags, plastics pouches used for water and milk, mono layer plastics, disposable plastic cups and glasses, woven bags and others. In terms of weight polythene bags contributes the maximum followed by woven bags, plastic sheets and thick plastic bags, monolayer plastics, plastic pouches and multi layer plastic containers.

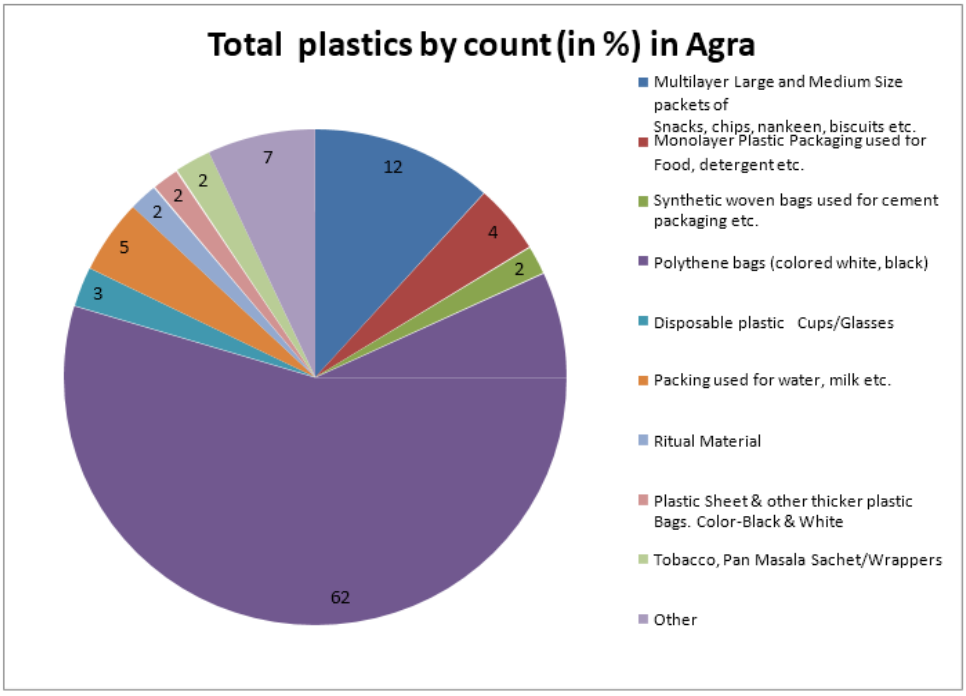


Figure 3.7: Breakup of plastic items in numbers

Source: NPC team

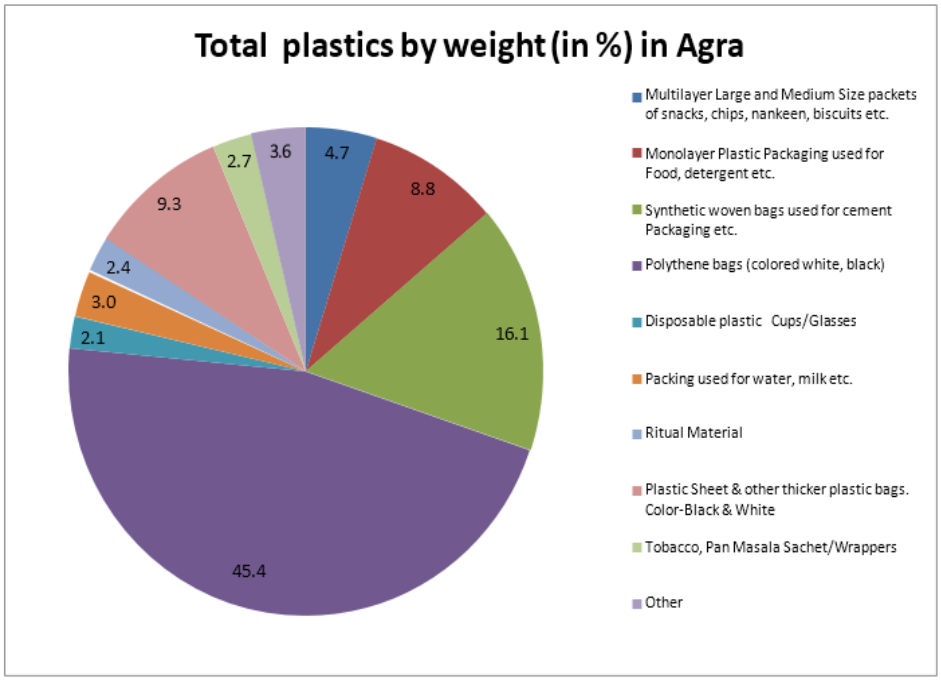


Figure 3.8: Breakup plastic items in terms of weight

Source: NPC team

3.6 Micro plastic Survey

Micro plastic sampling and analysis was undertaken in Yamuna in Agra (near Dussehra Ghat).

46 types of polymer have been found in the sample. 71% in fibre-form and 12% in film. Most of them are below 300 m. The major polymers with respect to sources are depicted below in **Table 3.1.**

Table 3.1: Major Polymers found in Micro plastic Study

Waste	Polymer
Multi-layer packaging waste	EVOH, PVAL, EVA, PVC, Polyimide, PP, LDPE, Polyacrylamide, Acronitrile film, PE/PP, Polyester film, HDPE, Polyethyleneoxide
Other packaging waste	Poly(alpha-methylstyrene), PVC, Polyimide, PP, LDPE, PVB, PE/PP,Polyester film, HDPE, PVDF, Styrene/Butadiene, Styrene / Maleicanhydride
Disposable cups, plates, take away food containers	Polyamide,Styrene/Isoprene,PIP,PES,Polyesterfilm,HDPE,Styrene/Butadiene,Styrene/Maleicanhydride
Laminated film such as silver foil, laminated disposable plates	PET,LDPE
foams	Polyurethane
toys	polybutene
Other plastic pieces such making basins, bathroom fixtures, sinks,etc.	PMMA(Polymethylmethacrylate)
Automobile parts, window glass	Polycarbonate, Polysulfone, Polyetheretherketone (PEEK),PC/PBT
Non stick cook ware coating	PTFE
Skin care product	Poly1-butene

Source: NPC team

3.7 Conclusions

Major hotspots have been identified, which trigger plastic leakage into river Yamuna through carriers like air, drains and run off. These include all the four types of hotspots. These include: (i) Plastic Value chain hotspots like plastics processed in leather factories; (ii) Plastic Leakage Source Hotspots in major wards in the city; (iii) Plastic Accumulation Hotspots in major drains of the city; and (iv) Plastic Application Hotspots considering poly bags found in macroplastic as well as microplastic. Massive amount of plastic was observed to be littered during the field study at various locations in Agra. Littering ranges 10% to 25% against 2% assumed in major studies carried abroad. Therefore, littering is one of the major reasons for the plastic not being collected and brought back into the value chain. However, majority of the waste categories found during Clean Up include plastic bags, Multi layer packaging, Plastic Sheet & other thicker plastic bags in black & white color, water pouches, Packaging Material e.g. Tobacco sachets, Biscuit packets, Surf excel, Rusks etc. as per clean up report. The findings of micro plastic survey confirm the findings of on land survey. A schematic diagram representing the leakage pathway has been described in Figure below.

3.8 Plastic Waste Leakage Pathway and Scenario

Plastic leakage pathway is depicted in figure below:

Source: NPC team

SUMMARY REPORT

PRAYAGRAJ

Chapter 4: Summary Report Prayagraj

4.0 Introduction

Prayagraj (previously known as Allahabad) is a major urban agglomeration located in the south eastern region of the state of Uttar Pradesh and its spatial extension falls at 25.4358° N and 81.8463° E. Prayagraj is a beautiful city situated at the confluence of the Rivers The Ganges and The Yamuna **(Figure 4.1).** Prayagraj is one of the destinations which hold the KumbhMela, world's largest congregation of devotees. The city was the nerve centre of activities during India's Freedom Movement. It has also played a leading role in the development of Hindu and Urdu literature. Prayagraj is in the southern part of Uttar Pradesh, at the confluence of the Ganges and the Yamuna. To the southwest is Bundelkhand, to the east and southeast is Baghelkhand, to the north and northeast is Awadh and to the west is the lower doab (of which Prayagraj is part). Prayagraj lies on the western part of the Great Indo-Gangetic Plain region and is under laid with sediments deposited in successive stages. There can be three distinct physical parts of the city (i) Trans-Ganga Plain, (ii) the Ganga- Yamuna doab (confluence), and (iii) Trans-Yamuna, all three of which are formed by Ganga and its tributary Yamuna. The city is divided by a railway line running east–west. South of the railway line is the Old Chowk area, while the British-built Civil Lines is in the north of it. The master slope of Trans Ganga is towards east or south east, with the altitude ranging from 89.30 masl-93.57 masl. Rivers of the district namely Yamuna, Tons, Sai and Varuna belongs to main drainage system of the Ganga**.** Dendritic drainage pattern is the most common features in the district which is the structurally controlled. Streams upto the fifth order are encountered in the district. In common with the rest of the doab, its soil and water are primarily alluvial. The average annual rainfall in Prayagraj is 934 mm. Climate is sub humid and is characterized by hot summer and pleasant monsoon and cold season. About 90% of rainfall takes place from June to September. From February there is rapid increase in temperature, May is the hottest month with the mean daily maximum temperature is 41.5°C and mean daily minimum temperature 26°C. After the onset of the monsoon there is appreciable drop in temperature, January is the coldest month with mean daily maximum temperature is 26.20°C and mean daily minimum temperature is 9.3°C. The mean monthly maximum temperature is 19.54°C and mean monthly minimum temperature is 6.23°C. The relative humidity is high during the southwest monsoon season, with mean monthly morning relative humidity at 63.92% and mean monthly evening relative humidity at 48%.

Figure 4.1: Prayagraj (previously known as Allahabad)

4.2 Demography & Land Use

The city is spread across 82 sq.km and is divided into 80 wards. The existing urban setting and growth trends of Prayagraj can be classified into three main categories: - 1. The Old City (consisting of Chowk, Ghantaghar, Bans Mandi, Katghar, Kotwali, Gaughat etc. This shall also include certain areas, though not contiguous but with similar character, like Daraganj, Bairhana, and Katra); 2. The New City (conceived during British rule and thereafter–This includes Civil Lines, Mumford Ganj, Ashok Nagar, Cantonment); and 3. The OG areas (satellite towns and ribbon developments along major corridors including Phaphamau, Jhunsi, Naini, Bamrauli, Manauri etc).

City population: The Municipal Corporation of Allahabad (MCA) administers an area of 82 sq km with a population of 11,17,094 (Census, 2011) among which male and female are 6,01,363 and 5,15,731 respectively. The town has witnessed a constant increase in population from 1951 to 2011 with a varying decadal growth rate. The population increased by four folds over the last six decades with increase in population from 3,32,295 in 1931 to 11,17,095 in year 2011. Allahabad city comes under Allahabad metropolitan area along with Cantonment board and urban outgrowths. Population of metropolitan area is 12,16,719. Male constitutes 6,55,734 and female constitutes 5,60,985 of the total population.

Slum Population: As per 2001 census, slum population in the city is 1,26,646 residing in 18,558 households constituting 13% to the city population, but as per the Oxfam trust survey in 2005, there are 283 poor settlements with a population of 3,63,550 (30% of the city population). The average slum household size is 6.8 which are slightly greater than city household size of 6.4. As per the survey, slums population in the city are 4, 70,467 and households are 91,025 residing in 185 slums of city. The household size of slums came down to 5.4 from 6.8 in 2001.

The city has grown organically where the old and new city areas are densely populated while the OG areas are emerging new areas of the city **(Figure 4.2).** The densely populated areas are the major sources of waste generation. The District is well connected by roads, railways and airways from the other parts of the Country

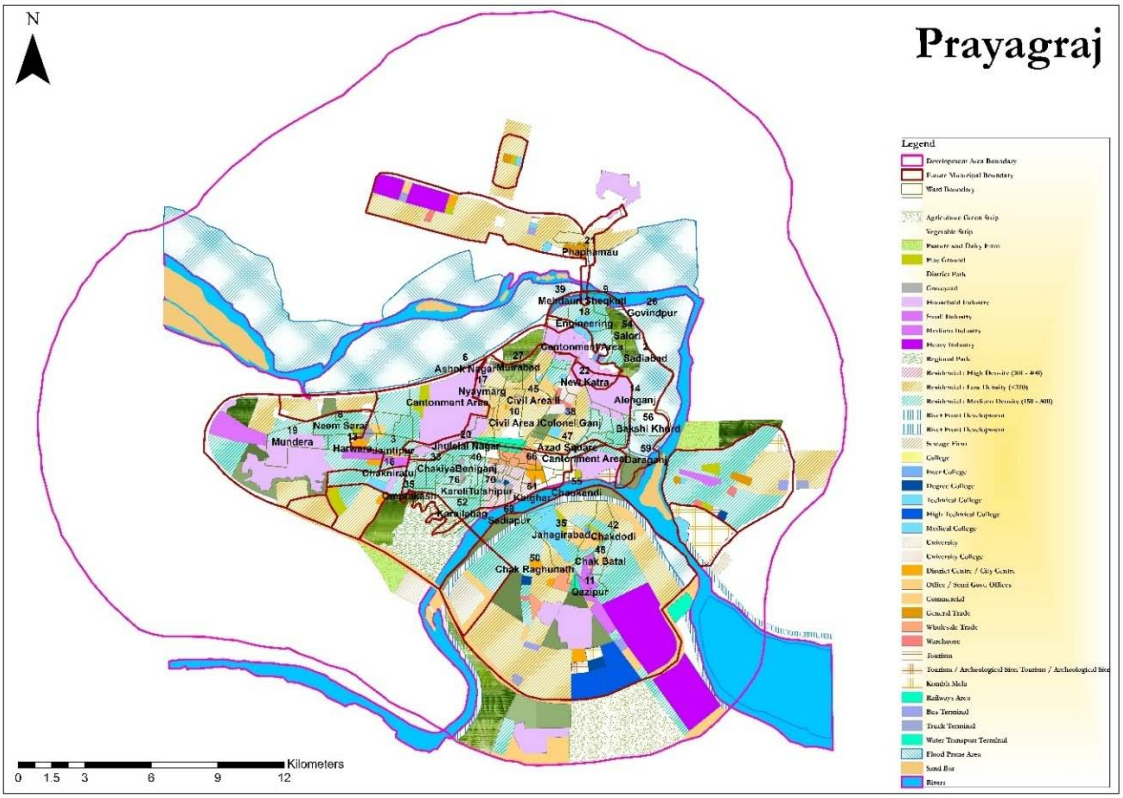


Figure 4.2: Demographic, Administrative and Land Use Map of Prayagraj

Source: Amit Jain, NPC team

4.3 Municipal Solid waste & Plastic Management in Prayagraj

Prayagraj Nagar Nigam (PNN) is responsible for the management of solid waste generated by the city. As in any other city SWM in Prayagraj also functions on these pillars viz., Collection, Transportation, and Processing & Disposal. Until recently, all domestic and trade waste was being discharged on the streets or in street bins, and street sweeping was the principal method of waste collection. With the introduction of door to- door collection systems in many urban areas, there is a sizeable reduction in the quantity of waste littering on the streets. The high value recyclables solids are extracted by the rag pickers from the transfer stations.

About 540 TPD of solid waste is generated every day in Prayagraj. The local residents of towns generate solid waste at the rate of about 450 grams per capita per day on an average. This average generation of solid waste includes local inhabitants (comprising

the wastes generated by the resident population, shops and commercial establishments, vegetable and fruit markets, construction and demolition and hospital wastes–non-infectious and non-hazardous) and the floating population in the town. Most of the waste generated in Prayagraj comprises food and other discarded waste materials such as paper, plastic, glass, metal, rags, and packaging materials. Another report, Slum Free City Plan of Action–Prayagraj, 2013 states thatabout680.0 MT (CDP) of solid waste is generated every day in the city. It has been assumed that the local residents of towns generate solid waste at the rate of about 539 grams per capita per day on an average. Also about 38% of slums have daily clearance of garbage, in 10% of slums have collected once in 2 days and 24% of slums are once in a week or even more. In about 28% of the slums the collection of waste is totally absent. Though the collection of waste is taking place in few slums, majority of the slum areas are found to be affected with in sanitary conditions, which require immediate attention from concerned authority.

Household waste constitutes around 247 TPD (46%) of the total waste generation in the city. The household waste is generated from a number of sources which include household (kitchen and yard) as well as items of daily consumption e.g., plastics. Generally, household waste constitutes Black Polythene, Single Use Plastic Carry Bags, Maggie Pouches and single Use Plastic carry bags etc. Generally, market waste constitute about 35 TPD (6 %) mainly includes disposable cups & plate, plastic straw, white plastic carry bags, chips & confectionery packet, milk pouches etc. Post-consumer product such as detergent bottles, beverage bottles, cleansing product bottle etc. are found in the commercial waste which constitutes around 1 %. Other Waste contributed from different sources such as construction debris, horticulture waste, Industrial Waste contributes 41% to the total waste generation. Around 27 TPD of mixed waste is generated from street sweeping. It also includes tobacco sachets, plastic bottles and chips packets. **Figure 4.3** shows ward wise plastic waste generation map of Prayagraj

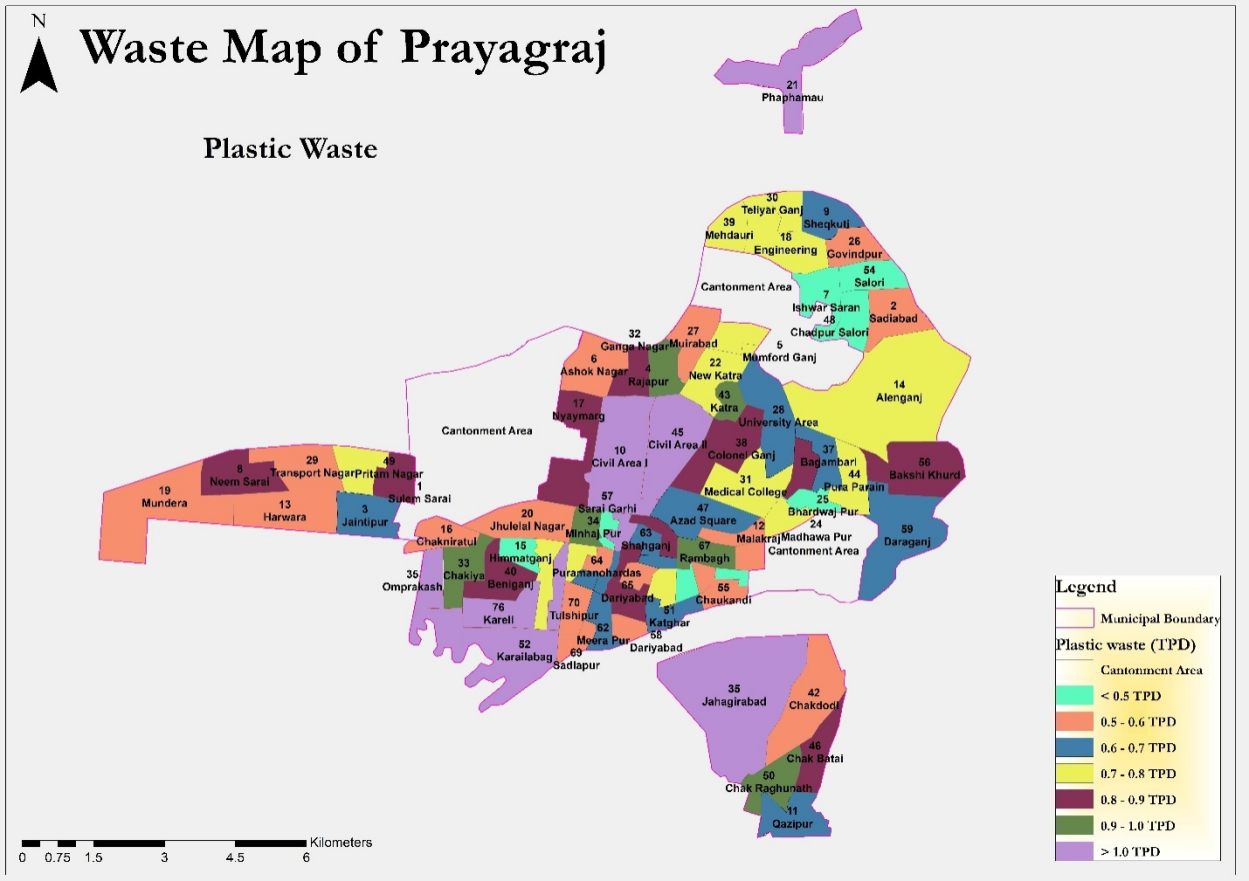


Figure 4.3: Ward wise Plastic waste generation map of Prayagraj

Figure 4.4: Mixed plastic waste, multilayered plastic waste found at Baswar Dump Site

4.4 Identification of Hotspots

A step wise approach has been adopted to identify the hotspots, which serve as source of plastic leakage into the river. This is based on IUCN's approach for defining the plastic leakage as a function of loss rate and leakage rate. The various steps include identification of vulnerable areas using fuzzy logic approach adopted by GIC, AIT Thailand **(Figure 4.5)** and identification of leakage points **(Figure 4.6 & Figure 4.7)** followed by field reconnaissance & verification **(Figure 4.8)** and cleanup activities. During the field survey at Prayagraj, littering of solid waste comprising majority of plastic waste was observed in abundance. This was

followed by discussion with PNN, which suggested hotspots, which were in line with predicted vulnerable areas.

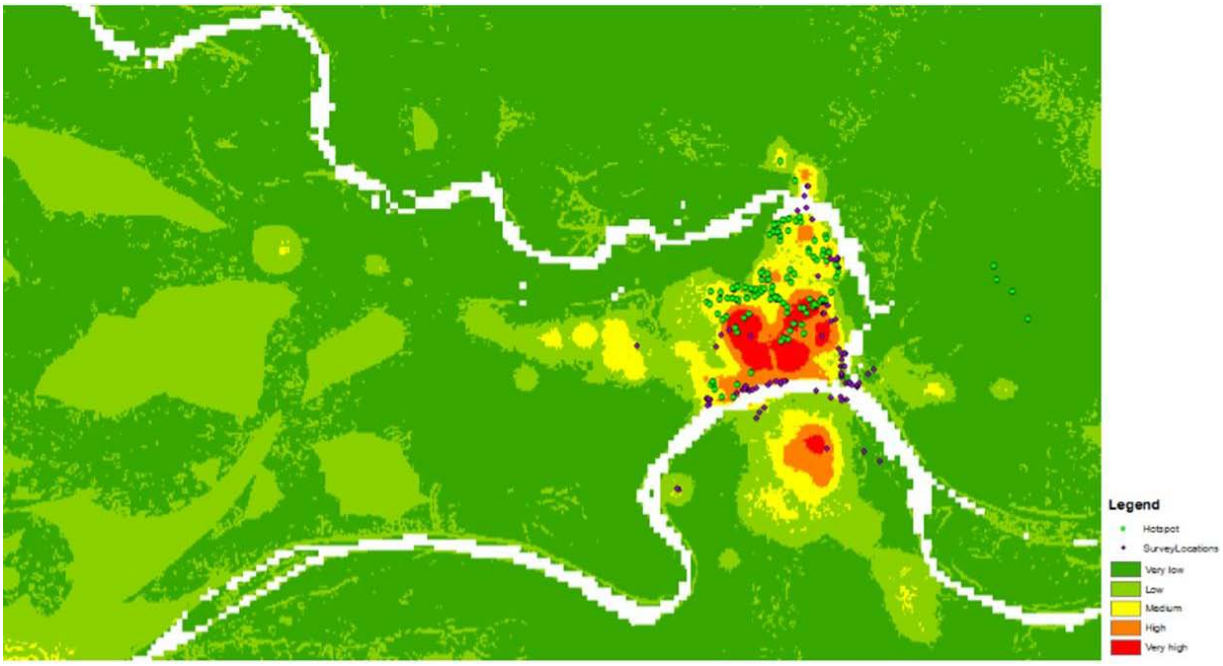


Figure 4.5: Plastic Leakage Vulnerable Areas identified using Fuzzy Logic Approach

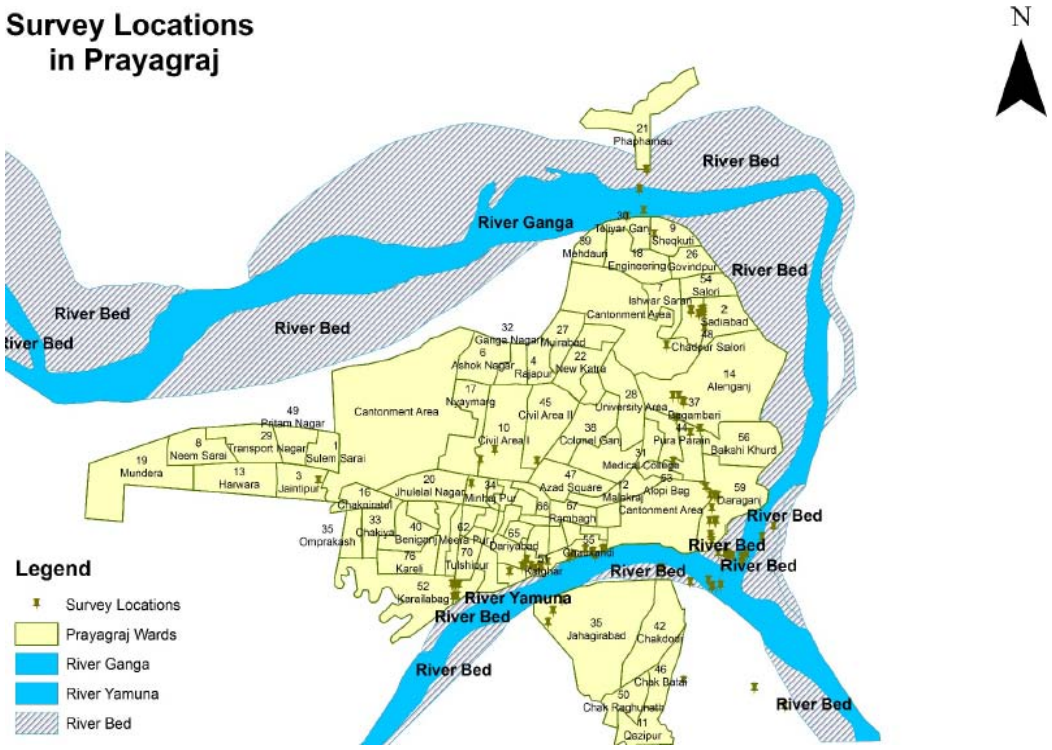


Figure 4.6: Map showing surveyed points at Prayagraj

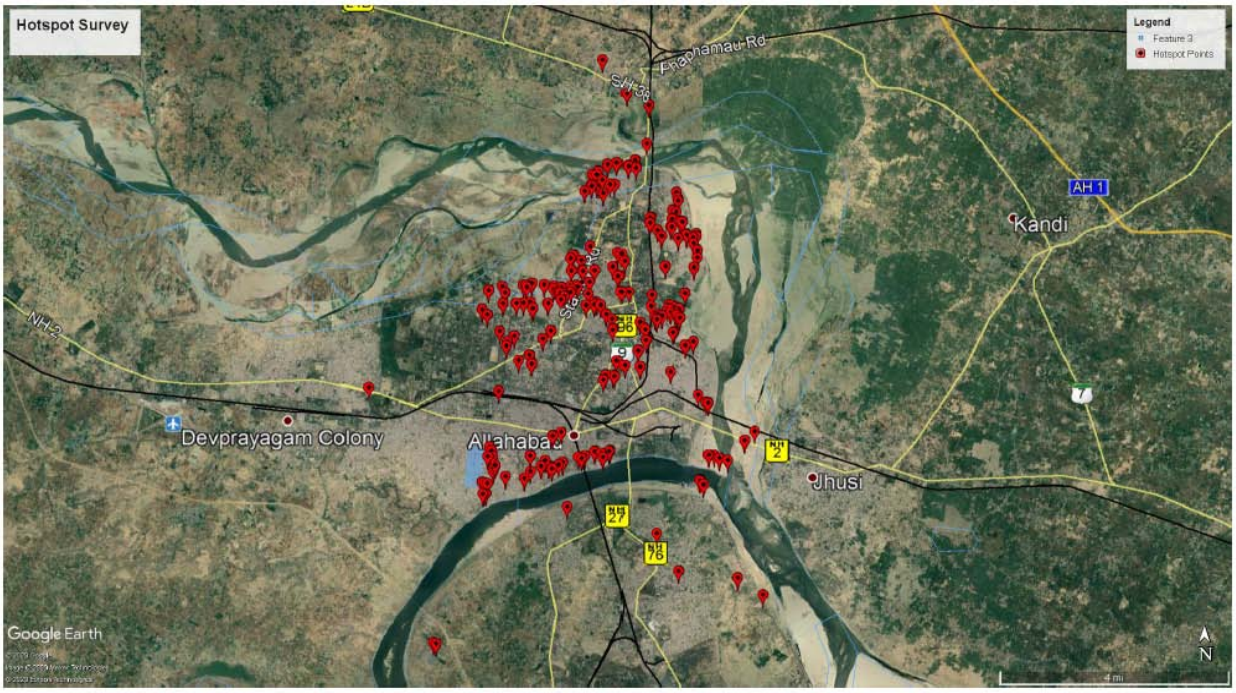


Figure 4.7: Hotspots identified at Prayagraj

Figure 4.8: Field Reconnaissance& Verification

4.5 Clean up Activities & Macro Plastic Assessment Studies

Clean up activities were undertaken at Ram Ghat, Katghar Basti, Salori Drain near AB Pulliya and Sangam Point below Naini New Bridge. These cleanup points are under observation for few months after cleanup and it was found that waste is again accumulated within a short

period of time that validated the identification of the hotspots. The following charts **(Figure 4.9 & Figure 4.10)** depict the prominent plastic wastes in Prayagraj, on the basis of count and on the basis of weight. **Figure 4.9** indicates that prominent plastic waste in decreasing order are Multilayer packaging packets, Polythene carry bags, Wrappers of Tobacco/Panmasala, Synthetic clothes/woven bags, Plastic sheets etc.

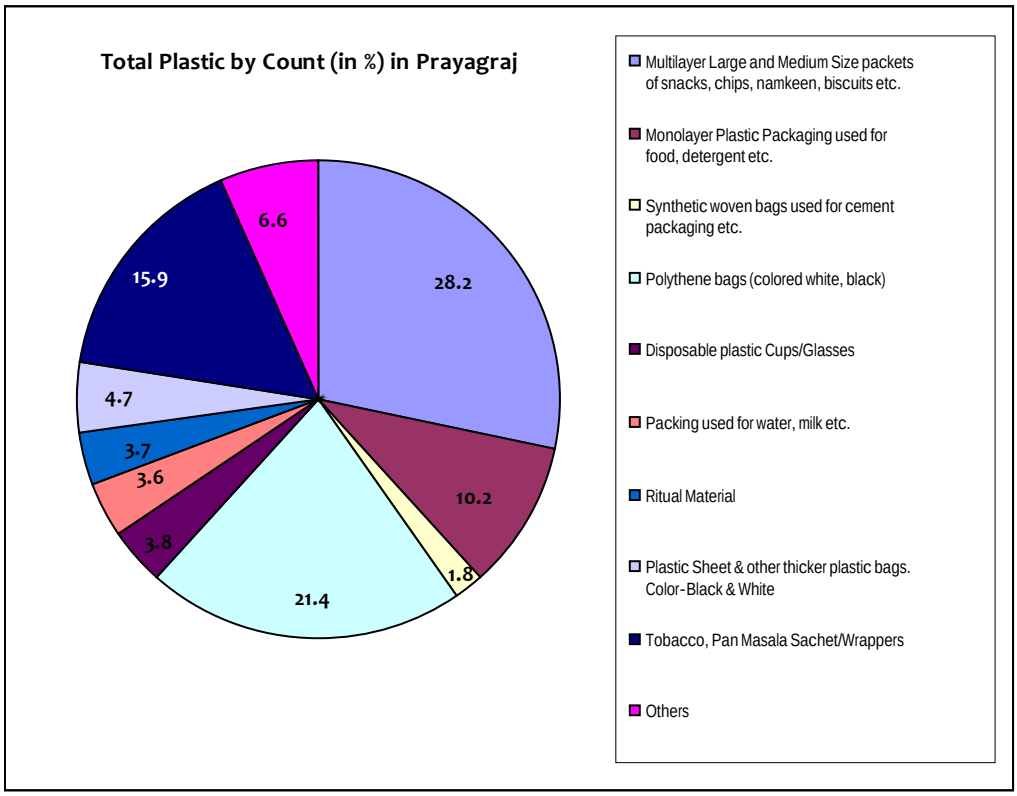


Figure 4.9: Breakup of plastic items in numbers

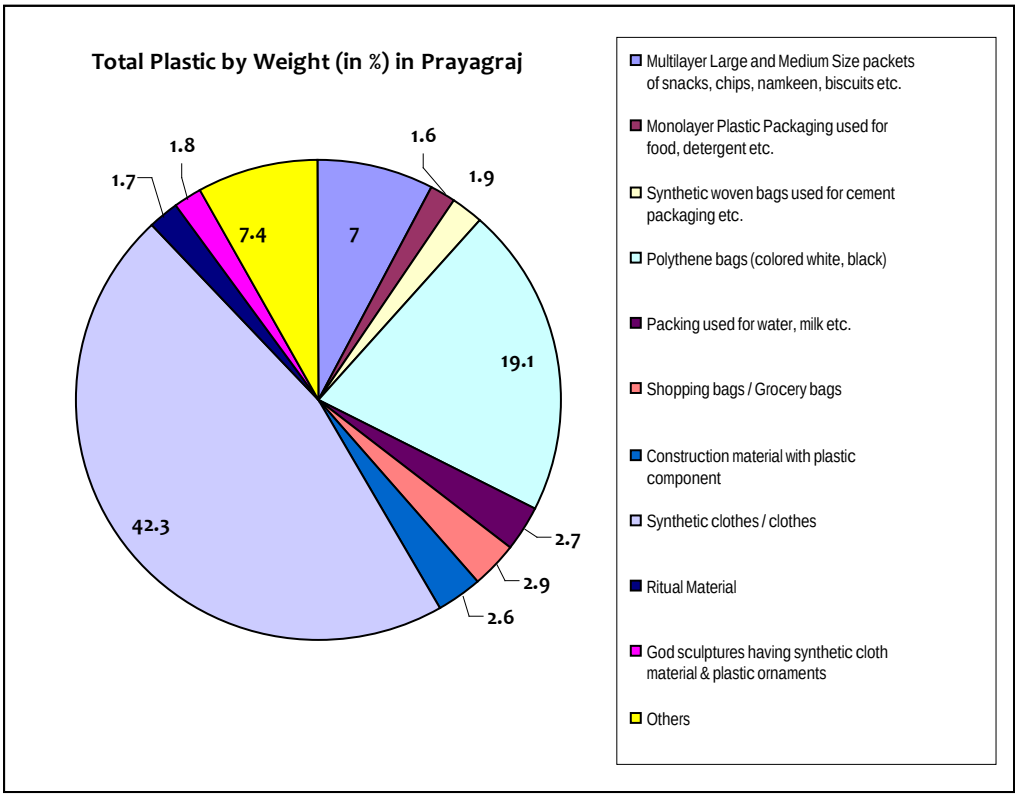


Figure 4.9: Breakup plastic items in terms of weight

4.6 Micro plastic Survey

Micro plastic sampling and analysis was undertaken one in Yamuna River and One in Ganga River at Prayagraj. Total number of polymer types found in Yamuna and Ganga is 40 and 17 respectively. Further, based on macroplastic assessment studies, land based waste sources have been correlated with microplastic survey as depicted below **Table 4.1: (a) & (b).**

Table 4.1: (a) Major Polymers found in Micro plastic Study

Types of Plastic	Total plastics by count (in %)	Sources of polymer types found in microplastic sample
Multilayer Large and Medium Size for snacks, chips, namkeen, biscuits etc.	28.2	EVOH, PVAL, PP, PVB(Polyvinyl butyral), LDPE
Multilayer Sachets for Shampoo, Tobacco, tea, coffee, tomato sauce etc.	10.2	EVOH, PVAL, PP, PVB (Polyvinyl butyral), LDPE
Hard Plastic such as HDPE Pipes, HDPE bottles, HDPE tubes, tray, PVC etc.	1.8	Polyethylene, PVC
Polythene bags (colored white, black)	21.4	Polythene
Disposable paper cups coated with plastic film, Take away food containers, disposable cup& plates	3.8	Polyamide, Styrene/isoprene copolymer, styrene/Isoprene, polysulfone

Types of Plastic	Total plastics by count (in %)	Sources of polymer types found in microplastic sample
Packing used for water, milk etc.	3.6	Polyethylene
Shopping Bags/ Grocery Bags	3.7	Polyethylene
Synthetic Clothes/Clothes	4.7	Polyester
Tobacco, Pan Masala Sachet/Wrappers	15.9	EVOH, PVAL, Polyethylene, PVDC, PVC, PP, PS, PET
others	6.6	PE, PP,PVC

(JRC Technical Reports–Guidance for identification of polymer in Multilayer films used in food contact materials, European Commission, 2016., Hussain et al., 2015)

Polymers not listed above may have following sources:

Table 4.1: (b) Major Polymers found in Micro plastic Study

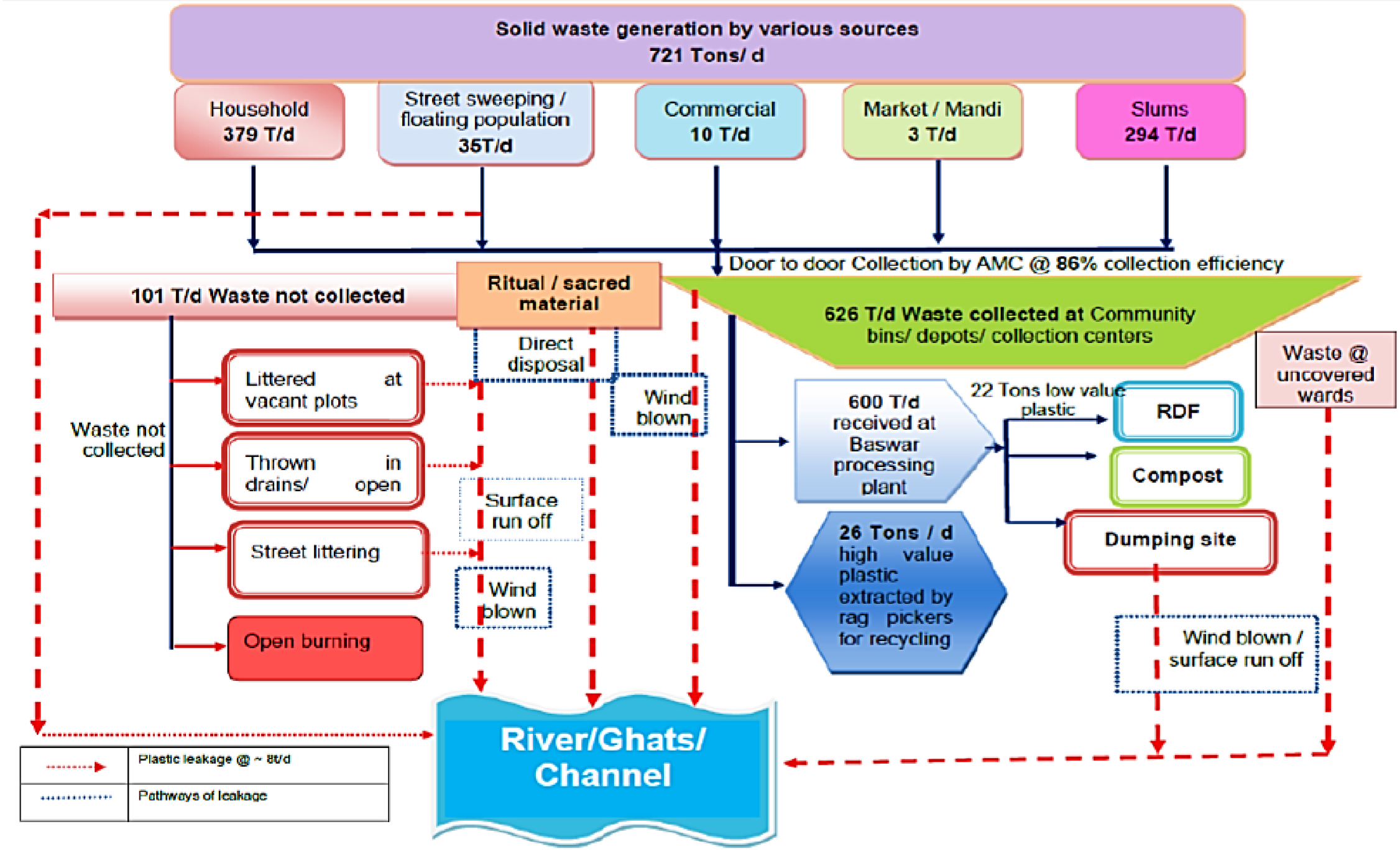
Waste	Polymers leached out
Rubber material waste	Polyisoprene
Other packaging waste	PVC, PP, PVB(Polyvinyl butyral), LDPE
Laminated films such as silver foil, laminated disposable plates	Polysulfone

4.7 Conclusions

Major hotspots have been identified, which trigger plastic leakage into river Yamuna and Ganga through carriers like air, drains and run off. Massive amount of plastic was observed to be littered during the field study at various locations in Prayagraj. Therefore, littering is one of the major reasons for the plastic not being collected and brought back into the value chain. However, majority of the waste categories found during Clean Up include plastic bags, Multilayer packaging, Plastic Sheet & other thicker plastic bags in black & white color, water pouches, Packaging Material e.g. Tobacco sachets, Biscuit packets, Surf excel, Rusks etc., as per clean up report. The findings of micro plastic survey confirm the findings of on land survey. A schematic diagram representing the leakage pathway has been described in Figure below.

4.8 Plastic Waste Leakage Pathway and Scenario

Plastic leakage pathway is depicted in figure below:



SUMMARY REPORT

MUMBAI

Chapter 5: Summary Report Mumbai

5.1 Introduction

Mumbai is located on the western sea coast of India from 18°53' North to 19°16' North Latitude and from 72° East to 72°59' East Longitude. It is the capital city of state of Maharashtra and also known as financial capital of India. It is the most populated city with a population of almost 12.64 million, as per census 2011. **Figure 5.1** shows the Mumbai municipal boundary.

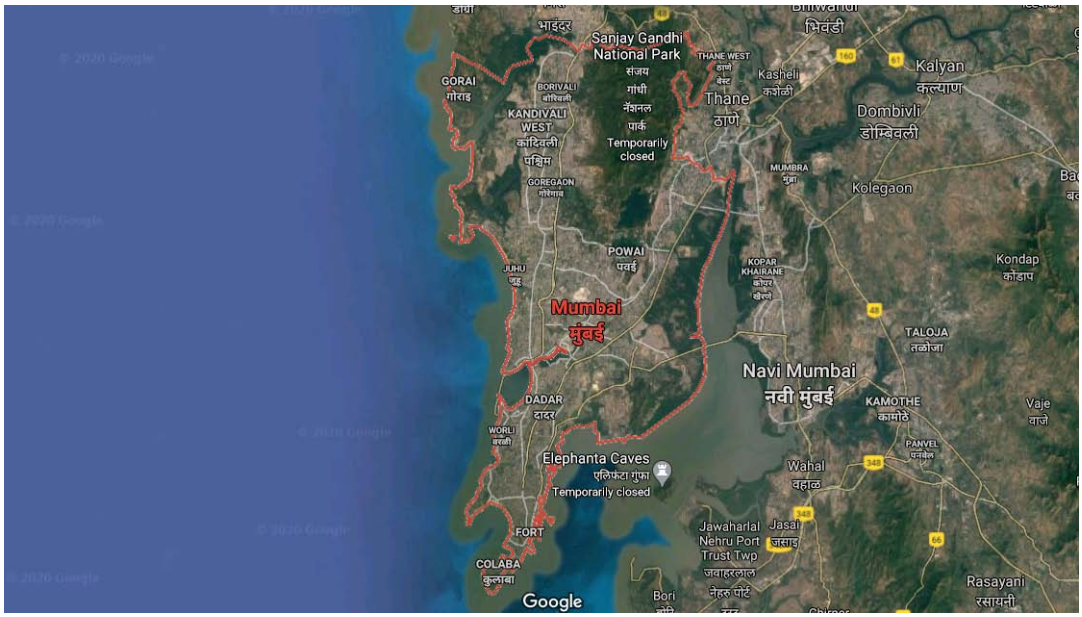


Figure 5.1: Mumbai Map

Mumbai is host to a number of industries, multinational companies and important financial institutions. With a per capita income thrice that of the national average, Mumbai makes huge contribution to the total tax revenues of the country. The city is also an important international sea port and strategic city from defense perspective.

5.2 Geography & Climate

5.2.1 PHYSIOGRAPHY

Mumbai lies at the mouth of the Ulhas River on the western coast of India, in the coastal region known as the Konkan. It sits on Sashti Island, which it partially shares with the Thane district. Mumbai is bounded by the Arabian Sea to the west. Many parts of the city lie just above sea level, with elevations ranging from 10 m to 15 m; the city has an average elevation of 14 m. The drainage pattern indicates the natural flow from west to east with major and minor drains draining into The Arabian Sea.

5.2.2 CLIMATE

Mumbai has a tropical climate, specifically a tropical wet and dry climate with eight months of dryness and peak of rains in June. The cooler season from December to February is followed by the hotter season from March to May. The period from June to about the end of September constitutes the south-west monsoon season, and October and November form the post-monsoon season.

The average annual temperature is 27.2 °C, and the average annual precipitation is 2,167 mm. In the Island City, the average maximum temperature is 31.2 °C, while the average minimum temperature is 23.7 °C. In the suburbs, the daily mean maximum temperature range from 29.1 °C to 33.3 °C, while the daily mean minimum temperature ranges from 16.3 °C to 26.2 °C. Flooding during monsoon is a major problem for Mumbai. Between June and September, the south west monsoon rains lash the city. Pre-monsoon showers are received in May. Occasionally, north-east monsoon rainfall occurs in October and November. The maximum annual rainfall ever recorded was 3,452 mm for 1954. The highest rainfall recorded in a single day was 944 mm on 26 July 2005.

5.3 Demography & Land Use

Mumbai is also recognized as the most densely populated city. Inverse proportion of Area and Population causes serious impact on its environment. As per data received from Health Department of MCGM, the estimated population of Mumbai was 12.69 million. As per Master Plan-2021, the estimated population will be approximately 25 million by 2021. About 40-50 % of the city's population lives in slum areas in Mumbai. Dharavi is considered to be one of the world's largest slums in Mumbai. The population density of 26,645 person per sq.km (excluding no development area). Also, Administrative Ward-wise population indicates that ward has maximum population of 9, 60,074 persons and minimum population of 1, 29,820 persons. According to the Census 2001 for Maharashtra, the average size of households declined from 5.1 members to 4.8 in 1991. During the last 30 years the sex ratio of Mumbai has increased from 670 in 1971 to 774 in 2001. Suburban districts have also shown improvements from 769 in 1971 to 826 in 2001. Mumbai has 24 cluster wards which Further, divided in 227 sub-wards.

About 40-50 % of the city's population lives in slum areas. Most prominent slum area is Dharavi, which is considered to be one of the world's largest slums. In Greater Mumbai 1,959 slum settlements have been identified with a total population of 6.25 million, which forms 54 per cent of the total population of the city (Census of India, 2001). The Island City houses only 17 per cent of the slum population whereas the western suburbs have high concentrations of slums especially in the inner western suburbs, where there are large slums with hazy boundaries forming a continuous area containing 58 per cent of the slum population. Average household size is 4.5 and the sex ratio is much better (842 females per thousand males) than in the rest of the city. Mumbai attracts a huge

number of tourists every year as Mumbai offers natural heritage and modern entertainment including leisure spots, beaches, cinemas, studios, holy places, amusement parks and historical monuments. About 6 million tourists visited Mumbai every year.

Figure 5.2 depicts the ward & village wise slum cluster map of Greater Mumbai. Also, **Figure 5.3** shows the Demographic, Administrative and Land Use Map of Mumbai.

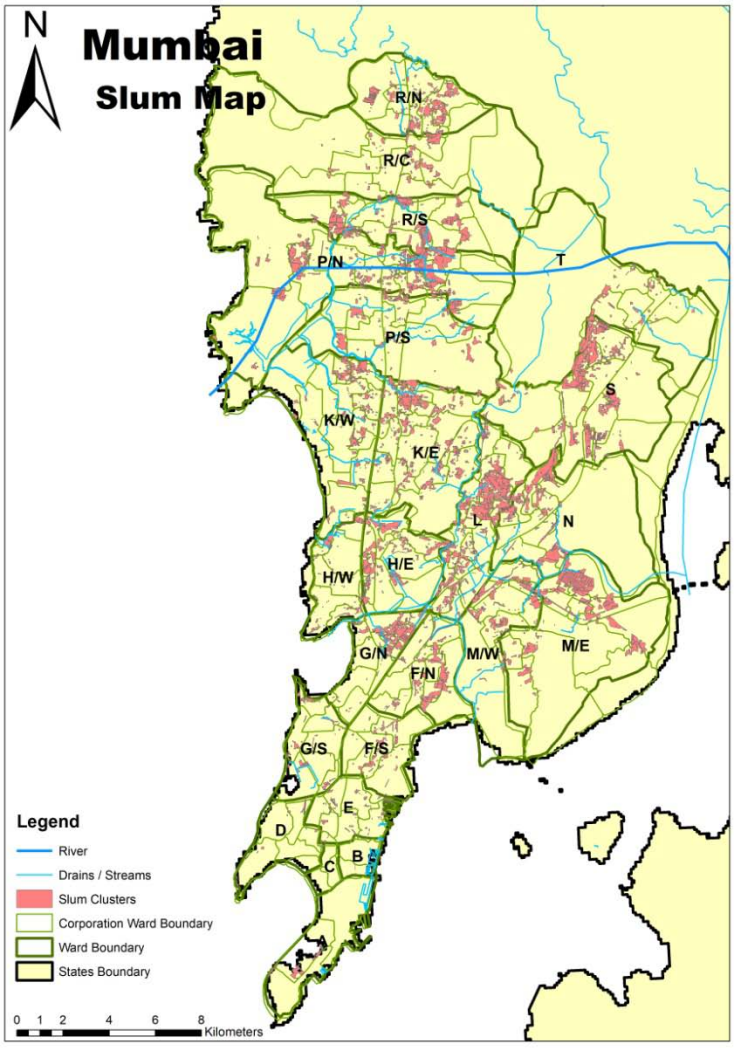


Figure 5.2: Wards & Village wise slum cluster map of Greater Mumbai.

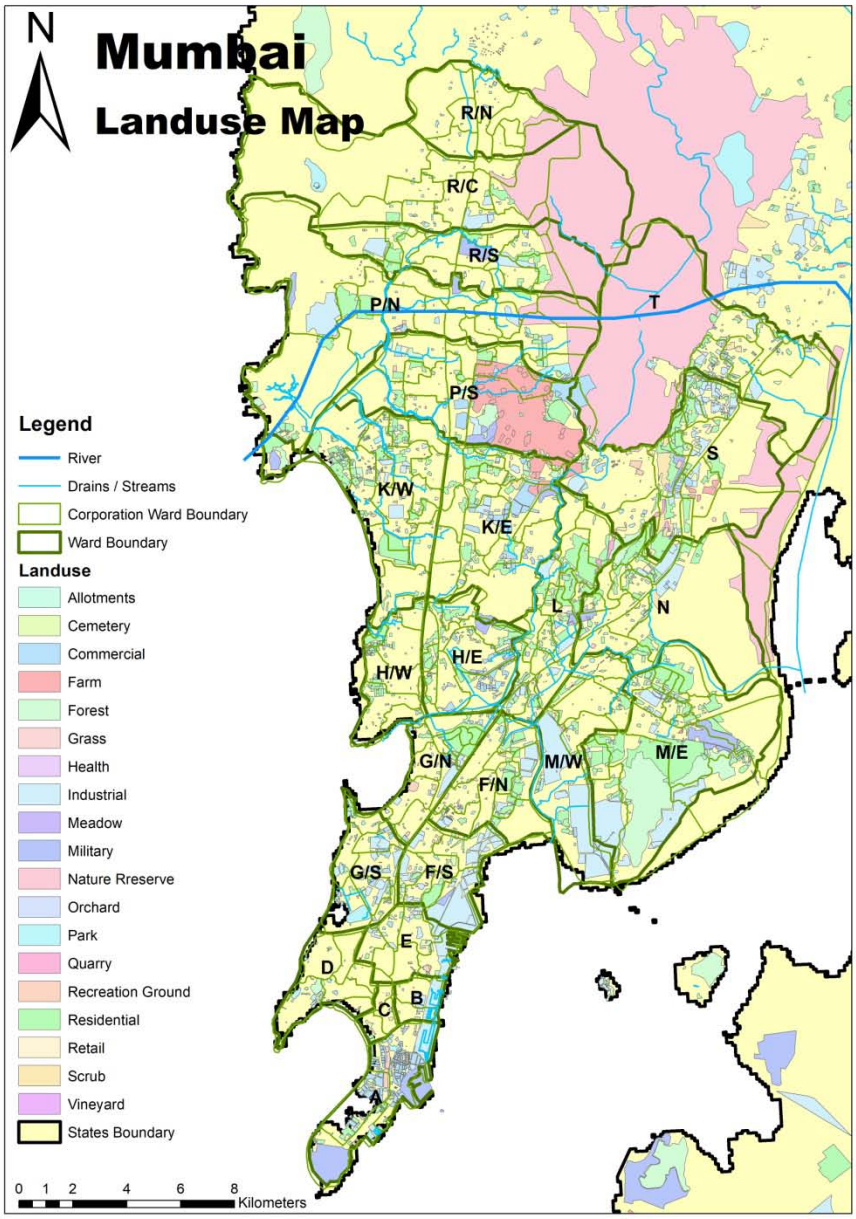


Figure 5.3: Demographic, Administrative and Land Use Map of Mumbai

Mumbai consists of two distinct regions: Mumbai City district and Mumbai Suburban district, which form two separate revenue districts of Maharashtra. The city district region is also commonly referred to as the Island City or South Mumbai. The total area of Mumbai is 603.4 km^2. Of this, the island city spans 67.79 km^2, while the suburban district spans 370 km^2, together accounting for 437.71 km^2 under the administration of Municipal Corporation of Greater Mumbai (MCGM). The remaining areas belong to various Defense establishments, the Mumbai Port Trust, the Atomic Energy Commission and the Borivali National Park, which are out of the jurisdiction of the MCGM. The Mumbai Metropolitan Region which includes portions of Thane, Palghar and Raigad districts in addition to Greater Mumbai, covers an area of 4,355 km^2 (45828 Ha). Existing Land use distribution for Greater Mumbai (2012) reveals that 65.3% (271.17sqkm) of the Planning Area of Greater Mumbai is developed, while natural areas, vacant lands, plantation

& salt pans constitute the remaining 34.7%. Of this developed area, 24.9% is occupied by Residential use, 5.4% by Industrial uses, 2.2% by Commercial uses and 0.9% by Offices. Amenities (Education, Medical, and Social Amenities) constitute 3.69%, open space 3.7% and Public Utilities & facilities 1.7%. Transport and Communication facilities constitute 12.8%. Together 21.9% of the developed area is under Amenities, Open Space, Public Utilities and Transport.

5.4 Municipal Solid Waste and Plastic Waste Management at Mumbai

As per the primary data analysis approx. 65,000 to 7,000 TPD of solid waste in generated by the Mumbai city from various sources like households, slums, markets, commercial public cleansing etc. and maximum waste generation is from household area. Municipal Corporation of Greater Mumbai (MCGB) is responsible for the management of solid waste generated by the city. The waste is collected door to door by MCGM/ BMC workers with proper demarcation of waste into dry and wet waste as per waste management rule 2016. Dry waste is collected at dry waste segregation centers available in each ward in household area and later is transferred to dry waste collection centres and Transfer Station (ST) and thereafter into landfill site. The high value recyclable component is segregated at each segregation center. Currently 46 dry waste segregation centers under BMC are in operation in Mumbai. The remaining solid waste is transferred to the processing facility located at Kanjur. Kanjur processing plant has the provision of Material Recovery Facility (MRF) for segregation of mixed solid waste (MRF Facility), Compost Facility (Windrow) and Bioreactor landfill facility (BLF). Currently two landfill facilities are in operation in Mumbai at Kanjur and at Deonar. During field visit, it has been observed that door to door collection is efficiently managed in Ward areas but door to door collection is inaccessible in slum area due to high population density.

The summary of plastic waste generation based on the secondary and primary data sources is described in **Table 5.1.**

Table 5.1: Summary of estimates pertaining to waste generation

Particulars	Values as per available secondary data		Values as per primary data collected on organized waste collection
	CPCB	Research paper(s)	
Solid waste generation (MT/d)	6500	7000	6959
Per capita solid waste generation (kg/c/d)	-	0.45	0.39
Plastic waste generation (MT/d)	433	210	86.79(11% of Dry Waste 789MTD)
% plastic waste in total solid waste	6.28%	3%	11%

Considering lack of door to door collection services in slums and inaccessible areas, it can be easily assumed that plastic leakage is 40% in these areas. **Figure 5.4** shows the cluster wise plastic waste map of Mumbai.

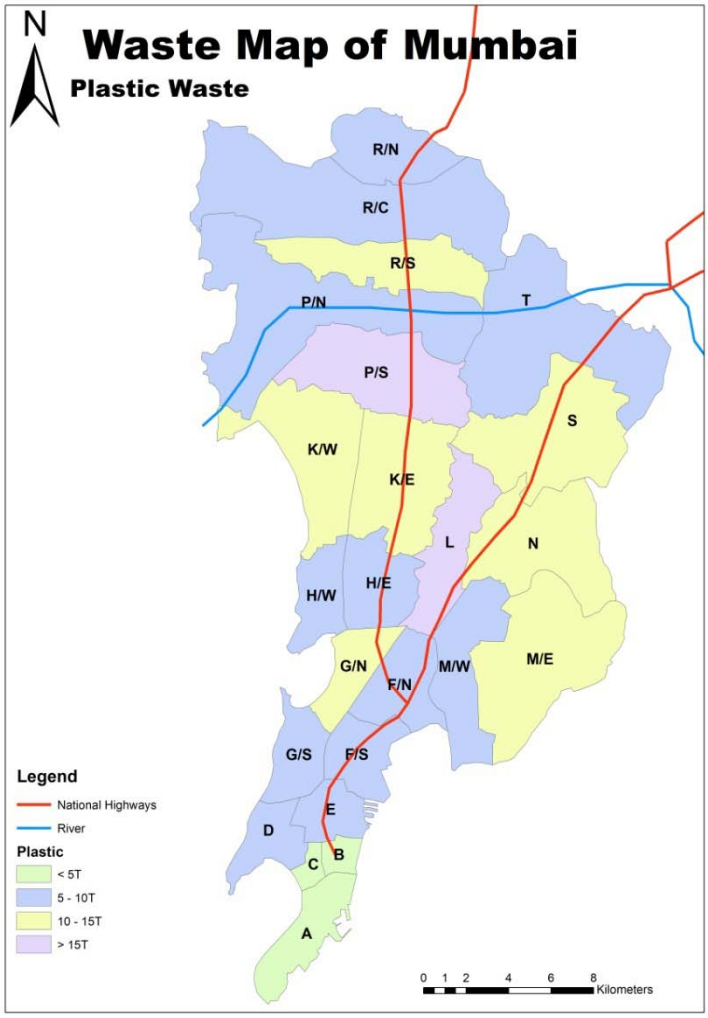


Figure 5.4: Cluster Wise Plastic Waste Generation Map

5.5 Identification of Hotspots

A step wise approach has been adopted to identify the hotspots, which serve as source of plastic leakage into the river. This is based on IUCN's approach for defining the plastic leakage as a function of loss rate and leakage rate. The various steps include identification of vulnerable areas using fuzzy logic approach adopted by GIC, AIT Thailand **(Figure 5.5)** and identification of leakage points **(Figure 5.6**) followed by field reconnaissance & verification **(Figure 5.7)** and cleanup activities. During the field survey at Mumbai, littering of solid waste comprising majority of plastic waste was observed in abundance. This was followed by discussion with MCGM/ BMC, which suggested hotspots, which were in line with predicted vulnerable areas. The major hotspot in Mumbai includes:

- Direct disposal of plastic waste into drains or into Mithi River from nearby slum residents,
- Littered on streets, nearby community bins in market area, on railway tracks etc.

finally finding its way into riverine ecosystem (Mithi River) and at last into the ocean (Arabian Sea) by various means.

- There are 186 outfall to the Arabian Sea which drains plastic mixed waste from the city.
    - 5 major outfalls in city which drain sewage mixed with plastic to Arabian Sea directly,
    - 8 at Mahim creek and 12 at Mahul creek.
    - 29 outfalls in western suburbs draining directly into sea
    - 14 drain into Mithi River which ultimately joins Mahim creek.
    - In eastern suburbs, 14 outfalls discharge in Thane creek while six discharge in Mahul creek and 8 into Mahim creek.
- Out of 186 outfalls in Mumbai, 135 are above mean sea level but below the high tide level, 46 outfalls below mean sea level. In addition, there is a 2,000 km roadside open drain systems that are mostly clogged with plastic and waste. Only 6 outfalls are above high tide level.

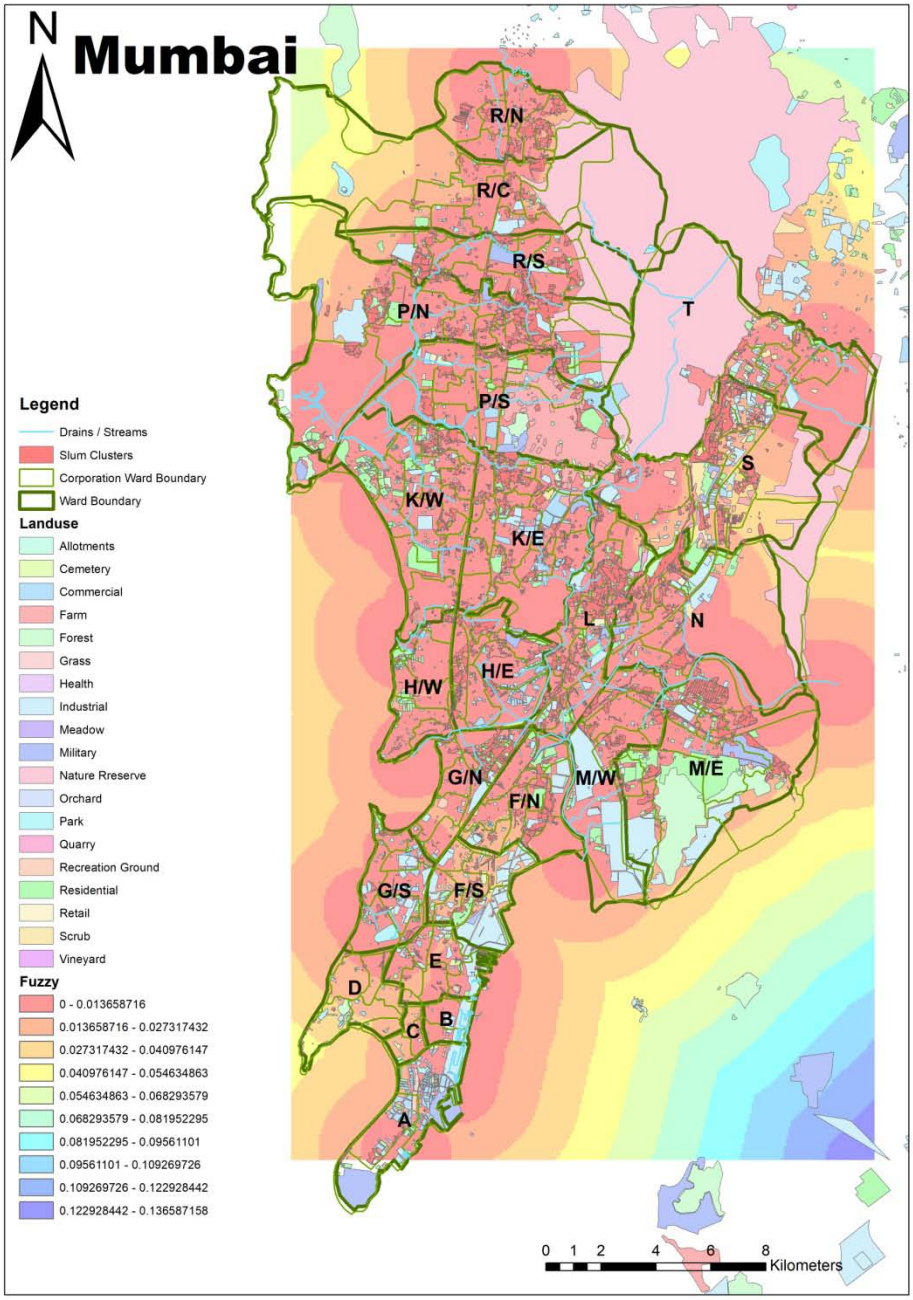


Figure 5.5: Plastic Leakage Vulnerable Areas identified using Fuzzy Logic Approach

Figure 5.6: Location of Probable Hotspots in Mumbai

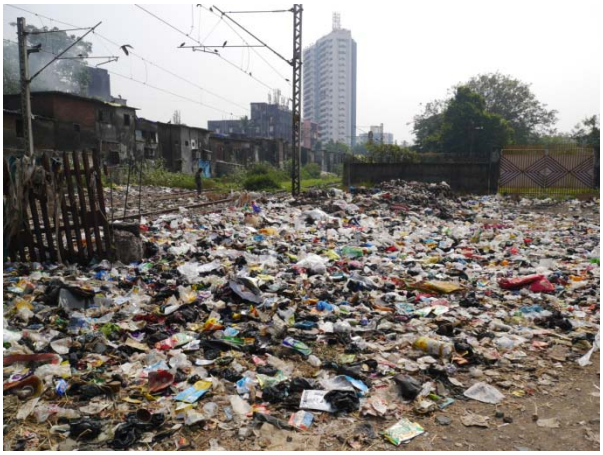


Figure 5.7: Field Reconnaissance& Verification

5.6 Clean up Activities & Macro Plastic Assessment Studies in Mumbai

Clean up activities were undertaken at (1) Sagar Vihar, Sector 8, Vashi, Mumbai (2) Gorai Creek, Near Gorai Bridge, Kandivali, Mumbai and (3) Chimbai Beach, Bandra West, Mumbai. The following charts **(Figure 5.8 & Figure 5.9)** depict the prominent plastic wastes in Mumbai, on the basis of count and on the basis of weight. **Figure 5.8** indicates that maximum number of prominent plastic waste in decreasing order are Multilayer packaging packets, Polythene bags, shopping bags/grocery bags, beverages bottles, footwear, packing used for milk & water, etc. In terms of weight Tires& rubbers, shopping bags/grocery bags, synthetic woven bags used for cement packaging, synthetic clothes, thermocol, multilayer packaging packets, footwear, polythene bags, beverages bottles, shopping/grocery bags and many others.

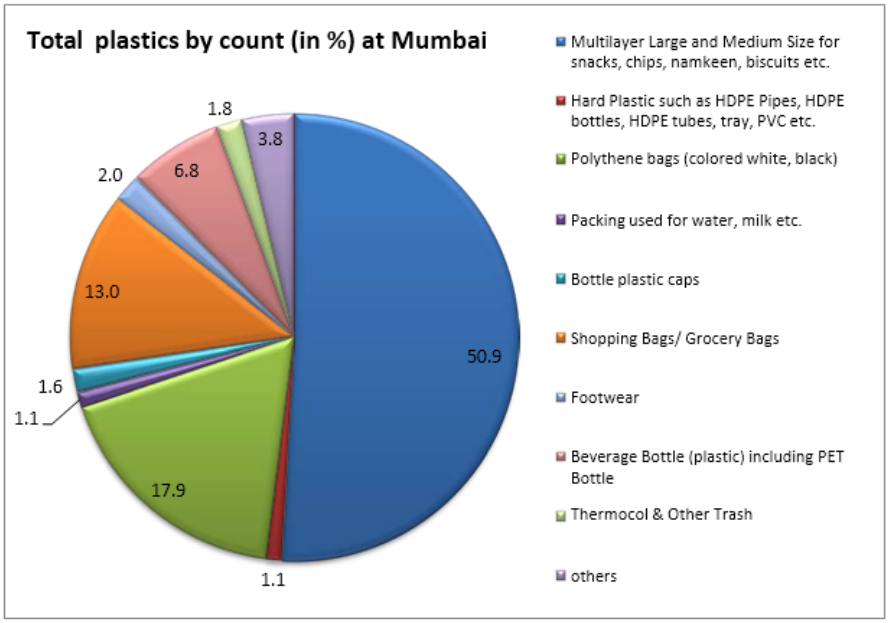


Figure 5.8: Breakup of plastic items in numbers

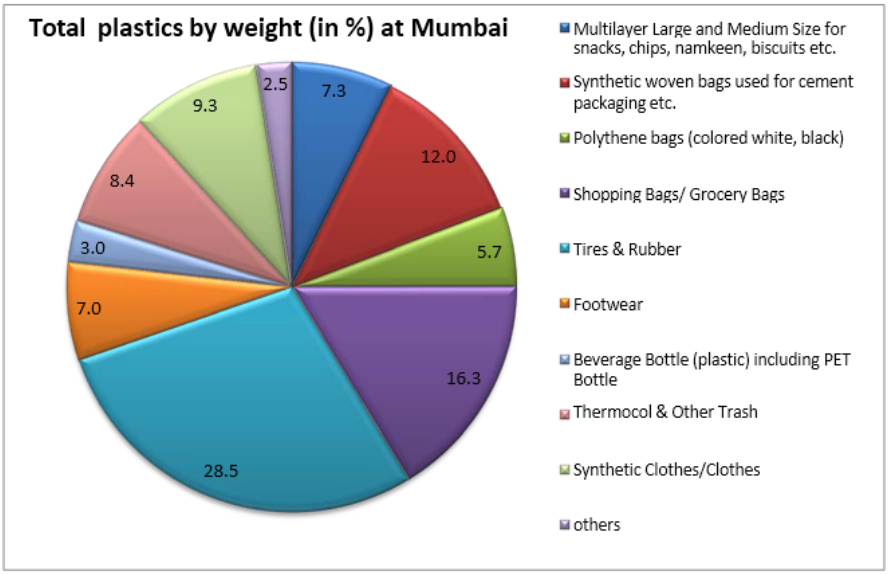
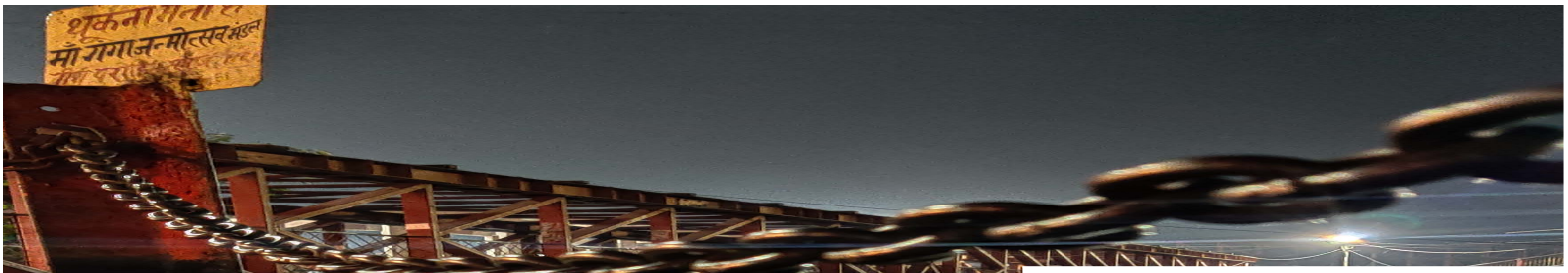


Figure 5.9: Breakup of plastic items in terms of weight

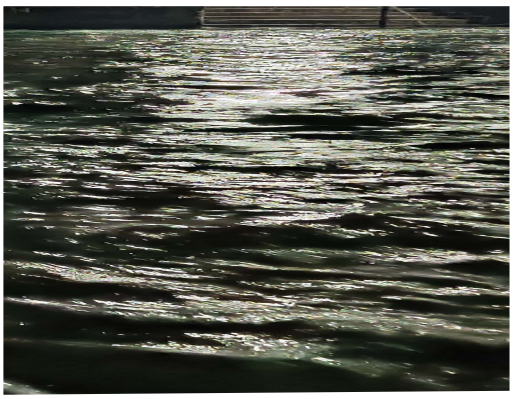
5.7 Conclusion

Major hotspots have been identified, which trigger plastic leakage into ocean through carriers like air, drains and run off in the city. These include all the four types of hotspots (i) Plastic Value chain hotspots like plastics waste generated in Slum Areas; (ii) Plastic Leakage Source Hotspots in major wards in the city; (iii) Plastic Accumulation Hotspots in major untapped drains of the city; and (iv) Plastic generated near railway lines by locals littering.

Massive amount of plastic was observed to be littered during the field study at various locations in Mumbai. Littering ranges 10% to 25% against 2% assumed in major studies carried abroad. Therefore, littering is one of the major reasons for the plastic not being collected and brought back into the value chain. However, majority of the waste categories found during Clean Up include polythene bags, Multi-layer packaging, synthetic clothes, water pouches, milk pouches, Aluminium Plates & bowls used for food packaging, plastic sheets, Packaging Material e.g. Tobacco sachets, Biscuit packets, Surf excel, Rusks etc. as per clean up report. A schematic diagram representing the leakage pathway has been described in **Figure** below.



ANNEXURE I



DETAILED CITY WISE REPORT

(HARIDWAR, AGRA, PRAYAGRAJ & MUMBAI

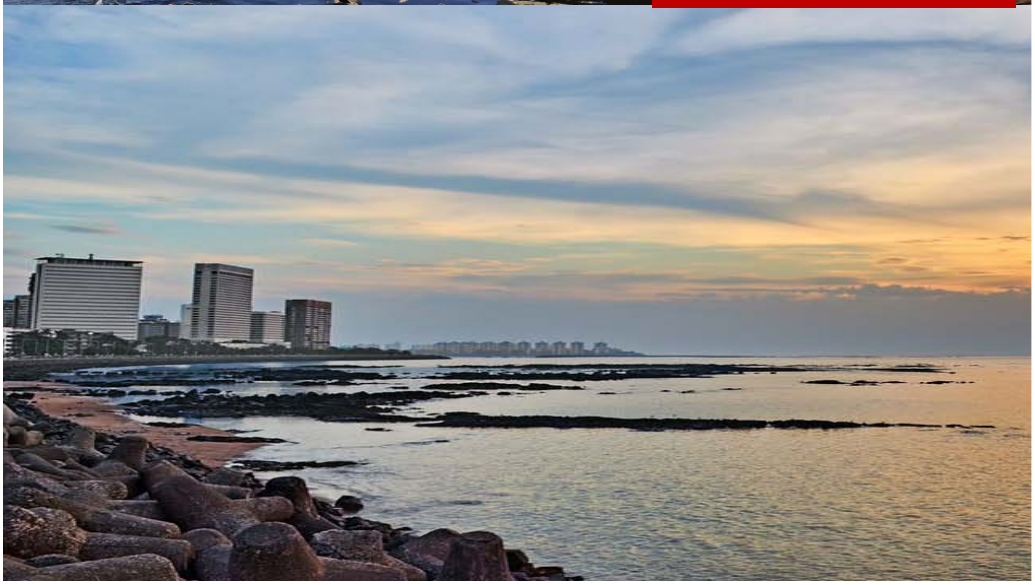


Table of Contents

1.1 Introduction 75

1.2 Geography & Climate 75

1.2.1 Physiography 75

1.2.2 Climate 77

1.3 Demography & Land Use 77

1.4 Solid Waste Management in Haridwar 79

1.5 Identification of Hotspots 89

1.6 Quantification of Total Plastic Waste Generation 92

1.6.1 Secondary Data Analysis 93

1.6.2 Primary Data Analysis 93

1.7 Leakages through barriers 102

PLASTIC LEAKAGE SCENARIO IN HARIDWAR

1.1 Introduction

Haridwar, is a city which falls in Uttarakhand state in India. It is located at latitude 29° 58' in the North and longitude 78°10' in the East. Haridwar is situated along Delhi-Niti Pass (DN Road) which starts from Delhi and passes through Meerut, Muzzafarnagar, Roorkee, Haridwar and goes till India-Tibet Boundary. It is the second largest city in the state and the district headquarter of the Haridwar district. Haridwar is regarded as a holy place for Hindus, hosting important religious events and serving as a gateway to several prominent places of worship. Most significant of the events is the Kumbha Mela, which is celebrated every 12 years in Haridwar. During the Haridwar Kumbh Mela, millions of pilgrims, devotees, and tourists congregate in Haridwar to perform ritualistic bathing on the banks of the river Ganges. However, during festive periods such as Kavad Mela, Somvati Amavasya Mela, Shivaratri, Ganga bath, Baisakhi (April–August), numbers increases (around 5 -6 million). **Figure 1** shows the municipal boundary of the city.

Figure 1: Municipal Boundaries of Haridwar City

Source: Google Maps

1.2 Geography & Climate

1.2.1 Physiography

The city is situated along the bank of Ganga River in the upstream at an altitude of 314 metres from the sea level, between Shivalik Hills in the North and Northeast and the Ganges River in the South. On the left side of the town is Chandidevi hill on which

a temple dedicated to Goddess Chandi is situated; on the right is Mansa Devi temple. Geologically, Shivaliks are separated by the Himalayas by a continuous reverse fault and fall in three main divisions, the upper Shivalik, middle Shivalik and the lower Shivalik. The Shivalik are mostly composed of sandstone and conglomerates. The river Ganga flows in a series of channels separated from each other called aits, most of which are well wooded. Other minor seasonal streams are Ranipur Rao, Pathri Rao, Rawii Rao, Harnaui Rao, Begam Nadi etc. The contour and drainage map of the city is shown in **Figure 2**. The contour and the major drainage pattern along with the river flow indicates that it emerges from the north, moves towards south west and then changes to east direction. The major part of the city is on the right bank (Eastern side) of the Ganga and has grown beyond the river on the western side as well. There are nineteen major storm water drains with a total length of about 17.9 km draining into Ganga. These include Pandewala, Kasa Nala, Shiv Mandir Nala, Latowali Nala, Jagjeetpur Nala, Avas Vikas Nala, Dev Pura Nala, Mayapur Nala, Lalita Rao Nala, Kusha Ghat Nala, Nago Ki haveli Nala, Nai Sota, Kangra Mandir Nala, Karanwal Nala, Karoli Nala, Bhimgoda Nala, Sapt Sarovar Nala and Lok Nath Nala. Practically the whole town, wherever roads or brick paved lanes/paths exist, have some kind of side drains leading to storm water drains, except in slums or some parts of peripheral areas. These drains are silted and carry a lot of waste into the river.

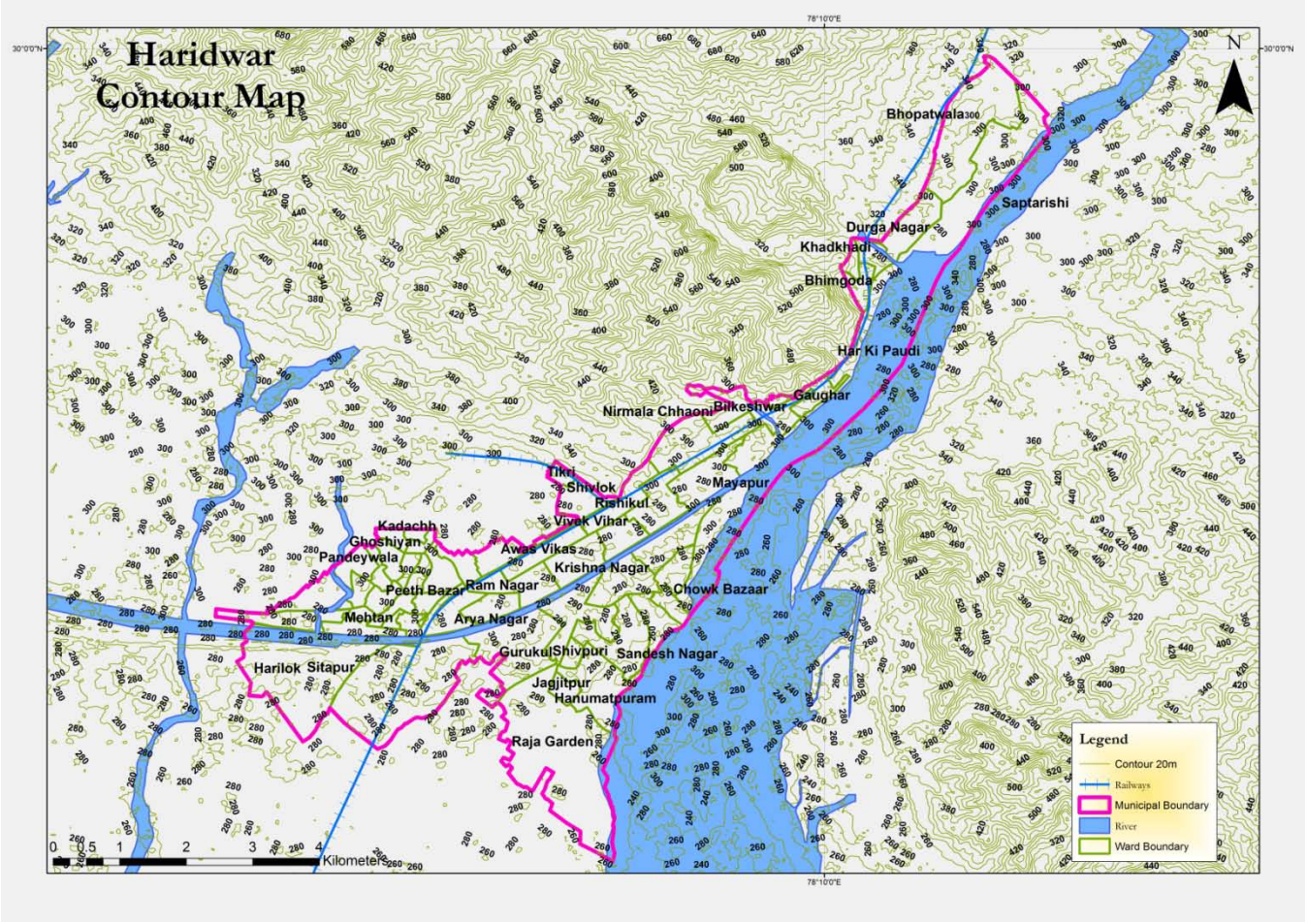


Figure 2: Contour and Drainage Map of Haridwar

Source: NPC team

1.2.2 Climate

The city experiences three seasons, summer, rainy and the winter. The summer season starts from April till June, the rainy season from July to September while winter season starts from October and ends in February. The general characteristics of climate of this region are:

Temperature: Hot during summers, cool to cold during winters and warm humid during Monsoon season. Annual maximum temperature is 30 to 42 degree Celsius. Annual minimum winter temperature ranges from 4 to 14 degree Celsius.

Humidity: During rainy season humidity ranges from 70 percent to 85 percent while during summer season it ranges from 40 percent to 60 percent. During winter season it is about 25 percent approximately.

Wind: The most probable wind direction is West, Northwest and Southwest. Summer is characterized by hot dust raising winds with velocities going up to 15 km/hour. Atmosphere is dusty In May/June.

1.3 Demography & Land Use

As per Census 2011, Haridwar has a population of 229,000. The population of Haridwar has maintained an upward trend with a few kinks in some decades. In the recent decades, as is observed, the decadal rate of growth gradually dropped down from 45.71% in 1981 to 16.00 % in 2001, the later being far below the national average. The average household size is about 5.4 persons. The demographic and administrative profile of Haridwar is given below in **Table 1**.

Table 1: Demographic and Administrative Profile of Haridwar

City Population 2011	2,29,000
floating population	6,93,000
slum population	86,880
Peak season floating population	50,00,000-60,00,000
Number of wards	60
Number of households	41335

There are 41,335 households falling in 60 wards in Haridwar. Slum population in Haridwar is 86,848. Average household size for slum households, as found from the baseline survey, is 7.1. The slums on encroached land and on the hill slope are generally worse in comparison to other slums. Of the below poverty line (BPL) population, 15 percent households and 10 percent of the poor do not have any legal rights of the land. In the absence of ownership of land and clear policy to address their problems, the poor suffer from many inadequacies in terms of access to basic services like water supply and sanitation, and infrastructure. Land availability is a major constraint in the slums. On an average 20 percent of all the families in the slums stays with some other family. The city receives 0.6 million

floating population. At the height of festivals, it can receive 5 to 6 million of floating population putting a pressure on city services. The city has an area of 12.17 sq.km. **Figure 3** shows the land use plan as per the approved master plan 2025. This would be utilized for urban activities, including housing, commerce, industries, tourism, community services, transport, parks, amusement and entertainment centers, parks and parking spaces. Besides being a tourist hub, Haridwar, in relative terms, is also industrialized area of Uttarakhand state. Haridwar is rapidly developing as an important Industrial township of Uttarakhand as the state government agency, SIDCUL has set up Integrated Industrial Estate, within the district attracting many important industrial houses setting up manufacturing facilities in the area. Haridwar already has a thriving Industrial area as BHEL and its ancillary units. The breakup of the land use is given in Table 2. It indicates that residential area constitutes the major part of the land followed by industrial area, area earmarked for fares and commercial and institutional area. Demographic pattern tally with land use pattern of the city with majority population residing in the eastern area. Land use pattern also indicates that residential area as well as the eastern part of the city is a major area of consumption as well as generator of bulk of solid waste within the municipal limits.

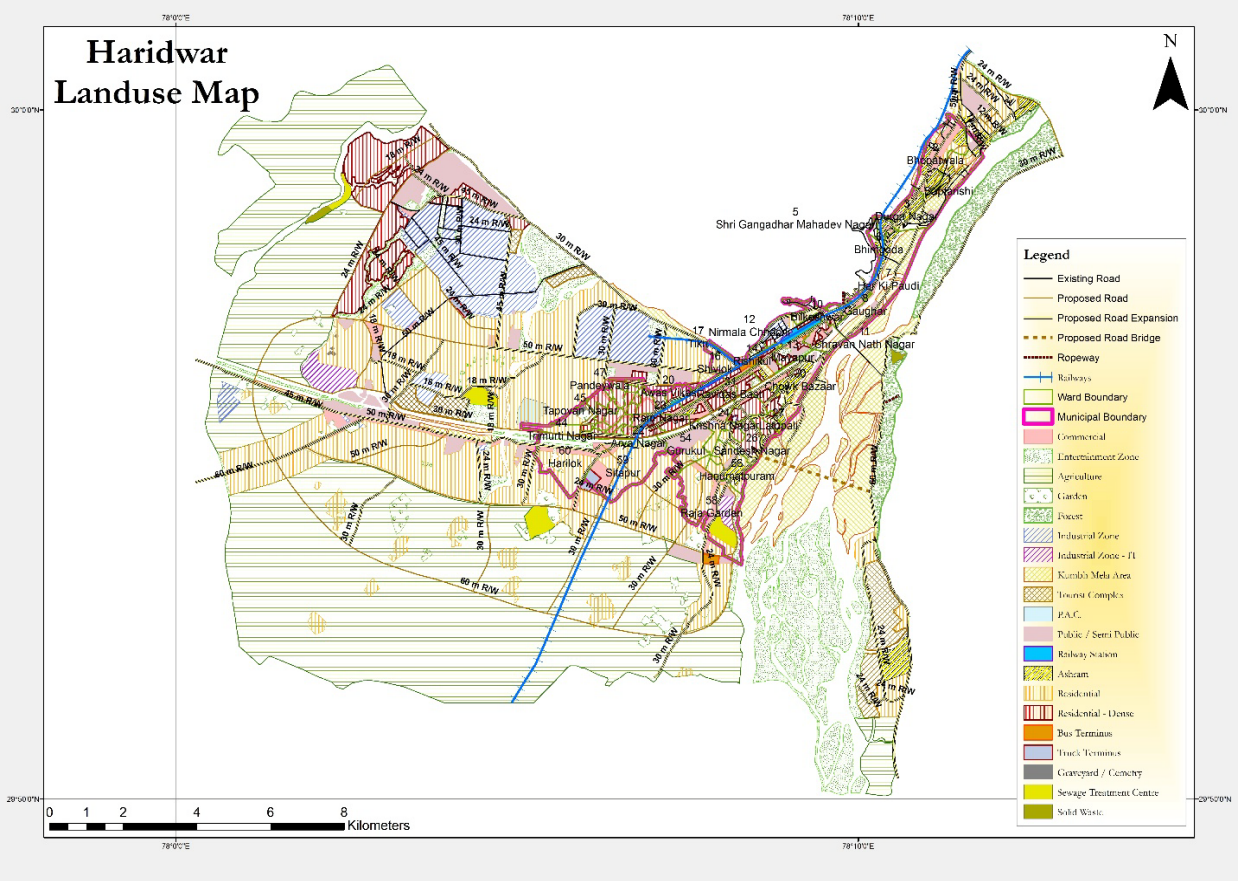


Figure 3: Demographic, Administrative and Land Use Map of Haridwar

Table 2: Land Use Haridwar City

Sr. No	Land Use	Area (In Hectare)	Area(in %)
1	2	3	4

Sr. No	Land Use	Area (In Hectare)	Area(in %)
1	Residential	**1455.33**	**7.23**
2	Aasharm	**240.20**	**1.19**
3	Business	**157.20**	**0.78**
	-Commerce	151.32	0.75
	-Main Business Centre	5.88	0.03
4	Office	**117.8**	**0.59**
5	Other Office	**49.3**	**0.25**
	-CISF	13.45	0.07
	-PAC	35.85	0.18
6	Industrial Area	**1139.70**	**5.67**
	Industry	135.7	0.67
	-BHEL Campus	1004.0	4.99
7	Tourism/Fare	**734.56**	**3.65**
8	Public Amenities	**294.00**	**1.46**
	-Schools/Colleges	54.94	0.27
	-Degree College or Gurukul College	76.97	0.38
	-Medical College	5.2	0.03
	-Technical Institute	0.95	0.01
	-Park	24.99	0.12
	-Cultural Centre	2.56	0.01
	-Hospitals	4.86	0.02
	-Sport Ground	68.84	0.35
	Electricity Centre	8.56	0.04
	Telephone	2.48	0.01
	Post Office	0.82	0.01
	Police Station	1.68	0.01
	Water body /Sewage Farm	14.78	0.07
	Temple/Mosque/ Church	8.31	0.04
	Graveyard/ Cemetery	18.06	0.09
9	**Transportation**	**626.40**	**3.11**
	Bus stand	0.72	0.01
	Road	523.86	2.60
	Railway Line	91.26	0.45
	Railway Station	10.56	0.05
10	**Garden (eucalyptus plantation)**	**578.50**	**2.88**
		(400)	**(1.99)**
11	Agriculture	**10553.32**	**52.46**
12	Infertile	**1100.21**	**5.47**
13	Open area island and Tree Plantation	**916.86**	**4.56**
14	River/Sewer/Canal	**1864.72**	**9.27**
15	Forest area	**690.80**	**3.43**
Total:		**20119.00**	**100.00**

Source: Master Plan Haridwar 2025 (1)

1.4 Solid Waste Management in Haridwar

Haridwar Nagar Nigam (HNN) is responsible for Solid Waste Management within the municipal boundaries as per Solid Waste Management Rules, 2016. They are

responsible to collect, transport, process, treat and dispose the municipal solid waste in a scientific manner. Since HNN has not updated its Detailed Project Report (DPR) on Solid Waste Management since 2009, NPC has adopted the consultative approach along with field data collection for assessment of MSW management (including waste collection, handling, treatment and its disposal) in the city. NPC team visited various hotspots of waste generation/collection in the city and interacted with various stakeholders. These include Officials of Haridwar Nagar Nigam, representatives of facility for waste treatment, representatives of commercial establishments, and several interviews with ragpickers and with door to door collectors/drivers etc. The outcome of this approach is shown in **Figure 4**.

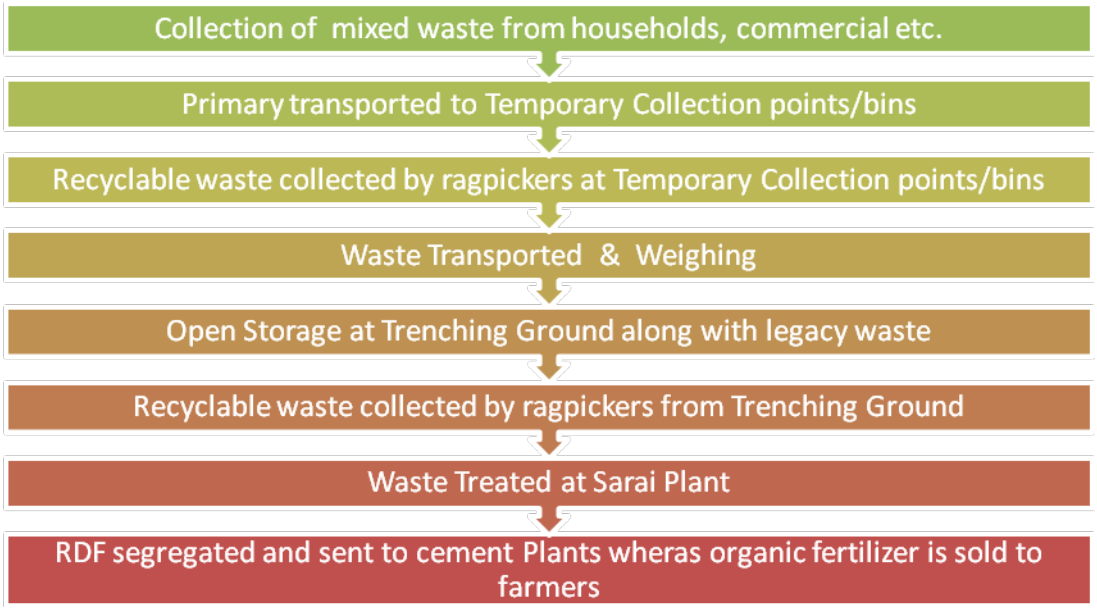


Figure 4: Flow diagram of waste management in Haridwar City

Salient features of solid waste management consisting of source, generation, composition, collection, transportation, treatment and disposal are given below.

Source: Major sources of solid waste generation in the city are households in located in 60 wards, commercial (e.g. markets, hotels, ghats etc.), industrial areas and street sweeping in residential and commercial areas of the city. According to the information available with Haridwar Nagar Palika Parishad & District Urban Development Authority, Haridwar City has a total of 43 slums out of which some are authorized and others are unauthorised and smaller in size. The population of the slums is 86,888. The city has 3 fruits and 3 vegetable markets, 72 ghats and a big industrial area. There are few markets in the city having small showrooms of various brands of fashion which are managing its waste on their own and also through HNN. However there are shopping malls (small & big) for example **"The Pentagon Mall",** which falls under the Industrial area SIIDCUL (State Infrastructure & Industrial Development Corporation Uttarakhand Ltd.), There are around 400 nos. of shops available within the mall premises out of which 70 nos. of shops are presently functional which includes restaurants such as Mc Donald, Dominos, Burger King, Namaste Foods, Stage Bars, Captain; Outfit accessories such as lifestyle, Trends,

Bata etc; Wave Cinema halls, Toys Shops, Wine shops. SIIDCUL, Haridwar has a total area of about 1758 acres out of which, the total allotable area is 1478.02 acres consisting of about 700 nos. of industrial units apart from the a major public sector undertaking M/s BHEL located adjacent to it. In SIIDCUL industrial area, major industrial units such as Hindustan Unilever Limited, VLCC, Lotus Beauty Care Products Pvt. Ltd, Raja Biscuits Pvt. ltd, PPI Blow Pack Pvt. Ltd, Cello Industries, Enn Tee International Pvt. Ltd etc are located. The type of products manufactured in this industrial area include Cosmetics, Ayurvedic, Herbal, pharmaceuticals, packaging materials, fabrics, PET bottles, single use plastics, plastic dana apart from the electrical & electronic components and mechanical parts, which are also processed/ manufactured in the industrial units.

Quantity: Daily MSW collection data collected from the private operator for the month of February 2020 has been depicted in **Table 3**. This table indicates that the quantum of waste generated ranges from 205.7 tpd to 353.22 tpd. Therefore, the average waste generation in the city is about 312 tpd, This waste may vary during festive and other occasion depending upon the floating population. Considering the slum population, the quantum of waste generated from them has been estimated to be about 30.41 tpd. Shopping malls like The Pentagon Mall generate about 3.5-5 tons mixed waste per day considering 50 kg waste generated by each of the existing shops. Hotels for example like **Hotel Madhuban located at Ranipur mod,** Haridwar informed that about 20-30 kg waste is generated per day, which is disposed in to nearby collection bin. During marriage season or any event like birthday party, business events etc. the waste quantum per day may increase up to 10 times i.e about 0.2-0.3 tons per day.

Table 3: Daily MSW Collected by Private Operator

Total Tonnage month of February		
Sr. No.	**Date**	**Tonnage**
1.	**1/2/2020**	**726.745**
2.	**2/2/2020**	**313.36**
3.	**3/2/2020**	**318.22**
4.	**4/2/2020**	**245.705**
5.	**5/2/2020**	**205.705**
6.	**6/2/2020**	**320.795**
7.	**7/2/2020**	**323.795**
8.	**8/2/2020**	**344.71**
9.	**9/2/2020**	**303.74**
10.	**10/2/2020**	**323.425**
11.	**11/2/2020**	**321.34**
12.	**12/2/2020**	**298.215**
13.	**13/2/2020**	**324.64**
14.	**14/2/2020**	**342.525**
15.	**15/2/2020**	**326.43**
16.	**16/2/2020**	**294.61**
17.	**17/2/2020**	**309.885**
18.	**18/2/2020**	**340.42**
19.	**19/2/2020**	**327.945**
20.	**20/2/2020**	**306.865**

Total Tonnage month of February		
Sr. No.	**Date**	**Tonnage**
21.	**21/2/2020**	**293.555**
22.	**22/2/2020**	**353.275**
23.	**23/2/2020**	**309.295**
24.	**24/2/2020**	**306.87**
25.	**25/2/2020**	**313.165**
26.	**26/2/2020**	**318.43**
27.	**27/2/2020**	**317.245**
28.	**28/2/2020**	**310.245**

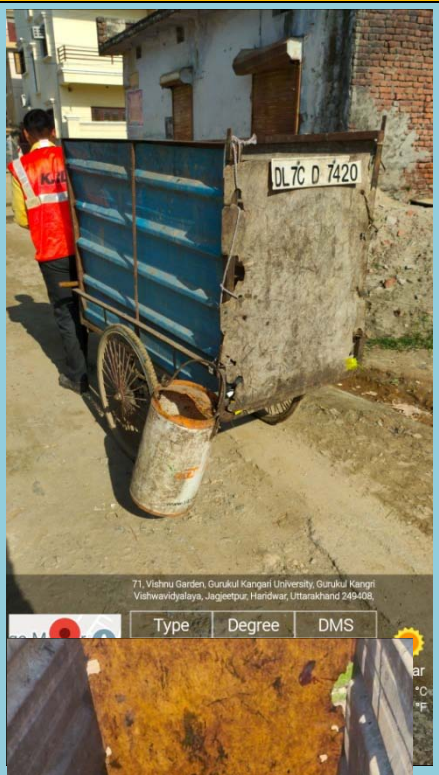
Composition: Most of the waste generated from households comprises of food and other discarded waste such as paper, plastic, glass, metal, packaging material etc Waste collected from commercial and market areas consists of multiplayer plastic, packaging waste, vegetables and fruits piles, transparent polythene, cardboard, hard plastic, printed packaging, About 5% of plastic is observed in tricycle during door to door collection from households. the types of waste incoming at the HNN collection point near the hotel comprises of polythenes, multilayer packaging's, clothes, luggage bags, milk pouches etc. Poly bags, polyesters/synthetic bags, packaging waste etc. are the predominant types of plastic waste coming from the market areas. The mixed waste from the commercial area mostly comprises of food waste, polythene, paper cups, cans, aluminium silver foil, black polythene, thermocol, cardboards etc. Waste generated from The Pentagon Mall premises comprises of transparent polythene, black polythene, Nylon sacks, thermocol, and cardboards in significant quantity while other types include synthetic ropes, multilayer packaging, pet bottles, hard plastic. The waste collected from ghats mainly comprises of waste cloths, silt, poly bags, packaging waste, flowers, fruits, vegetables etc The littered waste found near the BHEL plant, Haridwar comprises of polythene, multilayer packaging, synthetic clothes etc. The waste collected during the street sweeping mostly comprises of multilayer plastic packaging's, colored poly bags, synthetic bags, silt etc. **Waste accumulated in vacant** lands/plots was found in the industrial estates which mainly comprises of packaging materials, woven bags, fabrics etc.

Collection & Transportation:

M/s KRL Waste Management Pvt. Ltd, Sarai is the private operator, which has been engaged by HNN for waste management in the city. It is responsible for waste collection, transportation, storage, treatment & disposal. M/s KRL extends its collection services in 52 wards of the city (86%) including door to door collection from commercial areas & households. The mixed waste generated from Household, Commercial, Market etc is transported using 250-300 tricycles and stored at fifty collection points/bins from where the waste is transported by trucks to the weighbridge located at M/s KRL's Garage and then further, transported to treatment plant/dumping ground near sarai, Haridwar. M/s Akansha Enterprises under Namami Gange project is responsible for maintaining cleanliness of Ghats at Haridwar. The agency covers cleaning activities in 72 nos. of ghats with 400 sanitation workers. All the waste collected from ghats is finally transferred to

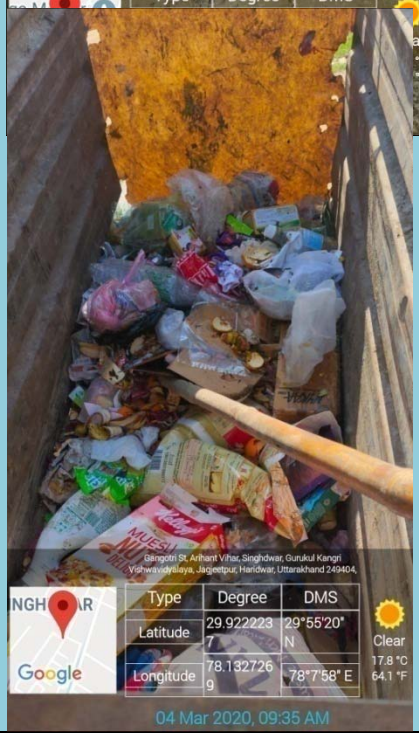
trenching ground adjoining landfill site. Presently street sweeping is carried out manually by sanitation workers of HNN. The collected waste from street sweeping is transported by seven trucks to the trenching ground near waste treatment plant. In industrial areas for example the mixed waste collected from shopping mall is stored at the back side of the mall. Industries located within the industrial areas are managing their waste through their own vendors/ragpickers. The ragpicker collects recyclable waste from trenching ground.

Table 4: Shows Door To door Collection



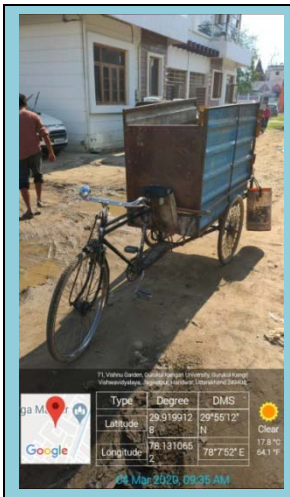
Plates affixed on the left side shows the type of tricycle used by the M/s KRL for door to door collection of waste from the household. The waste collectors is collecting waste through the indication of whistle jingle and the household comes out from homes to dispose the waste in the tricycle and the tricycle is transported manually to the collection point from where all the waste is transported via heavy vehicle to the KRL garage for weighing at weigh balance from where the same vehicle is transported to the KRL, Sarai waste treatment plant.

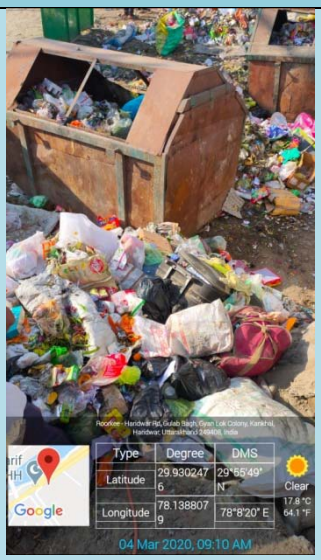
It was informed by the waste collector that there are around 250-300 nos. of tricycle used for the collection of waste within the city.



Plates affixed on the left side shows types of waste collected from household which comprises of multiplayer plastic packaging's, vegetables and fruits piles, transparent polythene, cardboard, hard plastic printed packaging's, remaining food from Household and others. About 5% of plastic is observed in tricycle during door to door collection from household.

Some photographs of Door to Door Collection of waste from households of Vishnu garden, Haridwar affixed below





Collection Points:

As discussed with Mr. Ajay it was stated as there are about 50 nos. of collection points exists within the city.

Plates affixed on the left side shows the collection point located near Hotel Jahanvidale. it was informed by the waste collector that waste collected from around 500 nos. of households reaches at this collection points and about 3-4 collection bins located at collection point is transported bins collected from here The waste collected through tricycles is unloaded at these collection points. It was informed by the waste collector that around 500 nos. of households

Plastic - 10-15%

It was found that ragpickers are collecting waste at the collection points near Hotel Jahanvidale. It was informed by the ragpickers that per day around 3-4 ragpickers are collecting waste from here. In addition to this, around 60-70 kg of waste filled in one tricycle.

Plates affixed on the right side show the rickshaws used by the rag pickers for collection of waste from the collection points

Plates affixed below shows the types of waste incoming at the collection point which comprises of polythenes, multilayer packaging's, clothes, luggage bags, milk pouches etc.

Plastic - 10-15%

The collection point is located near the canal.

Table 5: shows Commercial Waste Generation

Few plates affixed on the left side show the location of storage of waste generated from The Pentagon Mall premises which comprises of Transparent polythene, black polythene, Nylon sacks, thermocol, cardboards are in significant quantity and synthetic ropes, multilayer packaging, pet bottles, hard plastic. Storage area consists of silt plus ashes generated from tandoor kilns which are selling to the NGO for the preparation of compost.

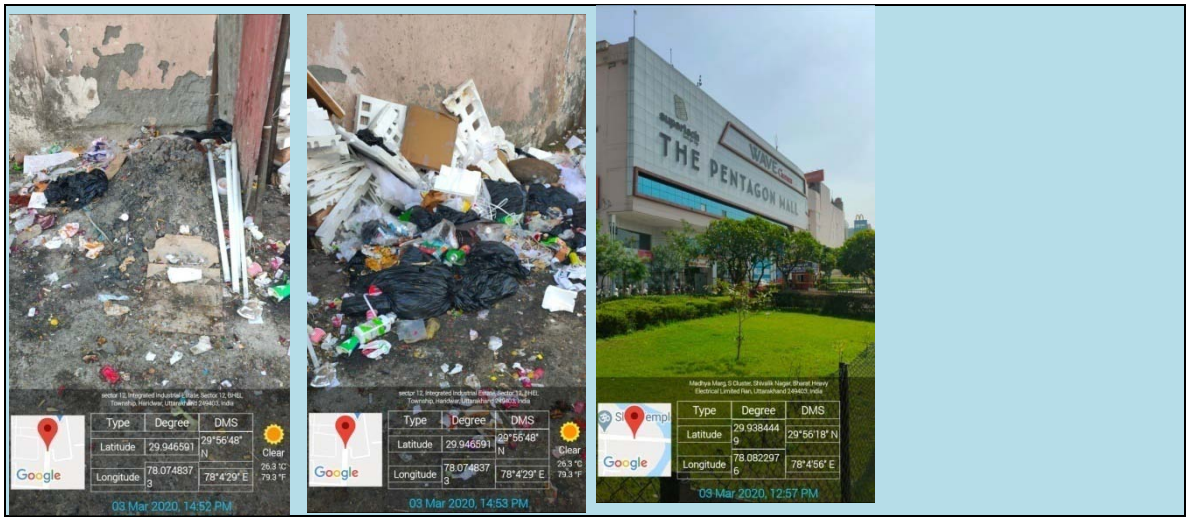


Table 6: shows Hotel Waste Generation

Plates affixed on the left side shows collection points where waste generated from the Hotel is stored in the same bins.

Plastic percentage- about 5%

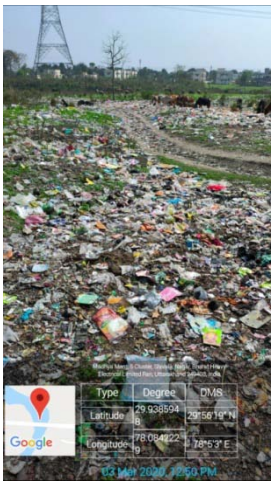
Table 7: Shows about Industrial waste

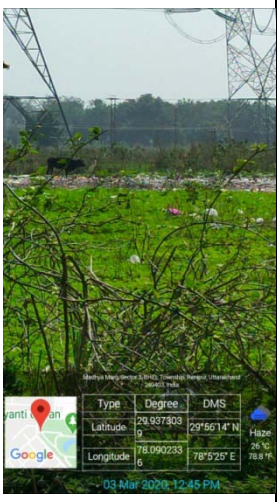
Plates affixed on the left side shows the quantity of llittering found near the BHEL plant, Haridwar which comprises of polythene, multilayer packagings, synthetic clothes etc.

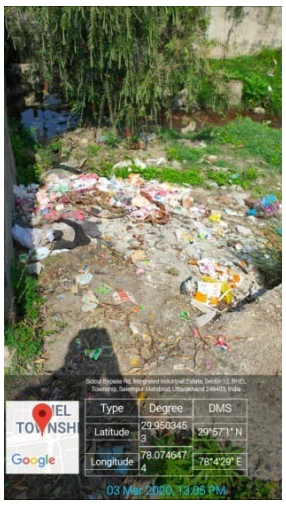
It was found that ragpickers are collecting waste from the same place.

While taking a foot on the same land it was observed that this land consists of legacy waste. Also fauna like cow, pigs, dogs etc was found there in searching of food.

Plastic percentage- about 5%







Plates affixed on the left side shows the conditions of drains found in the SIIDCUL (Industrial Area), Haridwar. The drains were filled with polythene and other trashes.

Also the red colour water was observed in the drain.

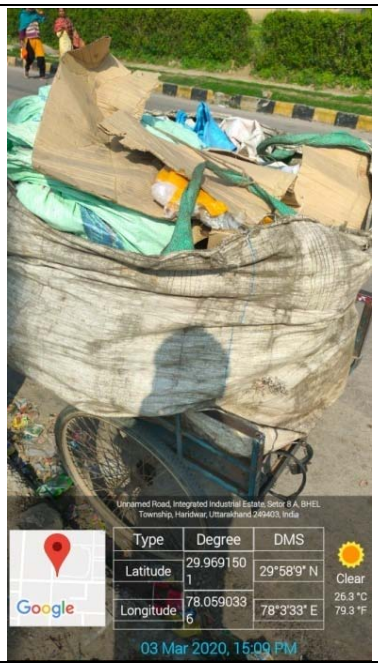
As SIIDCUL does not comes under the Haridwar municipal boundary. Also it was found that industrial units exists within the SIIDCUL, Haridwar are managing their waste through their own vendors/ragpickers. In addition to this, it was found that ragpickers are collecting waste from the industrial units. Plates affixed on the right side shows the types of waste collected by the ragpickers which comprises of cardboards, plastic etc. Also it was informed by the ragpickers they collect e-waste also from the industrial units.	

Table 8: shows about street sweeping

 	Street sweeping was carrying out by the Nagar Nigam and was found at the approach road to Vishnu garden, Haridwar and it was informed by the truck driver that around 7 nos. of trucks are doing street sweeping each day in the Haridwar city. These trucks transported and unloaded at the Sarai plant. The street sweeping comprises of multilayer plastic packaging's, colored polythenes, synthetic bags, silt etc. Plastic percentage- about 5%

Treatment & Disposal:

HNN has a treatment capacity of 150 tons of waste per day. Therefore, only 150 tons of waste is being treating per day in Haridwar city and the remaining 162 tpd waste is disposed in the trenching ground without any treatment. Informal sector collects recyclable waste from this dumping ground regularly. The RDF treatment plant operated by M/s KRL, the private operator consists of trommel screens of 45mm, 25mm and 4mm mesh sizes. RDF segregated form treatment plant is sent to cement plants. Inert/Non-recyclable waste is finally disposed in **the waste collected from Pentagon mall** is further, segregated by them. The segregated dry waste is sold to the M/s ITC Shivalik Nagar for further, processing and food waste is given to local NGO for animal feeding and making compost SLF (Sanitary landfill). Since industrial units are located in industrial are which falls outside the municipal boundary, they manage their waste through their own vendors.

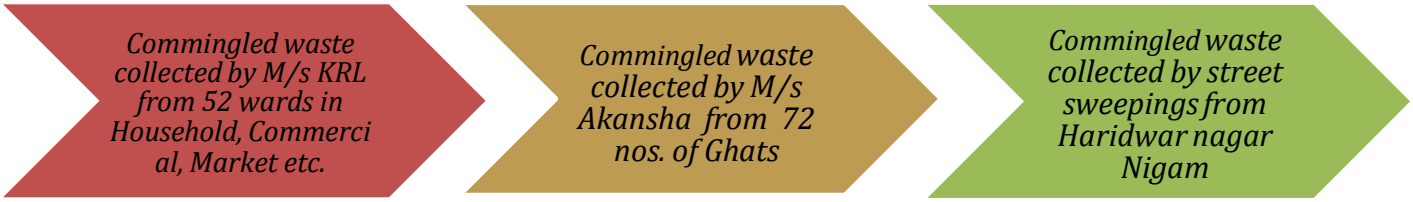


Table 5: Waste Generated per day during February-2020

1.5 Identification of Hotspots

A step wise approach has been adopted to identify the hotspots, which serve as source of plastic leakage into the river. This is based on IUCN's approach for defining the plastic leakage as a function of loss rate and leakage rate. The various steps include identification of vulnerable areas using fuzzy logic approach adopted by GIC, AIT Thailand **(Figure 5)** and identification of leakage points **(Figure 6 & Figure 7)** followed by field reconnaissance & verification **(Figure 8)** and cleanup activities. During the field survey at Haridwar, littering of solid waste comprising majority of plastic waste was observed in abundance. This was followed by discussion with HNN, M/s Akansha Enterprises, M/s KRL Waste Management Pvt. Ltd. which suggested hotspots, which were in line with predicted vulnerable areas. These include: Pul Jatwada, Shamshaan Ghat- bhim Goda, Har ki Podi, Sati Ghat, Daksh mandir, Alaknanada Ghat, Ranipur Jhaaal, Subhash Ghat, Kangda Ghat, Ghant Ghar ghat, Damp Kothi, Pant deep Parking, Kashyap ghat, Rodi vel, Kankhal, Sukhi Nadi, Laltarapur, Ush Ghat and Kassaban. **Some of the places where sacred waste/waste thrown by the people include:** Rishikul, Hathiwal, Jatwada, Kankhal Irrigation line, jagjeetpur irrigation line and Ramdev ki puliya.

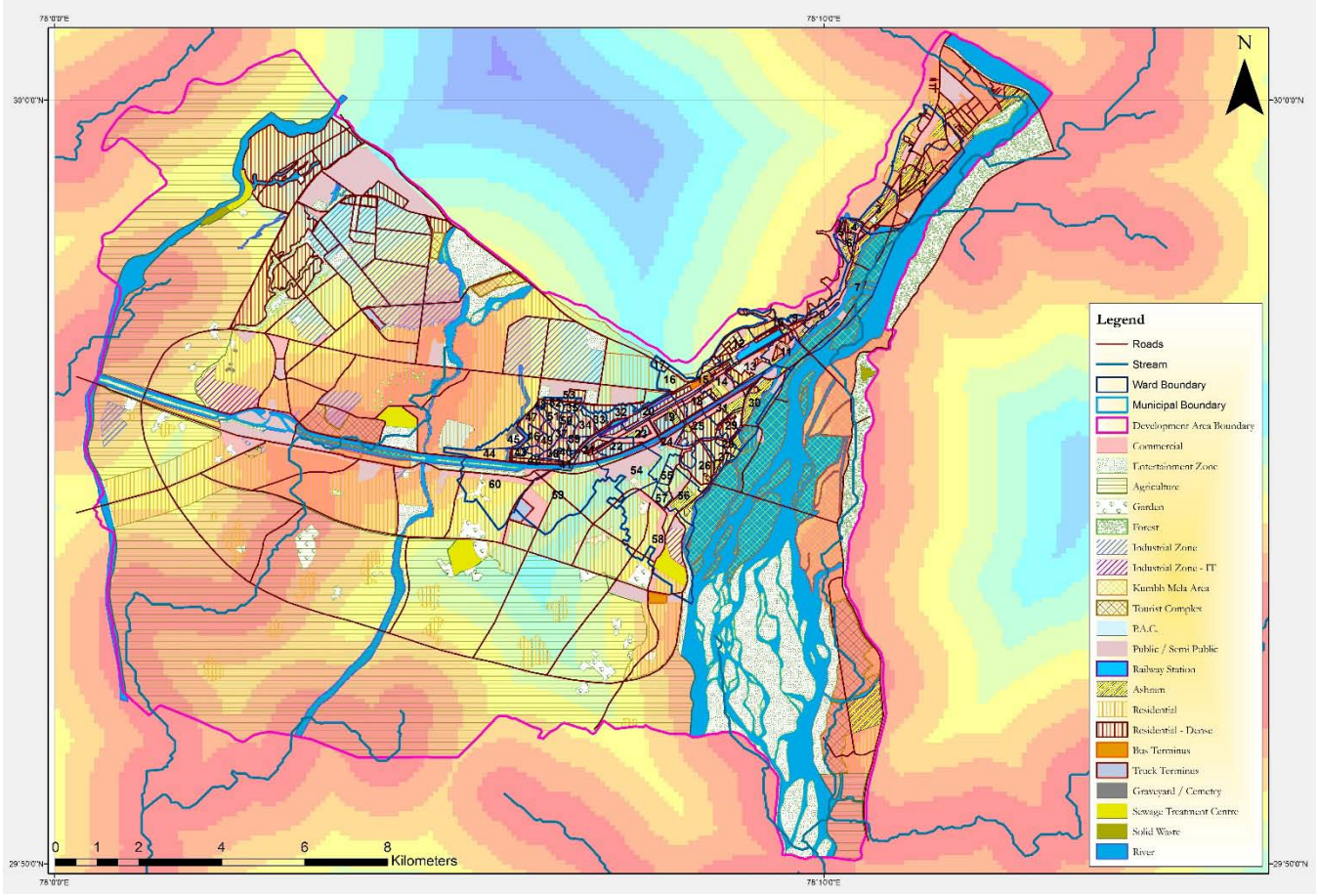


Figure 5: Plastic Leakage Vulnerable Areas identified using Fuzzy Logic Approach

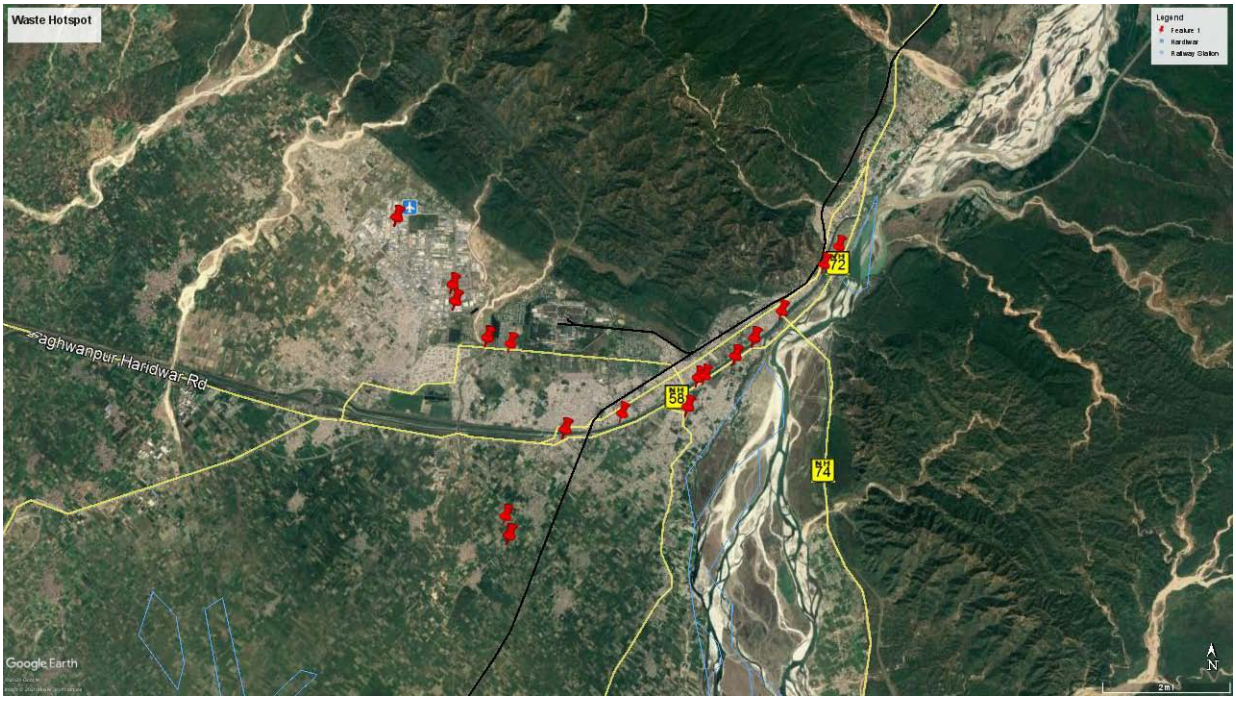


Figure 6: Location of Probable Hotspots in Haridwar

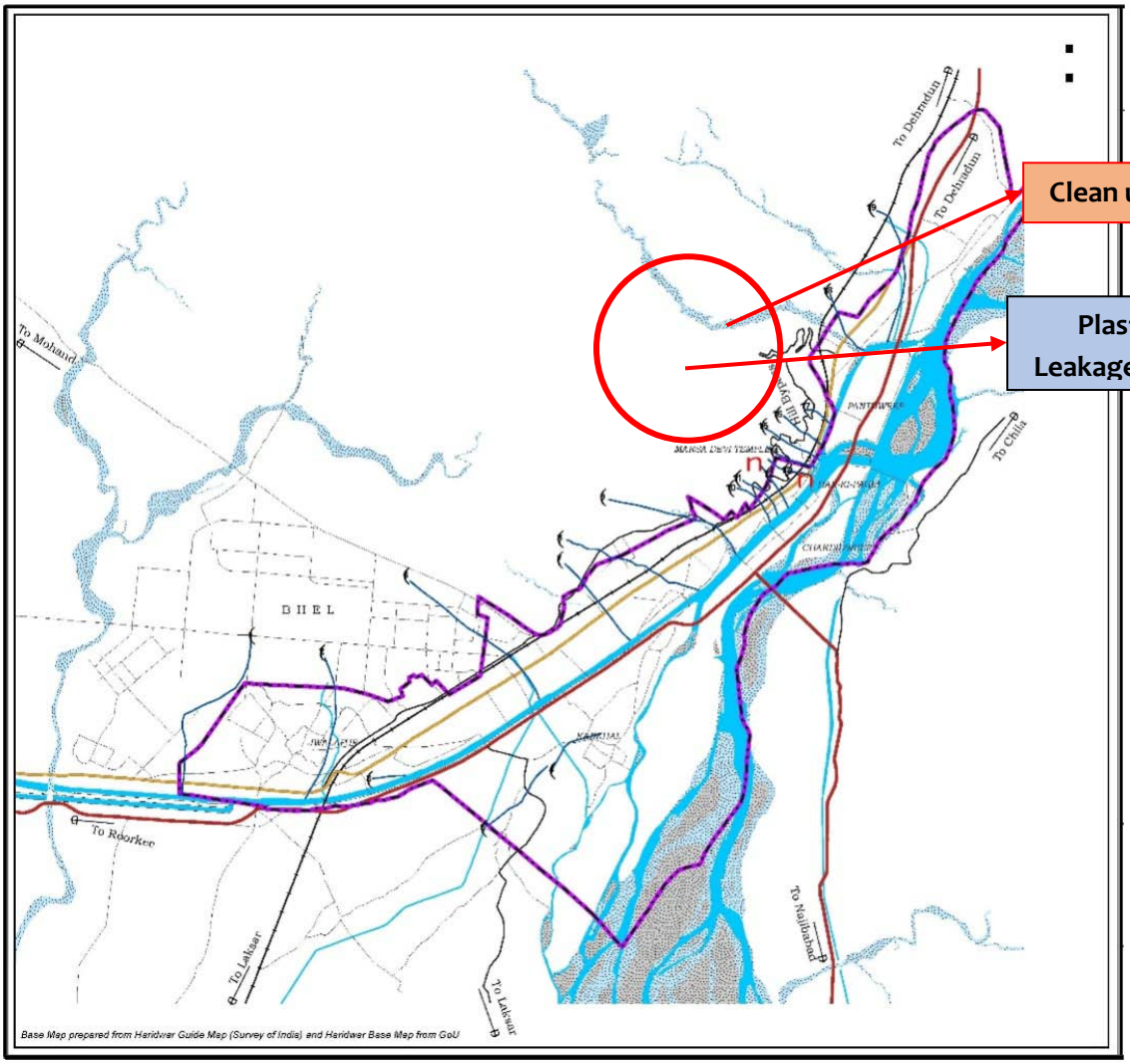


Figure 7: Drains and Sources of Plastic Leakage

Figure 8: Field Reconnaissance& Verification

1.6 Quantification of Total Plastic Waste Generation

Total plastic waste generation has been quantified based on secondary and primary data analysis as described below.

1.6.1 Secondary Data Analysis

The data provided by HNN indicates that the average waste collected during door to door collection from 52 wards is about 312 tons per day. Further, HNN has a treatment capacity of 150 tons of waste per day while the remaining 162 tpd waste reaches the trenching ground without treatment. Segment wise breakup of solid waste management as described in Integrated Solid Waste Management Report 2009 is summarized below in **Table 9.**

Table 9: Solid Waste generation as per DPR, ISWM- 2009

Year	**2010**
Equivalent population considering floating population	4,82,952
Per capita waste generation in residential areas in gms per day	220
Total waste from residential areas/day in MT/day	106
Commercial waste in MT/day	68
Street Sweepings	39
Total waste generation per day in MT	213
Per capita waste generation/day	**442gm/day**

(Source: INTEGRATED MUNICIPAL SOLID WASTE MANAGEMENT, 2009**)**

Note: Figures mentioned in the above tables is used ahead in estimation of plastic waste generation.

It can be inferred from the above table that commercial waste is 31% of mixed collected waste. Since HNN has a treatment capacity of 150 tons of waste per day, where about 46.5 tpd (31%) is contributed by commercial segment.

1.6.2 Primary Data Analysis

The waste treatment agency has informed that around 8 tons out of 150 tons of mixed waste is the plastic waste (About 5.33%), which reaches the treatment plant. Therefore, 5.33% has been taken to estimate the quantity of plastic waste generation from the total waste generation in the city. This waste includes both the unaccounted as well as accounted waste. The unaccounted waste consists of waste from 8 remaining wards of HNN, ghats and floating/ tourist population and waste generated during festive seasons as well as from industrial areas. In addition to the 312 tpd waste collected from 52 wards, the waste collected from the 72 nos. of ghats is estimated to be around 12 tons per day, which also reaches to the trenching ground. Therefore, around 174 tons tpd of mixed waste per day reaches the trenching ground where it is dumped without any treatment. The estimated projections of plastic waste generation from different stakeholders are described in **Table 10.**

Table 10: Estimated projections of plastic waste generation from different stakeholders

Estimated Waste per day collected by M/s KRL (excluding commercial establishments) (1)	Estimated Waste per day generated by the commercial establishments (2)	Estimated Waste per day generated by the remaining wards of Haridwar which are not cover by M/s KRL (3)	Estimated Waste per day generated by the slums populations (4)	Estimated Waste per day collected by the M/s Akansha Enterprises Pvt Ltd (5)	Estimated Waste collected by the Ragpickers (6)	Estimated Waste per day generated at dumping ground (7)	Total waste generated per day (8)
103.5 (in tons)	**46.5 (in tons)**	**13 (in tons)**	**30.41 (in tons)**	**12 (in tons)**	**6 (in tons)**	**174 (in tons)**	**367.41 (in tons)**
Source: DPR ISWM, 2009		Source: M/s KRL	Source:ISWM, 2009	Source: M/s Akansha	Source: local ragpickers	Source: M/s KRL	
Capacity of waste treatment plant- **150 MT** per day. • Commercial waste is 31 % of mixed of waste i.e., 46.5 mtd of considering 150 mtd.		Out of total 60 nos. of wards, 8 nos. of wards (about 6500 population) are not covered by M/s KRL and considering a factor of 400gm/day/capita. The total waste generated from these wards is 13,000 kg/day	The total population of slums mentioned in ISWM, 2009 is 86,888 Therefore, considering a factor of 0.35kg/day/capita the total waste generation is 30,410 kg/day	It was informed that about 12 tons of waste per day is collected from the 72 nos. of ghats	It was informed that there are around 150 nos. of ragpickers exists and each are collecting around 40 kg of dry waste.	Considering an average of about 312 tpd of waste collected by the M/s KRL out of which 150 tpd is reaching the treatment plant. Therefore, total waste reaching the trenching ground is (312-150= 162 tpd) + 12 (Waste collected by M/s Akansha) = 174 tpd.	**Estimated total waste generated in Haridwar city is comprises of waste steming from (1) + (2) + (3) + (4) + (7) = 367.41 tpd**
Considering 5.3% (8 plastic waste /150 mixed waste) of plastic waste, the untreated plastic waste generated from the total untreated mixed waste (367.41 - 150= 217.41 tons per day) is **11.52 tpd**.							

Note: The average mixed waste generated per day in the city is 312 TPD. Above estimation does not cover waste generated from the Floating population/Campings during festive months /SIIDCUL industrial area, Haridwar.

Table 10 indicates that the **estimated** total mixed waste generated from 60 wards including slum population and 72 ghats is about **367.41 tons per day which does not**

includes the waste collected by the informal sectors/ ragpickers. This estimate indicates that the amount of untreated waste is 217.4 tpd in Haridwar. Therefore, the estimated quantity of **plastic waste (5.3%) generated from the total mixed waste is 11.52 tons per day, which remains untreated** may have the probability of leakages through various sources such as through drains, open burning, artificial barriers, canals/ghats.

In order to account for daily visitors, tourists and floating population, the data for the year 2020 has been taken considering data projections from the report Integrated Municipal Solid Waste Management, 2009 as described in Table 11.

Table 11: Projected Floating Population ('000) as per DPR ISWM, 2009

Year	Residential Population	Projected Floating Population ('000)			
	Projected Population ('000)	Tourist load	Daily visitors	District Hq. floating population	Total
2020	258	656	25	12	951

Source: Integrated Municipal Solid Waste Management, 2009

The total estimated projections of plastic waste generation in Haridwar city from Tourist load/ daily Visitors/ Floating population in addition to total wards, ghats and ragpickers is summarized in **Table 12.**

Table 12: Total Estimated Plastic Waste Generation in Haridwar

Total waste generated per day (8)	Estimated Waste per day generated by the Tourist load (9)	Estimated Waste per day generated by the daily visitors (10)	Estimated Waste per day generated by District Hq. floating population (11)	Gross waste generated per day (12)
367.41 (in tons)	65.6 (in tons)	2.5 (in tons)	1.2 (in tons)	436.71 (in tons)
Calculated in above table	Source: ISWM, 2009	Source: ISWM, 2009	Source: ISWM, 2009	**Gross waste generated in Haridwar city is comprises of waste steming from (8) + (9) + (10) + (11) = 436.71 tpd**
	considering tourist load of 6,56,000 and 0.1 kg waste generation per capita per day as mentioned in ISWM, 2009. Therefore, total waste generation of tourist load is 65.6 tons	considering daily visitors of 25,000 as mentioned in ISWM, 2009 and 0.1 kg waste generation per capita per day. Therefore, total waste generation by daily visitors 2.5 tons	considering District Hq. floating population of 12,000 and 0.1 kg waste generation per capita per day as mentioned in ISWM, 2009. Therefore, total waste generation by District Hq. floating population	

Total waste generated per day (8)	Estimated Waste per day generated by the Tourist load (9)	Estimated Waste per day generated by the daily visitors (10)	Estimated Waste per day generated by District Hq. floating population (11)	Gross waste generated per day (12)
			is 1.2 tons	
As informed, about 8 tons of plastic waste extracting out of 150 tons of mixed waste reaching at waste treatment plant Therefore, considering 5.3% (8 plastic waste /150 mixed waste) of plastic waste untreated generated from the total mixed waste untreated (436.41 - 150= 286.71 tons per day) is **15.19 tpd.**				

Considering 100 gm of waste generation per capita per day by the floating/camping population (mentioned in the DPR - ISWM, 2009), the total mixed waste generation has been estimated to be 436.71 out of which 150 tons of waste is treated per day. Therefore, the remaining 286.71 tpd is the untreated waste, which is disposed in the trenching ground. The total plastic waste is about 15.19 tpd considering plastic constitutes about 5.3% of the total waste. This waste has the probability of leakages through various sources such as drains, open burning, artificial barriers, canals/ghats etc.

A scenario analysis of the probable plastic waste leakage in the city has been carried out considering normal days and festive days. The findings of these scenarios are described in Table 13 and Table 14.

Table 13: Plastic leakage analysis during Normal days

Matrix for estimation of plastic waste (MTPD) generation in normal days in Haridwar city in the range of Minimum and Maximum		
Particulars	**Estimated waste generation considering 86% DTDC collection excluding slums waste generation (in tons per day)**	**Estimated waste generation considering 100% DTDC collection including slums waste generation (in tons per day)**
excluding estimated quantity of waste collected by the local ragpickers	393.3	436.71
150 tons of waste per day treated at treatment plant with sanitary landfill	**(-150)**	**(-150)**
Untreated quantity of waste	243.3	286.71
Considering 5.3% of plastic from the mixed waste as per the information received by the waste treatment	**12.89**	**15.19**

agency.		
Estimate Minimum and maximum range of plastic waste untreated/at trenching ground/leakages	Minimum	Maximum

Table 14: Plastic leakage analysis during Festive Season of one month (July)

Matrix for estimation of plastic waste (MTPD) generation during festive season in the month of July in Haridwar city considering minimum and maximum range of 500-600 MT of additional waste generated during this period as mentioned in DPR, ISWM, 2009		
Particulars	**Estimated quantity of waste generation during festive season considering minimum range i.e 5000000 population mentioned in ISWM, 2009**	**Estimated quantity of waste generation during festive season considering minimum range i.e 600 MT mentioned in ISWM, 2009**
considering a factor of 100gm/day /capita waste generation by floating population during camping as mentioned in ISWM, 2009	500	600
50% of waste is considered as biodegradable as mentioned in ISWM, 2009	250	300
remaining waste	250	300
Considering 5.3% of plastic from the mixed waste as per the information received by the waste treatment agency.	13.25	15.9
Estimate Minimum and maximum range of plastic waste untreated/at trenching ground/leakages	Minimum	Maximum

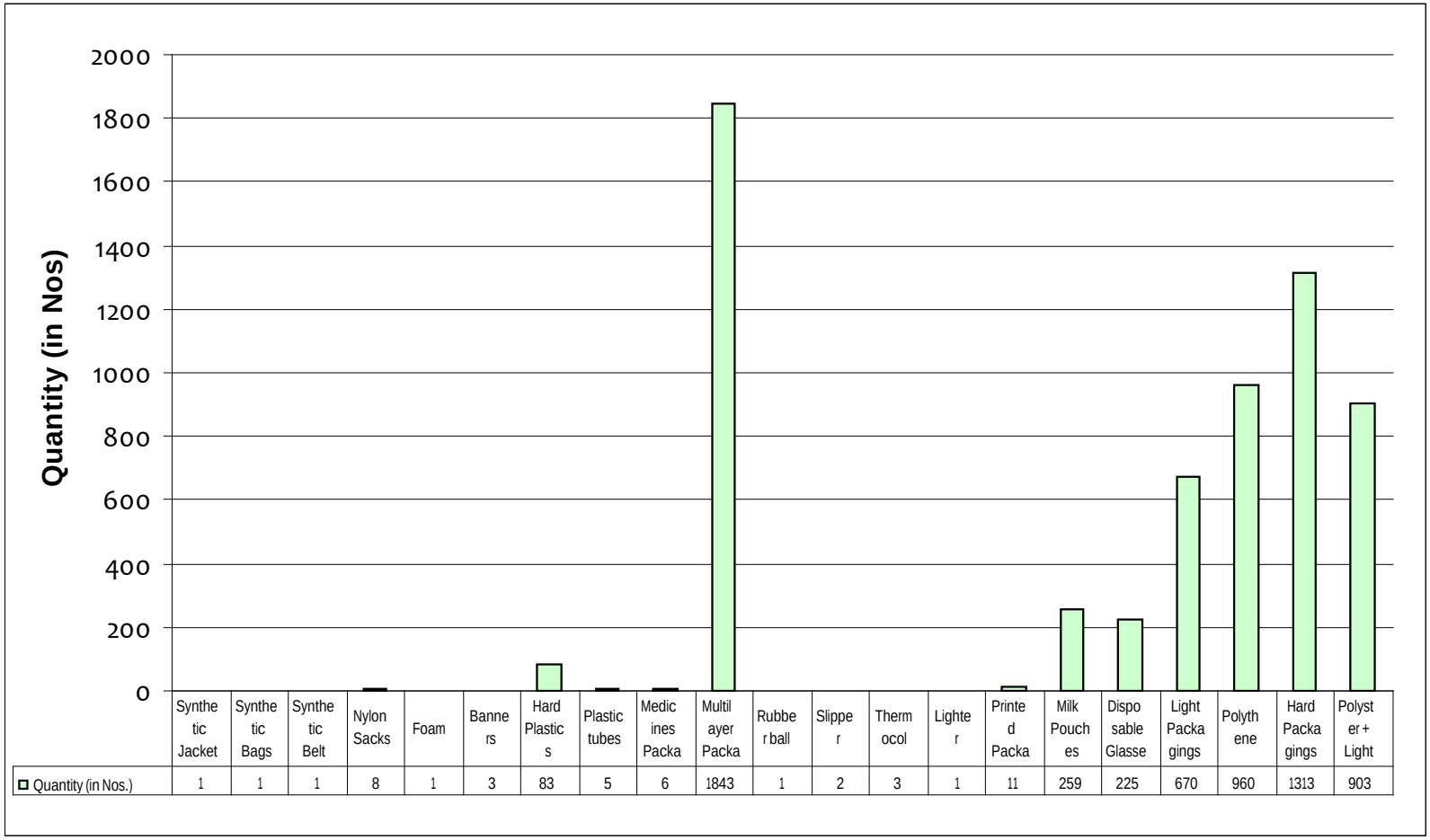
The total mixed waste generated in the month of July is in the range of **893.3 tons** (minimum) and (maximum) **1036.71 tons.** However the waste treatment capacity is 150 tons per day in Haridwar city. The remaining waste is dumped untreated at trenching ground near which may have a probability of leakages through various sources such as drains, open burning, artificial barriers, sacred waste/waste thrown by people into the canal/ghats/irrigation channel/river.

Table 13 and Table 14 indicate that an additional amount of plastic waste generation per day during festive season falls in the range of **13.25 tons (minimum)** and **15.9 tons**

(maximum). However the plastic waste generated during normal days falls in the range of 12.89 tons (minimum) and 15.9 tons (maximum). Therefore, the total mixed waste generated during the month of July (festive period) is in the range of **26.14 tons (minimum) and 31.09 tons (maximum) per day.**

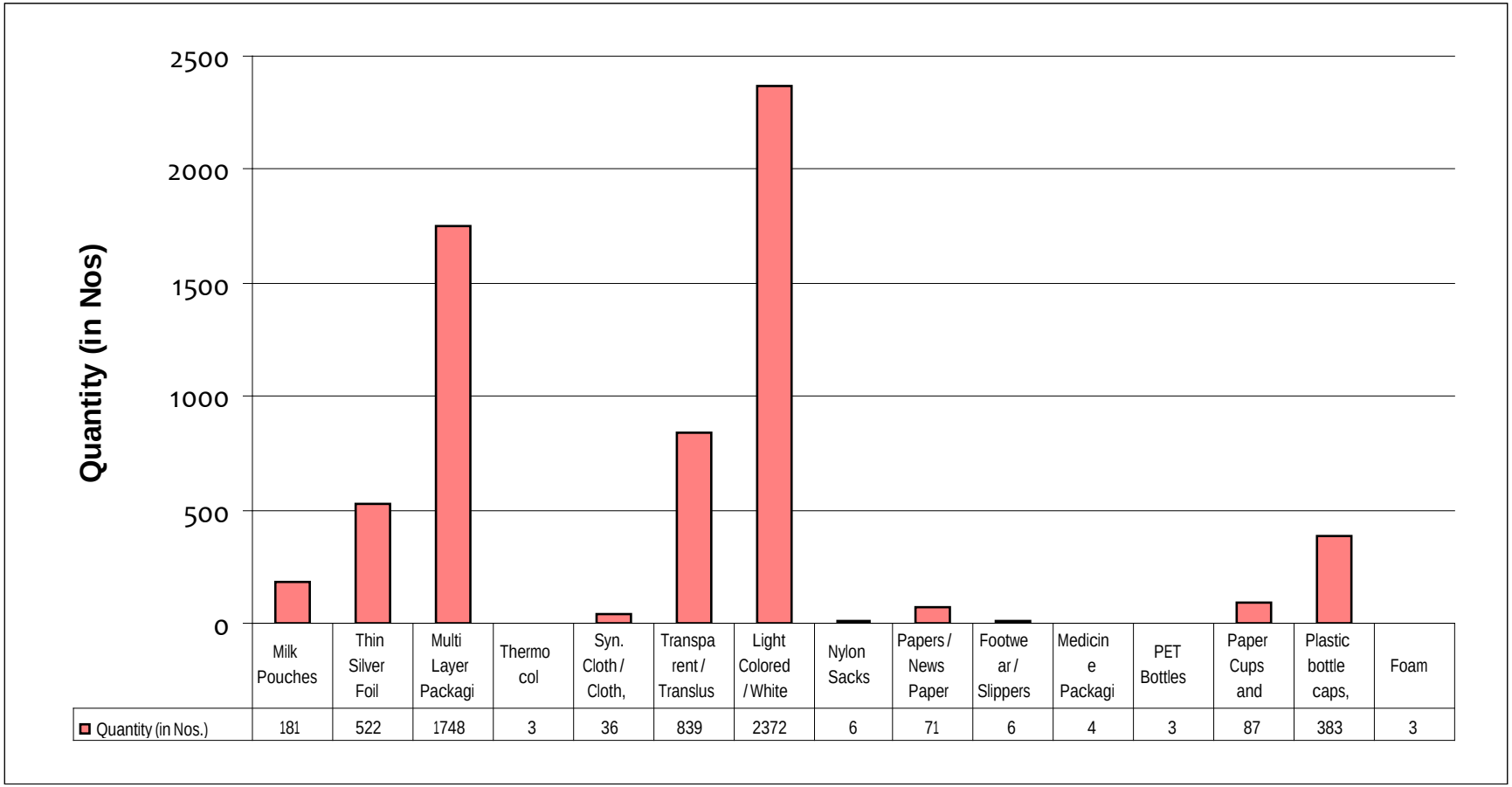
Types of plastics found in Haridwar city during carrying out Clean Up drive's

Types of plastics found in Clean Up - 1 near Vishnu Ghat Bridge, Haridwar, Utarakhand (nature of Plastic Waste segregated in this Clean Up in sample gunny bags assessed (08 bags)



Figures 9: Shows Types of Plastic Found in Clean Up Drives in Haridwar

Types of Plastics found in Pant Deep Parking, Haridwar



Figures 10: Shows Types of Plastic Found in Clean Up Drives in Haridwar

Snapshot of cleanup Drive carried out in Haridwar

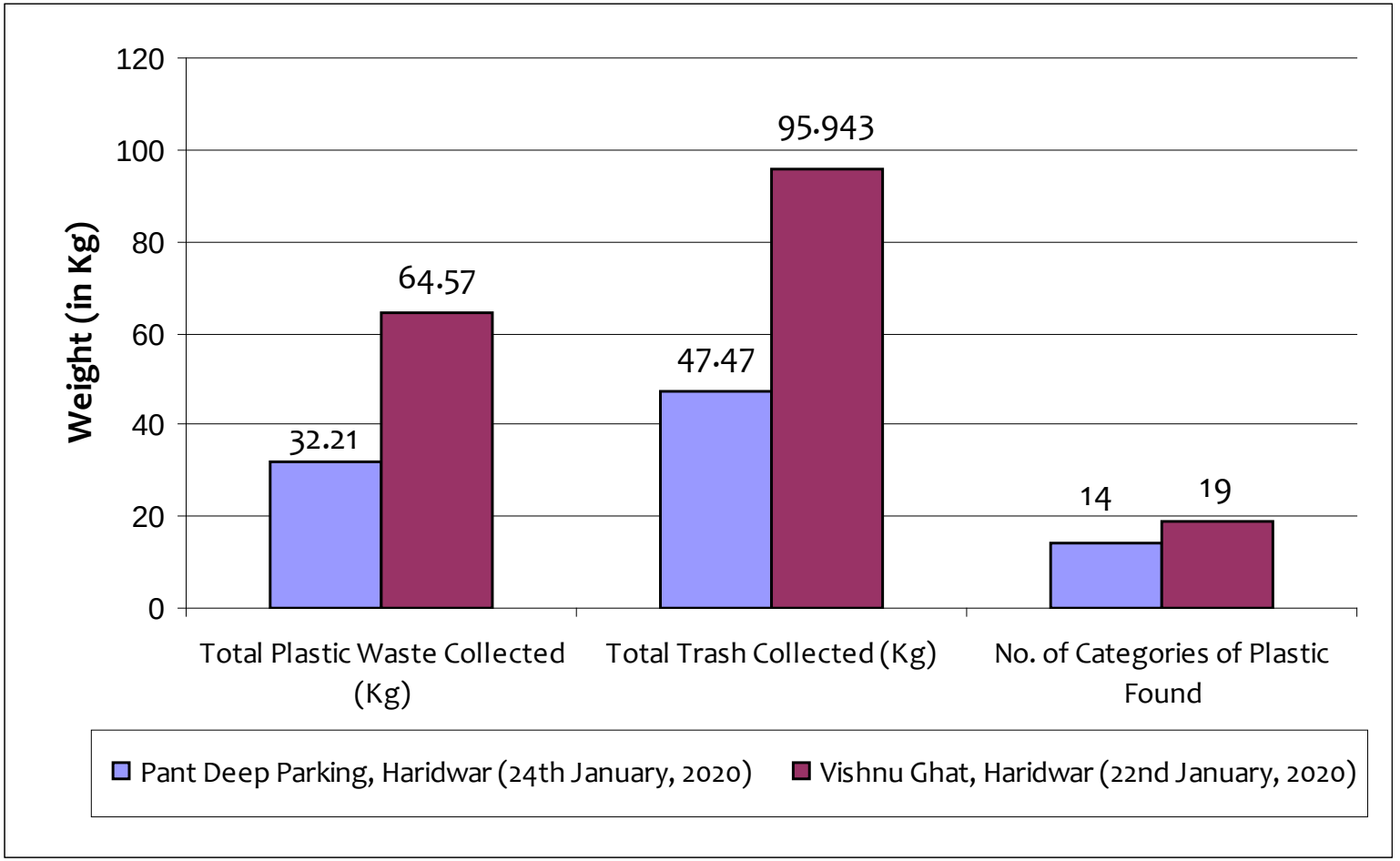
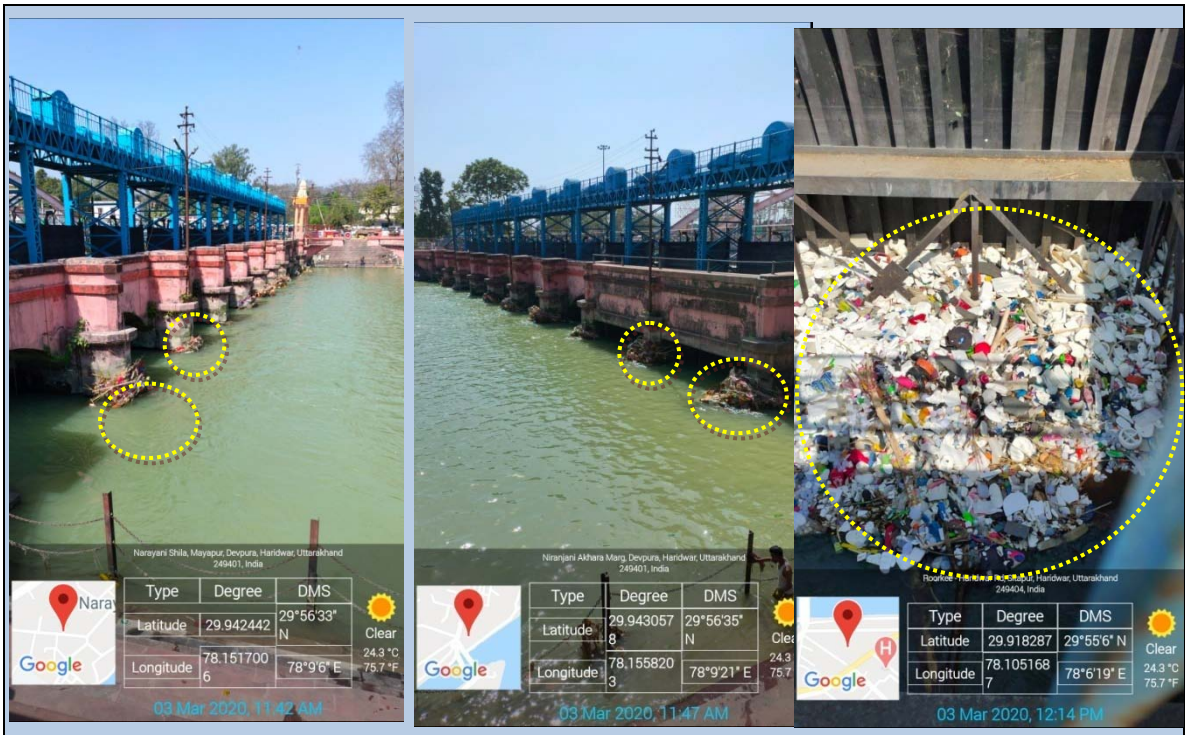
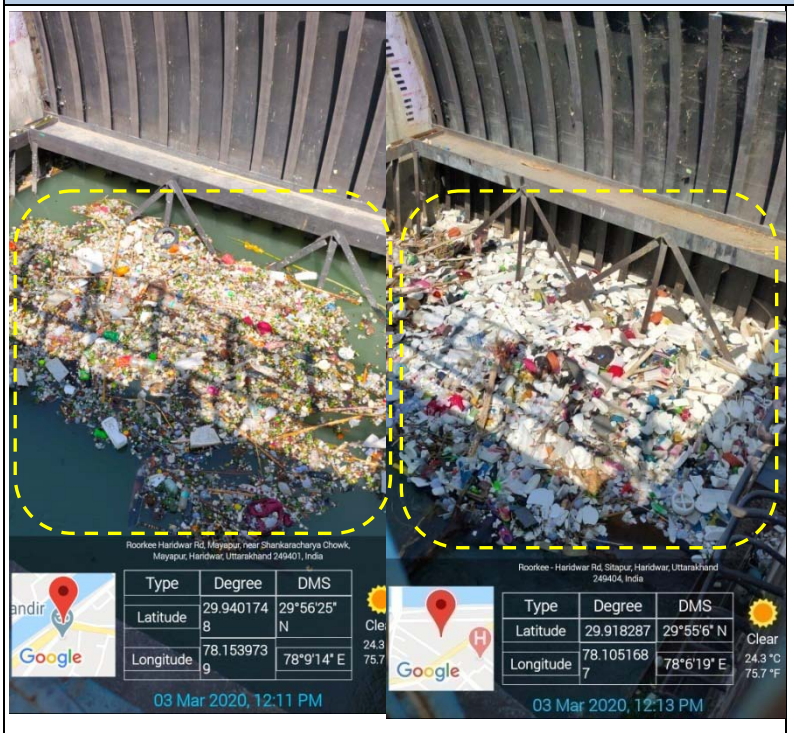


Figure 11: Shows Quantity of Plastic Collected in Clean Up drives in Haridwar

1.7 Leakages through barriers

Figures 12: Shows Leakage Through Barriers



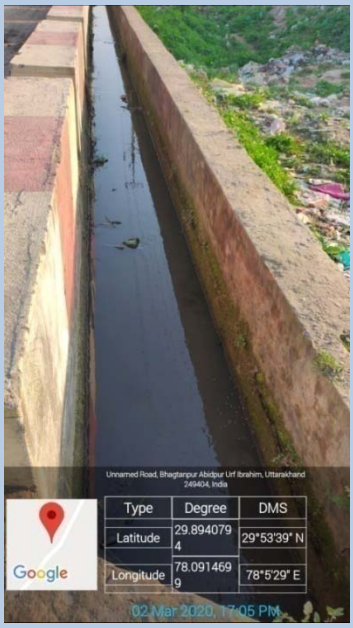


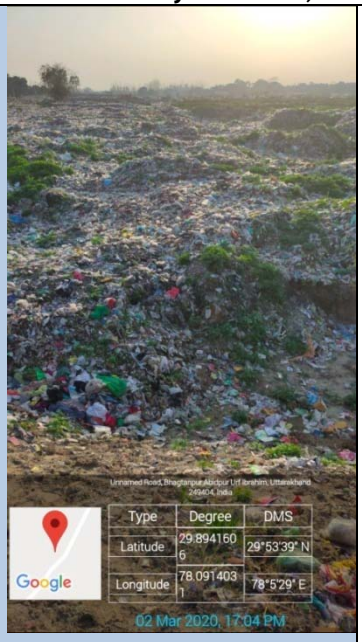
Huge waste was found stuck in the sluice valves at the barrage near Pul jatwada which is one of the source of plastic leakage in to the Ganga river. The waste comprises of thermocole, plastics, synthetic clothes, footwear etc.

Dead animal floated in the flowing water near the sluice valve of barrage at Pul Jatwada, Haridwar

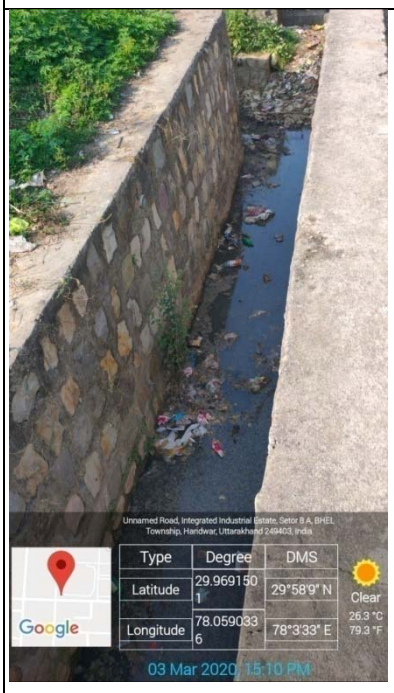
Also found one dead animal floated in the flowing water near sluice valve of the barrage at Pul jatwada, Haridwar.

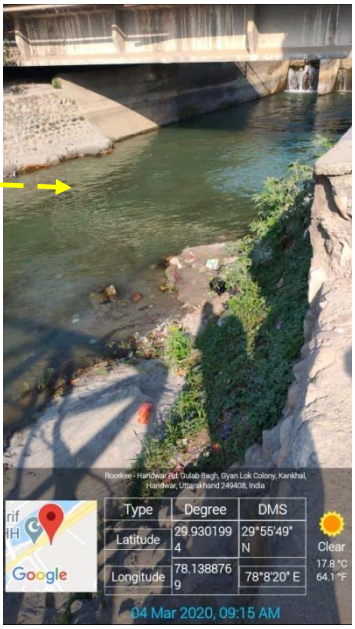
Figures 13: Shows Path Ways Barriers, Drains and Nala through open dump:





through drains



 	**through collection points/bins:** those collections ponits are situated near the canal/channel have possibility of leakage of waste in the the same.

`Plastic Leakages in Haridwar City within Municipal Boundary

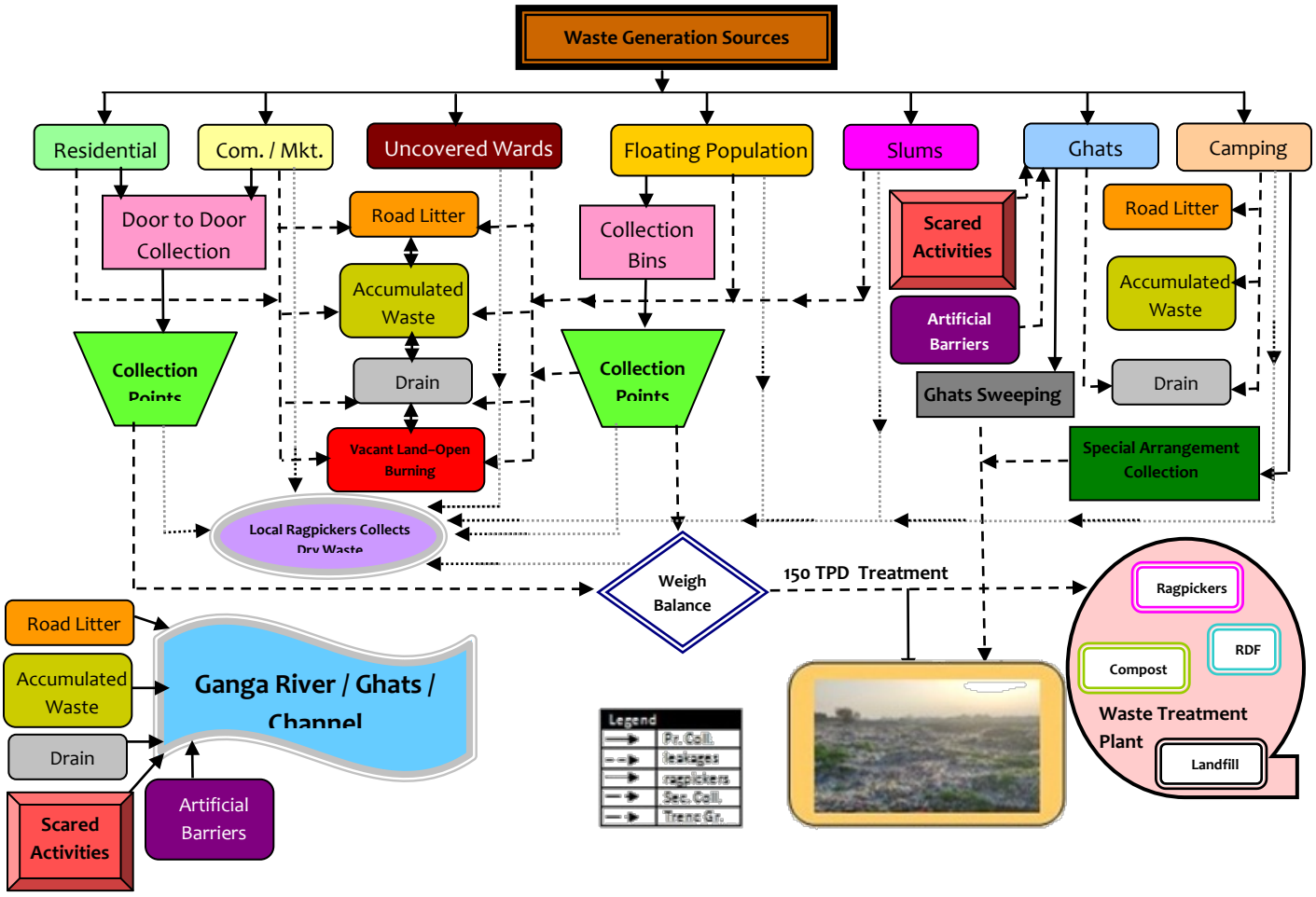


Figure 14: Flow Diagram of Plastic Waste Generation and Leakages

TABLE OF CONTENT

1.1Introduction **108**
1.1.1. Agra 108
1.1.2. Geographical and Climatic Condition 108
1.1.2.1. Climatic Condition 110
1.1.2.2. Demography & Administrative Set Up 110
1.2 LandUse **111**
1.3 Tourism in Agra **113**
1.4 Total Sold Waste Generation **113**
1.4.1 Section A: Secondary Data Analysis 113
1.4.2 Section B: Primary Data Analysis 114
1.4.3 Sector-wise Waste Generations 114
1.4.4 Household Waste 115
1.4.5 Slums 115
1.4.6 Market Waste 118
1.4.7 Commercial Waste 119
1.4.8 Industrial Waste 120
1.4.9 Street Sweeping 120
1.5 Municipal Solid waste Management in Agra **124**
1.5.1 Primary Collection of Waste 124
1.5.2 Secondary Collection of Waste 126
1.5.3 Secondary Storage 126
1.5.4 Transportation of Waste 127
1.5.5 Disposal of Waste 128
1.6 Identification of Hotspots **132**
1.7 Quantification of Total Plastic Waste Generation **137**
1.7.1 Section A - Secondary Data Analysis 137
1.7.2 Section B–Primary Data Analysis 138
1.8 Prominent Plastic Categories Observed During Cleanup Drives in Agra **143**
1.9 Plastic leakage Scenario in Agra city from sources **145**
1.10 Plastic Leakage into the Environment **148**
1.10.1 Road Littering 148
1.10.2 Secondary Storage Littering 151
1.10.3 Open Drains 153
1.10.4 Burning of Plastic Waste 154
1.10.5 Littering & Mismanagement of Waste in Slums 156
1.10.6 Open Drain Barriers 158
1.11 Plastic Leaking in the Riverine system **161**

PLASTIC LEAKAGE SCENARIO IN AGRA

1.1 Introduction

1.1.1 Agra

Agra city is of historic importance, which is amply evident from the numerous historical monuments in and around the city. Being centrally located on the national map, Agra forms an important regional urban centre and a prominent tourist destination of India. The Hindu epic Mahabharat are fersitto as "Agraban", part of Brajbhoomi, and the home land of Lord Krishna. The heritage of the city is linked with the Mughal dynasty but numerous other rulers also contributed to the rich past of this city. Agra was founded by Sikandar Lodhi in the 16th century. It grew into an important power centre and the Delhi sultan shifted his capital from Delhi to Agra 1504. Agra houses one of the '7 wonders of the World' i.e., Taj Mahal. Agra becomes all the more important due to its presence within municipal limits.

1.1.2 Geographical and Climatic Condition

Agra is geographically located at 27°12' North latitudes and 78°12' East longitudes. The city of Agra is situated on the Western Bank of river Yamuna at about 200 Kms from Delhi in the state of Uttar Pradesh. Being centrally located on the national map, Agra (akaAkbarabād) forms an important regional urban center and a prominent tourist destination in India. It is a Class I town, municipality and administrative head quarters of Agra District and falls under Agra division of Uttar Pradesh. Its borders touch Rajasthan to its west and south, the district of Firozabad to its East and the districts of Mathura and Etah to its North. The city also falls in the center of the four –culture areas-Braj, Bundelkhand, Rajputana and western U.P. Both these factors have played significant roles in shaping the life and history of the city **(Figure A1.1)**

Figure A1.1: Location of Agra in Uttar Pradesh

Agra has an extremely strategic location on the confluence of three distinct geo-physical regions namely the plain of Uttar Pradesh, the plateau of Madhya Pradesh and the desert of Rajasthan. It falls in Great Indo-Gangetic Plain region and its strata consist of mainly sandy soil. The ground water level varies generally 6 to 8m below ground level. The altitude varies from RL 150 m to 170m above mean sea level. The city stretches for about 9.0 kms along the Yamuna River. The contour and the major drainage pattern along with the river flow indicate west to east direction as shown in **Figure A1.2**.The major part of the city is on the Western side of Yamuna and has grown beyond the river on the eastern side and is called the Trans Yamuna area while the original part is called as CIS Yamuna.

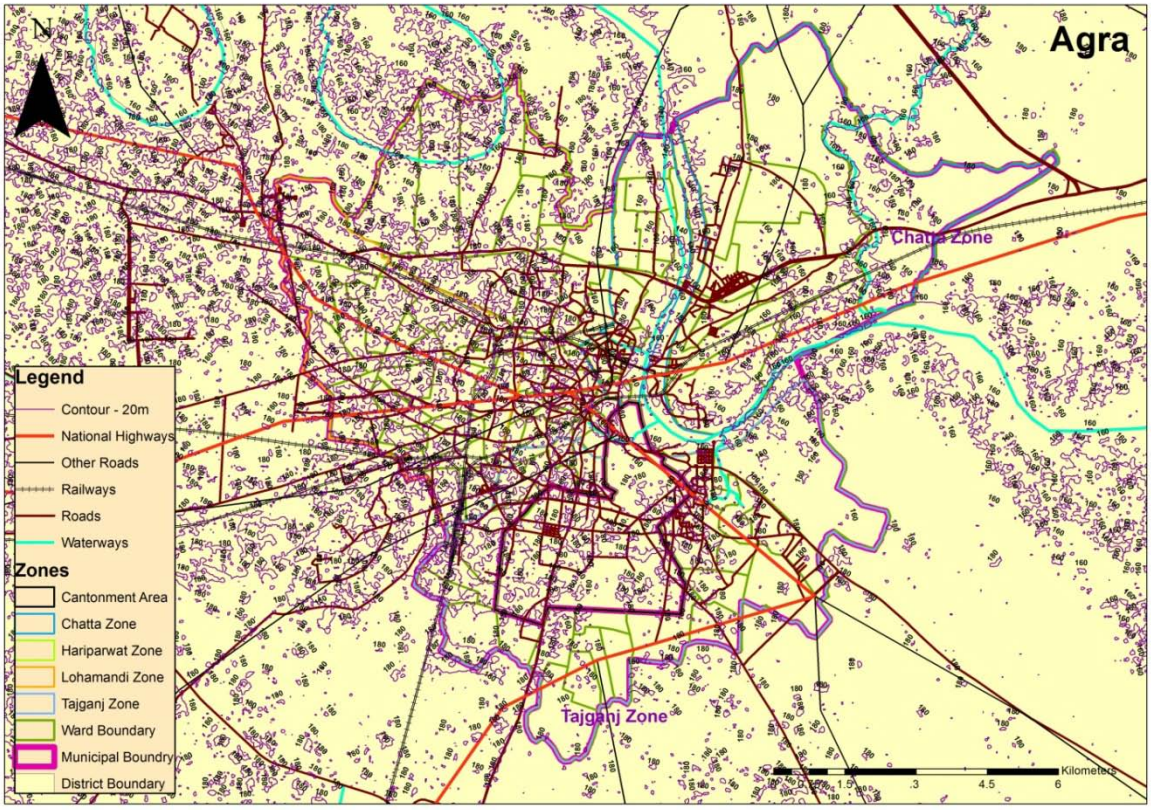


Figure A1.2: Drainage and Contour Pattern of the Agra City

Climatic Condition

The climate of Agra is extreme and tropical in nature. The temperature drops to 3°C in winter and rises to 47°C in summer. The city experiences three seasons, the summer, rainy and winter seasons. The summer season starts from April and ends in June, the rainy season starts from June and ends in September with an annual rainfall of 686mm while winter starts in November and last still February. Thick fog is experienced in December and January months of the year.

Demography & Administrative Set Up

Table A1.1 represents the city profile as per mentioned in DPR for Municipal Solid Waste Management scheme for Agra Nagar Nigam (ANN)(1).

Table A1.1: City Profile

S. No	Particulars	Quantities
1.	Total Area	126.15sq.km
2.	Population	1773408
3.	Floating Population	391037
4.	Population Density	12580 person/sqkm
5.	No. of household	264053

S. No	Particulars	Quantities
6.	Number of Ward	100
7.	Number of Zones	4

**Source-DPR Agra Nagar Nigam & Solid Waste Management Monitorable Action Plan, Agra NagarNigam, 2017(2)*

Demographic and administrative profile of the city is shown in **Figure A1.3.** It indicates that Hariparwat, Lohamandi, Cantonment and Tajganj zones on the western side of the river are densely populated while Chatta zone is an upcoming area. It also indicates that western part of the city is major centre of consumption as well as generator of municipal solid waste.

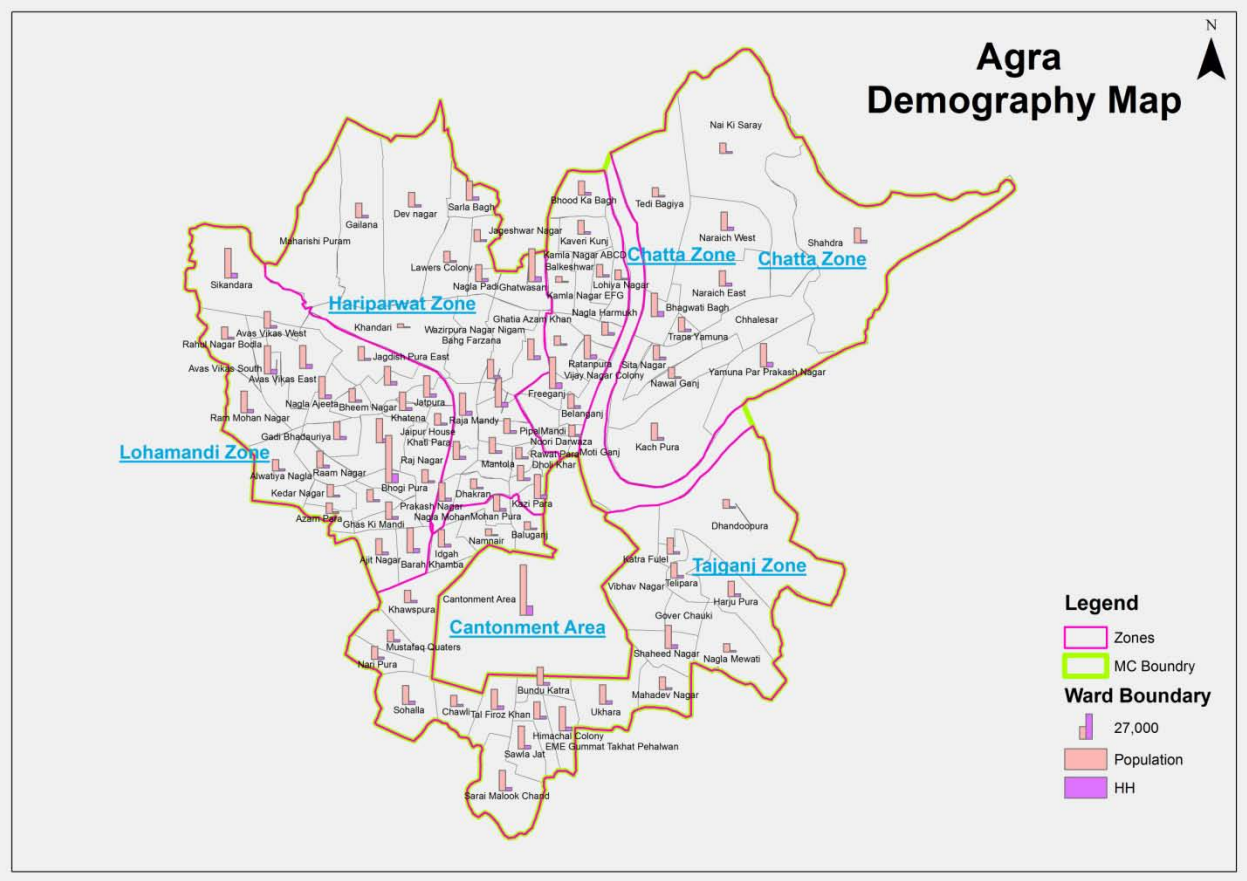


Figure A 1.3: Demographic and Administrative Profile of Agra City

1.2 Land Use

The first Master Plan of Agra was prepared for the plan period 1971-2001. In this Master Plan the land use was prepared for an area of 8360 Ha. The second Master Plan for a plan period of 2001-2021 stands approved and the land use break up is provided for an area of 20,036.97 Ha. This would be utilized for urban activities, including housing, commerce, industries, tourism, community services, transport, parks, amusement and entertainment

centres, parks and parking spaces. The breakup of land use in Agra City is described in **Table A1.2**and shown in **Figure A1.3**. About 50 per cent of area is for residential use and about 2percent for commercial use. Demographic pattern tally with land use pattern of the city with majority population residing in the western area. Land use patter also indicates that residential area generates bulk of solid waste within the municipal limits.

Table A1.2: Existing Land Use of Agra Development Area 2001

S. No.	Land use	Area in Hectare	Percentage
1	Residential	4866.34	61.84
2	Commercial	148.74	1.88
3	Wholesale Commercial	58.88	0.75
4	Community Facilities	842.62	10.66
5	Govt. and Commercial Office Space	177.93	2.25
6	Industrial	542.72	6.87
7	Open Space & Reservation	105.22	2.25
8	Historical Monuments	116.48	1.47
9	Traffic and Transportation	858.65	10.87
10	Crenulations/Burial Grounds	31.25	0.40
11	Nursery	24.09	0.30
12	Gardens	69.12	0.87
13	Sewage Farms	38.35	0.49
	Total	**7901.39**	**100.00**

Source-AgraMasterPlan-2021 (3)

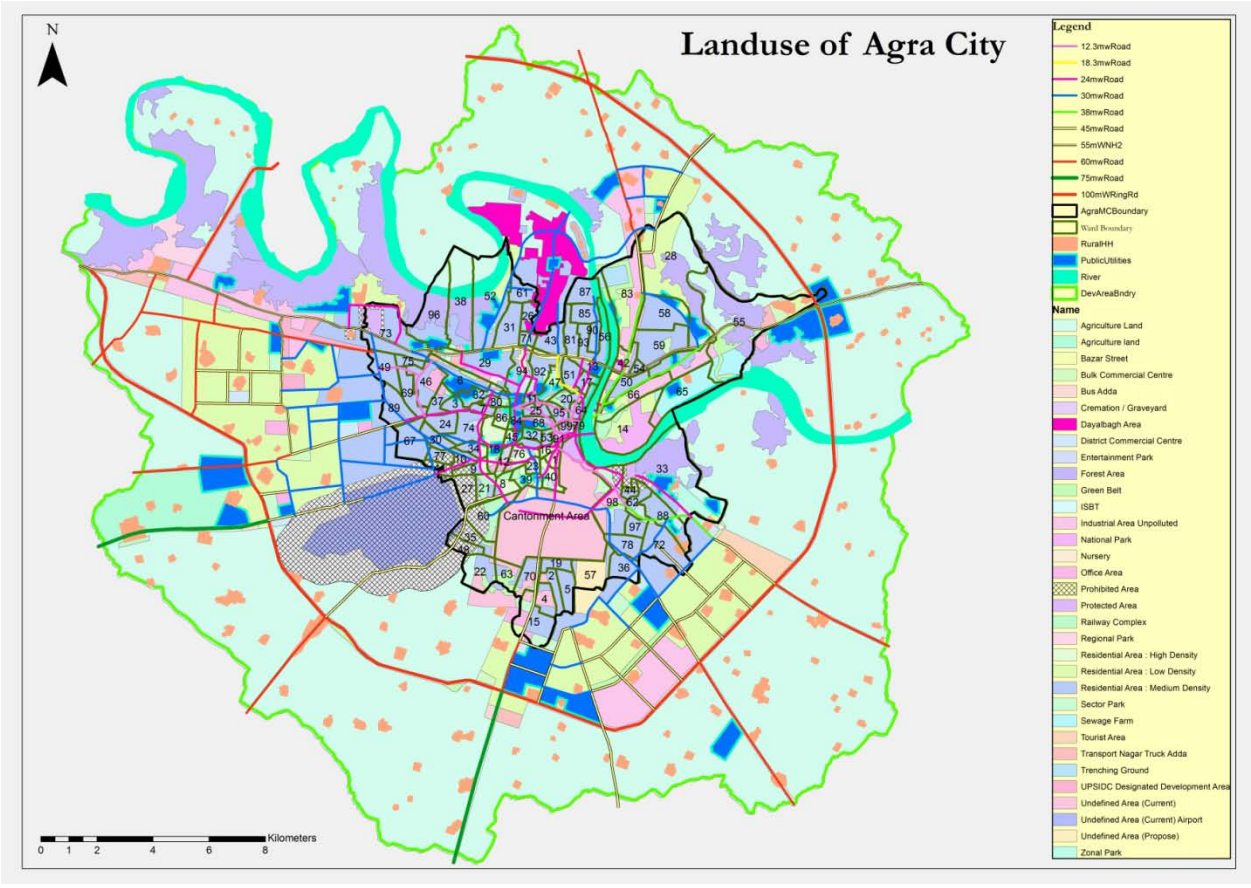


Figure A1.4: Land Use of Agra City

1.3 Tourism in Agra

Agra is one of the key tourist destinations attracting tourists from all over the world. The city forms one edge of the prime tourist circuit in India- the so-called Golden Triangle, the other two cities being Delhi and Jaipur. The city is rich in its art, heritage and culture, which are also reflected in its historical monuments. This makes the city as one of the most attractive tourist places of the country. The Agra city currently has three world heritage sites: the Taj Mahal, Agra Fort and Fatehpur Sikri. This entire area is called Taj Trapezium Zone (TTZ), 10,400 sq.km area around the monument where industrial and business activities are limited.

1.4 Total Sold Waste Generation

The growing population along with rising tourist inflow leads to higher consumption and waste generation in the city. Therefore, an attempt has been made to describe the solid waste generation and management in the city through secondary and primary data collection and field survey.

1.4.1 Section A: Secondary Data Analysis

The total solid waste generated in the city as per ANN is **824 metric tonnes per day** (4),translating to 550 grams per capita per day which is higher than the standard/norms prescribed in the Manual on Municipal Solid Waste Management; Ministry of Urban Development & Poverty Alleviation, Government of India (5). Another report, Solid Waste Management Monitorable Action Plan, Municipal Action plan of Agra 2017 states that 712 **metric tonnes per day** of solid waste is generated in Agra (6).

As per DPR for SWM Scheme for Agra, 2017(2), the per capita waste generated in different zone of Agra Nagar Nigam ranges from **368.5 to 452.28 gms** excluding drain silt.

The solid waste generation and projections from 2020 to 2045 has been presented in **Table A1.3** (4). It is expected to increase from 1348 tonne per day to 1556 tonne per day with an average annual growth rate of about 1%.

Table A1.3: Solid Waste Generation Corresponding to Projected Populations

Year	2020	2025	2030	2035	2040	2045
Projected Population (In millions)	1.460	1.541	3.182	3.259	3.378	3.460
Growth Rate (in percentage)	3.13	2.42	3.65	2.42	3.65	2.42
Solid Waste Generation (metric tonne)	1348.68	1381.34	1431.82	1466.50	1520.09	1556.90

1.4.2 Section B: Primary Data Analysis

The primary data from Agra Nagar Nigam indicates that the total municipal solid waste generation in the city are about 850-870 metric tonnes **per day.** This is based on per capita generation of 400 gm with collection efficiency 91 %. Therefore, an average value of ***~866* metric tonnes per day** of municipal solid waste has been considered to know about the plastic leakage scenario in Agra.

1.4.3 Sector-wise Waste Generations

In Agra municipal area, some of the specified locations with particular waste collections include residential areas, institutional/community areas, vegetable markets (retail wholesale), hotels and restaurants, commercial areas, hospitals and dispensaries, domestic/stray animals/dairies, industries, historical place and also street cleansing materials. There are four different sources of the waste generation consisting of household, market, commercial and industrial areas in the city as described in **Table A1.4** and depicted in **Figure A1.5**

Table A1.4 Estimated projection of solid waste in different sources as DPR of Agra Nagar Nigam 2017 (2)

Particulars	Quantity TPD	Total Waste (%)	Typical Waste Generators
Total Solid Waste	866	100 %	-
Household Waste	597.54	69%	High Income Group, Low Income Group / Slums
Market Waste	34.64	4%	Vegetable Market, Meat & Fish Shop, Bakery & Sweet Shop, Juice Shop
Commercial Waste	216.5	25%	Restaurant, Hotel, Office, School & Educational Institute
Industrial Waste	17.3	2%	Factory, Workshop & Kabadi Shop

*Source: DPR Agra Nagar Nigam & Solid Waste Management Monitorable Action Plan, Agra Nagar Nigam (2)

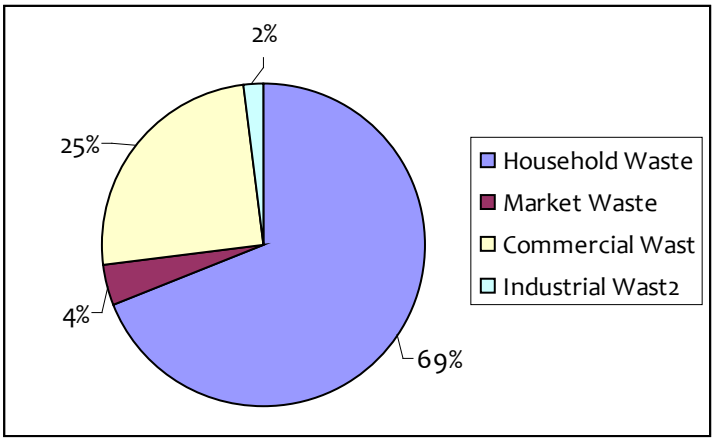


Figure A1.5: Percentage of Different Sources in Total Waste Generation in Agra City

1.4.4 Household Waste

Household waste constitutes 69 % of the total waste generation in the city. The household waste is generated from a number of sources which include household (kitchen and yard) as well as items of daily consumption e.g. plastics. Generally, household waste constitutes Black Polythene, Single Use Plastic Carry Bags, Maggie Pouches and ingle Use Plastic carry bags etc. In household segment door to door collection coverage is about 91 %. A pictorial representation of door to door collection is shown in Figure A1.6. Figure A1.6 indicates that door to door collected waste from household includes clear white plastics, black plastics, disposable plates, beverages bottle, chips packet, single use plastics carry bags etc.

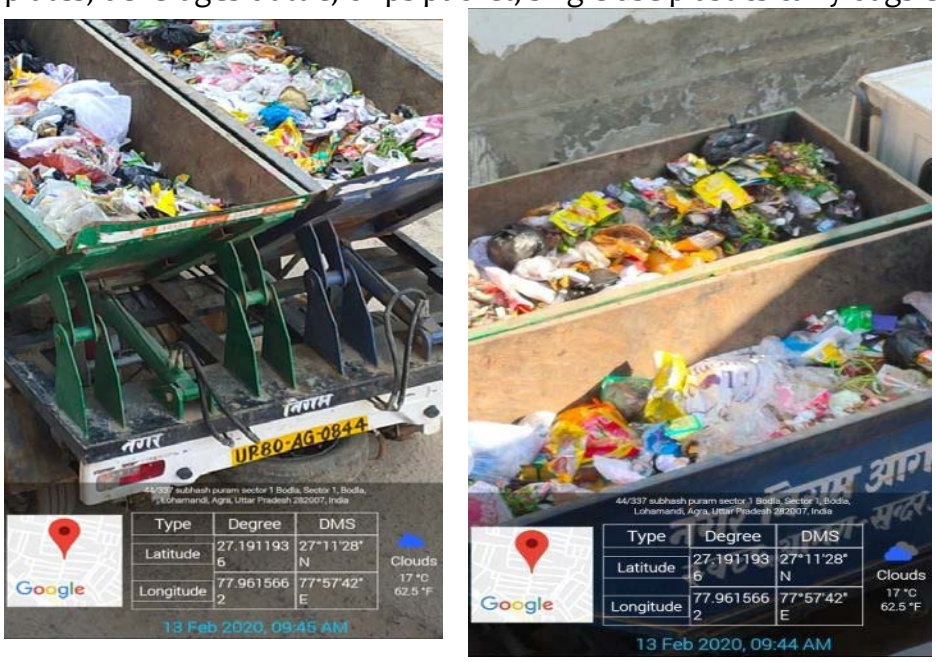


Figure A1.6 Depicts the Door to Door Collection of Household Waste.

Source-NPC team

1.4.5 Slums

Economic level plays a vital role in generation of household plastic waste. **The city has 417 slums constituting about 56% of the city population.** Three socio economic levels, which have been identified, are given below.

1. High Income Group
2. Middle Income Group
3. Low Income Group or Slum

The low income group and slum households have an annual income of Rs. 60,000 per annum. The socio-economic and slum map of Agra is shown in **Figure A1.7**. Mainly in high

income group & middle income group, waste generation is high as compared to slums due to reduced purchasing power. Per capita waste generation in slum is approximately 0.3 kg/capita. Though waste generation is low in slums, it's littering and mismanagement is rampant (**Figure A1.8**). **Figure A1.8** also indicates the littering of waste into drainage and banks of water bodies. Slums which are in close vicinity of the river are more likely to contribute to the plastic pollution. The primary data analysis indicates that only 2 to 3 % waste is collected from the slum. Therefore, the drainage and water bodies serve as carrier to the river. **Table A1.5** represents the demographic detail & total household waste generation, with respect to slum establishment.

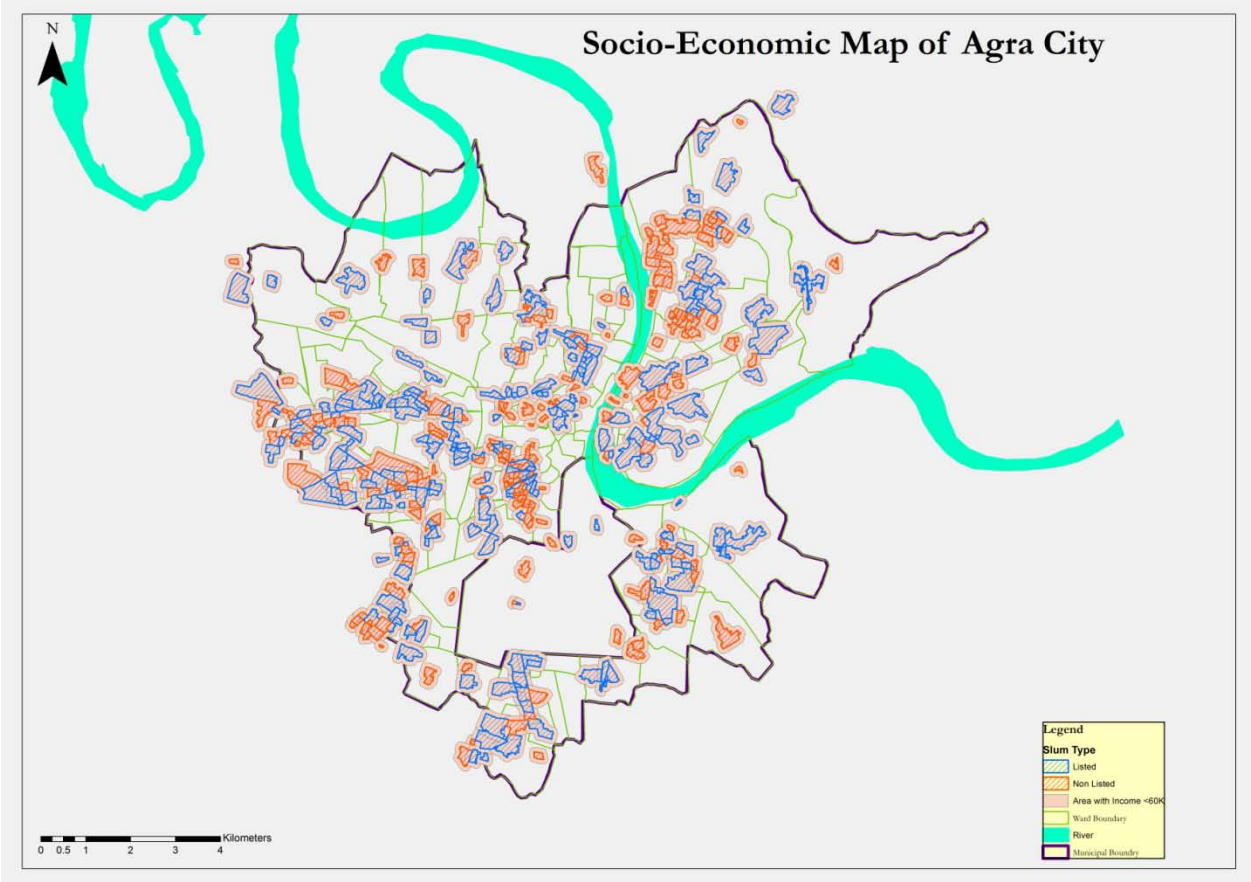
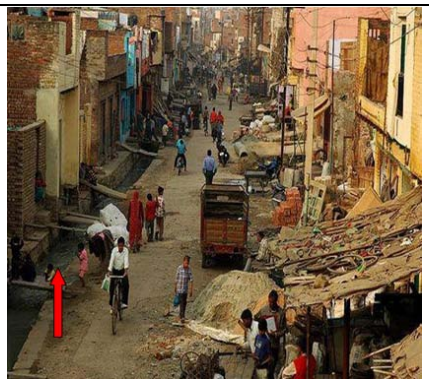


Figure A1.7: Socio Economic and Slum Map of Agra

Table A1.5: Estimated slum population as per primary data

S. No	Particulars	Quantity	Remarks
1.	Slums	417slums	About 56% of the city population lives in slums (2).
2.	Number of household with slum	123846	
3.	Slum Population	495384	Assuming 4-6 per person lives in a single household and total population is estimated as number of household (2).
4.	Slums Waste generation	148 TPD *only 2 to 3% waste is	Total waste generation is estimated as total population* 300 gm waste generation per person (2).

S. No	Particulars	Quantity	Remarks
		collected from the slum as per primary data	



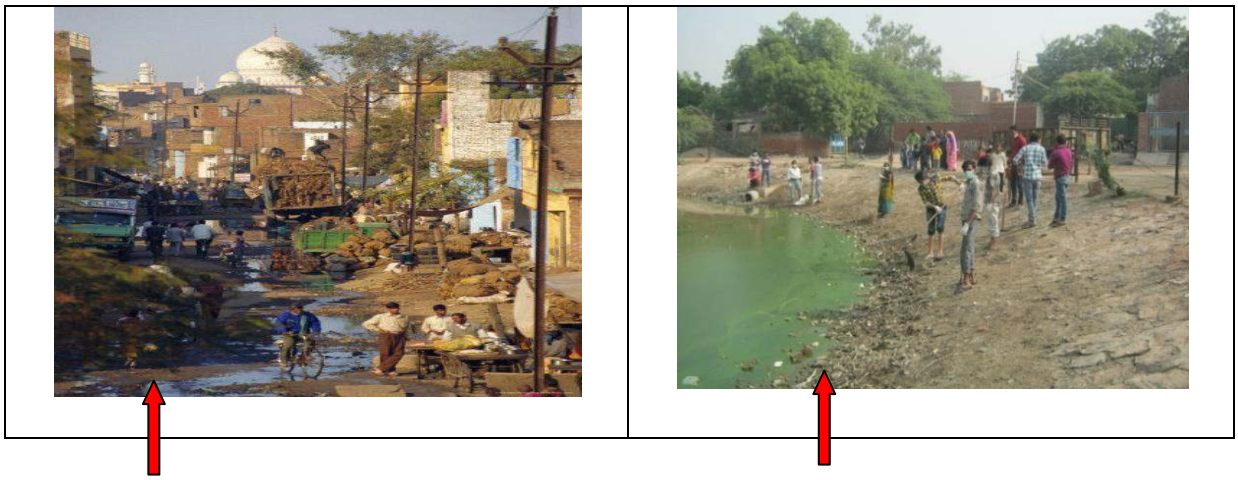


Figure A1.8: Slum Condition in Agra
Source: Agra Nagar Nigam

1.4.6 Market Waste

Market waste constitutes 4% of the total waste generation in Agra city. Typically, waste generator constitutes vegetable market, eatry shops, bakery & confectionary shops etc. Generally, market waste constitute disposable cups & plate, plastic straw, white plastic carry bags, chips & confectionery packet, milk pouches etc. **Figure A1.9** represents waste collection from and vegetable market.

Figure A1.9: Waste Collection from Market Waste

Source: Agra Nagar Nigam

1.4.7 Commercial Waste

Commercial waste constitutes 25 % of the total waste generation in Agra city. Typical waste generator in commercial area consists of restaurant, hotel/lodge/guest house, dharmshala, marriage hall, marriage hall, office, school & educational institutes with hostel etc. **Figure A1.10** and **Figure A1.11**represent waste generated from the commercial area. Post-consumer product has a high fraction in commercial Waste. **Figure A1.11** represent post-consumer product such as detergent bottles, beverage bottles, cleansing product bottle etc.

Figure A1.10: Waste from commercial waste such as plastic wrapper, pen wrapper made from clear plastic etc	Figure A1.11: Post consumer product such as used detergent bottles, beverage bottles, cleansing product bottle

Source: http://iwma.ie/commercial- waste/

1.4.8 Industrial Waste

Industrial Waste contributes 2% to the total waste generation and includes mainly, plastic waste, textile rejects, footwear rejects, foams, tobacco sachets etc and represent in **Figure A1.12.** There are various small scale and cottage industries in Agra city. Based on field observations made by the team about these industries, the plastic waste is primarily generated from Petha (local sweet) and Footwear unit. Petha units are mostly located at Noori Darwaza and Raja Mandi. Thin white plastic covers are used for covering Petha boxes that are littered in significant amount after single use and thrown in drain (nallah) and nearby secondary collection points. The synthetic leather and rubber trimming from footwear industry also accounted for the plastic pollution. Waste from Large leather and Rubber industry is not prominent but job works done by individuals for larger establishment at cottage level do not practice recycling rather throw waste in open areas or drains (nallahs). It was also observed that accumulated waste at open dump or dustbins was burnt in order to reduce the volume when it remains unattended for several days.

Figure A1.12: Littering of Industrial Waste such as Packaging Material, Cardboard etc
Source: NPC team

1.4.9 Street Sweeping

Street cleaning is one of the fundamental services rendered by municipal authorities in India which ensures clean and hygienic urban conditions. Around 84 MT/day of mixed waste is generated from street sweeping as per DPR, Agra Nagar Nigam. It also includes tobacco sachets, plastic bottles and chips packets. Until recently, all domestic and trade waste was being discharged on the streets or in street bins, and street sweeping was the principal method of waste collection. With the introduction of door to- door

collection systems in many urban areas, there is a sizeable reduction in the quantity of waste littering on the streets. Further, a change in composition of street sweeping waste has also been observed. However, inefficient waste collection systems coupled with public littering significantly contribute to waste piles in streets. **Figure A1.13** shows the street sweeping by manual and mechanized methods and collected waste.

Manual sweeping is commonly practiced in India, as many streets are congested and narrow road conditions are not conducive for mechanical sweeping. A wide variety of tools and equipment are available for manual and mechanical sweeping as are as following:-

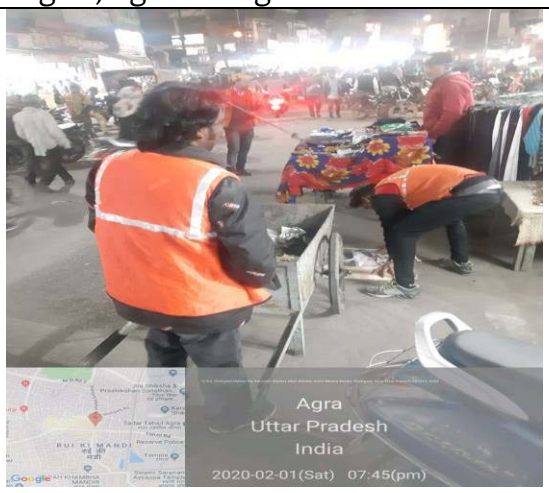
- Long handled broom
- Metal tray and metal plate
- Containerized handcart or tricycle
- Secondary storage bin
- Dumper placer or compactor
- Mechanical street sweeper
- Container lifting device

As per ANN, there are about 1402 sweeping staff covering about 1967 Km of road length out of which length of minor road is 1508.3 Km, length of major road is 253.56 Km whereas length of dual carriage and highway is 205.10 Km. Street sweepings including solid waste and silt from the drains is required to be collected by containerized handcarts and shall be transported separately through existing tractor and trolley mechanism.

The coverage of street cleaning in Agra is mainly done with special focus on busy centres, markets, and tourist spots as under:-

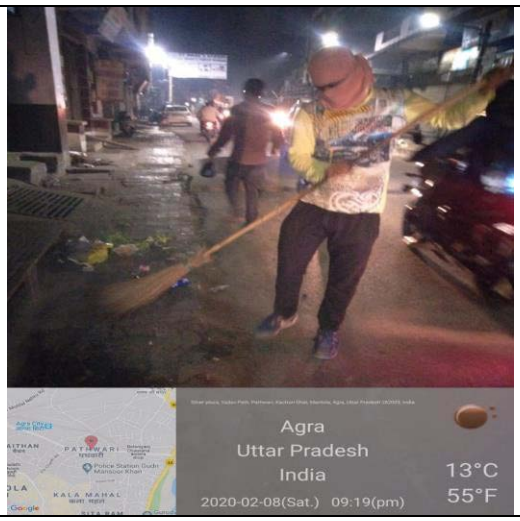
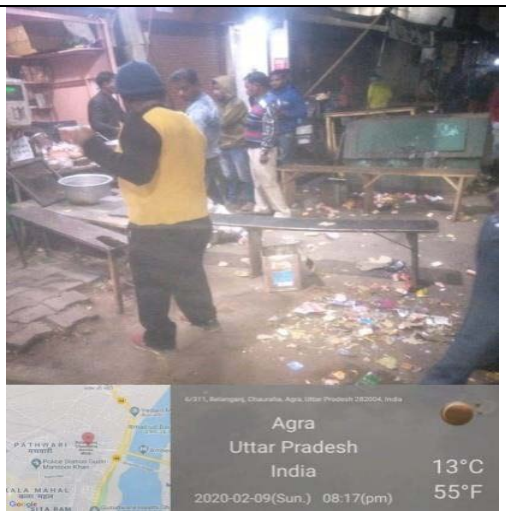
- Parks & open spaces
- City Centres - commercial area & markets
- Bus terminals 3 Nos.
- Roads around Railway stations

100 Ft Road, Krishna Bag Colony, Tedi Baghia, Agra through RCV Vehicle



Street Sweeping at Shahganj, Agra

Figure A1.13: Street Sweeping by Agra Nagar Nigam
Source: Agra Nagar Nigam

<table>
<tr><td> 
</td><td> 
</td></tr>
<tr><td>Street Sweeping at Silver Plaza, Kachori Ghat</td><td>Waste such tobacco sachets found during street sweeping at Belan Ganj, Agra</td></tr>
<tr><td colspan="2">  </td></tr>
<tr><td colspan="2">Waste collected during street sweeping at Ghatiya Market, Agra such as plastic bottles, chip Packets etc.</td></tr>
<tr><td> 
</td><td> 
</td></tr>
<tr><td colspan="2">Waste collected during street sweeping at Ghatiya Market, Agra such as plastic bottles, Chips packets & tobacco sachets etc.</td></tr>
</table>

1.5 Municipal Solid waste Management in Agra

ANN has more than 1.7 million people living within its municipal limits. As in any other city, solid waste management (SWM) in Agra also functions on the three major pillars viz., Collection, Transportation, Processing and Disposal. Collection and transportation system include primary and secondary collection and transportation system supported by secondary storage. Processing and disposal system includes decentralized, centralized processing as well as disposal in existing sanitary landfill facility. The existing solid waste management system is shown in **Figure A1.14, Figure A1.15, Figure A1.16** and **Figure A1.17** while each of the components is described below.

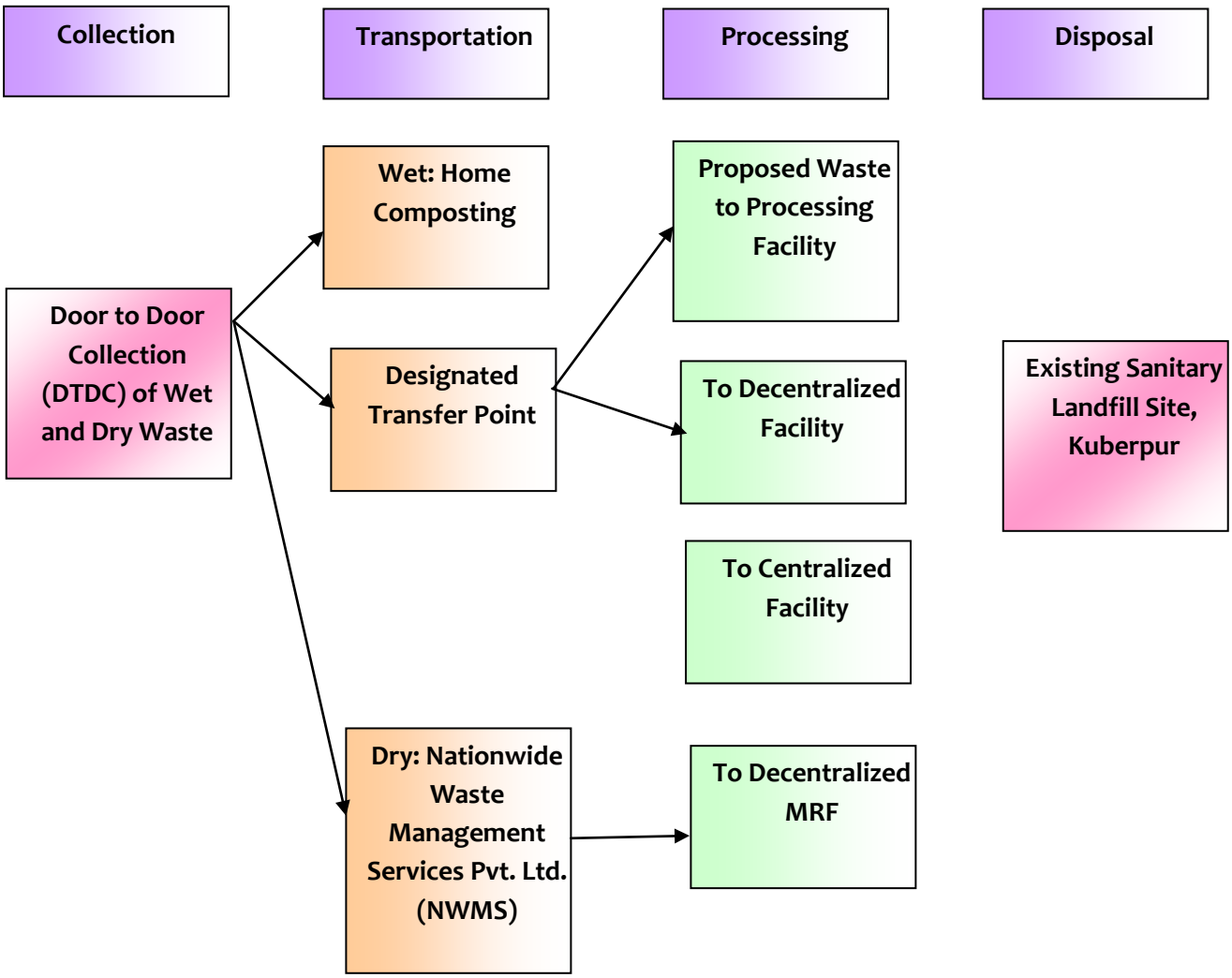


Figure A1.14: Flow Chart of Solid Waste Management in Agra
Source: NPC team, Primary Data

1.5.1 Primary Collection of Waste

- Door to door collection in all wards of city

- Community participation on cost recovery basis
- Minimize the multiple handling of waste
- Improvement in the productivity of labor and equipment.
- Primary Collection is done by mainly door to door collection and community bin system
- Primary Collection is done by DTDC agencies.

Photoplate A1.6: Door to door Collection waste

Figure A1.15: Door to door segregation
Source: Agra Nagar Nigam

1.5.2 Secondary Collection of Waste

- Street sweepings including solid waste and silt from the drains to be collected by containerized handcarts, which are transported separately through existing tractor.
- Containers to be lifted by RCV directly and DP vehicles.
- Street sweeping staff of ANN is responsible for collection of inerts by day and night sweeping of commercial areas and all the streets of the city. Inerts are collected in the1.1 m3 bins strategically placed on roadside.

Figure A1.16-Street sweeping done by RCV directly and DP vehicles
Source: Agra Nagar Nigam

1.5.3 Secondary Storage

It means collection of waste from community bins, storage points or transfer station, and transportation to the final disposal site. The waste is stored in Secondary storages bins/ Dhalao ghars by the DTDC agencies, from where it becomes the responsibility of ANN to transport it further. Further, ANN plans to phase out the containerized secondary storage facilities in time bound manner to make city bin free.

In Agra, there are 4 Transfer and collection stations as described below.

a. ISBT Transfer Point–Spaak Global, Om Motors & Constructions, SRMT
b. Four Point Hotel Transfer Point–Arva Associates
c. Kalindi Plaza Transfer Point–Spaak Global
d. Indian Oil Building, Near Ruikim and ifatak Transfer Point –SEWA

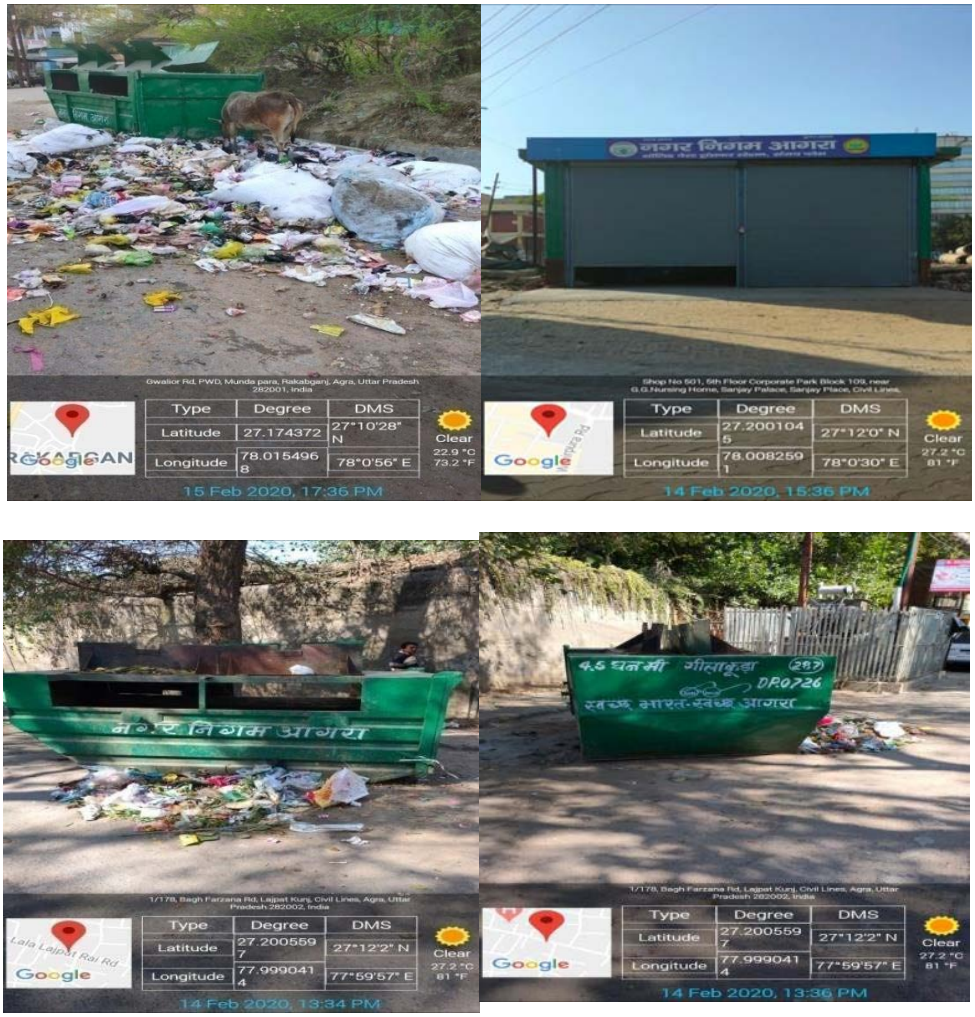


Figure A1.17: Community Bin System/Secondary Storage

1.5.4 Transportation of Waste

Transportation of waste is carried out by ANN and Nationwide Waste Management Services Pvt. Ltd. (NWMS). Transportation includes daily transportation of segregated waste to the transfer station/treatment site. Separate transportation of domestic waste, commercial and institutional waste and sweeping silt is carried out through the fleet dedicated for particular waste stream. NWMS is only transportation of Dry waste up to their Material Recovery Facility (MRF) at Rambagh- Tedhi bagiya, Agra after receiving the dry waste from DTDC agencies. Radio Frequency Identification (RFID) technology is being used more and more as a way to track containers and verify service. Transportation of waste is done by two ways:–

1. **Primary Transportation**

   Small vehicles of up to 2 m^3 capacity is used to transfer waste unloaded by Private/ Government Waste Collection Agencies (such as DTDC Agencies & Road Sweepers) at the Dhalao ghars/Bins to Secondary Transfer Stations from where the larger vehicles of ANN take it to Kuberpur Scientific Landfill Site**(Figure A1.18).**

Figure A1.18- Primary Transportation of Waste to Transfer Station

2. Secondary Transportation

Vehicles of capacity higher than 2 m^3 are used for secondary transportation of waste. These shall be responsible for transfer of Wet and Inert Waste from respective Transfer points to the place of processing.

Figure A1.19-Transfer of Waste from Transfer Point to Disposal Site

1.5.5 Disposal of Waste

Agra is generating more than 800 tons/day (TPD) of municipal solid waste (MSW), which is mainly disposed off in the open dumpsite located at Kuberpur. Kuberpur site having total area of 75 Acres was planned as an Integrated Waste Processing cum Sanitary Landfill site. The capacity of 750 TPD waste processing plant was installed for processing of incoming waste, whereas a small Sanitary landfill covering an area of 15,000 Sqm was developed to fill the residual inert coming from processing plant. Kuberpur site became operational for use in December 2011. However, in 2013 the concessionaire stopped operating Processing Plant and thereafter mixed waste dumping started at this site. As of now, approximately 30Acres of area is covered with unprocessed waste with a dumping height ranging from 5meters to 20 meters. The accumulated waste in this dumpsite is estimated to be about 0.8 million MT. This site is still operating and receiving waste from entire jurisdiction of Agra Nagar Nigam. The waste is being deposited randomly without any compaction and pollution prevention measures. (7)

A team, of officials from Central Pollution Control Board (CPCB), Regional Directorate Lucknow, Regional Office, Uttar Pradesh Pollution Control Board (UPPCB), Agra, UP Jal Nigam & Agra Nagar Nigam visited and inspected the Municipal Solid Waste Treatment, Storage & Disposal Facility (MSWTSDF) at Kuberpur, Agra U.P. on 4th August 2019. During the visit the team observed that Kuberpur, Agra dumpsite does not have any treatment facility available for municipal solid Waste. As reported, average 700 to 750 tons mixed MSW is being dumped at the site on daily basis (8). During the field study, it was informed that presently around 22 % of plastic waste was found in mixed waste that is dumped at the site. Heaps of mixed plastic waste including color plastic polythene bags were found at Kuberpur dump site **(Figure A1.20)**

(a) Heaps of Mixed Plastic Waste at Kuberpur Dumpsite

(b) Mixed Plastic Waste, Multilayered Plastic was at Kuberpur Dumpsite

(c) During Visit still Mixed Waste is Dumped at Kuberpur Dump site

(d) During Visit still Mixed Waste is Dumped at Kuberpur Dump site

Figure A1.20 (a) (b) (c) (d): Condition of Kuberpur landfill site

Source: NPC Team

1.6 Identification of Hotspots

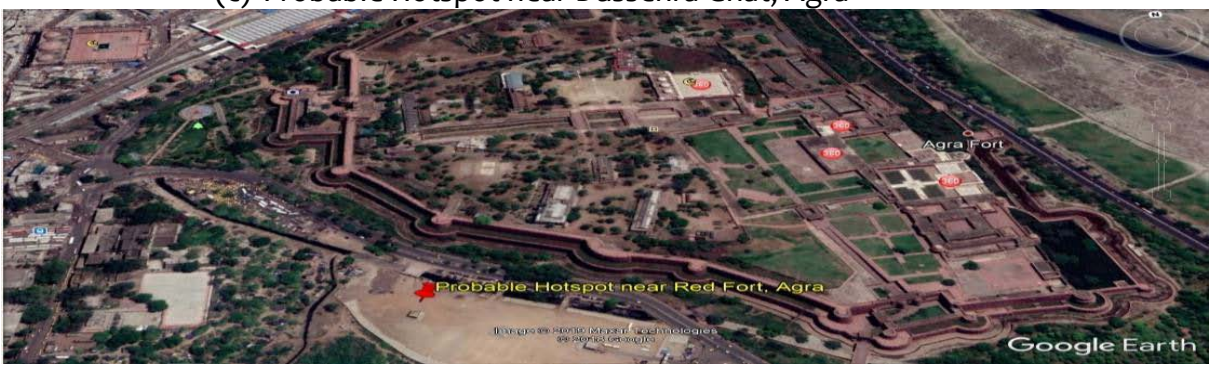
A two way approach was adopted to identify the hotspots for plastic leakage. At first, field survey was carried out. During the field study at Agra, littering of solid waste comprising majority of plastic waste was observed in abundance. This was followed by discussion with ANN on 7th November 2019. A number of hotspots which have been identified and photo documented based on field survey and discussion with ANN are given below and photo documented in **Figure A1.21, Figure A1.22** and **Figure A1.23.**

1. Kailash Ghat
2. Balkeshwar ghat near Balkeshwar temple
3. Hathi Ghat (Balkeshwar Temple)-Clean Up Done
4. Dussehra ghat (Backsideof TajMahal)
5. Just opposite to Agra fort Zhalkari Bai statue Chowk
6. Across the river and across Shamsan left to Mehtab Bagh
7. Cross the Ambedakar Bridge statue (Eitmadullah Tomb just near to Rambagh)
8. Pohiya Ghat

(a) Hotspot in Agra City

(b) Probable Hotspot near Balkeshwar Ghat, Agra

(c) Probable Hotspot near Dussehra Ghat, Agra



(d) Probable Hotspot near Red Fort Agra

(e) Probable Hotspot near Shamshann Telganj, Agra

(f) Probable hotspot near Kailash Ghat, Agra

Figure A1.21 (a) (b) (c) (d) (e) (f): Identified Hotspot in Agra city

Source: Agra Nagar Nigam

Pictorial representation of hotspot near the Ghat captured by NPC team are given below:

FigureA1.22: Hotspot in Agra Captured by NPC Team

Figure A1.23: Hotspot in Industrial Sector Agra Captured by NPC Team

The probable hotspots identified in above **Figure 1.21 to Figure 1.23** were further, subjected to fuzzy logic approach adopted by GIC, Asian Institute of Technology in order to identify the vulnerable areas in the city, which could be the possible point of plastic leakages in the city. The output of this approach is depicted in **Figure A1.24 and Figure A1.25**. This indicates that probable hotspots were located in vulnerable areas identified for leakage of plastics in the city.

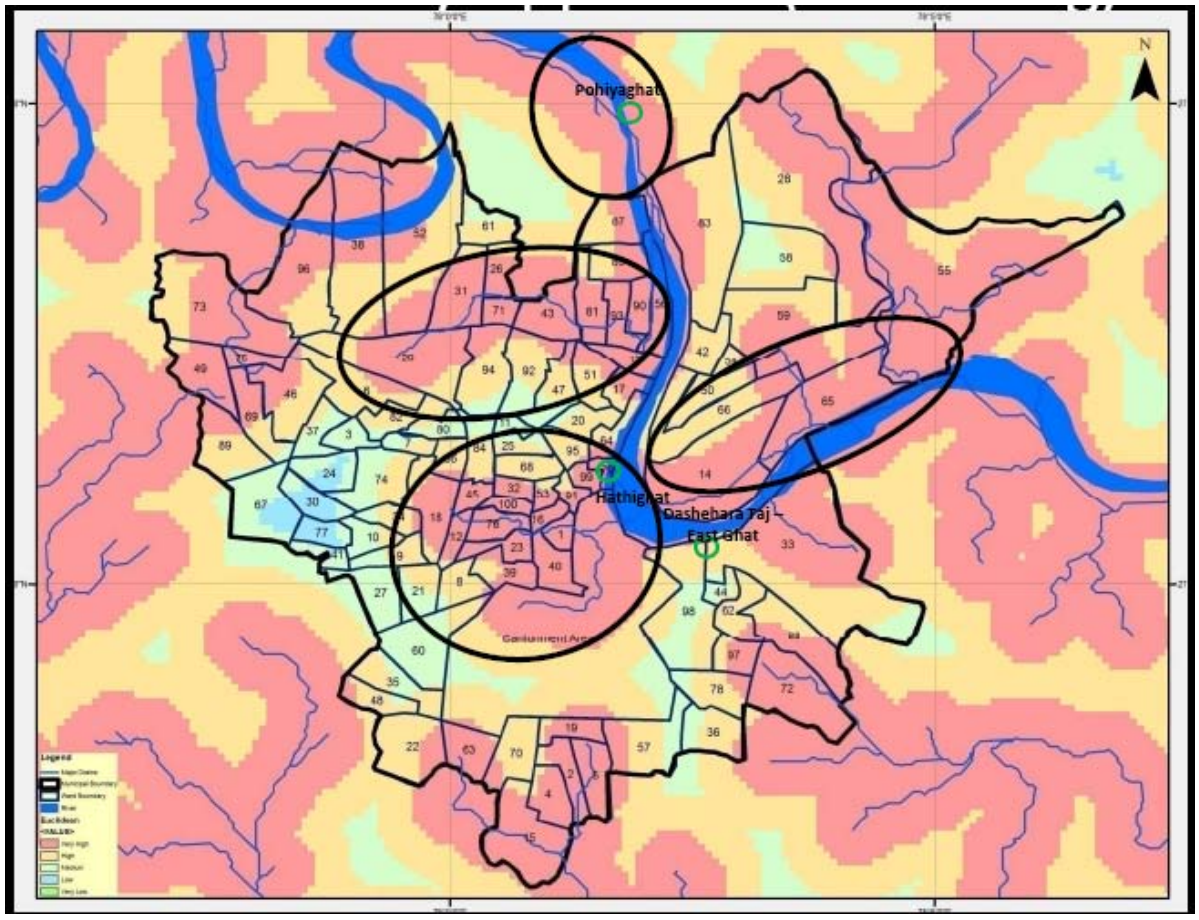


Figure A1.24: Plastic Leakage Vulnerable Areas identified using Fuzzy Logic Approach

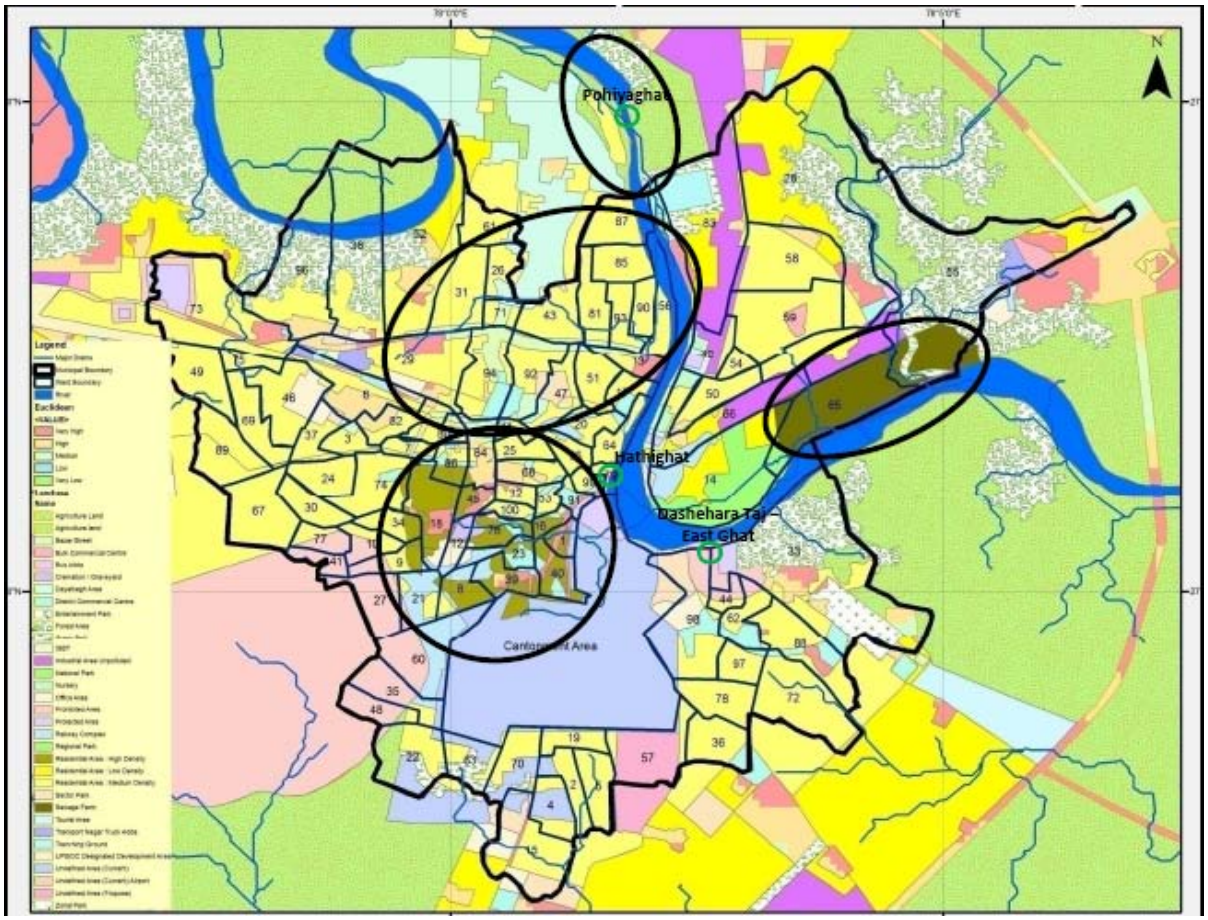


Figure A1.25: Location Plastic Leakage Vulnerable Areas on Land Use Map

In order to establish the plastic leakage scenario, it is pertinent to study the total plastic waste generation and assess their probable leakage based on IUCN approach. As per this approach, the leakage of plastic is measured as a function of a loss rate and a release rate. Mismanaged waste is commonly defined as plastic waste managed in a way that might include some leakage through carriers like air and water into the environment. The following sections describe each of these items along with their pictographically representation.

1.7 Quantification of Total Plastic Waste Generation

Total plastic waste generation in Agra has been quantified based on secondary data and primary data analysis as described below.

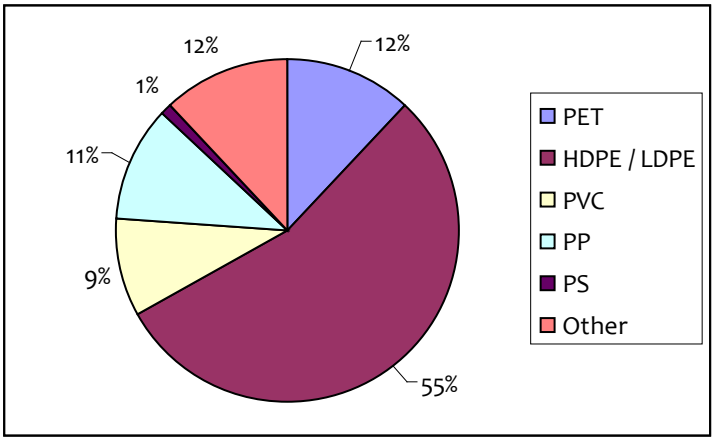
1.7.1 Section A - Secondary Data Analysis

A study was carried out by CPCB **"Assessment & Characterization of Plastic Waste Generation in 60 Major Cities of India"** in January 2015 (9). According to this report, an average total MSW of about 520MT/Day of municipal solid waste was disposed off at chhalesar dumping site. The data revealed that mixed plastic waste constituted about

78.87 Kg/MT of solid waste at the dump site. The quantity of plastic waste ranged from a minimum of about 58.6 Kg/MT to a maximum of about 95.15 Kg/ MT. Therefore, it can be inferred that percentage of plastic contributing to the total sold waste is 7.8 % in Agra. This plastic waste consisted of PET, HDPE/LDPE, PVC, PP, PS and other types of plastics. The percentage composition of each type is described in **Table A1.6** and shown in **Figure A1.26**. However, 55 % plastics waste is generated from HDPE/LDPE materials consisting of carry bags, household items and multilayer films.

Table A1.6: PW (Kg/MT) in Agra as per CPCB Report

SERIAL OF DAYS TOTAL	PET	HDPE/LDPE	PVC	PP	PS	OTHER	Total
DAY1	10.33	42.724	5.972	8.484	1.122	11.014	79.646
DAY2	8.786	42.688	7.624	6.746	1.24	7.672	74.756
DAY3	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**



FigureA1.26: Percentage Contribution in Total Plastic as per CPCB

1.7.2 Section B–Primary Data Analysis

The quantification and characterization of plastic waste generated was estimated during primary survey and their compilation has been carried out for analysis and reporting in this section.

Based on primary data the ward wise waste generated from various establishments is estimated. Certain information from secondary sources was also compiled. Studies carried out by RCUES (2) on the physical and chemical characteristics of the generated waste in Agra Nagar Nigam are summarized and presented in **Table 1.7.**

Table A1.7: Plastic Composition Present in Generated Waste as per DPR, Agra Nagar Nigam

Categories	Domestic Waste (%weight)	Commercial Waste (%weight)	Market Waste (%weight)
Thermocol	0.6	5.86	2.69
P.V.C/ pipes	0	4.18	0
Plastics	3.98	5.86	0
Polythene	4.98	7.95	3.03
Total	**9.56**	**23.85**	**5.72**

Source: DPR, Agra Nagar Nigam, 2017

As informed by the MRF plant having a capacity of 210 TPD, 40 % of plastic waste, which is recycled comes in Dry waste. This waste comes after the rag pickers have already extracted the high value and recyclable plastic from the mixed solid waste at various collection points/ dhalaos and community garbage bins. The field study also indicated that only 4 to 5 % of high value plastic waste is collected by rag pickers. Collating the plastic waste generation as per DPR Agra Nagar Nigam(2) and picked up by rag pickers or the informal sector, the total plastic waste generation in Agra has been estimated in **table A1.8.**

Table A1.8: Estimated Plastic Waste Generation by the Primary Data

Particulars	Plastic Generation (TPD)	Remarks
Estimated Plastic in total Domestic Waste	55-60	10% plastic waste present in total household waste 597.54 TPD as per DPR, Agra Nagar Nigam, 2017.
Estimated Plastic in total Commercial Waste	50-55	24% plastic waste present in total commercial waste 216.5 as DPR, Agra Nagar Nigam, 2017.
Estimated Plastic in total Market Waste	2-4	6% present plastic waste in total market waste 34.64 TPD as per DPR, Agra Nagar Nigam, 2017.
Estimated total Plastic waste generation	110-130	
Estimated plastic generation in slum	9-13	Estimated from the slum population as mention in DPR Agra Nagar Nigam, 2017 and taking 9 % plastic waste as per CEPHEEO guidelines
Estimated total Plastic waste recycled in dry waste	80-85 *Only from formal collection	Out of 113 TPD total plastic waste, 40 % plastic is recycled from the dry waste as informed by the MRF facility (210TPD).
Estimated high value plastic collected by rag pickers	4-5	Only 4 to 5% of plastic collected by rag pickers
Estimated Plastic littered	10-30TPD	Most of the contribution of plastic littering comes from mismanagement of waste from slums, secondary storage, uncollected waste, and dumping site of Agra city.

It can be inferred that the amount of plastic that gets collected and is attempted to bring back into the value chain is approx. 80-90 tonnes per day, which is 10% of the total solid

waste generated. These values estimated by the primary data collected during NPC field study are much higher than the values reflected by the various available report and secondary sources. A summary of plastic waste assessment both from secondary and primary sources of data has been summarized in **Table A1.9** and leakage into the riverine ecosystem has been depicted in **Figure A1.27.**

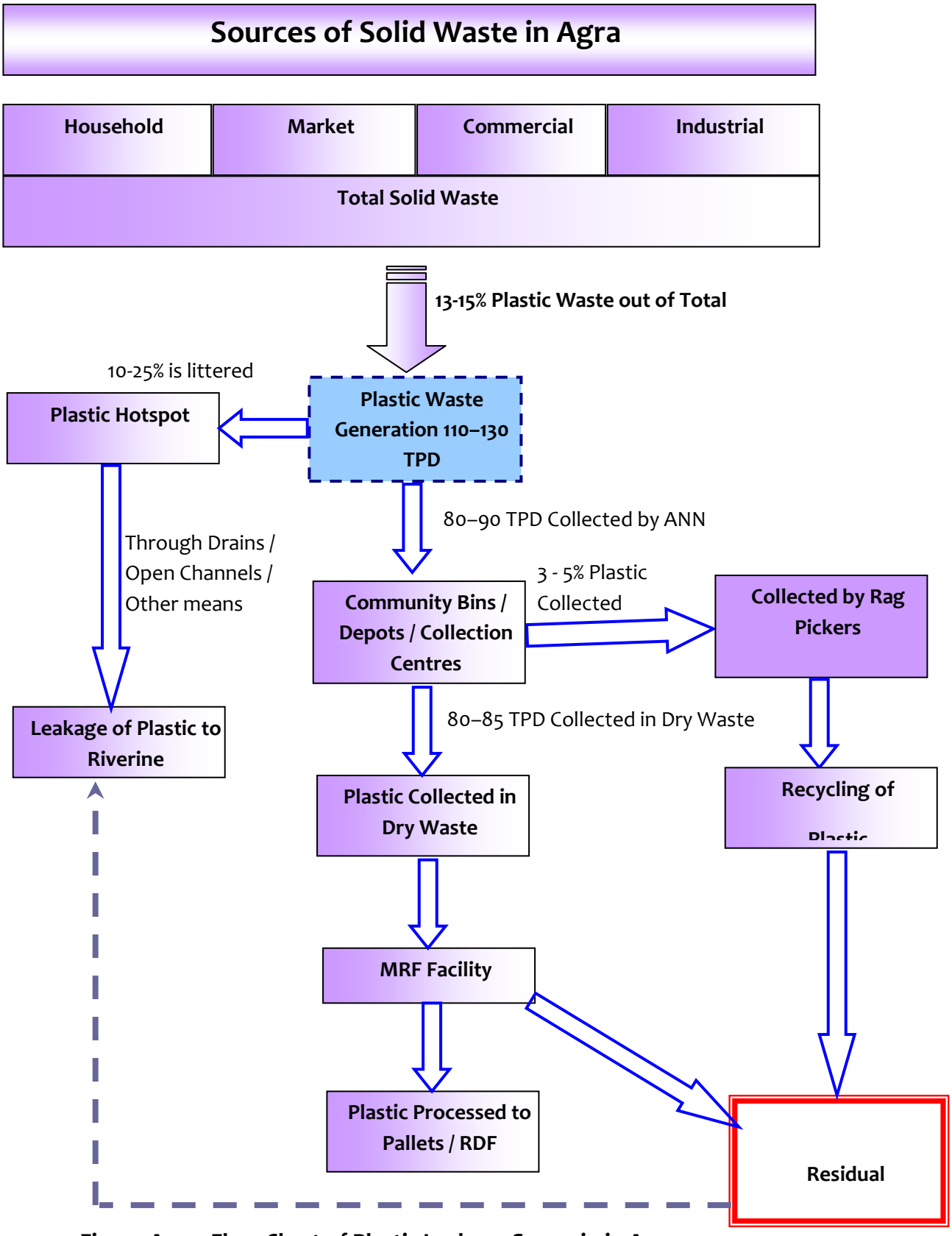


Figure A1.27: Flow Chart of Plastic Leakage Scenario in Agra

Table A1.9: Summary of Estimates Pertaining to Waste Generation

Particulars	Values as per available secondary data				Values as per primary data collected by NPC
	Action Plan Agra (2017)	City Sanitation Plan (projected valued in 2020)	CPCB2016	Research paper (s)	
Solid waste generation (T/d)	712TPD	1350TPD	520		866
Per capita Solid waste generation (kg/c/d)	0.45	0.559			0.40
Plastic waste generation (T/d)	-	-	40.89		110-130
Per capita plastic waste generation kg/c/d	-	-	-	-	
% plastic waste in total solid waste	-	-	7.8		13-16%

1.8 Prominent Plastic Categories Observed During Cleanup Drives in Agra

Cleanup activities were carried out at three hotspots of plastic litter in Agra as per the following details in **Table 1.10. Figure A1.28** indicates quantity of total waste and plastic waste collected during each clean up. Accumulation of waste at Hathi ghat after a gap of three months validates it as a hotspot and a potential source of leakage into the river.

Table A1.10: Clean up activity at different hotspots

S. No.	Name of Hotspot	Date of Cleanup Activity Undertaken
1	Hathi Ghat, Agra	6 Nov 2019
2	Pohiyaghat, Agra	3 Jan 2020
3	Hathi Ghat, Agra	20 Feb 2020

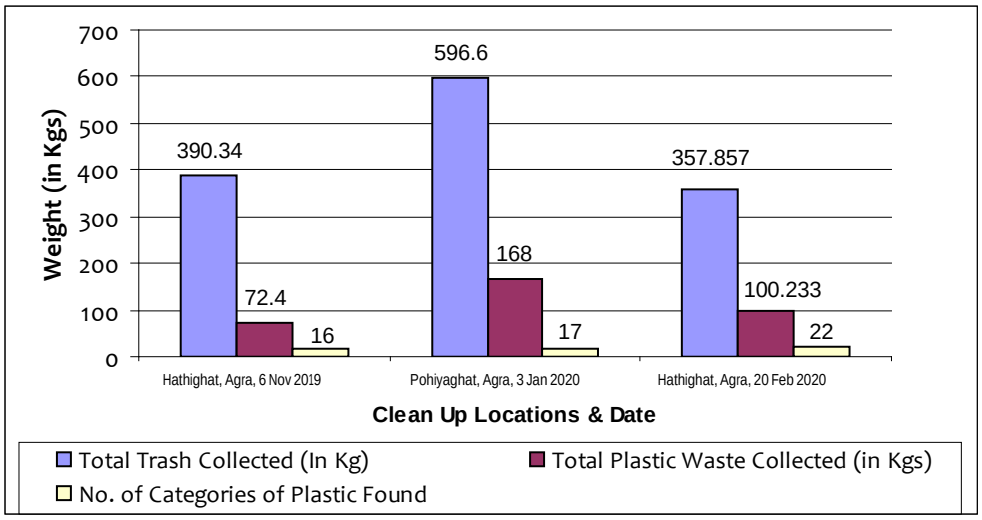


Figure A1.28: Snapshot of Cleanup Drive Carried out in Agra

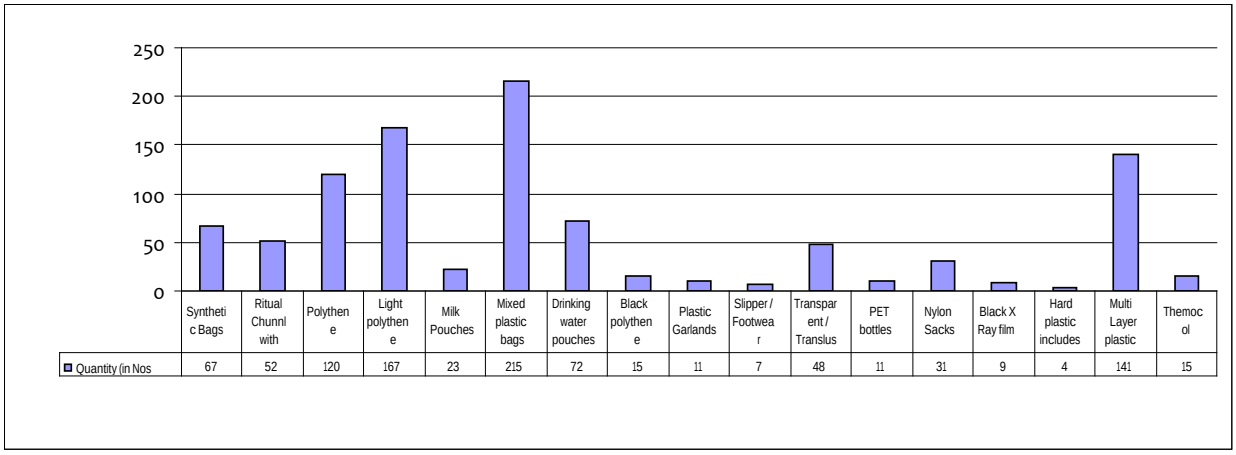


Figure A1.30: Plastic Types found in Clean up Drive in Poiya Ghat (3rd Jan 2020)

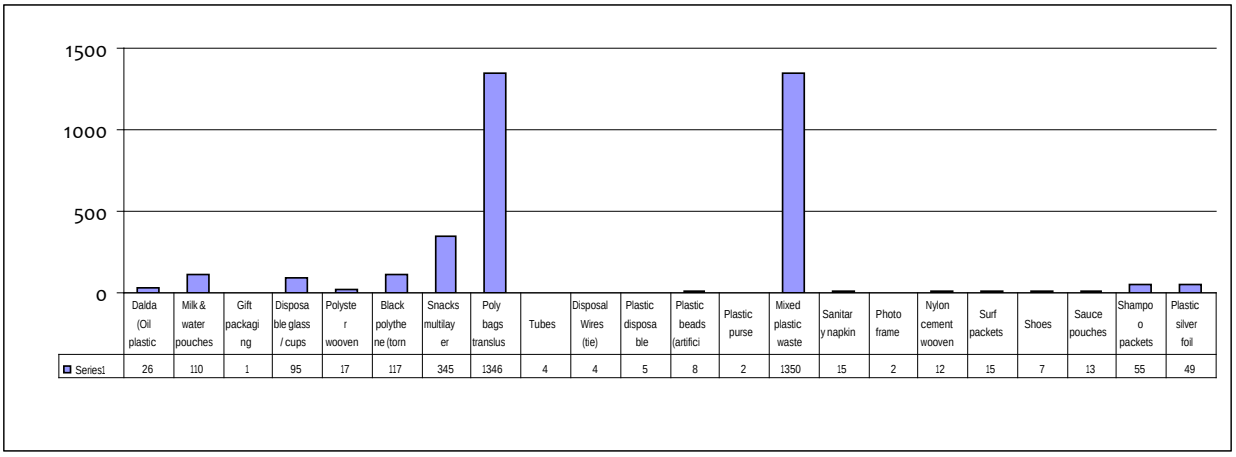


Figure A 1.31: Plastic Types found in Clean up Drive in Hathi Ghat (20th Feb 2020)

To summarize, the top five prominent plastic categories observed during cleanups in Agra are:-

1. Mixed plastic carry bags
2. Multilayer Packaging
3. Disposable cups &plates
4. Milk & water pouches
5. Packaging plastics

1.9 Plastic leakage Scenario in Agra city from sources

Plastic leakage scenarios from households and commercial / market sources have been depicted in **Figure A1.32 and Figure A1.33.**

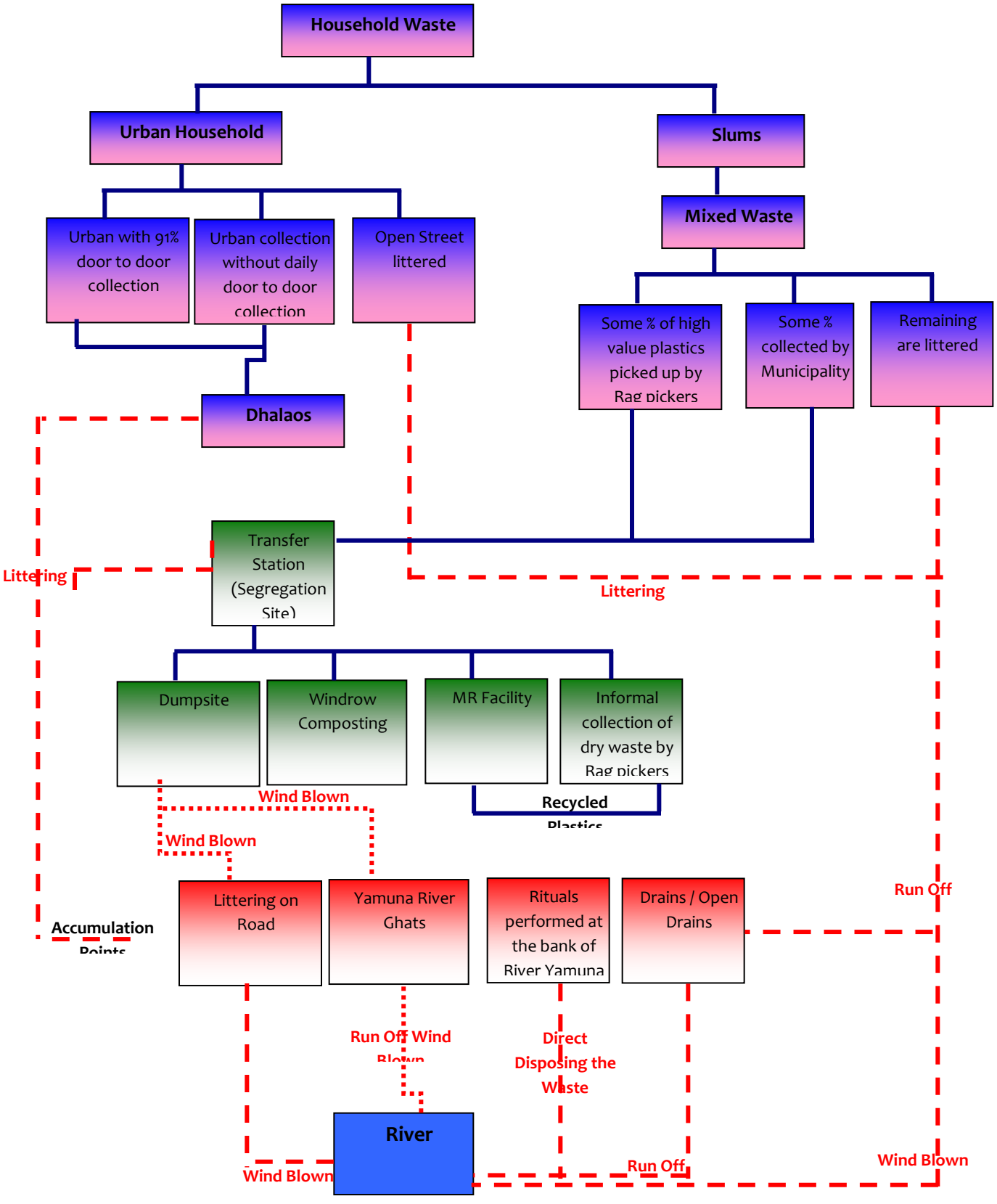


Figure A1.32: Flowchart of Plastic Leakage Scenario in House hold Waste

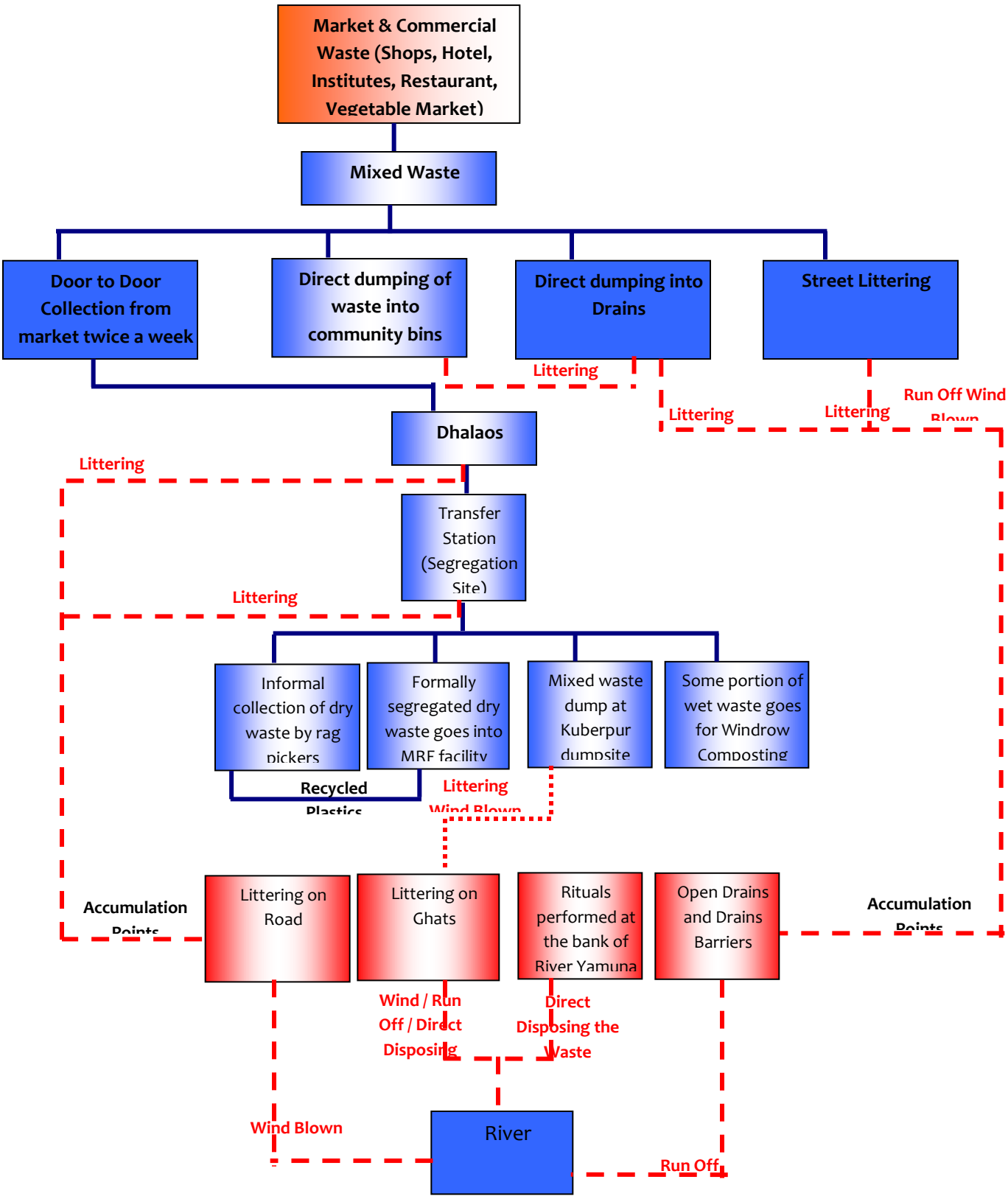


Figure A1.33: Flowchart of plastic Leakage Scenario in Market & Commercial Waste

Figure A1.32 & Figure A1.33 indicate that Littering and direct disposal of waste into the river are major causes of plastic leakages. The major carriers of plastic waste, which have been identified are wind, run off and open drains.

1.10 Plastic Leakage into the Environment

Plastic leakage is defined as the plastic leaving the techno sphere and accumulating in the natural environment. (IUCN, 2020) Plastic waste has a significant impact on environment. Plastics are mainly introduced into the environment through in effective waste management practices. This includes pictorial representation of all the pathway that leaks the plastic into the environment as listed below and depicted in **Figures A1.34 to Figure A1.52.**

1. Road littering
2. Secondary storage littering
3. Open Drain
4. Burning of plastic waste
5. Littering & mismanagement of waste in Slum
6. Open Drain Barrier

1.10.1 Road Littering

FigureA1.34: Mixed Plastic Waste, Rituals waste at Kamla Nagar, Agra

FigureA1.35: Heap of Plastic Waste, Woven Plastic Waste at Agra

FigureA1.36: Littered Mixed Plastic Waste in Agra City

Source: NPC team

Figure A1.37: Multi Color Plastic, Polythene Bag, Chips Packet Littered at Agra

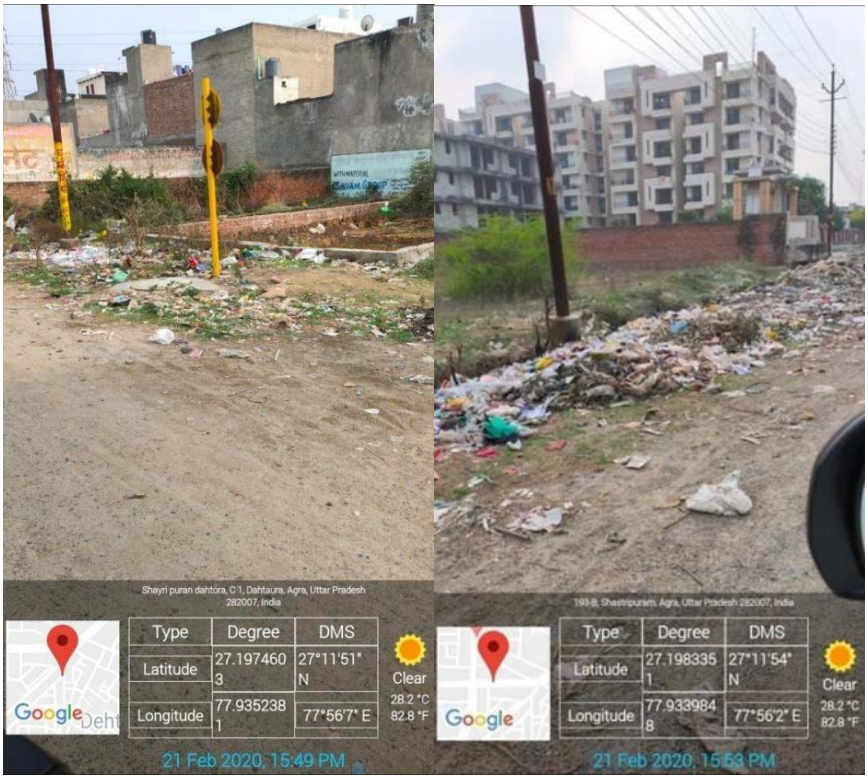


Figure A1.38: Littered Plastic was found at Agra

Source: NPC Team


Figure A1.39: Macro Plastic Floating the Yamuna River, Agra

Figure A1.40: Leather Bag, Chips Packet, Plastic Bag etc was Around the Yamuna River, Agra

1.10.2 Secondary Storage Littering

Dhalaos/Community bins are secondary storage but along these most of waste are littered and become an open dumping site. Current bin locations have become an open dumpsite for the people residing in the immediate proximity. Community bins are over flowing as the bins are transported regularly for disposal. Waste is being disposed unscientifically.

Figure A1.41: Mixed Plastic Waste is Dump and Littered Around the Secondary Storage

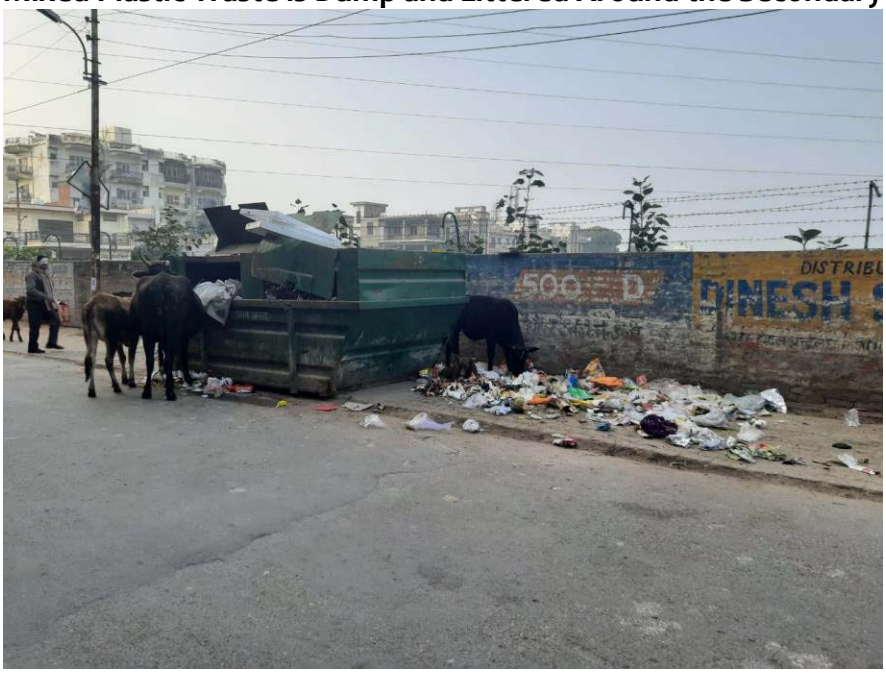


Figure A1.42: Waste Littered in near by Secondary Storage

Figure A1.43: Littering of Plastic Sachets found during Field Visit

1.10.3 Open Drains

Open drain is the main hotspot in plastic leakage scenario. Pictorial representation of open drains captured during field visit and majority of drains clogged due to plastic waste were present in it.

Figure A1.44: Open Drain Carry Plastic Waste into the Riverine Ecosystem

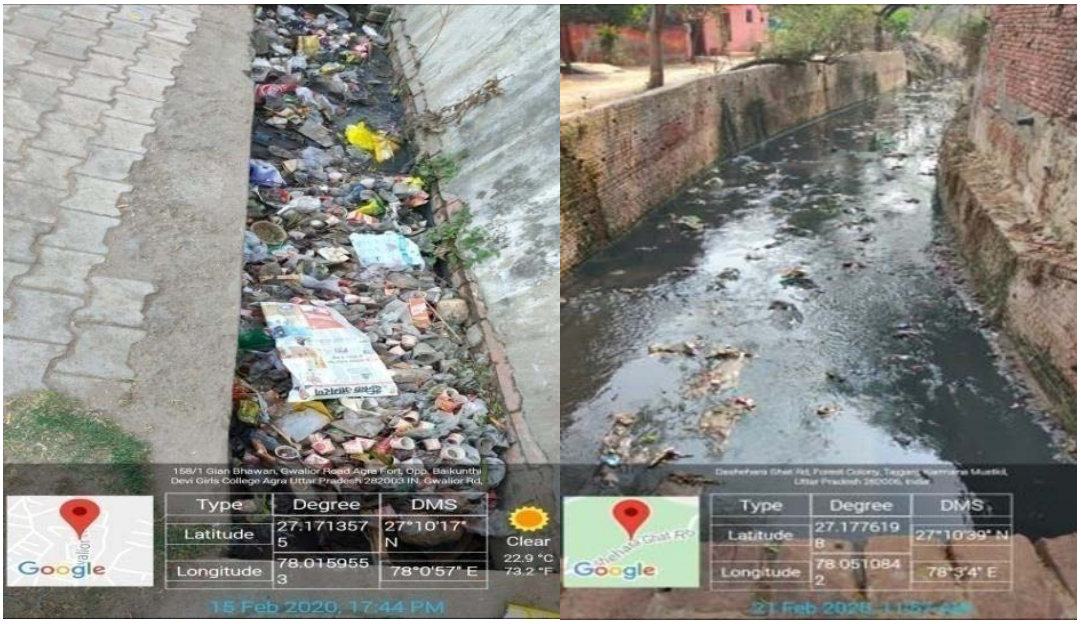


Figure A1.45: Open Drain was Clogged Due to Plastic Waste

Figure A1.46: Mixed Wastes is Floating in Open Drain

1.10.4 Burning of Plastic Waste

Burning of plastic waste such as footwear, packaging material was found in industrial region.

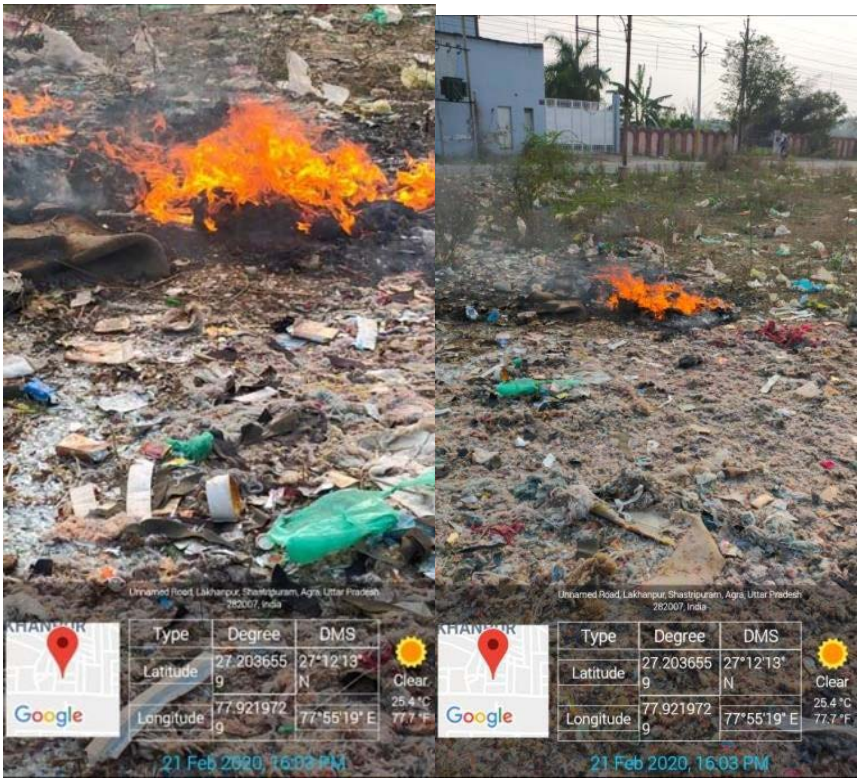


Figure A1.47 (A): Burning of Waste Were Found in Industrial Sector

Figure A1.47 (B): Burning of waste was found in industrial sector

Figure A1.47-(C): Burning of waste were found in industrial sector

1.10.5 Littering & Mismanagement of Waste in Slums

Mismanagement of waste in slums area: Only 2 to 3% waste is collected in the slum rest are littered.

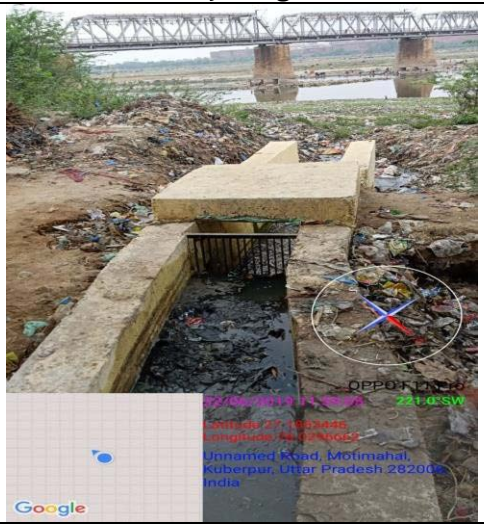
Figure A1.48: Littered mixed waste were found in slum, Agra

Figure A1.49: Condition of slum in Agra

1.10.6 Open Drain Barriers

Drain barrier is also a main hotspot of plastic leakage because is waste is clogged in barrier and when the waste water come with pressure the waste is floating down in the river.

<table>
<tr><td> 
</td><td> 
</td></tr>
<tr><td>Manoharpur Drain</td><td>G.G. Puram, Kamla Nagar</td></tr>
<tr><td> 
</td><td> 
</td></tr>
<tr><td>Lohiya Nagar</td><td>Rajbada</td></tr>
</table>

	
Chinikaroja	Yamuna Brij Nala
	
LohiyaNagar2	Belanganj Police Chawki
	
Moti Mahal Brigde	Taj Poorvi Gate

	
Nagla Bhudhi	Paliwal Park (Vedant Mandir)
	
Kakretha	Kakretha2
	
Taj pachimi Gate (JalalBhukari)	Mantola

	
Gokul Nagar Foundary Nagar	Vidhya Puram Foundary Nagar
	
KatraWazirKha2	ChhiniKa Roza 2

FigureA1.50: Drain Barrier in Agra

1.11 Plastic Leaking in the Riverine system

Photo captured by NPC team

Figure A1.51: Macro Plastic Leaking into the River Yamuna, Agra

Figure A1.52: Macro Plastic such as Disposable Cups, Chips Packets Leaking into the River Yamuna, Agra

Based on the 10% of the total solid waste generated, ward wise plastic waste generation map has been prepared and depicted in **Figure A1.53.**

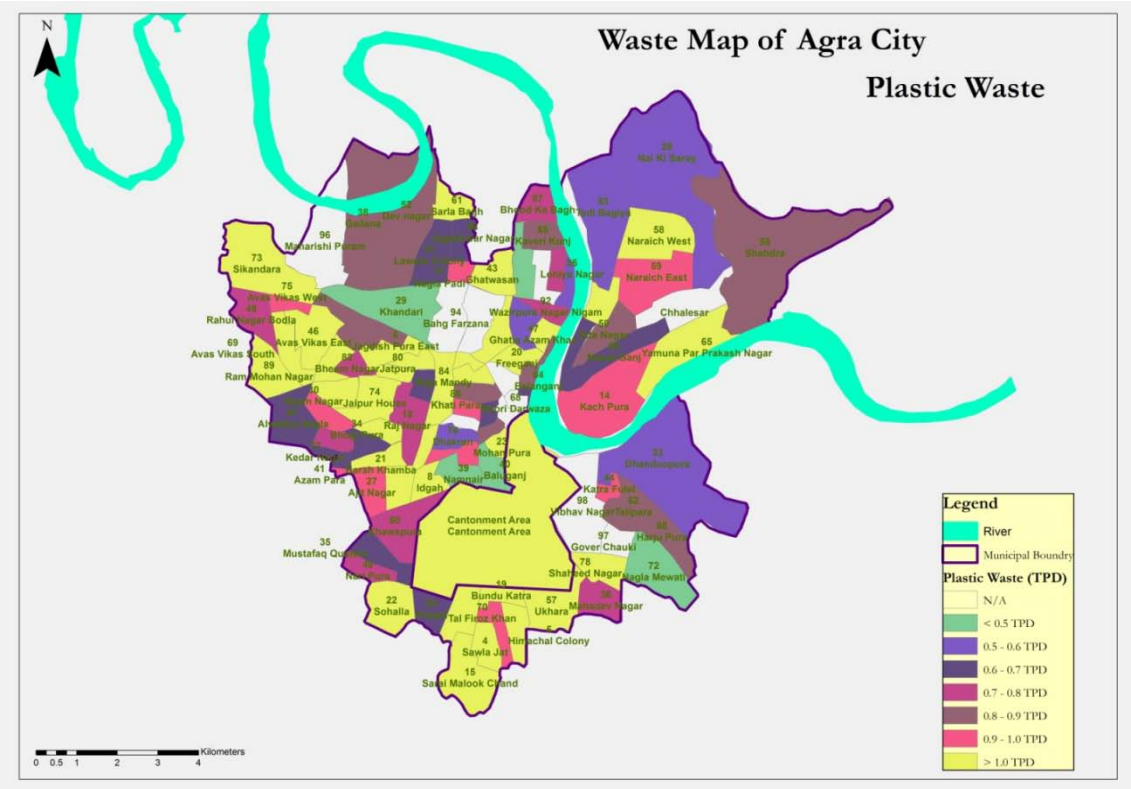


Figure 1.53: Ward-Wise plastic waste generation Map of Agra

Massive amount of plastic was observed to be littered during the field study at various locations in Agra. Therefore, littering is one of the major reason for the plastic not being collected and brought back into the value chain. However, majority of the waste categories found during Clean Up includes Multilayer packaging, Plastic Sheet & other thicker plastic bags in black & white color, water pouches, Packaging Material e.g. Tobacco sachets, Biscuit packets, Surf excel, Rusks etc. as per cleanup report. **Figure A1.53** also indicates the wards where counter measures can be implemented to prevent leakage of plastics into the river.

REFERENCE

1. Agra Nagar Nigam
2. Detailed Project Report for Municipal Solid Waste Management Scheme For Agra, 2017
3. Agra Master Plan 2021
4. City Sanitation Plan for Agra
5. Municipal Solid Waste Management Manual by CPHEEO
6. Solid Waste Management Monitorable Action Plan, Municipal Corporation of Agra
7. www.nagarnigamagra.com, Agra Nagar Nigam website
8. Report in Nagar Nigam Agra in Original Application No.116-2014.pdf
9. Assessment&CharacterizationofPlasticWasteGenerationin60MajorCities,CPCB
10. AnnualReportofUPPCB2018
11. Municipalsolidwastemanagementchallengesandhealthriskproblematicsolutionsat Agra city, U.P., India

Table of Contents

1.0 Introduction 166
1.1 Prayagraj 166
1.2 Geographical and Climatic Condition 166
1.2.1 Physiography 166
1.2.2 Climate 168
1.3 Demography & Administrative Set Up 168
1.4 Population Density (Ward wise) in Prayagraj 171
1.5 Floating Population 173
1.6 Land use Analysis Master Plan provisions 173
1.7 Solid waste management in Mumbai 174
1.8 MSW Composition in Prayagraj 181
1.9 Estimation of plastic waste generation in Prayagraj based on primary data 186
1.10 Hotspot identification 189

PLASTIC LEAKAGE SCENARIO IN PRAYAGRAJ

1.0 Introduction

1.1 Prayagraj

Prayagraj (previously known as Allahabad) is a major urban agglomeration located in the south eastern region of the state of Uttar Pradesh at the confluence of Rivers Ganga and Yamuna. It is located between 25.4358° N and 81.8463° E (**Figure 1**). The city draws the attention of pilgrims and heritage lovers from all over the world due to its historical, cultural, mythological and spiritual offerings. Prayagraj is one of the destinations, which holds the KumbhMela, world's largest congregation of devotees. The city has been described in ancient scriptures as 'Teerthraj', the holiest pilgrimage centre and is indeed a perfect place to have a soulful escape. For the Mughals, the city had a great strategic importance to control their empire, and it also became a prominent administrative hub under the British rule. The city was the nerve centre of activities during India's Freedom Movement. Being centre of higher education, it has also played a leading role in the development of Hindu and Urdu literature.

Figure 1: Prayagraj (previously known as Allahabad)

1.2 Geographical and Climatic Condition

Pratapgarh is north of the city, Bhadohi is east, Rewa is south, Chitrakoot (earlier Banda) is west, and Kaushambi, which was till recently a part of Prayagraj, is North-West **(Figure 2).**

1.2.1 Physiography

Prayagraj lies on the western part of the Great Indo-Gangetic Plain region and is under laid with sediments deposited in successive stages. There can be three distinct physical parts of the city (i) Trans-Ganga Plain, (ii) the Ganga- Yamuna doab (confluence), and (iii) Trans-Yamuna, all three of which are formed by Ganga and its tributary Yamuna. Prayagraj is in the southern part of Uttar Pradesh, at the confluence of the Ganges and the Yamuna. To the southwest is Bundelkhand, to the east and southeast is Baghelkhand, to the north and northeast is Awadh and to the west is the lower doab (of which Prayagraj is part). The city is divided by a railway line running east–west. South of the railway line is the Old Chowk area, while the British-built Civil Lines is in the north of it. Prayagraj is well placed geographically and culturally. Geographically, part of the Ganga-Yamuna Doab (at the mouth of the Yamuna), culturally it is the terminus of the Indian west. The longitude representing Indian Standard Time longitude (25.15°N 82.58°E) passes near the city. It is located at an average altitude of 98 m above mean sea level. The master slope of Trans Ganga is towards east or south east, with the altitude ranging from 89.30 mamsl-93.57 masl. Rivers of the district namely Yamuna, Tons, Sai and Varuna belongs to main drainage system of the Ganga **(Figure 3).** Dendritic drainage pattern is the most common features in the district which is the structurally controlled. Streams up to the fifth order are encountered in the district. In common with the rest of the doab, its soil and water are primarily alluvial.

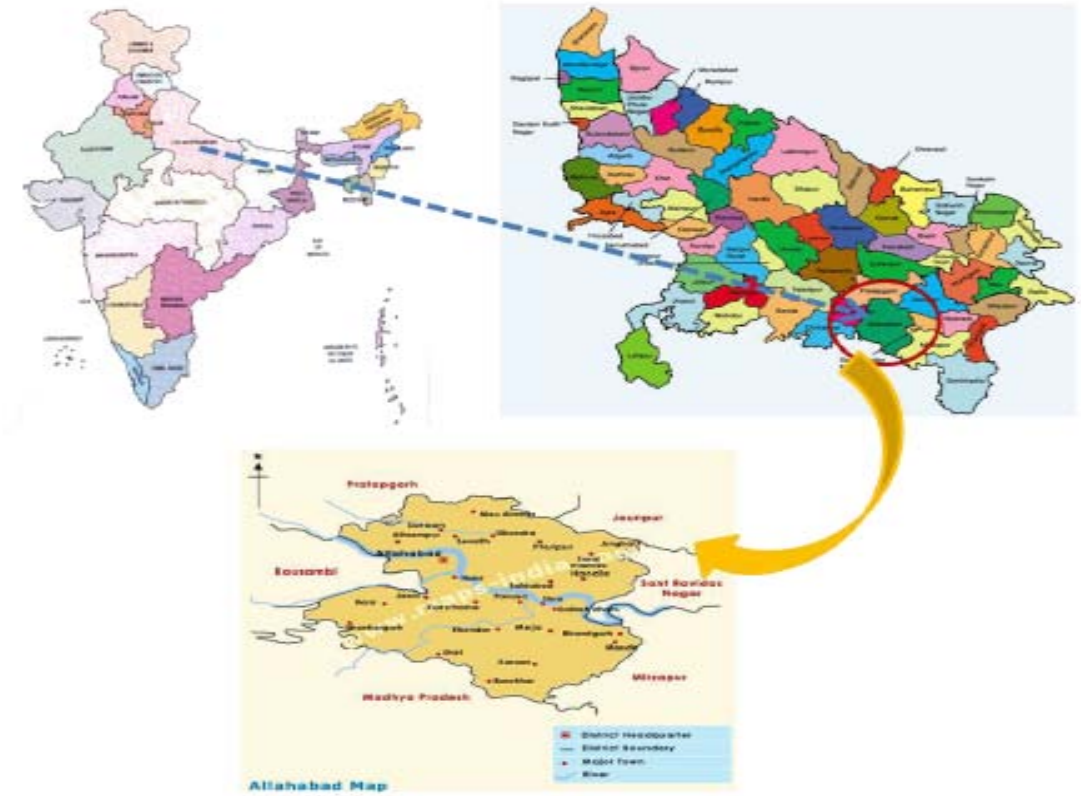


Figure 2: Location of Prayagraj in Uttar Pradesh

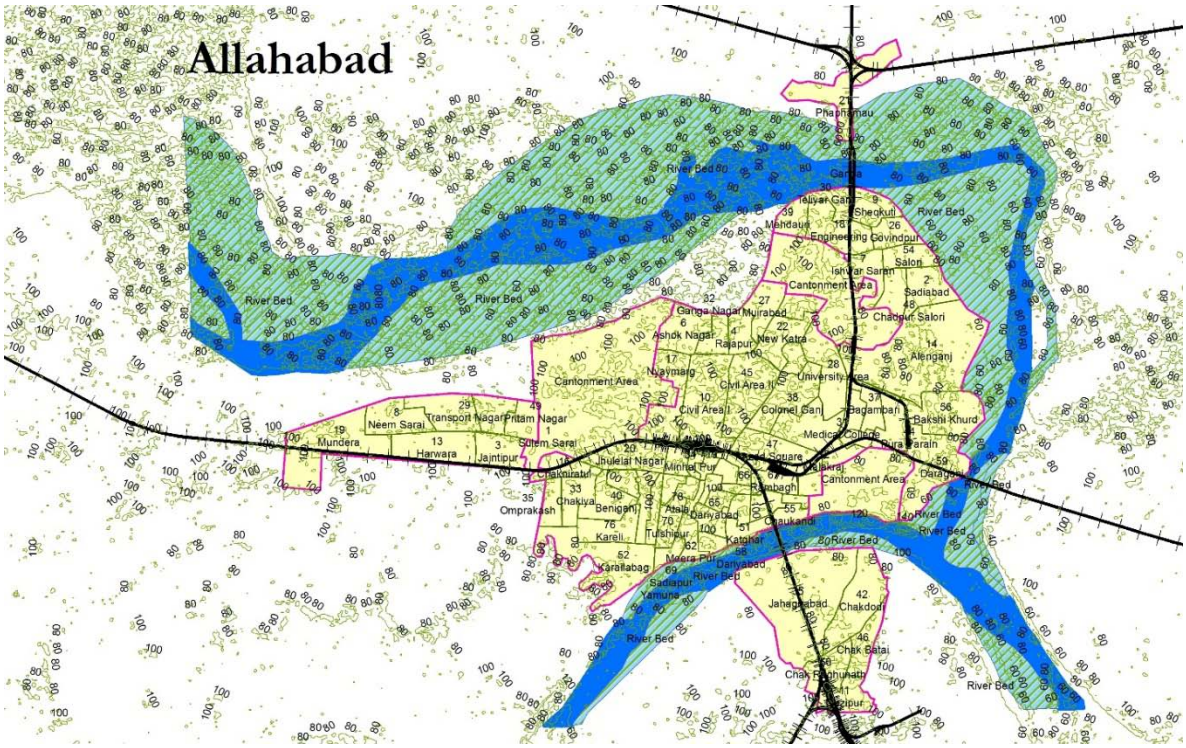


Figure 3: Contour Map of Prayagraj City

1.2.2 Climate

The average annual rainfall in Prayagraj is 934 mm. Climate is sub humid and is characterized by hot summer and pleasant monsoon and cold season. About 90% of rainfall takes place from June to September. During monsoon surplus water is available for deep percolation to ground water. From February there is rapid increase in temperature, May is the hottest month with the mean daily maximum temperature is 41.5°C and mean daily minimum temperature 26°C. After the onset of the monsoon there is appreciable drop in temperature, January is the coldest month with mean daily maximum temperature is 26.20°C and mean daily minimum temperature is 9.3°C. The mean monthly maximum temperature is 19.54°C and mean monthly minimum temperature is 6.23°C. The relative humidity is high during the southwest monsoon season, with mean monthly morning relative humidity at 63.92% and mean monthly evening relative humidity at 48%. Winds are generally high with some increase in force during summer and southwest monsoon season. The mean wind velocity is 5.16 Km/hr and the potential evapotranspiration rate is 1456.7 mm. Prayagraj falls in a "low damage risk" wind and cyclone zone.

1.3 Demography & Administrative Set Up

City population: The Municipal Corporation of Prayagraj administers an area of 82 km^2 with a population of 11, 17,094 (Census, 2011). The male and female population is 6,01,363 and 5,15,731 respectively. The population increased by four folds over the last six decades with increase in population from 3,32,295 in 1931 to 11,17,095 in year 2011. Prayagraj city comes under Prayagraj metropolitan area along with Cantonment board and urban outgrowths. Population of metropolitan area is 12, 16,719. Male constitutes 6,55,734 and

female constitutes 560,985 of the total population.

Slum Population: As per the survey slums population in the city are 4, 70,467 and households are 91,025 residing in 185 slums of city constituting more than 30% of the total population. The average slum household size is 6.8 which is slightly greater than city household size of 6.4. The household size of slums came down to 5.4 from 6.8 in 2001. The entire population is administratively divided into 5 municipal zones and 80 wards. The city profile of Prayagraj is given in **Table 1.**

Table 1: City profile of Prayagraj

Particulars	
Coordinates:	25.45°N81.85°E
Elevation:	98 m (322 ft)
Area of ULB	82 Km^2
Municipal Wards	80
Municipal Zones	5
Growth	20.63%
Urban Population (as per 2011 Census)	11.17 Lakh
Projected Population (as per Master Plan-2021)	20.50 lakh
Average Household Density	1,087/km2 (2,820/sq mi)
Govt Type	Mayor–Council
Body	Prayagraj Municipal Corporation

Source: Final Census Report of U.P.-2011

Considering the growth trend of population and based on interaction with municipal corporation, (ANN) officials, the current population of Prayagraj has been considered approx. 20, 00,000 in this report for estimating the current waste generation.

Prayagraj city is the district headquarters of the district. The existing urban setting and growth trends of Prayagraj can be classified into three main categories: - 1. The Old City (consisting of Chowk, Ghantaghar, Bans Mandi, Katghar, Kotwali, Gaughat etc. This shall also include certain areas, though not contiguous but with similar character, like Daraganj, Bairhana, and Katra); 2. The New City (conceived during British rule and thereafter). This includes Civil Lines, Mumford Ganj, Ashok Nagar, Cantonment; and 3. The OG areas (satellite towns and ribbon developments along major corridors including Phaphamau, Jhunsi, Naini, Bamrauli, Manaurietc).The city is spread across 82 sq.km and is divided into 80 wards **(Figure 4).**The Prayagraj Urban Agglomeration includes the Prayagraj Municipal Corporation area and Prayagraj Outer Growth(OG)areas. The OG areas include Subedarganj Railway Colony, Triveni Nagar(N.E.C.S.W.), T.S.L. Factory, Mukta Vihar, Bharat Pump and Compressor Factory, A.D.A. Colony, Doorbani nagar, ITI Factory and Res. Colony, Shiv Nagar, Gandhi Nagar, Manas Nagar, Industrial Labour Colony, Gangotri Nagar, Mahewa West, Begum Bazar, Bhagal Purwa, Kodra, IOC Colony, Deoghat, ADA Colony and Jhalwagaon, Prayagraj (CB), Arail Uparhar and Chak Babura Alimabad. Prayagraj Municipal Corporation (PMC) is responsible for the management of the MSW generated in the city.

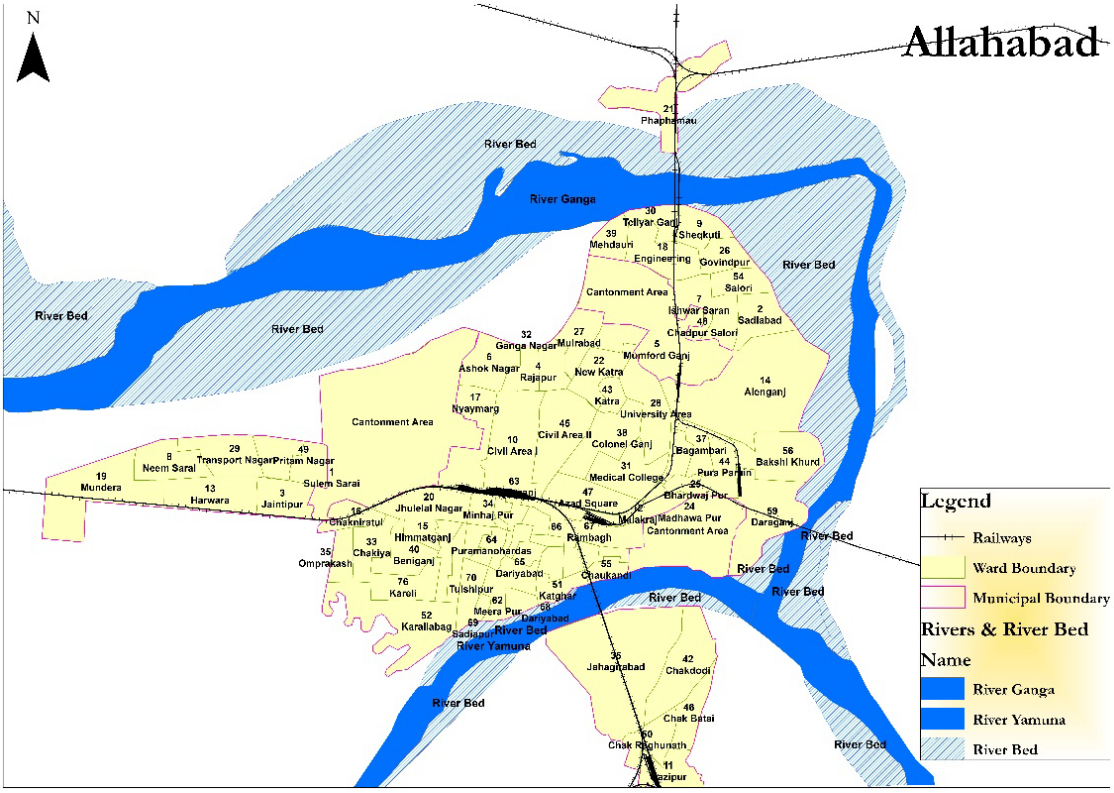


Figure 4: Administrative Ward Map of Prayagraj City

The city has grown organically where the old and new city areas are densely populated while the OG areas are emerging new areas of the city. The densely populated areas are the major sources of waste generation. The District is well connected by roads, railways and airways from the other parts of the Country **(Figure 5).** It has one of the major junction of railways in northern India along with nine sub stations. Also, the city is connected with major roads. The city is connected to most other Uttar Pradesh cities and major Indian cities such as Kolkata, New Delhi, Hyderabad, Patna, Mumbai, Visakhapatnam, Chennai, Bangalore, Guwahati, Thiruvananthapuram, Pune, Bhopal, Kanpur, Lucknow and Jaipur.

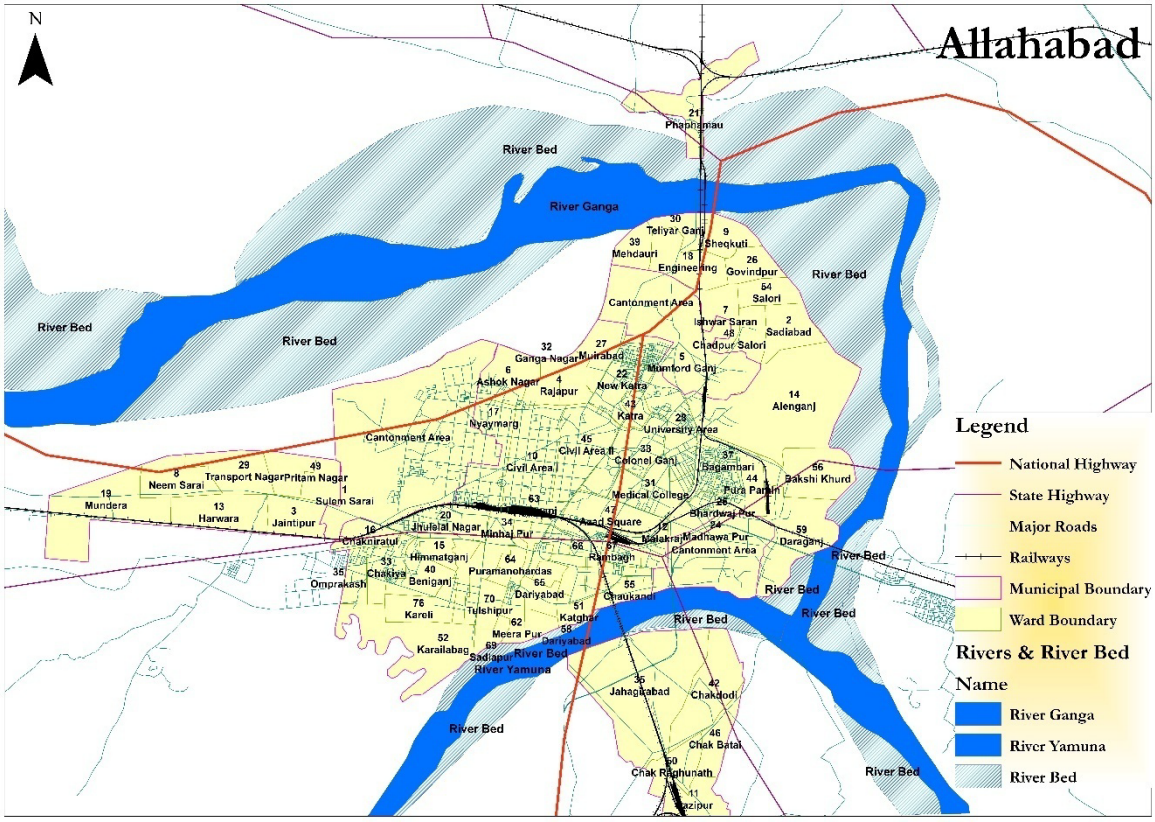


Figure 5: Communication Map of Prayagraj

The main industries of Prayagraj are tourism, fishing and agriculture. There are secondary activities and manufacturing which may be registered or unregistered.

Agriculture: The main crops cultivated in the district are wheat, paddy, potato and sugarcane

Minerals: The mineral products that are commonly found are glass sand, building stone, kankar, brickearth etc.

Industry: Prayagraj has some glass and wire-based industries. The main industrial areas of Prayagraj are Naini and Phulpur, where several public and private sector companies have their units, offices and factories. Bharat Petroleum Corporation Limited, India's largest oil company (which is also state-owned), is setting up a seven million tones per annum(MTPA)capacity refinery at Lohgara, with an estimated investment of Rs.62 billion. Prayagraj Bank which began operations in 1865 was founded in Prayagraj. The third All India Census for Small-Scale Industries shows that there are more than 10,000 unregistered small-scale industry units in the city. An integrated industrial township is also proposed over 1,200 acres of area in Prayagraj under the Dedicated Freight Corridor Corporation of India.

1.4 Population Density (Ward wise) in Prayagraj

Prayagraj is divided in to 80 wards having different population densities. The ward wise population and population density of entire city are given in **Table 2**. The ward wise

population is shown in **Figure 6.**

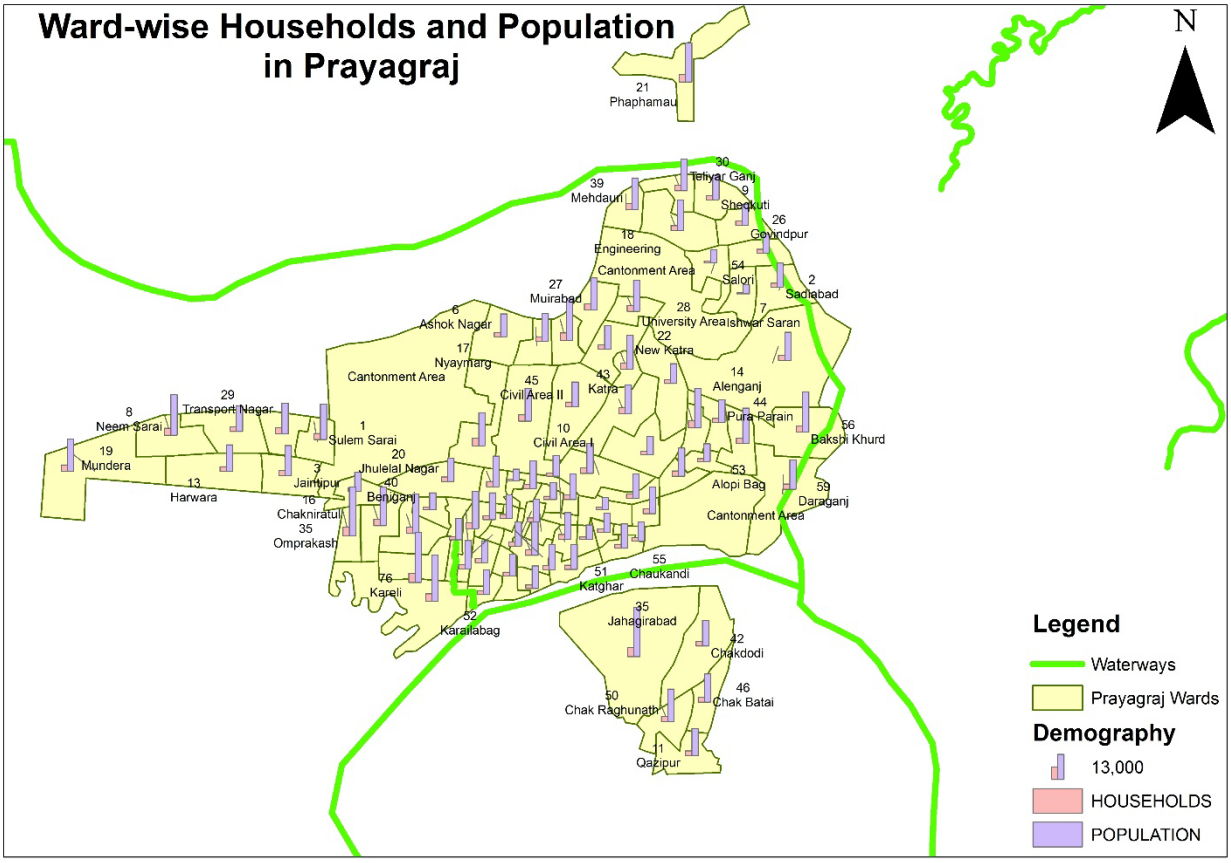


Figure 6: Demographic and Administrative Profile of Prayagraj City

Table 2: Ward wise population details

Ward No.	Population		Ward No.	Population		Ward No.	Population	
	Number	Density		Number	Density		Number	Density
1	17654	**70**	28	9937	**85**	55	12322	**212**
2	12125	**108**	29	12983	**122**	56	20288	**115**
3	15211	**163**	30	15799	**54**	57	5889	**330**
4	14056	**59**	31	9361	**95**	58	11397	**404**
5	15436	**52**	32	20955	**63**	59	14812	**65**
6	11532	**116**	33	19527	**52**	60	7379	**490**
7	6750	**83**	34	15380	**37**	61	9586	**825**
8	20360	**116**	35	24864	**56**	62	10856	**403**
9	12206	**81**	36	22660	**485**	63	14185	**-**
10	16600	**249**	37	11332	**61**	64	10786	**199**
11	13654	**48**	38	14670	**143**	65	17784	**370**
12	12196	**25**	39	15888	**60**	66	12932	**82**
13	13375	**156**	40	19799	**92**	67	6087	**194**
14	14163	**530**	41	9626	**27**	68	13440	**415**
15	8681	**39**	42	12790	**190**	69	12337	**260**
16	9540	**37**	43	17099	**22**	70	10910	**213**
17	16631	**155**	44	17680	**71**	71	8598	**300**
18	15593	**132**	45	12472	**167**	72	18884	**436**
19	16069	**192**	46	14102	**127**	73	11401	**423**
20	11574	**152**	47	15153	**46**	74	10532	**686**
21	19763	**184**	48	4528	**60**	75	12202	**582**

Ward No.	Population		Ward No.	Population		Ward No.	Population	
	Number	Density		Number	Density		Number	Density
22	11921	**99**	49	15604	**73**	76	25256	**276**
23	13581	**48**	50	16486	**82**	77	13483	**508**
24	14126	**22**	51	12443	**50**	78	14342	**1115**
25	19960	**51**	52	23241	**268**	79	12718	**779**
26	10671	**66**	53	8904	**41**	80	11693	**498**
27	16122	**84**	54	9612	**67**			
Source:CensusofIndia,2011								

1.5 Floating Population

Prayagraj attracts a huge number of tourists every day. Over 100 million tourists visited Prayagraj during the Maha Kumbh Mela 2013. In addition, tourists flock to Prayagraj to take holy dip in Triveni Sangam throughout the year. As per City development plan, daily footfall of tourist increases from 50-60 thousands in year 2007-08 to around 80-90 thousands of tourists in the year 2011-12.

1.6 Land use Analysis Master Plan provisions

The proposed future growth for Prayagraj is clearly outlined by the Prayagraj Master Plan 2021. As per the Prayagraj Master Plan 2001, a total area of 216.89 sq. km was proposed to be developed, whereas as per the land use survey conducted in 2002, only about 43.42% of that land, i.e., 94.18 sq. km was developed. The current master plan covers about 309.17 sq.km of land under different categories of land use of which residential land use covers 36%, commercial 2.41%, industrial 5.57%, recreational 16.02%, public/semi-public 3.82%, public utilities 2.23% and transportation 12.09%. However, a significant 13.26% is put to other uses such as horticulture, forestry, and dairy farms. The land use provisions are given **Table 3** and shown in **Figure 7**.

Table 3: Percentage of Land Use pattern at Prayagraj

S. No.	Landuse	Area (sq.km)	Percentage (%)
1	Residential	111.64	36.11
2	Commercial	7.46	2.41
3	Industrial	17.22	5.57
4	Government	26.24	8.49
5	Recreational	49.53	16.02
6	Public/semi-public	11.79	3.82
7	Publicutilities	6.90	2.23
8	Transportation	37.36	12.08
9	Otherlanduses	40.99	13.26
Total		**309.17**	**100**

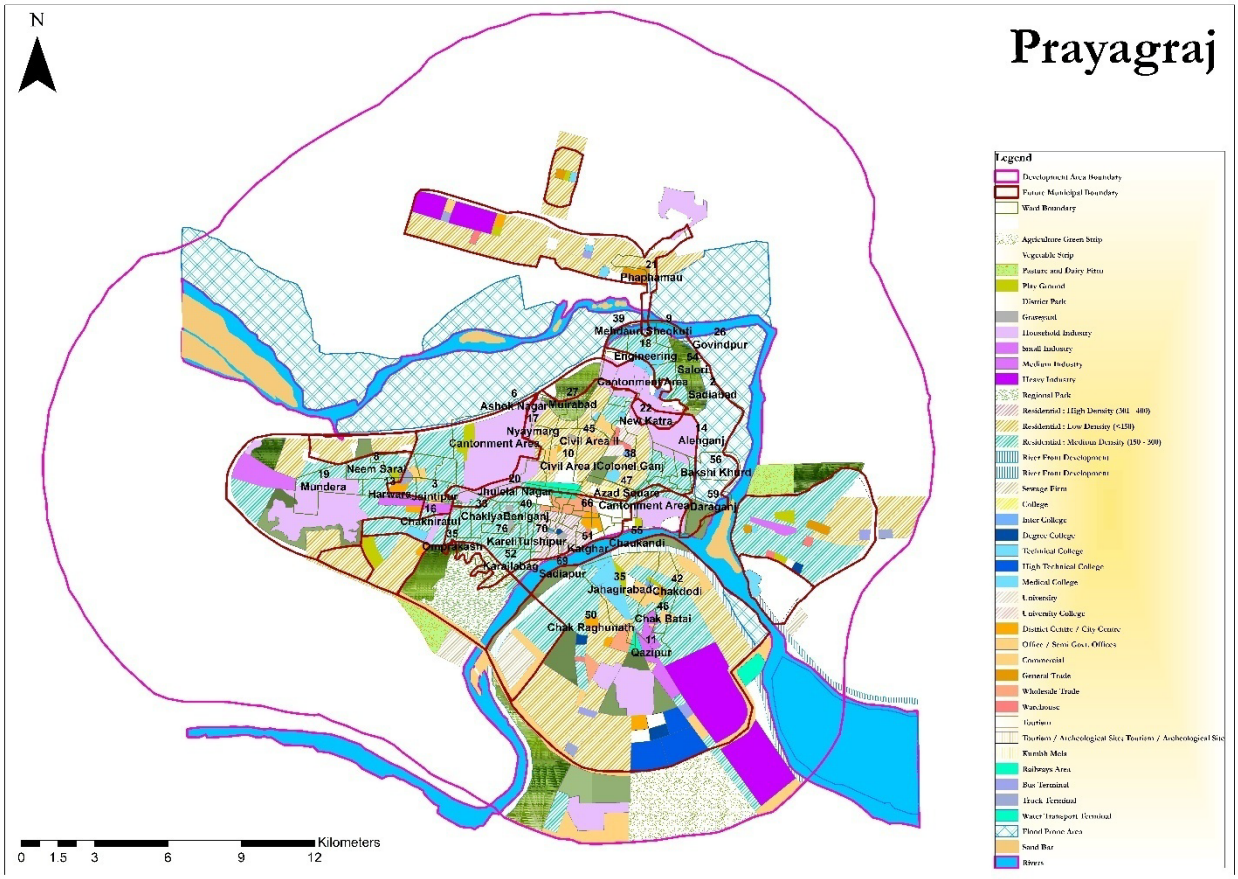


Figure 7: Land Use Pattern Map of Prayagraj

1.7 Solid waste management in Mumbai

Data on solid waste generation in Prayagraj

As per PMC estimates, about 540 TPD of solid waste is generated every day in Prayagraj. The local residents of towns generate solid waste at the rate of about 450 grams per capita per day on an average. This average generation of solid waste includes local inhabitants (comprising the wastes generated by the resident population, shops and commercial establishments, vegetable and fruit markets, construction and demolition and hospital wastes–non-infectious and non- hazardous) and the floating population in the town. Most of the waste generated in Prayagraj comprises food and other discarded waste materials such as paper, plastic, glass, metal, rags, and packaging materials.*(Ref: City Development Plan for Prayagraj, 2041; CRISIL, April 2015)*. Another report, Slum Free City Plan of Action–Prayagraj, 2013 states that the about 680.0 MT (CDP) of solid waste is generated every day in the city. It has been assumed that the local residents of towns generate solid waste at the rate of about 539 grams per capita per day on an average. The solid waste generation has also been projected for 2021 and indicated in **Table 4.**

Table 4: Projection of solid waste generation in Prayagraj

Year	Population	Per capita waste generation (kg/capita/day)	Total waste generation (ton/day)
1997	8,61,129	0.474	408
2001	9,90,298	0.506	501
2006	11,38,843	0.541	616

Year	Population	Per capita waste generation (kg/capita/day)	Total waste generation (ton/day)
2011	13,09,669	0.578	757
2016	15,06,119	0.617	929
2021	17,32,037	0.66	1143
2026	19,91,843	0.705	1404

From the above table it can be inferred that the solid waste generation in Prayagraj in 2020 has been projected to be approx. 1000 Tons/day. The results and discussions of the research paper revealed that the per capita MSW generation rate is 0.39kg/capita/day.

Sources of solid waste generation in Prayagraj

The solid waste generation in Prayagraj is primarily from households, street sweeping, markets and commercial establishments. The contribution MSW sources in terms of absolute generation in Prayagraj are summarized in **Table 5** while percentage contribution is summarized in **Figure 8.**

Table 5: Sources of solid waste in Prayagraj

Source of Solid Waste	Solid Waste Generated(TPD)
Households	247
Street Sweepings	27
Hotels and Restaurants	6
Markets (vegetable markets, mandis etc.)	35
Commercial Establishments (Institutions etc.)	5
Other Sources (Construction Debris, Horticulture Waste etc.)	220
Total	**540**

Source: Nagar Nigam Prayagraj

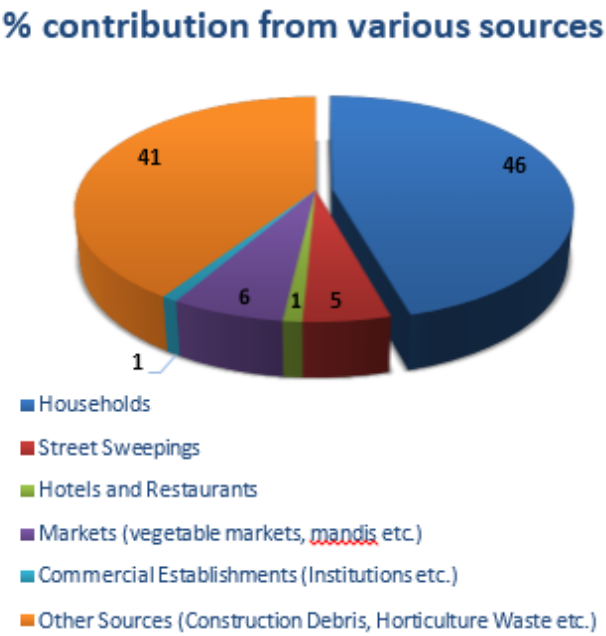


Figure 8: Percentage contribution of different sources to MSW in Prayagraj

Figure 8 indicates that household contributes the maximum amount of MSW followed by other sources, markets, hotels and restaurants and commercial establishments. Source

wise waste generation in each zone and each ward is summarized in Table 6 and depicted in Figure 9, Figure 10 and Figure 11. The three figures indicate that core area with maximum population density is the major contributor to solid waste from the city.

Table 6: Zone Wise and Ward Wise different waste generation at Prayagraj

Zone Number	Ward Name	Ward Number	ZONE DETAILS							WARD DETAILS						
			Population	Household	Domestic Waste (TPD)	Commercial, institution and other waste (TPD)	Street sweeping and drain waste (TPD)	C&D Waste (TPD)	Plastic waste (TPD)	Population	Household	Domestic Waste (TPD)	Commercial, institution and other waste (TPD)	Street sweeping and drain waste (TPD)	C&D Waste (TPD)	Plastic waste (TPD)
Zone 1	Sulem Sarai	1	382442	58294	121.748	35.372	18.810	39.190	17.593	19727	2905	6.621	0.969	0.868	1.808	0.846
	Jaintipur	3								16199	2421	5.142	0.741	0.706	1.471	0.659
	Harwara	13								14512	2336	4.606	0.692	0.636	1.324	0.593
	Pritam Nagar	49								16995	3031	5.394	1.070	0.776	1.616	0.724
	Transport Nagar	29								14112	2284	4.479	0.616	0.611	1.274	0.571
	Himmatganj	15								9425	1438	2.991	0.751	0.449	0.936	0.419
	Chakniratul	16								10438	1396	3.313	1.317	0.556	1.158	0.519
	Jhulelal Nagar	20								12557	2182	3.986	1.294	0.634	1.320	0.591
	Omprakash Nagar	35								27091	4743	8.599	1.396	1.199	2.499	1.119
	Shahganj	63								16259	2318	5.161	4.001	1.099	2.290	1.026
	Sarai Garhi	57								6405	822	2.033	1.347	0.406	0.845	0.379
	Dariya Shah Ajmal	80								12720	1889	4.037	0.990	0.603	1.257	0.563
	Sultanpur Bhawa	72								20308	2916	6.446	2.539	1.078	2.246	1.006
	Karela Bagh	52								25113	3951	7.971	1.599	1.148	2.392	1.072
	Kareli	76								27484	4268	8.723	2.277	1.320	2.750	1.232
	Beniganj	40								21536	3357	6.836	0.746	0.910	1.895	0.849
	Chakiya	33								21125	2616	6.705	1.383	0.971	2.022	0.906
	Puramanohardas	64								12200	1724	3.872	2.662	0.784	1.634	0.732
	Minhaj Pur	34								16651	2629	5.285	3.251	1.024	2.134	0.956
	Atala	78								15972	2098	5.070	1.072	0.737	1.535	0.688
	Bakshi Bazaar	77								14243	1997	4.521	2.251	0.813	1.693	0.759
	Mundera	19								9238	1540	2.932	1.662	0.551	1.149	0.515
	Neem Sarai	8								22132	3433	7.025	0.746	0.932	1.943	0.870
Zone 2	Meera Pur	62	194560	31205	61.750	23.820	10.270	21.390	9.584	11777	1982	3.738	1.680	0.650	1.355	0.607
	Dariyabad	65								19328	2920	6.135	1.077	0.865	1.803	0.808
	Sadiapur	69								13416	1971	4.258	0.439	0.564	1.174	0.526
	Tulshipur	70								12030	1892	3.818	1.407	0.627	1.306	0.585
	Katghar	51								13569	2207	4.307	1.129	0.652	1.359	0.609
	Dariyabad	58								12460	1829	3.955	1.375	0.640	1.333	0.597
	Malviya Nagar	73								12438	2620	3.948	0.695	0.557	1.161	0.520
	Attar Suiya	79								14004	2114	4.445	1.049	0.659	1.373	0.615
	Mohatsimganj	66								14057	2347	4.462	3.443	0.949	1.976	0.885
	Narainsingh Nagar	71								9374	1617	2.975	2.604	0.670	1.395	0.625
	Meera Ganj	75								13282	2172	4.216	2.989	0.865	1.801	0.807
	Azad Square	47								14418	2401	4.576	1.078	0.679	1.414	0.633
	Muthi Ganj	60								8020	1232	2.546	1.268	0.458	0.953	0.427
	Muthi Ganj bagh 1	68								14727	2288	4.674	1.819	0.779	1.623	0.727
	Bahadur Ganj	74								11660	1613	3.701	1.772	0.657	1.368	0.613
Zone 3	Govindpur	26	340666	56573	108.127	53.27	19.37	40.35	18.0767	11577	2144	3.675	1.162	0.580	1.209	0.542
	Shiv kuti	9								13178	1951	4.183	1.217	0.648	1.350	0.605
	Phaphamau	21								19900	3014	6.316	3.340	1.159	2.414	1.082
	Nyaymarg	17								11652	2415	3.698	3.872	0.908	1.893	0.848
	Ashok Nagar	6								12553	2190	3.984	0.990	0.597	1.244	0.557
	Ganga Nagar	32								22777	3505	7.229	1.070	0.996	2.075	0.930
	Rajapur	4								15342	2627	4.870	2.415	0.874	1.821	0.816
	Civil Area I	10								18056	3238	5.731	8.316	1.686	3.512	1.573
	Civil Area II	45								14612	2642	4.638	6.326	1.316	2.741	1.228

Zone Number	Ward Name	Ward Number	ZONE DETAILS							WARD DETAILS						
			Population	Household	Domestic Waste (TPD)	Commercial, institution and other waste (TPD)	Street sweeping and drain waste (TPD)	C&D Waste (TPD)	Plastic waste (TPD)	Population	Household	Domestic Waste (TPD)	Commercial, institution and other waste (TPD)	Street sweeping and drain waste (TPD)	C&D Waste (TPD)	Plastic waste (TPD)
	Alenganj	14								15796	2598	5.014	1.630	0.797	1.661	0.744
	Mehdauri	39								17271	2931	5.482	0.793	0.753	1.569	0.703
	Muirabad	27								12688	2034	4.027	1.297	0.639	1.331	0.596
	New Katra	22								13142	2574	4.171	2.718	0.827	1.722	0.772
	Mumford Ganj	5								15694	2770	4.981	1.531	0.781	1.628	0.729
	Old Katra	43								18615	2823	5.900	2.310	0.987	2.057	0.920
	Colonel Ganj	38								15945	2655	5.060	2.250	0.880	1.830	0.819
	Teliyar Ganj	30								17089	2625	5.420	1.200	0.800	1.660	0.742
	Medical College	31								10233	1886	3.250	3.120	0.760	1.590	0.713
	University Area	28								11653	2038	3.700	1.730	0.650	1.360	0.608
	Sadiabad	2								13180	1905	4.180	0.930	0.610	1.280	0.572
	Chadpur Salori	48								4924	716	1.560	1.410	0.360	0.740	0.333
	Salori	54								10443	1802	3.310	1.050	0.520	1.090	0.488
	Ishwar Saran	7								7329	1030	2.330	1.230	0.430	0.890	0.399
	Engineering	18								17017	2460	5.400	1.360	0.810	1.690	0.757
Zone 4	Madhawa Pur	24	184745	29887	58.64	17.67	9.16	19.08	8.547	16673	3221	5.292	1.626	0.830	1.730	0.775
	Krishna Nagar	23								13253	2193	4.207	0.813	0.602	1.255	0.562
	Rambagh	67								6620	1144	2.101	6.342	1.013	2.111	0.946
	Bagambari	37								12001	1894	3.809	2.294	0.732	1.526	0.684
	Malakraj	12								13178	2254	4.183	0.820	0.600	1.251	0.560
	New Basti	41								10460	1696	3.320	1.188	0.541	1.127	0.505
	Bhardwaj Pur	25								21923	3458	6.958	0.669	0.915	1.907	0.854
	Pura Parain	44								19145	2691	6.077	0.500	0.789	1.644	0.737
	Khalashi Line	61								10437	1614	3.313	0.879	0.503	1.048	0.470
	Chaukandi	55								13356	2308	4.239	1.021	0.631	1.315	0.589
	Daraganj	59								16134	2818	5.121	0.477	0.672	1.400	0.627
	Bakshi Khurd	56								22037	3061	6.995	0.193	0.862	1.797	0.805
	Alopi Bag	53								9528	1535	3.024	0.844	0.464	0.967	0.433
Zone 5	Jahagirabad	36	80466	12447	25.54	10.53	4.33	9.02	4.04	20589	2880	6.535	2.836	1.124	2.343	1.050
	Chak Batai	46								15330	2412	4.866	2.281	0.858	1.787	0.801
	Chak Raghunath	50								18086	2902	5.740	2.323	0.966	2.013	0.903
	Chakdodi	42								13083	2058	4.153	1.102	0.631	1.314	0.589
	Qazipur	11								13378	2195	4.246	2.000	0.750	1.562	0.700

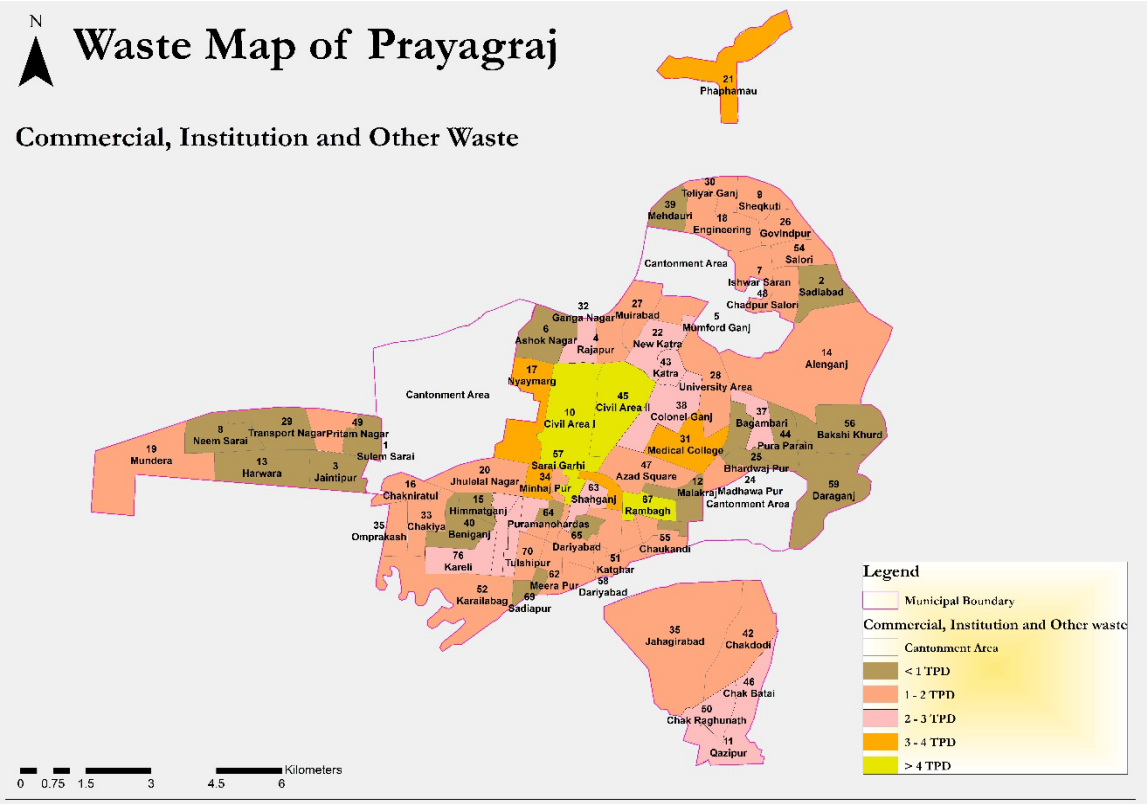


Figure 9: Ward Wise Commercial, Institution and other Waste generation at Prayagraj

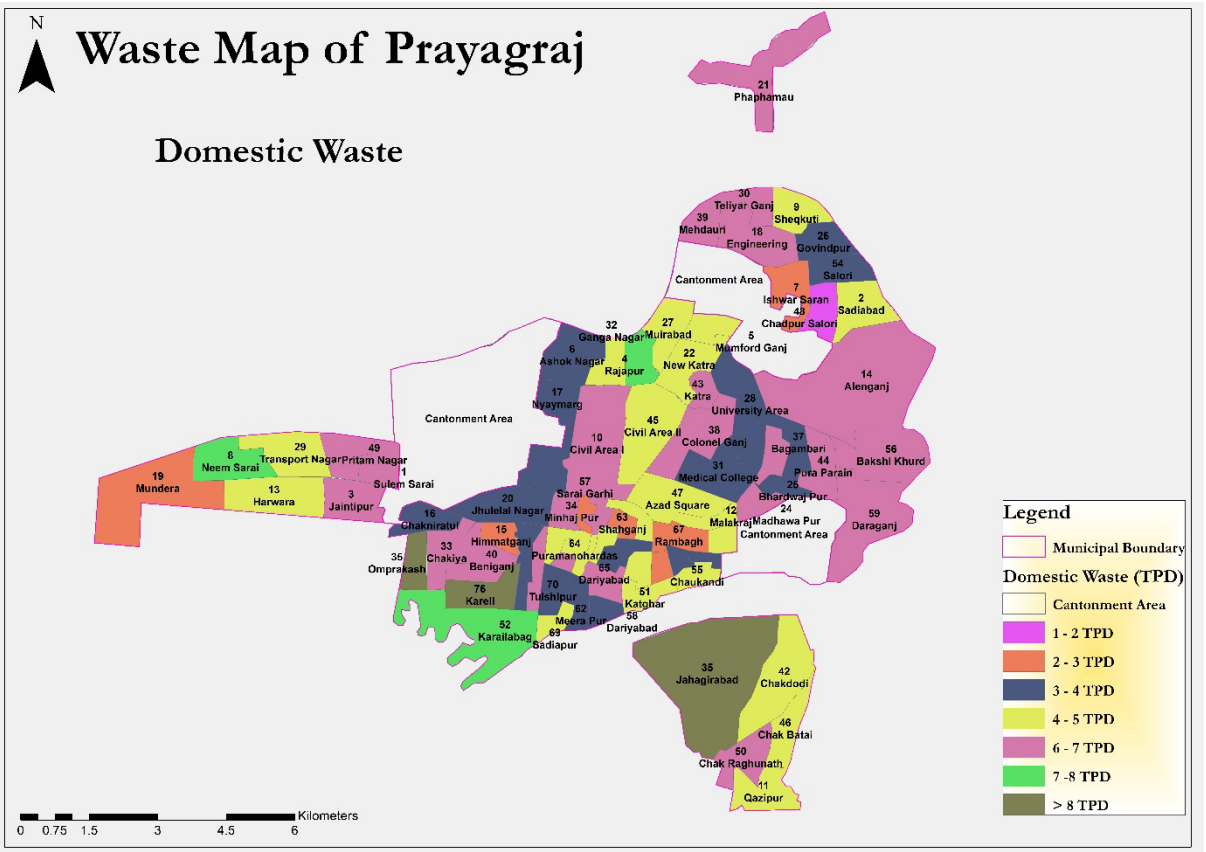


Figure 10: Ward Wise Domestic Waste generation at Prayagraj

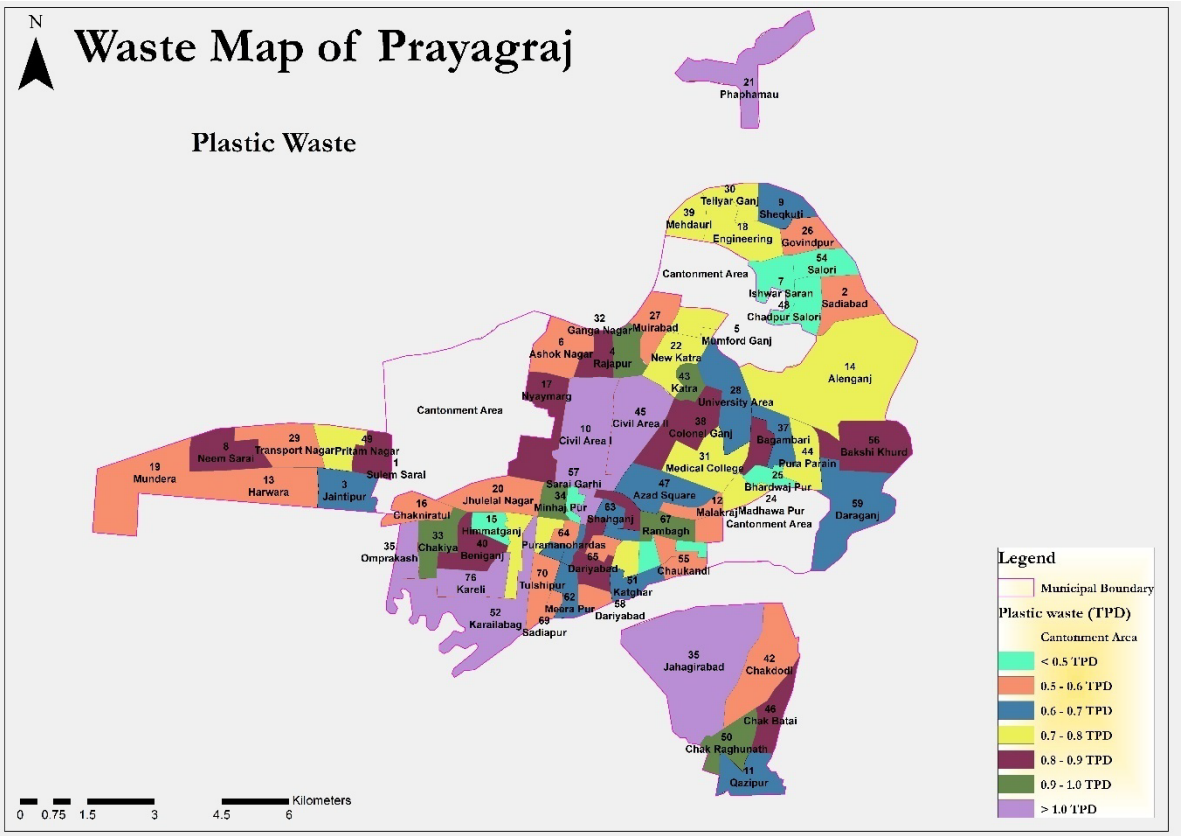


Figure 11: Ward Wise Plastic Waste generation at Prayagraj

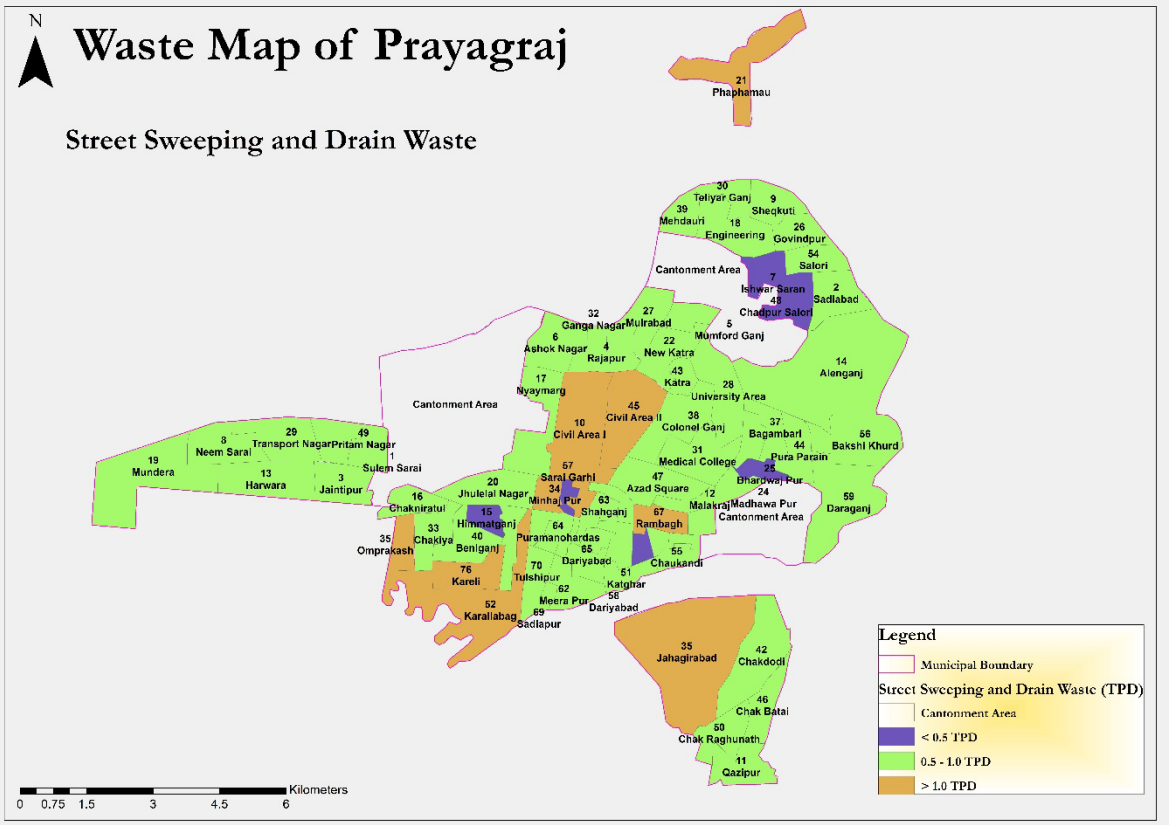


Figure 12: Ward Wise Street Sweeping and Drains Waste generation at Prayagraj

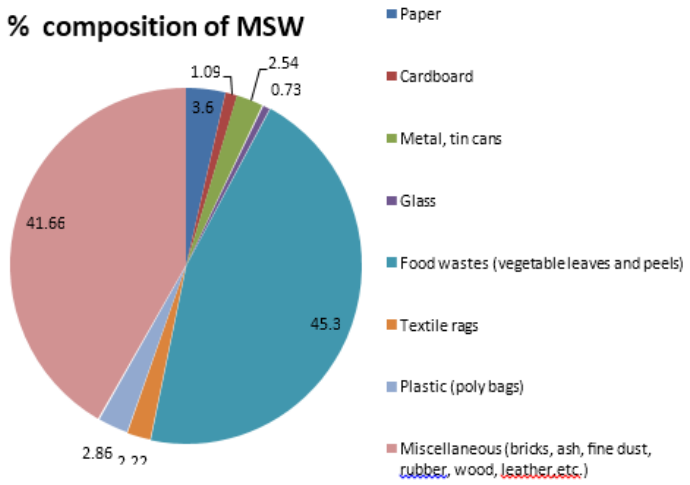
1.8 MSW Composition in Prayagraj

The results of the analyses show that MSW contains 45.3% organic matter and 40% miscellaneous materials (bricks, fine dust, rubber, wood, leather, wastewater, etc.). The percentage of recyclable materials (glass, paper, plastic, metals) has been found to be very low. This may be due to rag pickers, who collect and segregate recyclable / high value materials from collection points and disposal sites. The tentative composition of the solid waste generated in the city is summarized in the **Table 7** below:

Table 7: Composition of solid waste in Prayagraj

Constituents	% Of weight
Paper	3.6
Cardboard	1.09
Metal, tin cans	2.54
Glass	0.73
Food wastes (vegetable leaves and peels)	45.3
Textile rags	2.22
Plastic (poly bags)	2.86
Miscellaneous (bricks, ash, fine dust, rubber, wood, leather,etc.) 41.66	
Total	**100**
Moisture content	**25.86**

Source: Nagar Nigam Prayagraj



Thus, according to the above study, the plastic waste contribution in the total municipal solid waste is approximately 3%. However, this composition accounts only poly bags and not other types of plastic waste.

Solid Waste Collection and Transportation

Solid waste collection and transportation has been described below in terms of primary collection, secondary collection and transportation.

Primary Collection

Door to door collection efficiency is 61% and it has been initiated in almost of all the wards. There are about 129,835 households, which are being covered under door to door collection MSW collection service. Slum areas are not fully serviced by waste collection services. **Table 8** gives the details of the door-to-door collection services coverage.

Table 8: Details of door to door collection service coverage

PROPERTYCATEGORY	NUMBER
Households	121000
Hotels and Restaurants	145
Commercial Establishments (institutions, offices)	3840
Any other establishments (incl. markets)	4850
Total	**129835**

Source: SLB 2013, Nagar Nigam Allahabad

Field studies indicate that there is a rampant practice of throwing the wastes into the streets and drains by many households in the city as well as within the community of small restaurants and eateries. This littering of waste has resulted in clogging of drains. Excessive use of polythene bags has also emerged out to be one of the reasons for frequent clogging of drains.

Solid waste is collected in handcarts by the private operator and is disposed off to nearby secondary collection point. However, others throw the household waste outside their residences from where sweepers of Prayagraj nagar nigam collect waste by means of rickshaw trolley and dump the same into the dustbins or onto streets (open dump). In some of the cases, generators themselves dispose off waste in nearby waste collection points/ containers, onto the streets, or in the nearby drains.

The sanitation workers (*safai karamcharis*) employed by the local administration carry out street sweeping, collect drain silt and waste heaps from roadsides and dispose them at nearby open dumps. These unorganized disposal methods have resulted in accumulation of solid waste on roadsides and vacant plots and in low lying areas and storm water drains.

Secondary Collection

Secondary collection process is at an average level as shown in **Figure 13.** The bins are found overflowing with waste resulting in its littering. As per the *SWM DPR 2007*, the MSW collected from each of the primary collection points mentioned above is transported to designated open dump areas and DP containers (mostly on the main roads), which are the secondary collection points identified are nearly 50 in number and about 160 Dust bins spread over all 80 wards of the city. The waste collection from the secondary collection points starts by Dumpers and Tractor trolleys from 8 AM in the morning and goes on till 5 PM in the evening. These vehicles transfer the MSW to trenching grounds/ crude dumping sites at *Buxi Band* and *Kareli* area near Yamuna river **(Figure 14).**

Figure 13: Bad condition of secondary collection bins.

Figure 14: Road Side Open Dumping

Transportation System

Most of the times, solid waste is transported in open trolleys hauled by tractors. These open trolleys are overloaded with waste, resulting in road littering during transportation. The loading and unloading of waste is done manually. It has been found that sanitation worker (*safai karamchari)* is involved in this activity generally do not use any Personal Protection Equipment (PPE) during the execution of their services. Prayagraj Nagar Nigam (PMV) has 85 transportation equipment / vehicles. **Table 9** gives information about the number of vehicles used in collection and transportation of solid waste in the city. 380 MT/Day out of the total generated waste of 540 MT/ Day of waste in the city is collected and transported to the final disposal site. It indicates that 30% the generated waste remains uncollected and littered within the city's municipal boundaries.

Table 9: Vehicles Used in Collection and Transportation of Solid Waste

Vehicle Category	Number Of Vehicles	Capacity Of Each Vehicle (Mt)
Ashok Leyland–110HP	4	4.5
TATA–1613–135HP	3	4.5
Swaraj Majda–80HP	8	3.0
TATA–709–80HP	11	3.0
TATA–207–65HP	2	2.5
JCBs	9	
RCs–135HP	6	
Tractor Trolleys	8	2.0
Three Wheelers	32	0.5
Loaders–48HP	2	
TOTALNO.OFEQUIPMENTS/VEHICLES	**85**	

The waste transportation vehicles are operated, supervised and maintained at workshop located in front of railway station (south side) in the city. The existing dump sites/trenching grounds namely, *Buxi Band* and *Kareli*, are located at an average distance of 10 km, from the city center. The transportation vehicles make three to four trips per day to transport the MSW to these dumping sites. It takes about 1.5 to 2.0 hours to make a trip depending on the traffic conditions. The waste is transported in open vehicles and this creates unhygienic conditions in the city.

Figure 15: Vehicle used for collecting waste

Solid Waste Treatment and Disposal

Total 16305 MT/month of solid wastes is being generated in the city and waste received at disposal point is 3650 MT/month whereas waste received at processing and recycling facilities is 10250MT/month. The total waste processed is 7635MT/month and the waste rejected at processing facilities is 2700 MT while waste disposed in open dump site is 3650 MT/month. Prayagraj city have an engineered scientific treatment and disposal mechanism under process in place. User Charges demand per year by the PMC is Rs. 28.1 million, while User charges collected per year is Rs. 3.1 million (11.5% of collection efficiency).

Existing MSW Processing System:

The existing waste processing plant and landfill site is situated at Baswar. The existing waste processing unit has

- A pre segregation unit with capacity of 500. 0 MT/day
- A compost plant with capacity of 300 MT/day **(Figure 16 a&b)**
- A RDF plant with capacity of 250 MT/day
- A plastic plant recycling Unit with the capacity of 25 MT/day

There is no C& D waste processing plant and Waste to energy plant. The capacity of pre segregation unit, compost plant, RDF plant and plastic plant recycling Unit is sufficient to cater the demand taking into 105 variations. Currently, there is no treatment facility for domestic hazardous waste and sanitary waste.

(a) Generation of Compost from Waste

(b) Packing of Compost produced

Figure 16 (a) & (b): Composting Facility at Prayagraj

Figure 17: Mixed plastic waste, multilayered plastic waste found at Baswar Dump Site

1.9 Estimation of plastic waste generation in Prayagraj based on primary data

The consultation with the PMC and officials of Baswar plant indicated that the plastic composition is **3-4%** of the total waste collected and received at the Baswar landfill site. A ragpicker's and waste collector's survey across the waste picker's hierarchy was also conducted by NPC to get information about waste composition. These include ragpickers with small shops, big shops and waste collectors with hydraulic press. The findings of this survey are summarized in **Table 11, Table 12 and Table 13.**

Table 11: Findings of Rag pickers with Small Shops

Type of recyclable waste collected	Quantity (kg/d)
Carton	55
Injection Plastic Product	1
Aluminium Foil	3
PET Bottles	2
Total recyclable waste	61
Plastic waste	3
No. of small ragpickers	~ 30
Total solid waste collected(61 x 30)	1830
Total Plastic waste collected(3x 30)	90

Table 12: Rag pickers with Big Shops

Type of recyclable waste collected	Quantity (kg/d)
Cartoon	60
Injection Plastic	2
Aluminium Foil	5
PET Bottles	50
Total recyclable waste	117
Plastic waste	52
No. of big rag pickers	~ 25
Total solid waste collected(117 x 25)	**2925**
Total Plastic waste collected(52x25)	**1300**

Table 13: Only PET Bottle hydraulic press shop

Type	Quantity
PET	1 ton /day
No. of shops	25
Total PET collected (1000 x 25)	25000 kgs

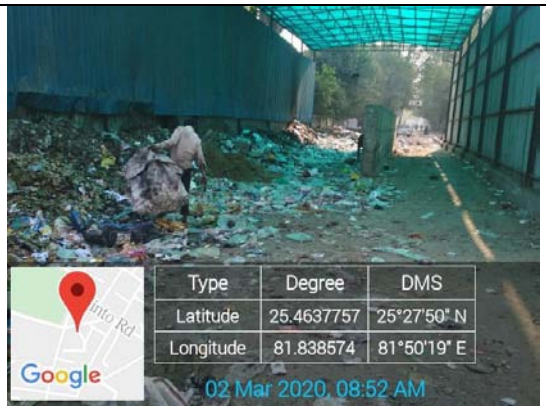
Total Plastic waste collected by rag pickers is estimated to be (25000+1300+90) **26,390**

kgs or approx. 26 tons/ day. The total quantity of plastic waste generation in Prayagraj has been estimated by collating the plastic waste collected by PMC and picked up by ragpickers or the informal sector and the plastic waste collected by Municipal Corporation.

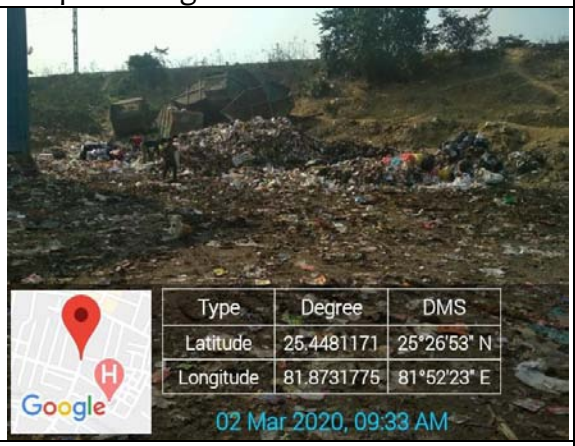
S. no.	Particulars	Value
	Plastic waste collected by Municipal corporation	
1	Solid waste collected by PMC per day as received at Baswar plant	*617952 kg/d*
2	% plastic in the collected waste at Baswar Plant	3.5%
3	**Amount of plastic waste collected**	***21628 Kg/ d***
	High value Plastic waste collected by Informal sector/ Rag pickers	
4	Recyclable Solid waste collected by rag pickers	*29755 Kg/d*
5	High value Plastic waste collected by rag pickers	26390 kg / d
6	Total waste generation of city(1 +4)	*647707 kg/d*
7	**Total plastic waste generated per day ((3 +5)**	**48018 kg / d**

It can be inferred that the amount of plastic that gets collected and needs to be addressed is is approximately 48 tons per day,whichis~7.8 % of the solid waste generated. These values are higher than the values from different secondary sources. The difference may be on account of littering **(Figure 18),** which may not have been accounted earlier. The littered plastic finds its way to the adjoining drains and water bodies and finally ending up in the Ganges and the Yamuna.

Civil Lines Behind Big Bazar: Plastic percentage 20%- commercial area



Rajapur Behind Bus Stop Service Station Plastic 8% (commercial)

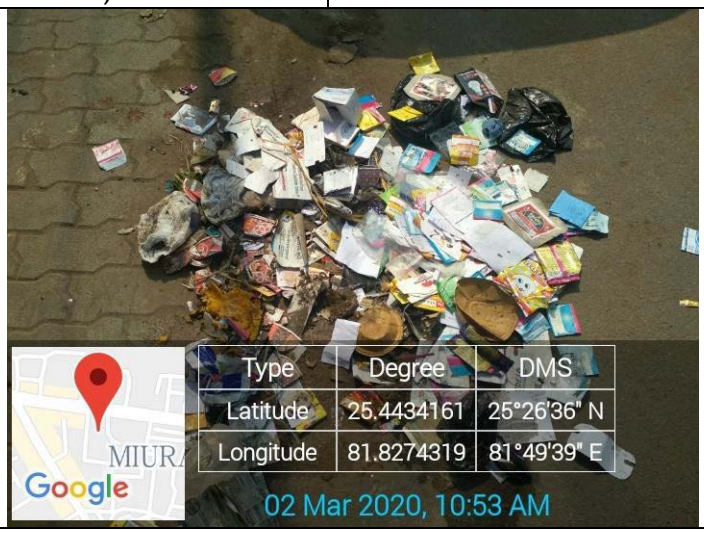


Hasimpur Plastic 7-8%

Haza–Plastic10-12%

At Bakshi Band Sabji Band mainly Construction material, Plastic 1-2%

Lida Road–Plastic10-12%



In front of Medical store, Katnoo Road, 2-3% of plastic

Figure 18: Littered Plastic in Prayagraj

An effort was made to correlate the secondary data with the findings of NPC survey. The basis of this waste data is summarized in **Table 14.**

Table 14: Waste Data from the PMC

Zone	Residential property	Mix Residential cum commercial Property	Commercial Property	Unauthorized shop small like tea shop, restaurants
No. of households / property				
Khuldabad	73253	3842	1378	3000
Mutthiganj	24498	3372	1371	
Katra	54311	2751	2534	
Allapur	29592	2739	797	
Naini	12660	908	280	
Total	**194314**	**13612**	**6360**	**3000**
Waste Generation index	**1.95 kg /Family/ day**	**2.6 kg /Family/day**	**1.6 kg /Family/ day**	0.7 **kg /Family/day**
Total waste generated(kg / day)	**378912.3**	**35391.2**	**10176**	**2700**

Zone	Residential property	Mix Residential cum commercial Property	Commercial Property	Unauthorized shop small like tea shop, restaurants
Sumtotal			427180kgs/day	

Source: Prayagraj Nagar Nigam

Table…… indicated that the waste generated is calculated to be **427** tons per day, and at 7.8%, corresponding plastic waste generation comes to be 33.3tonsper day. Hence it can be inferred that there is a high possibility of plastic waste generation from the un serviced or poorly serviced slum areas. Apparently, the waste generated in the slums is not adequately captured under the existing solid waste management plan of the city.

1.10 Hotspot identification

A step wise approach has been adopted to identify the hotspots, which serve as source of plastic leakage into the river. This is based on IUCN's approach for defining the plastic leakage as a function of loss rate and leakage rate. The various steps include identification of vulnerable areas using fuzzy logic approach adopted by GIC, AIT Thailand **(Figure 19)** and identification of leakage points **(Figure 20 & Figure 21)** followed by field reconnaissance & verification **(Figure 22)** and cleanup activities. This indicates that probable hotspots were located in vulnerable areas identified for leakage of plastics in the city. During the field study at Prayagraj, littering of solid waste comprising majority of plastic waste was observed in abundance. **Table 15** describes the list of locations or prime hot spots of waste littering in Prayagraj

Table 15: List of littering/ unserviced dumping points/ hotspots

S. No.	Particulars	Name of ward	Block no.
1	Prayagraj Nagar Nigam charge no.&01	Mundera ward no & 19	26]30
		Chakiya ward no.33	140]141&1]141&2]149&1 149&2]149&3]223]224&1]224&2
		Chakniratul wardno.&16	164]170]171
		Sulem sarai ward no.01	184&1]184&2]185]186
			187&1]187&2]188
		Jayantipur ward no.03	207]208]210&1]210&2]204
2	Prayagraj Nagar Nigam charge no.&02	Jhulelal nagarwardno.04	04
		Beniganj ward no.40	33&1]33&2]33@204]36&1]36&2
		Sadiapur ward no.69	80]88
			94]95
		Dariyabad ward no. 65	162
			165
3	Prayagraj Nagar Nigam charge no.&03	Shahganj ward no. &63	141&1]142&2
		Gadhi sarai ward no. & 57	134]136]137]138]139
		Atala ward no.&78	48
		Dariyabad ward no. &58	184
		Atarsuiya ward no. 79	82]83]86
		Mindajpur ward no.34	111]112
4	Prayagraj Nagar Nigam charge no.&04	Narayan singh nagar ward no. 71	22&1]22&2]27
		Moitsimganj ward no. 66	45
			485&1]48&2
		Chaukhandi ward no.55	135
			140&1

S. No.	Particulars	Name of ward	Block no.
		Mallahi basti Keedganj 140&2	140&2
5	Prayagraj Nagar Nigam charge no.&05	Ashok nagar ward no.6	50
			51
			51&1
			54]55
		Rajopur ward no.&4 Nevada dirjan basti-60 Nevada dirjanbasti&61	78&1]78&2
			79]60]61
			67
		Ganganagar ward no.32	91]100
			105
		Ashok nagar	228]229
6	Prayagraj Nagar Nigam charge no.&06	Teliyarganj ward no.30	34&1]34&2
			230
			39
		Meindauri ward no.39	50
			56
			64
		Shivkuti ward no.08	68
		Salori ward no.54	131]132&1]132&2
			133
			146
		Chandpur ward no.48	149
			150
			165
		Ishwar sharan ward no.7	18]188
		Badi bagiya harijan basti block no 192	189]190]191
		Shiv kuti ward no&9	192
			197
			207]208
7	Prayagraj Nagar Nigam charge no.&07	Karnalganj ward no.38	14
		Malak raj ward no.12	25]29
			34
		Medical college ward no.31	59
		Vishwa vidyalay ward no28	70&1
		Alenganj ward no14	81&1]81&2]87
			90
			92
		Bhardwaj puram ward no.25	110&1]110&2]111&1]112&2
		Badharmi gaddi ward no.37	142]143
			139
		Alopiaag ward no.53	152]154
		Madhwapur ward no.24	181
			182
		Azaad square ward no.47	201
			207
8	Prayagraj Nagar Nigam charge no.&08	Pura parain ward no.44	76
			86
			95
			97
		Daraganj ward no.59	110
			111

S. No.	Particulars	Name of ward	Block no.
			122
			123
		Baksikhurd ward no.56	133]134&1]134&2
			146&1]146&2
		Krishna nagar Keedganj ward no.23	152
			153
			154&1
			155
		Naini ward no.&11	4]5]6]7]8
			11]12]13]14]15
		Naini ward no.&36 o 42	199&1]199&2]199&3]194]67]69
		Naini ward no.&36	197&1]197&2]192
			193]194]195]196
		Naini ward no.&50	200]201]202
		Naini ward no.&46	45&1]45&2]49&1]49&2]49&3
		Naini ward no.&42	76]77]78&1]78&2
		Naini ward no.&50	22&1]22&2
		Naini ward no.&42	73]75
		Naini ward no.&11	1]2]3
		Naini ward no.&50	26]27
		Naini ward no.&42	59]60]61]62
		Naini ward no.&46	52&1]52&2
		Naini ward no&46	47]48

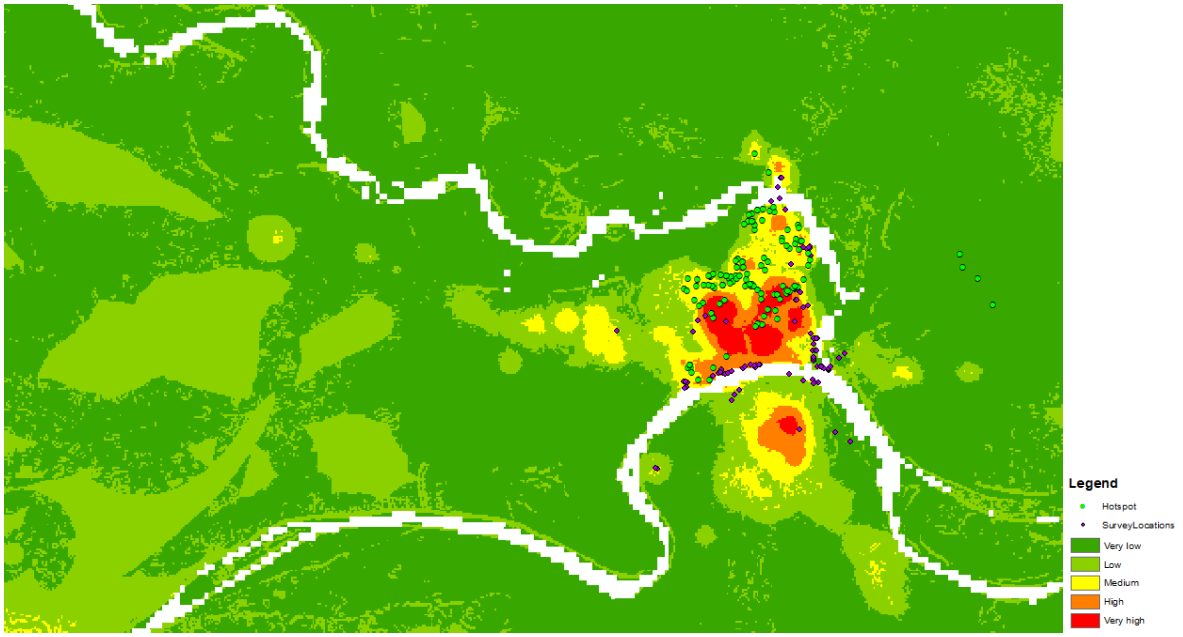


Figure 19: Plastic Leakage Vulnerable Areas identified using Fuzzy Logic Approach

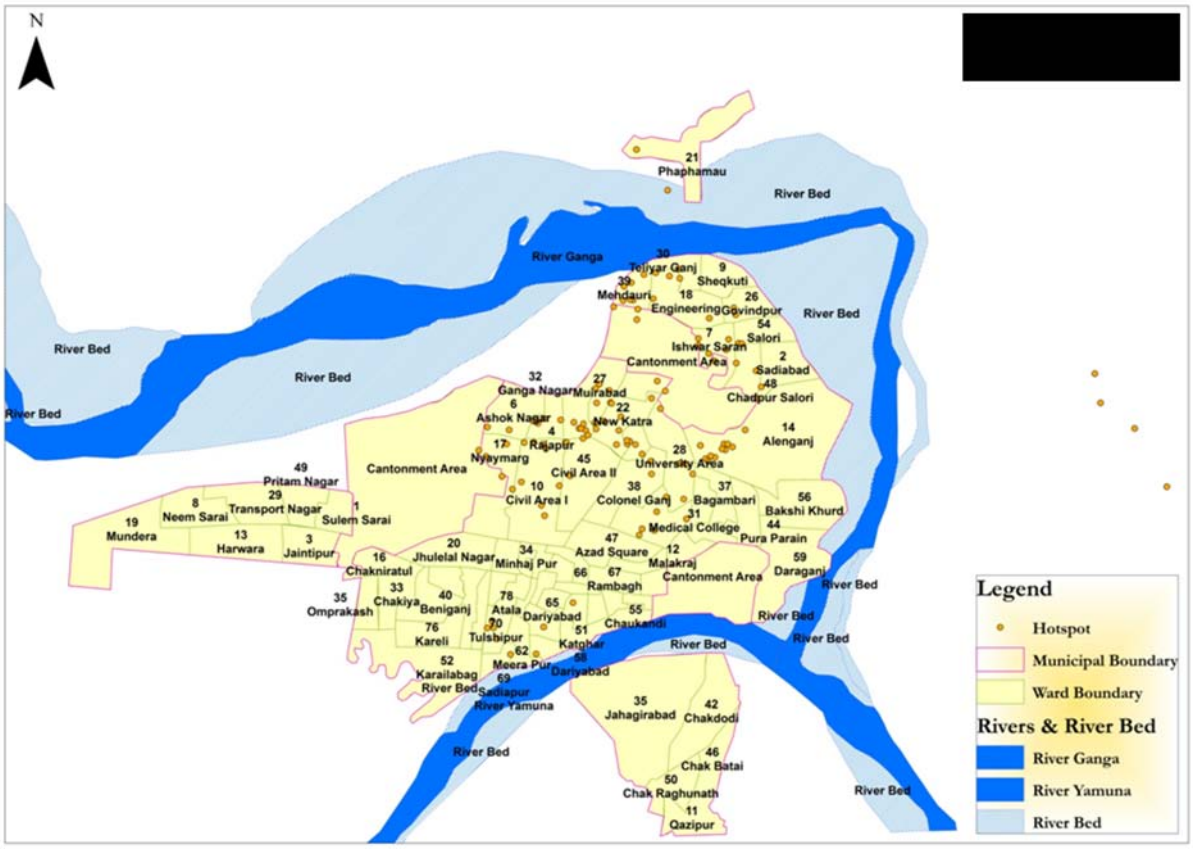


Figure 20: Location of Probable Hotspots in Haridwar

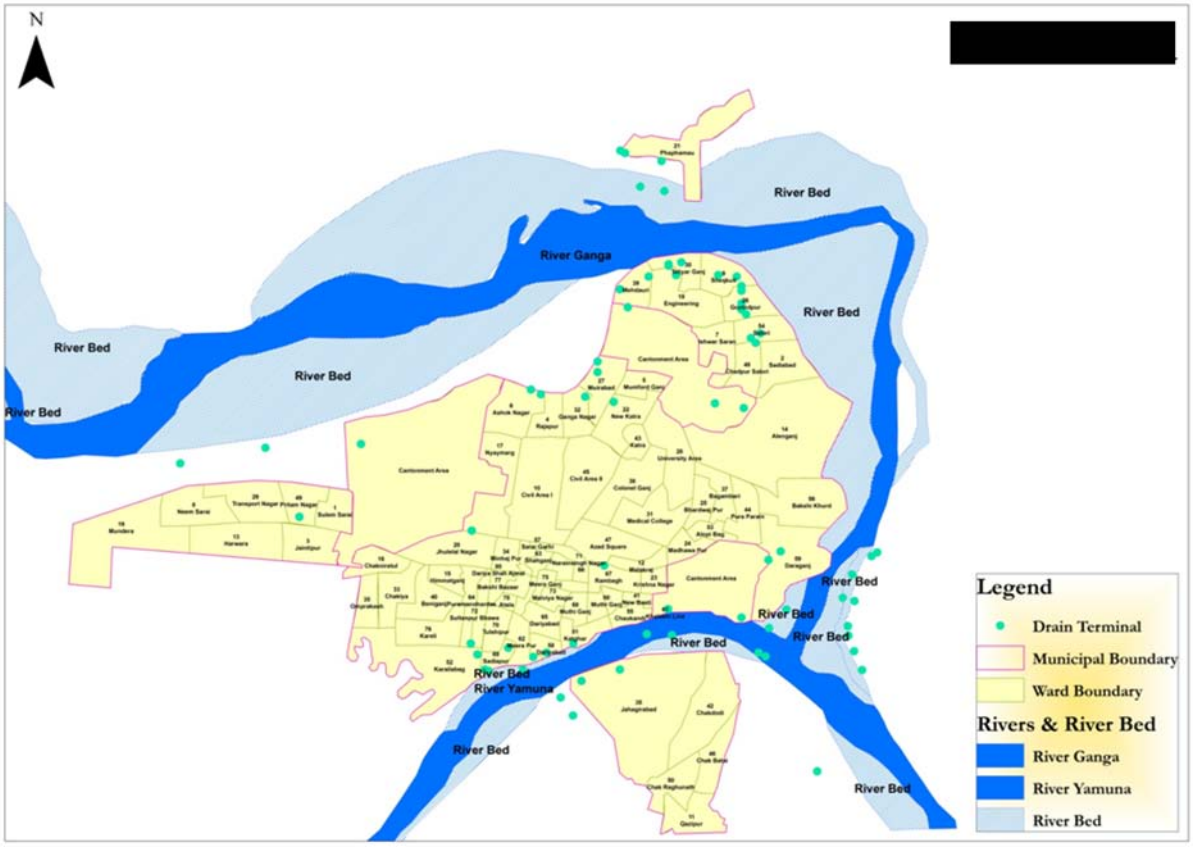


Figure 21: Drains and Sources of Plastic Leakage

Assessment of categories of plastics in the total plastic waste

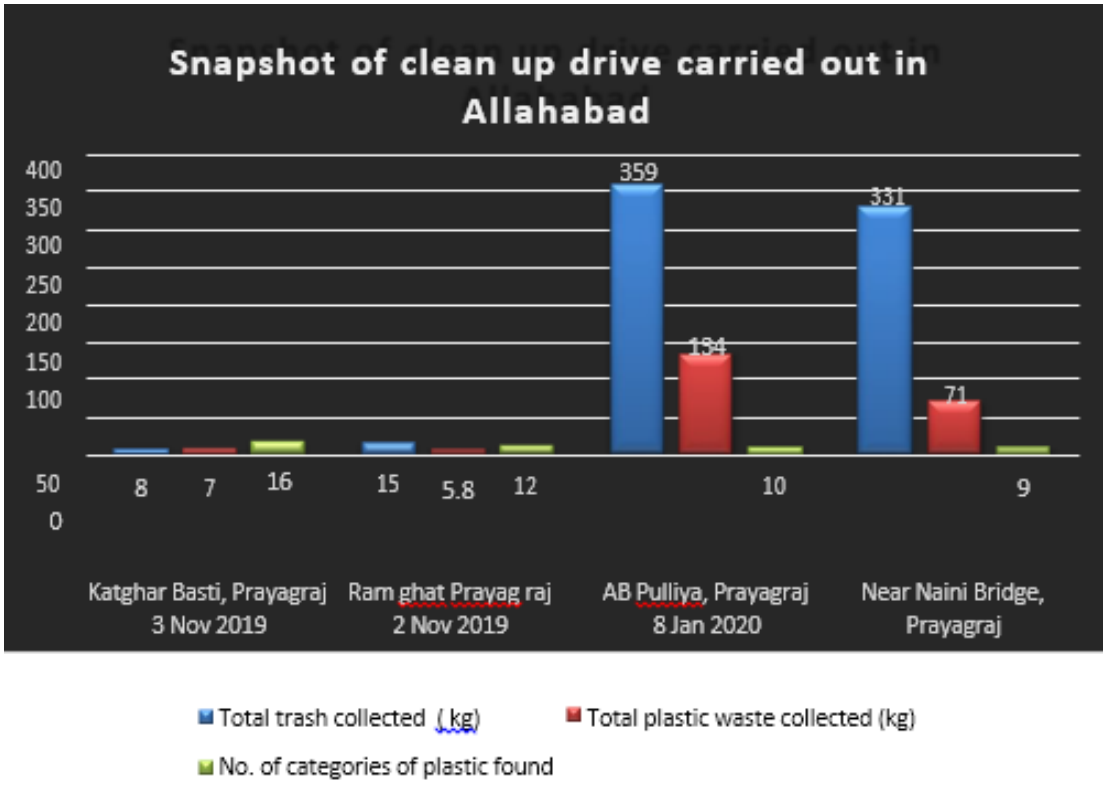
Ads per secondary data, LDPE/HDPE and PP were most prominent categories of plastics prevalent in the plastic waste in Prayagraj. As per NPC's assessment the following observations were made with regard to the category of plastics in the plastic waste stream.

Prominent plastic categories observed during cleanup drives in Prayagraj

Cleanup activities were carried out at four hotspots of plastic litter in Prayagraj as given in **Table 16** and the results are shown in **Figure 22.**

Table 16: Clean up activity at four hotspots

S.no.	Name of Hotspot	Date of Clean up activity undertaken
1	Katghar Basti, Prayagraj	3-Nov-19
2	Ramghat, Prayagraj	02-Nov-19
3	ABPulliya,Prayagraj	08-Jan-20
4	Kumbh area, below Naini new bridge, Arail Prayagraj	12th March 2020



The classification of plastics collected during cleanup drives is shown in **Figure 22.**

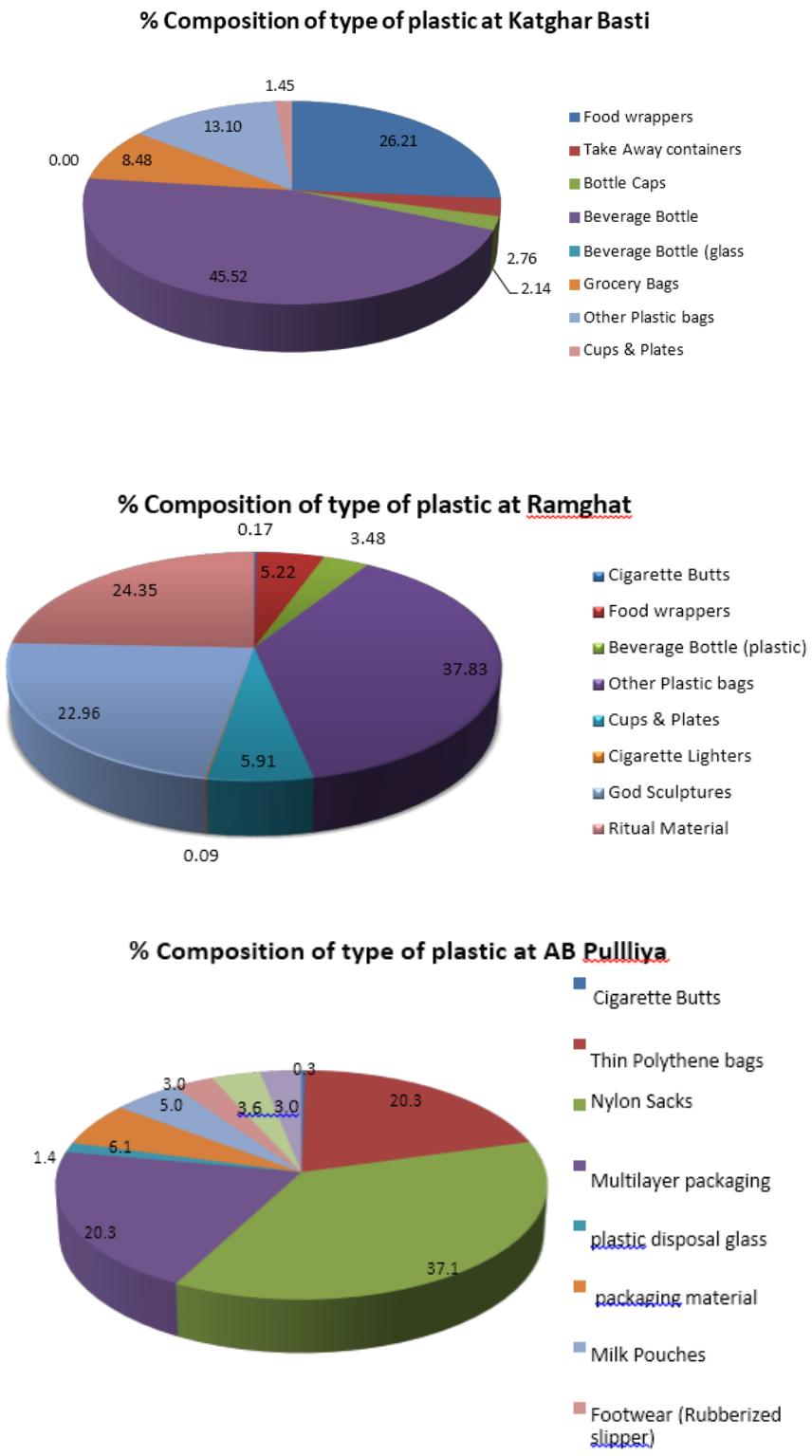


Figure 23: Composition of plastic waste found during cleanup drives

To summarize, the top five prominent plastic categories observed during cleanups are:

- Beverage bottles/PETbottles
- Nylon sacks
- Packaging plastic
- Poly carry bags

- Multilayer packaging

Prominent plastic waste as per physical observation at various hotspots

During physical observation at various hotspots the prominent plastic categories found include

- Food wrappers / take away packets
- Poly carry bags
- Packaging material

Figure 24 depict the dominant plastic categories at Plastic waste hotspots

Figure 24: Type of Plastic Littering at the Hotspot

Quantification of plastic leakage

The quantification of plastic waste leakage has been carried out considering 10% of the total solid waste generated as plastic waste in each ward. The ward wise plastic waste generation map has been prepared and depicted in **Figure 25.**

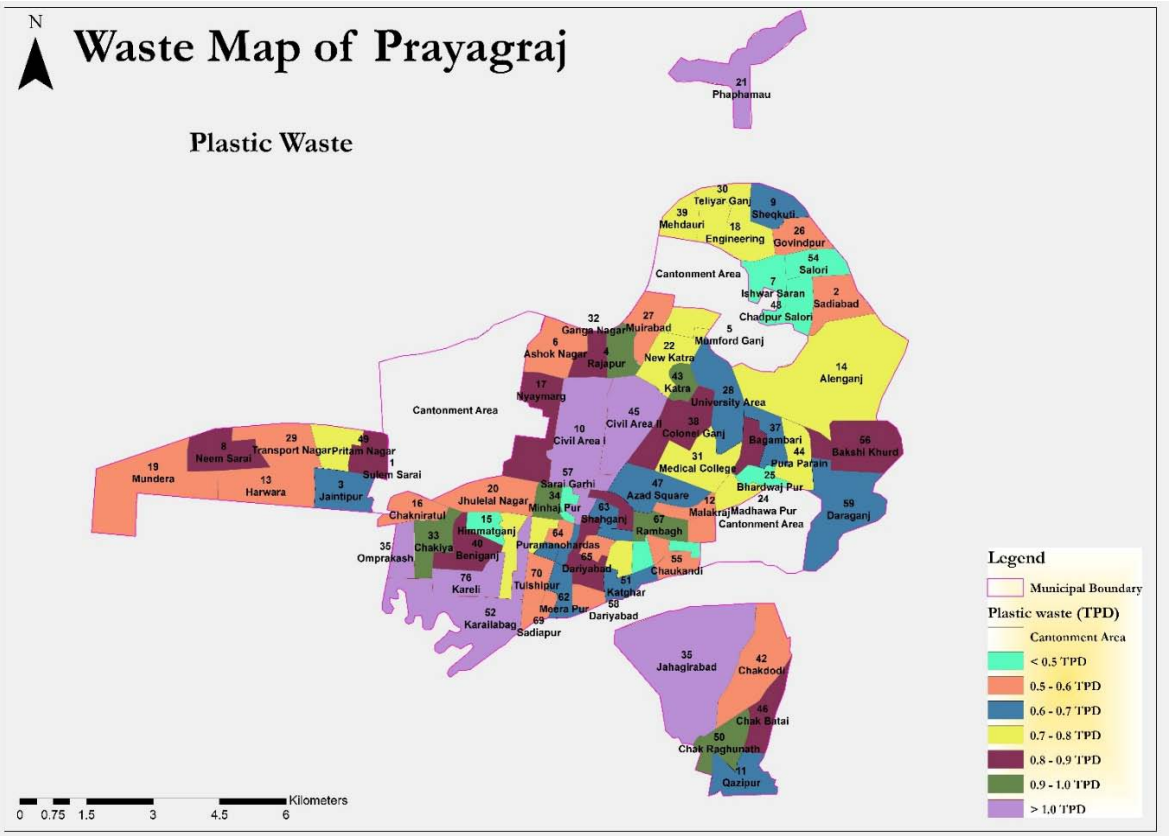


Figure 25: Ward wise Plastic waste Generation in Prayagraj

Summarizing the total solid waste generation as per primary data collection, the total waste generation in the city is calculated to be 721Tons per day and the total waste received at Baswar plant daily is approx.600Tons per day; 26T/d high value plastic is being taken away by the rag pickers. Hence, it can be concluded that the waste collection efficiency by PMC overall is 86% for Prayagraj. Based on the figures of solid and plastic waste generation per day in the city, as estimated by the primary data collected, the quantification of plastic leaking into the environment has been described in **Table 17.**

Table 17: Plastic Leakage Estimation

S. No.	Particulars	
1	Total solid waste generated in the city	~721 Tons per day
2	Total waste received at Baswar processing facility	~ 600Tons per day
3	High value Plastic waste picked by ragpickers from community bins/collectiondepots	~26 Tons per day
4	Collection efficiency	~86%
5	Plastic waste generated	~56 tons / d (33 +23)
6	Plastic waste brought back to value chain	~ 48 tons
7	**Hence, plastic waste littered**	**8 tons/ d**
8	Waste quantity littered@ 14% of (721 + 26)	~101 Tons / day
9	**Plastic waste littered @ 7.8%**	**~7.8tonsper day**

Thus, it can be anticipated that at least **7.8tons** of plastics per day leaks into the eco system, land and riverine system by various means and pathways. The various pathways of plastic waste litter are:

- Street littering
- Direct disposal in to drains/ open channel
- Surface run off
- Wind-blown from uncovered transfer stations/ wards
- Open dumping at hotspots
- Open burning

The leakage scenario has been depicted in the following flow chart **(Figure 26)**
While the Photo documentation is given in **Figure 27.**

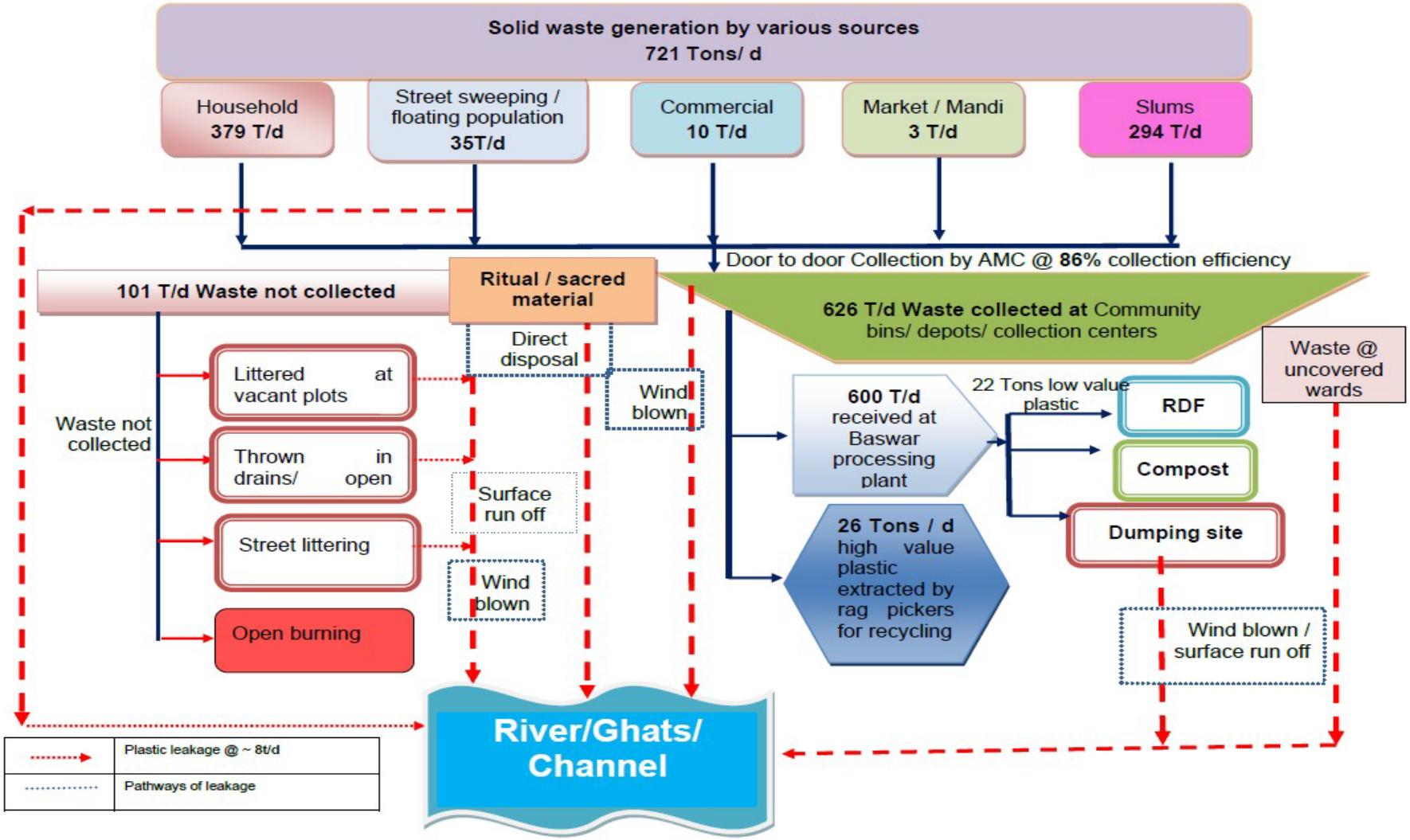
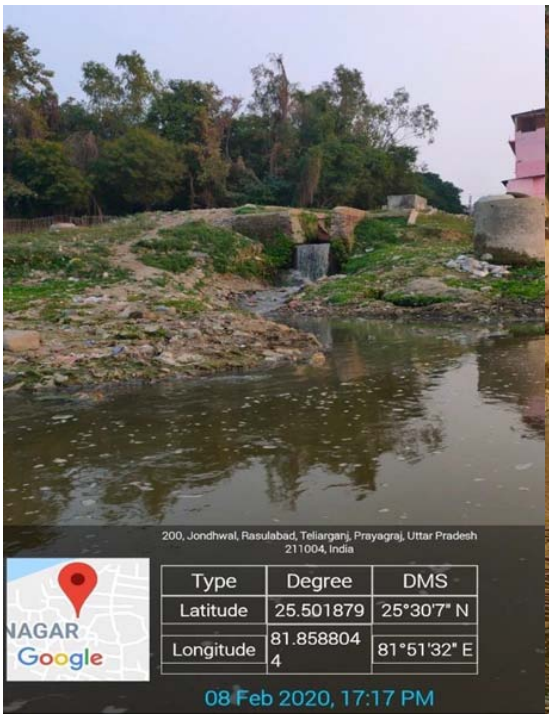
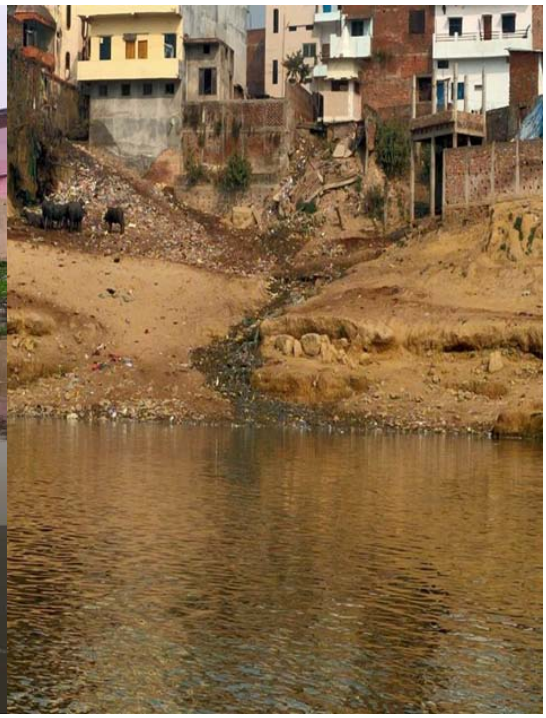
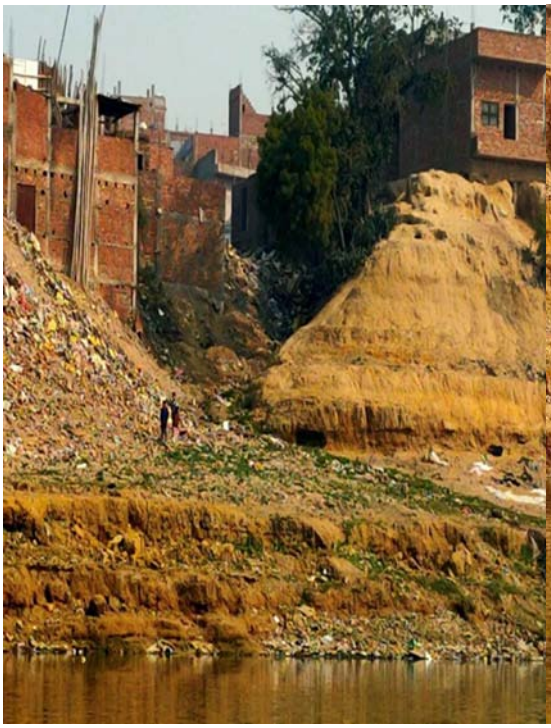
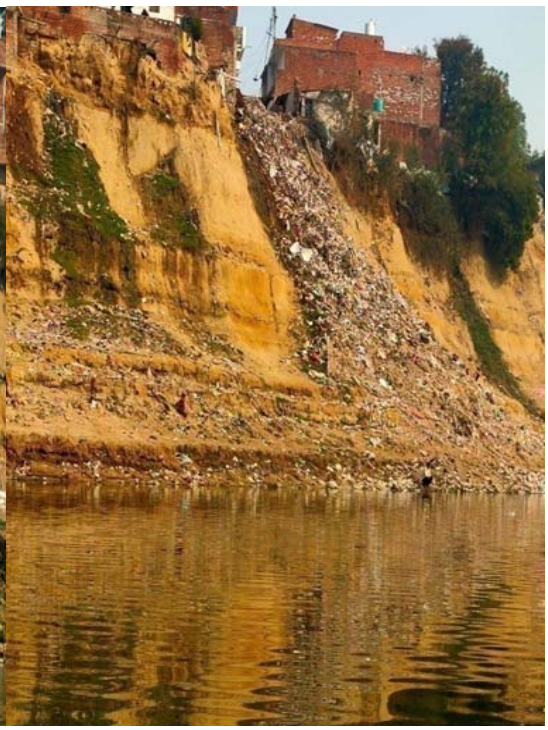


Figure 27: Flow chart of plastic leakage into the environment


200, Jondhwal, Rasulabad, Teliarganj, Prayagraj, Uttar Pradesh 211004, India
NAGAR
Google
Type | Degree | DMS
Latitude | 25.501879 | 25°30'7" N
Longitude | 81.8588044 | 81°51'32" E
08 Feb 2020, 17:17 PM







	
Plastics in drain at G.T Road, at Bangraulli Chauraha	Bengraulli Gaon Drain going to Ganga River. Plastic10-15%

Figure 28: Photo documentation of plastic leakage

Massive amount of plastic was observed to be littered during the field study at various locations in Prayagraj. Therefore, littering is one of the major reasons for the plastic not being collected and brought back into the value chain. However, majority of the waste categories found during Clean Up includes beverage bottles/PET bottles, nylon sacks, packaging plastic, poly carry bags, multilayer packaging.

Table of Contents

1.1 Introduction to Greater Mumbai 202
1.1.1 Greater Mumbai 202
1.2 Geographical and Climatic Condition 202
1.2.1 Physiography 202
1.2.2 Climate 203
1.3 Demography 203
1.4 Land Use 205
1.5 Tourism in Mumbai 208
1.6 Natural Economic Resources 208
2.1 Solid waste management in Mumbai 210
2.1.1 Data on solid waste generation in Mumbai as per secondary data 210
2.1.2 Cluster Wise Waste Generation on the basis of composition 210
2.1.3 Household Waste 214
2.2.1 Dry Waste Collection & Sorting Centers 220
2.3 Disposal & Treatment 223
3.1 Plastic Waste Generation in Greater Mumbai 226

PLASTIC LEAKAGE SCENARIO IN MUMBAI

1.1 Introduction to Greater Mumbai

1.1.1 Greater Mumbai

Mumbai, the capital city of the state of Maharashtra and also known as financial capital of India is the most populated city in India. Mumbai is located on the western sea coast of India from 18°53' North to 19°16' North Latitude and from 72° East to 72°59' East Longitude. **Figure 1** shows the Mumbai municipal boundary. Mumbai being an island city is surrounded by Arabian Sea from three sides. Due to limitation of expansion, it is the densest metropolis of the world. Municipal Corporation of Greater Mumbai (MCGM) or Brihanmumbai Municipal Corporation (BMC) is governing civic body in Mumbai.

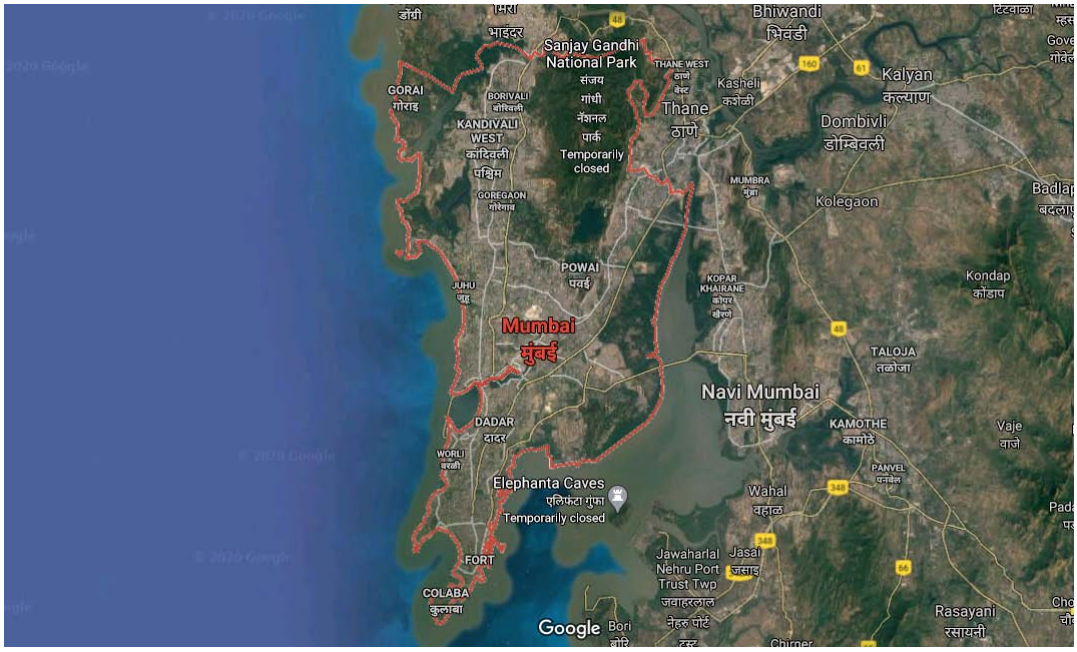


Figure 1: Mumbai City Map

1.2 Geographical and Climatic Condition

1.2.1 Physiography

Mumbai lies at the mouth of the Ulhas River on the western coast of India, in the coastal region known as the Konkan. It sits on Sashti Island, which it partially shares with the Thane district. Mumbai is bounded by the Arabian Sea to the west. Many parts of the city lie just above sea level, with elevations ranging from 10 m to 15 m; the city has an average elevation of 14 m. The drainage and contour pattern is shown in **Figure 2**. The drainage pattern indicates the natural flow from west to east with major and minor drains draining into The Arabian Sea.

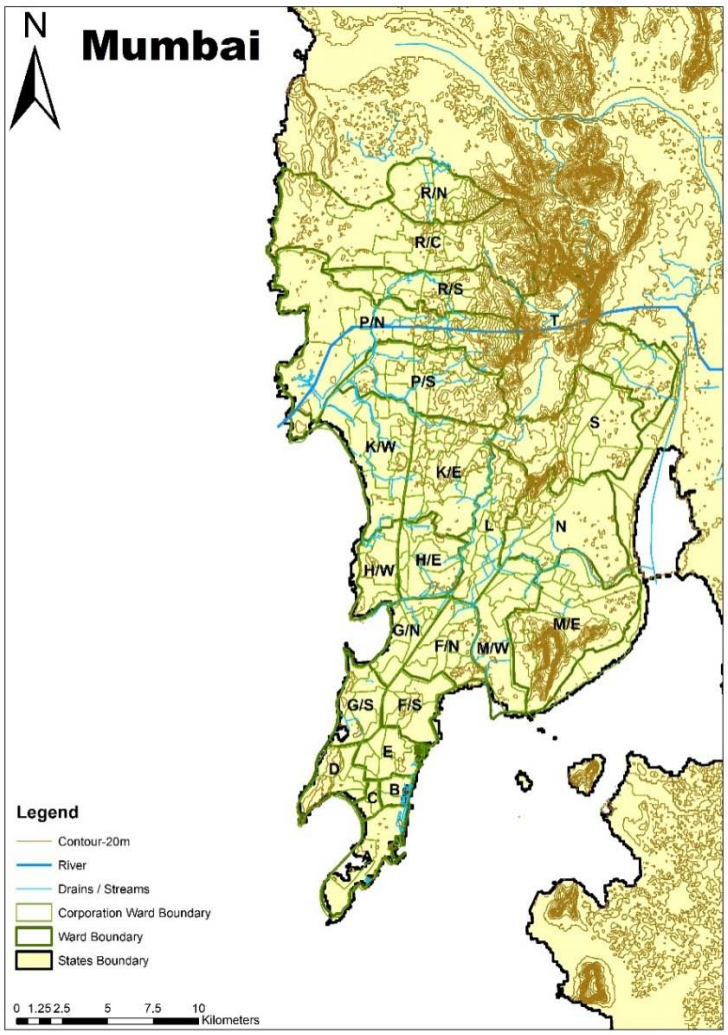


Figure 2: Drainage and contour pattern of the Mumbai city

1.2.2 Climate

Mumbai has a tropical climate, specifically a tropical wet and dry climate with eight months of dryness and peak of rains in June. The cooler season from December to February is followed by the hotter season from March to May. The period from June to about the end of September constitutes the south-west monsoon season, and October and November form the post-monsoon season.

The average annual temperature is 27.2 °C, and the average annual precipitation is 2,167 mm. In the Island City, the average maximum temperature is 31.2 °C, while the average minimum temperature is 23.7 °C. In the suburbs, the daily mean maximum temperature range from 29.1 °C to 33.3 °C, while the daily mean minimum temperature ranges from 16.3 °C to 26.2 °C. Flooding during monsoon is a major problem for Mumbai. Between June and September, the south west monsoon rains lash the city. Pre-monsoon showers are received in May. Occasionally, north-east monsoon rainfall occurs in October and November. The maximum annual rainfall ever recorded was 3,452 mm for 1954. The highest rainfall recorded in a single day was 944 mm on 26 July 2005.

1.3 Demography

Mumbai consists of two distinct regions: Mumbai City district and Mumbai Suburban district, which form two separate revenue districts of Maharashtra. The city district region is also

commonly referred to as the Island City or South Mumbai. Mumbai has a population of almost 12.64 million, as per census 2011. As per Master Plan-2021 estimated population of Mumbai will be approximately 25 million by 2021. Mumbai is also recognized as the most densely populated city. The city has an area of 603.4 km^2. The population density of the city is 26,645 person per sq.km (excluding no development area). Inverse proportion of Area and Population causes serious impact on its environment. About 40-50 % of the city's population lives in slum areas. Most prominent slum area is Dharavi, which is considered to be one of the world's largest slums. Mumbai has 24 cluster wards and 227 wards which are further, divided in 227 sub-wards. Also, Administrative Ward-wise population indicates that ward has maximum population of 9, 60,074 persons and minimum population of 1, 29,820 persons. The administrative profile of the city is given in Table 1.

Table 1: City Profile

S. No.	Particulars	Quantities
1.	Total Area	603.4 km^2
2.	Population	12.64 million
3.	Floating Population	6 million/year
4.	Population Density	26645 persons/km^2
5.	No. of household	2.7 million
6.	Number of cluster Wards	24
7.	Number of Wards	227

In Greater Mumbai 1,959 slum settlements have been identified with a total population of 6.25 million, which forms 54 per cent of the total population of the city (Census of India, 2001). The Island City houses only 17 per cent of the slum population whereas the western suburbs have high concentrations of slums especially in the inner western suburbs, where there are large slums with hazy boundaries forming a continuous area containing 58 per cent of the slum population. Average household size is 4.5 and the sex ratio is much better (842 females per thousand males) than in the rest of the city. Cluster wise population and area (in Km^2) is given in **Table 2** while cluster and ward map is given **Figure 3.** Ward P/S has the highest population while ward B has the lowest population.

Table 2: Cluster wise population and area

Cluster	Area in km^2	Population
A	11.20	188,691
B	2.65	129,820
C	1.91	169,463
D	8.30	353,759
E	7.27	401,102
F/N	12.85	539,548
F/S	9.87	368,146
G/N	8.31	610,944
G/S	9.74	385,256
H/E	12.41	568,313
H/W	8.65	313,694
K/E	24.00	840,258
K/W	25.18	763,567
L	15.62	920,155
M/E	38.19	823,772
M/W	17.62	420,079
N	29.68	635,231
P/S	46.70	960,074
P/N	25.19	472,718
R/C	47.95	573,334

Cluster	Area in km²	Population
R/N	14.17	439,941
R/S	18.31	704,966
S	32.55	758,564
T	44.91	348,249
TOTAL	**476.24**	**12,689,644**

Source: https://portal.mcgm.gov.in/irj/go/km/docs/documents/MCGM%20Department%20List/Environment/Docs/English_ ESR_2016-17.pdf

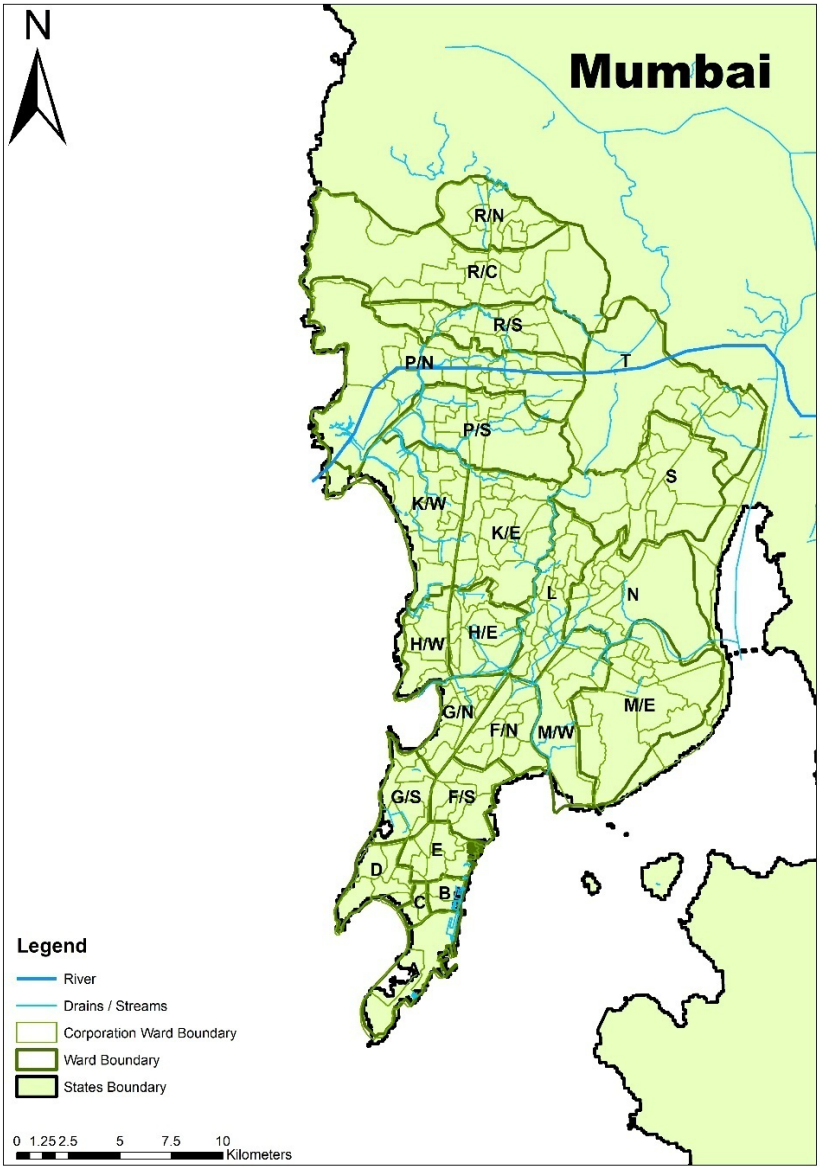


Figure 3: Cluster and Ward Map

Mumbai attracts a huge number of tourists every year as Mumbai offers natural heritage and modern entertainment including leisure spots, beaches, cinemas, studios, holy places, amusement parks and historical monuments. About 6 million tourists visited Mumbai every year. This floating population also contributes substantially to the total solid waste generation in the city.

1.4 Land Use

The total area of Mumbai is 603.4 km^2. Of this, the island city spans 67.79 km^2, while the suburban district spans 370 km^2, together accounting for 437.71 km^2 under the administration of Municipal Corporation of Greater Mumbai (MCGM). The remaining areas belong to various Defense establishments, the Mumbai Port Trust, the Atomic Energy Commission and the Borivali National Park, which are out of the jurisdiction of the MCGM. The Mumbai Metropolitan Region which includes portions of Thane, Palghar and Raigad districts in addition to Greater Mumbai, covers an area of 4,355 km^2 (45828 Ha)

Existing Land use distribution for Greater Mumbai (2012) is presented in **Table 3**, while the breakup is shown in **Figure 4** given below. The analysis reveals that 65.3% (271.17 sqkm) of the Planning Area of Greater Mumbai is developed, while natural areas, vacant lands, plantation & salt pans constitute the remaining 34.7%. Of this developed area, 24.9% is occupied by Residential use, 5.4% by Industrial uses, 2.2% by Commercial uses and 0.9% by Offices. Amenities (Education, Medical, and Social Amenities) constitute 3.69%, open space 3.7% and Public Utilities & facilities 1.7%. Transport and Communication facilities constitute 12.8%. Together 21.9% of the developed area is under Amenities, Open Space, Public Utilities and Transport.

Table 3: Existing land use distribution for Greater Mumbai (2012)

Existing Landuse Categories (2012)	Area (ha)	% of Total Area
Residential	10,327.09	24.9%
Commercial	911.46	2.2%
Offices	360.96	0.9%
Industrial	2,242.88	5.4%
Open Spaces	1,537.78	3.7%
Education Amenities	853.81	2.1%
Medical Amenities	318.44	0.8%
Social Amenities	355.81	0.9%
Public Utilities and Facilities	693.43	1.7%
Transport & Communication Facilities	5,306.92	12.8%
Urban Villages	318.42	0.8%
Primary Activity (P1, P3, P4, P5, P6, P7)	939.22	2.3%
Unclassified	1,829.77	4.4%
Vacant Land (only under construction)	1,121.97	2.7%
Developed Area	**27,117.96**	**65.3%**
Natural Areas	11,303.82	27.2%
Vacant Land (Excluding under construction)	2,282.82	5.5%
Primary Activity (P2 and P8)	801.11	1.9%
Undeveloped Area	**14,387.75**	**34.7%**
Total Planning Area	**41,505.71**	**100.0%**
Area under Special Planning Authority	4,322.79	**9.4%**
Total Greater Mumbai area	**45,828.50**	

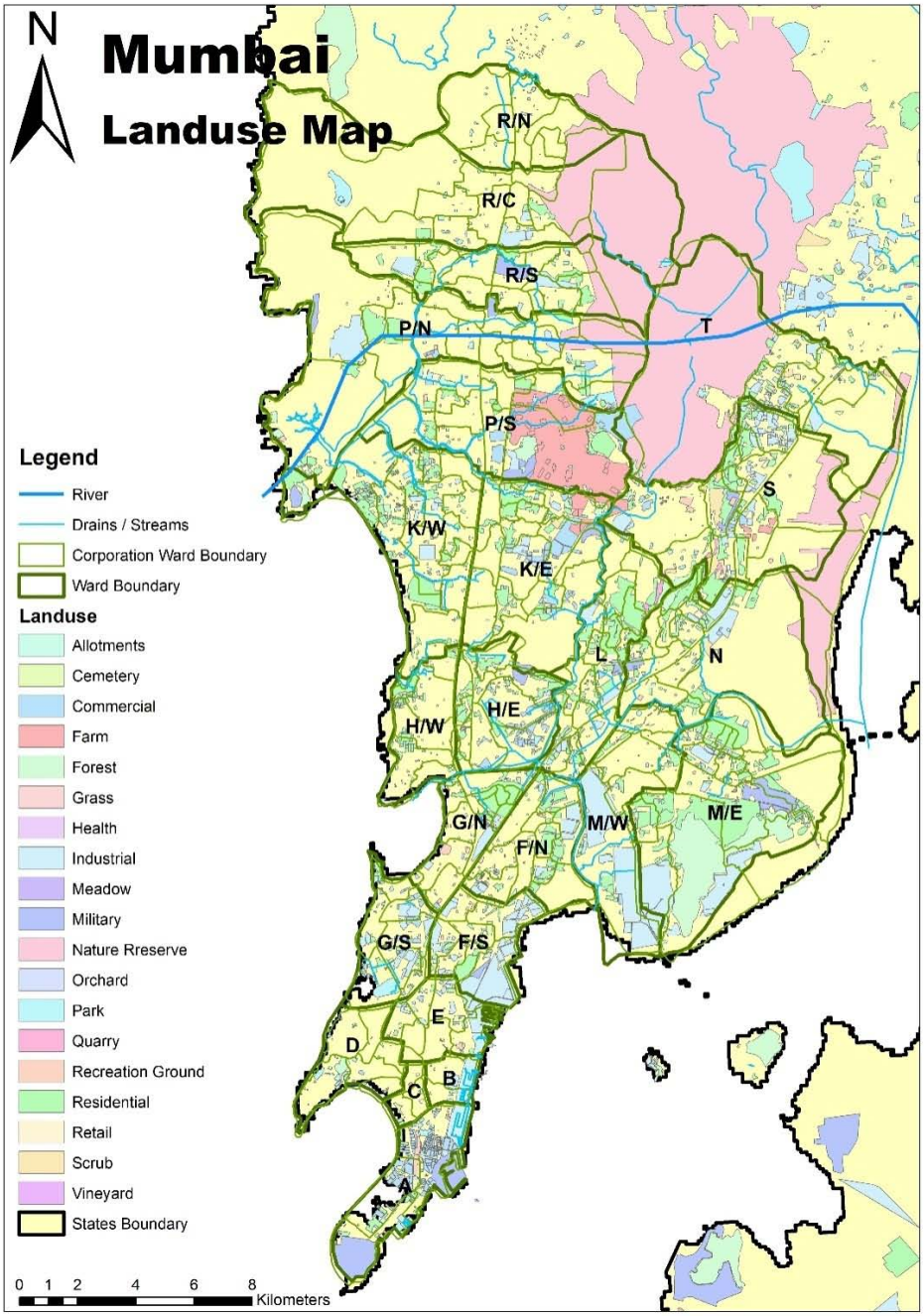


Figure 4: Land Use Map of Mumbai

The District is well connected by roads, railways and airways from the other parts of the Country. It has an International airport at Ville-Parle. A well-developed International Sea port is also located in Mumbai District which is hardly 15 kms from this District. Mumbai Suburban District falls under the Maharashtra Littoral, the micro level division of coastal plains and Islands. It is a part of an island (as of today), which lies entirely outside the main land of Konkan separated by a narrow Thane creek and a wider Harbour Bay. This island is originally consisted of eight separate islands, which are amalgamated into one due to human interference by bridging of breaches and infilling of central tidal depressions in between the islands. The land located in the North of Mahim creek is known as Salsette Island which together with Trombay area forms the Mumbai Suburban District. The District spreads from Bandra to Dahisar on the Western Railway side and Kurla to Mulund on the Central Railway side including Chembur and Chembur Camp. Mumbai transport connectivity map is shown in **Figure 5**.

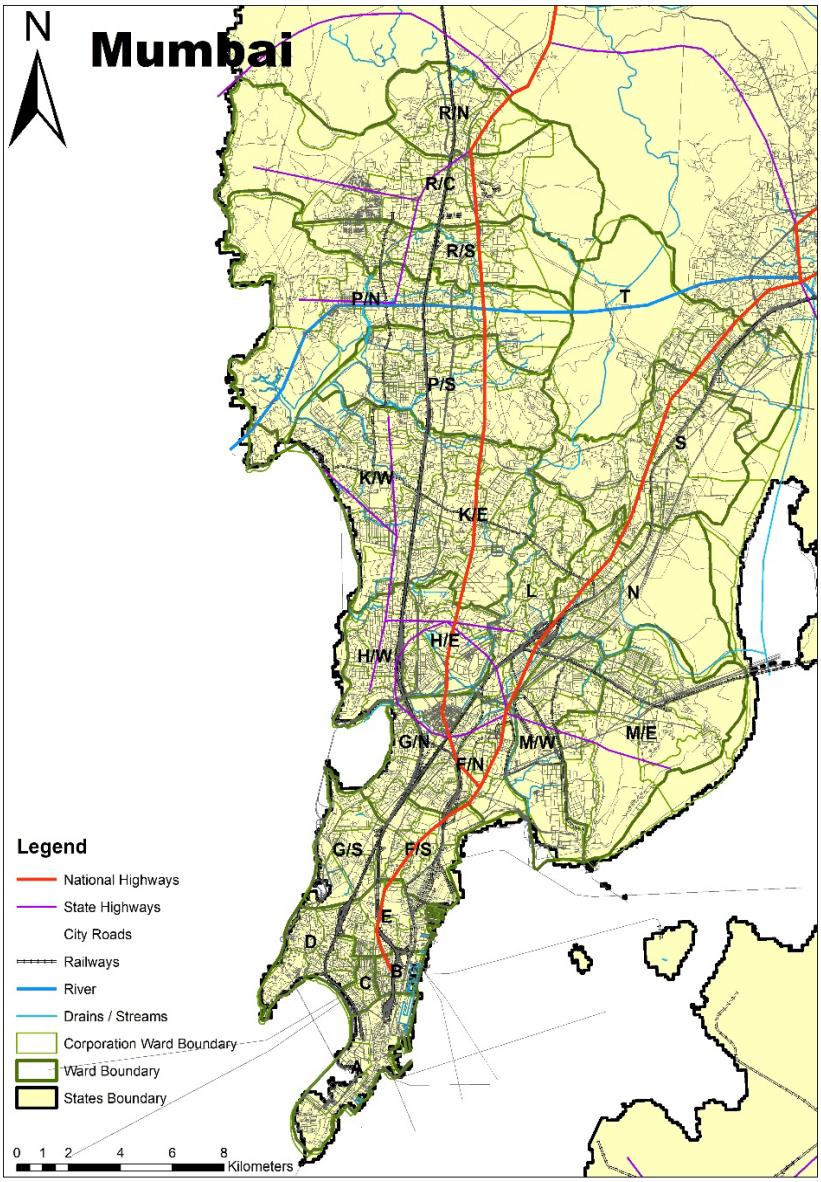


Figure 5: Mumbai city Transportation connectivity map

1.5 Tourism in Mumbai

Mumbai is one of the key tourist destinations attracting tourists from all over the world. Famously known as the City of Dreams, Mumbai formerly known as Bombay is a beautifully blended melting pot of cultures and lifestyles. The city soaks in everything into its fabric, making it its very own. From upcoming actors struggling to make it big on the silver screen; from Bollywood superstars to big industrialists to tribes of fisherman and slum dwellers, Mumbai is a city that proudly boasts of stories from different walks of human survival. The Mumbai city currently has many tourist spots such as Gateway of India, Marine Drive, Haji Ali, Sidhivinayak temple, Elephanta Caves, Juhu Chowpatty Beach, Hanging Garden, Nehru Planetarium, Malabar Hill and many more.

1.6 Natural Economic Resources

1) Forestry

The National park on the Northern outskirts of the Western Suburb of the District is the only existing forest in the vicinity of the city. Some pockets of forests are also visible in the catchment areas of Tulsi, Vihar and Powai lakes. Earlier there used to be considerable vegetation growth in many parts. Now the immense growth of urbanization and industrialisation has reduced the forest cover of the city.

2) Minerals and mining

No minerals of economic importance are found in the Mumbai area except some deposits of bauxite in the laterite plateau, East of Kanheri Caves.

3) Soil and Cropping pattern

The soil is essentially derived from the Deccan trap, which cover the entire area covering Mumbai. Initially substantial area was under cultivation with rice, coconut and vegetables etc.

4) Agriculture

As per 2011 Census, 0.4 percent of the total workers are engaged as cultivators and 0.67 percent of the total workers are engaged as agricultural labourers in the District. Therefore, agriculture is very less practised in the district.

5) Fisheries

Marine fishery is an important economic activity of the District. The Mumbai Suburban District has a number of fishing villages all along the coast, where fishing is carried out between September and May. Versova is an important centre of fishing activities in the District.

6) Industry

Mumbai Suburban is one of the most industrially advanced and developed districts in the State. All types of major industries like cotton, steel, oil, chemicals, fertilizers, pharmaceuticals, oil refinery, manufacturing of machinery and equipment etc. are located in this District.

2.1 Solid waste management in Mumbai

Municipal Solid Waste (MSW) generation sources in Mumbai are prominently Households, Restaurants, Commercial area, Market area, Public Cleansing, Offices, hospitals and hotels etc. During field survey in Mumbai city, it has been observed that households from residential areas and slums contribute to high volume of MSW. MCGM has framed its own Bye-laws in 2006, named as "Greater Mumbai Cleanliness & Sanitation Byelaws" to manage municipal solid waste in MCGM area. These Bye-laws are applicable to every public place within the limits of Greater Mumbai, to every generator of Municipal solid waste and to every premise under the ownership or occupation of any person within the limits of MCGM.

2.1.1 Data on solid waste generation in Mumbai as per secondary data

The report from erstwhile Planning Commission indicate that the current MSW management system in Mumbai is inefficient. The rapidly increasing amounts of municipal solid waste being produced in Mumbai in combination with poor management planning and insufficient financial resources, makes today's situation a severe problem (Srivastava et al., 2015: 321).

Solid waste generated in Mumbai is over 7200-7500 Metric Tonnes per day (MTPD). Categories of waste that are separately collected in terms of types and quantity of waste generated are; 72.6% organic wet waste i.e., food, vegetable & fruit waste; 3.51% organic-dry waste i.e., wood & cloths; 17.37% Sand, Stone & Fine earth; 3.24% plastic and 3.28% paper & recyclables like metals (**Table 4**). Total of 7200- 7500 tonnes of waste is transported by vehicles in 4846 trips per day.

Table 4: Composition of solid waste In Mumbai

Sr. No.	Type of Solid Waste	Percentage
1	Food Waste(organic- wet)	72.6%
2	Wood, Cloth (organic-dry)	3.51%
3	Sand, Stone & Fine earth	17.37%
4	Plastic	3.24%
5	Paper and recyclables (including metals)	3.28%
	Total	**100.00**

Source: Environment Status Report 2017-18, MCGM

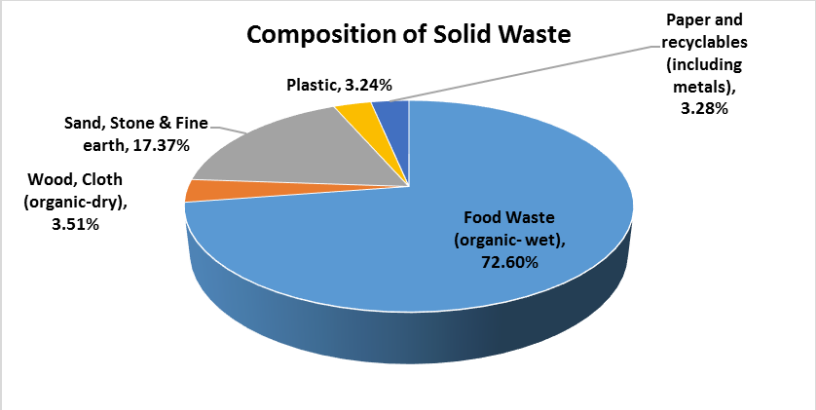


Figure 6: % Composition of Solid Waste in Mumbai

2.1.2 Cluster Wise Waste Generation on the basis of composition

Cluster ward wise waste generation and composition is given below in **Table 5** Also, different types of waste generation are also shown in **Figure 8 to Figure 11.**

Table 5: Cluster Ward Wise waste Generation & composition in Mumbai

Cluster	Population	Total waste generation	Food Waste	Wood & cloth	Sand stone & fine earth	Plastic	Paper & recyclables
A	188,691	103.78	75.76	3.11	17.64	3.11	4.15
B	129,820	71.40	52.12	2.14	12.14	2.14	2.86
C	169,463	93.20	68.04	2.80	15.84	2.80	3.73
D	353,759	194.57	142.03	5.84	33.08	5.84	7.78
E	401,102	220.61	161.04	6.62	37.50	6.62	8.82
F/N	539,548	296.75	216.63	8.90	50.45	8.90	11.87
F/S	368,146	202.48	147.81	6.07	34.42	6.07	8.10
G/N	610,944	336.02	245.29	10.08	57.12	10.08	13.44
G/S	385,256	211.89	154.68	6.36	36.02	6.36	8.48
H/E	568,313	312.57	228.18	9.38	53.14	9.38	12.50
H/W	313,694	172.53	125.95	5.18	29.33	5.18	6.90
K/E	840,258	462.14	337.36	13.86	78.56	13.86	18.49
K/W	763,567	419.96	306.57	12.60	71.39	12.60	16.80
L	920,155	506.09	369.44	15.18	86.03	15.18	20.24
M/E	823,772	453.07	330.74	13.59	77.02	13.59	18.12
M/W	420,079	231.04	168.66	6.93	39.28	6.93	9.24
N	635,231	349.38	255.05	10.48	59.39	10.48	13.98
P/S	960,074	528.04	385.47	15.84	89.77	15.84	21.12
P/N	472,718	259.99	189.80	7.80	44.20	7.80	10.40
R/C	573,334	315.33	230.19	9.46	53.61	9.46	12.61
R/N	439,941	241.97	176.64	7.26	41.13	7.26	9.68
R/S	704,966	387.73	283.04	11.63	65.91	11.63	15.51
S	758,564	417.21	304.56	12.52	70.93	12.52	16.69
T	348,249	191.54	139.82	5.75	32.56	5.75	7.66
TOTAL	**12,689,644**	**6979.30**	**5094.89**	**209.38**	**1186.48**	**209.38**	**279.17**

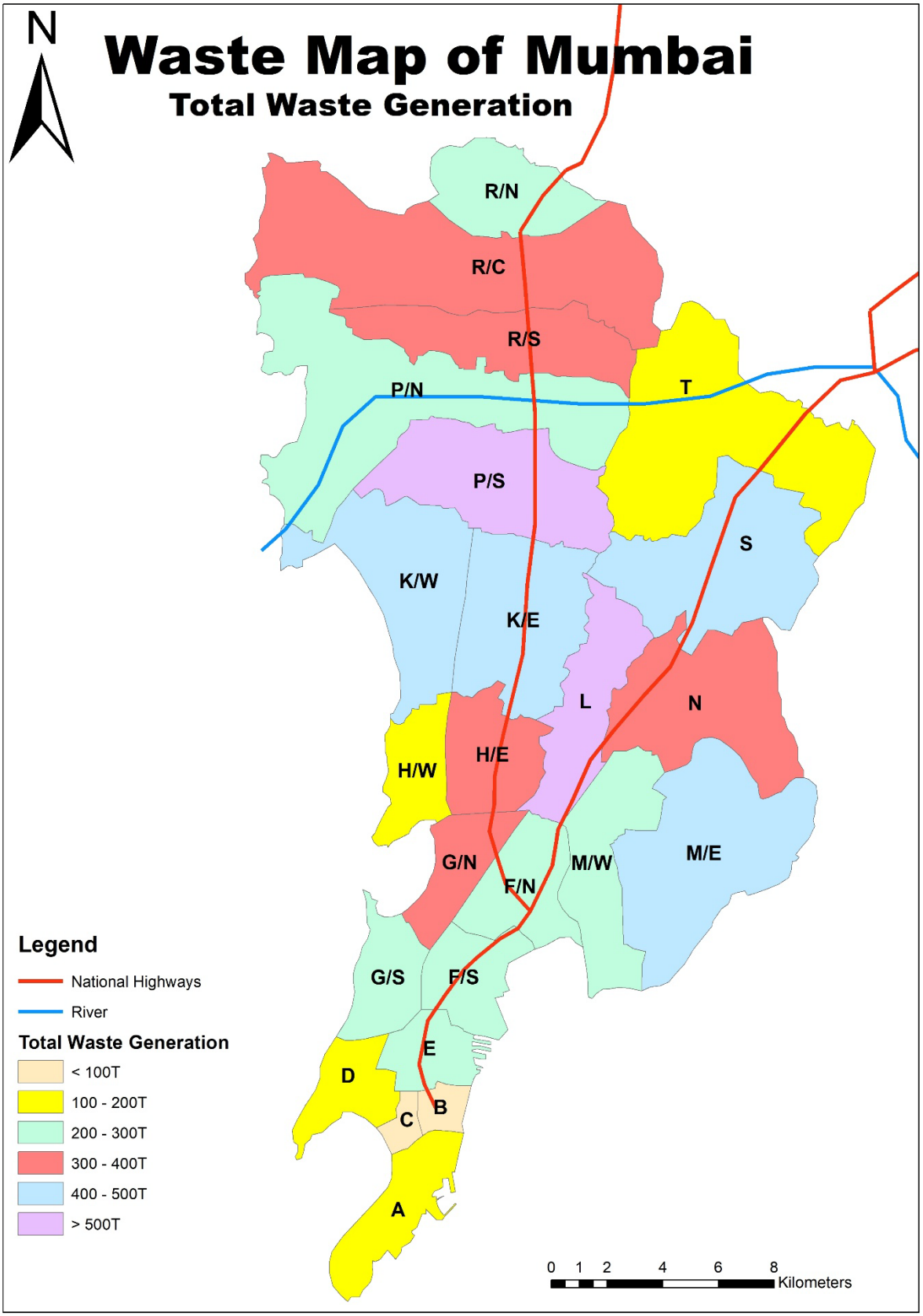


Figure 7: Total Solid Waste Generation in Mumbai

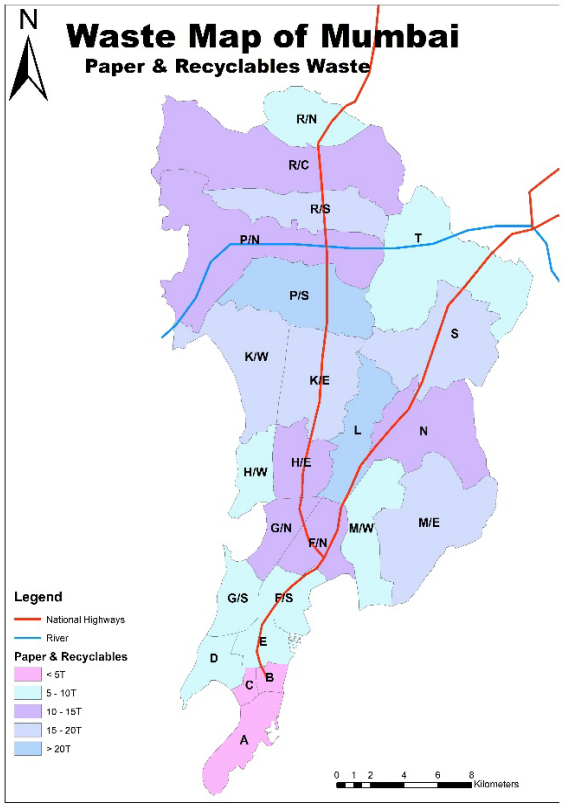


Figure 8: Paper & Recyclables Waste Generation in Mumbai

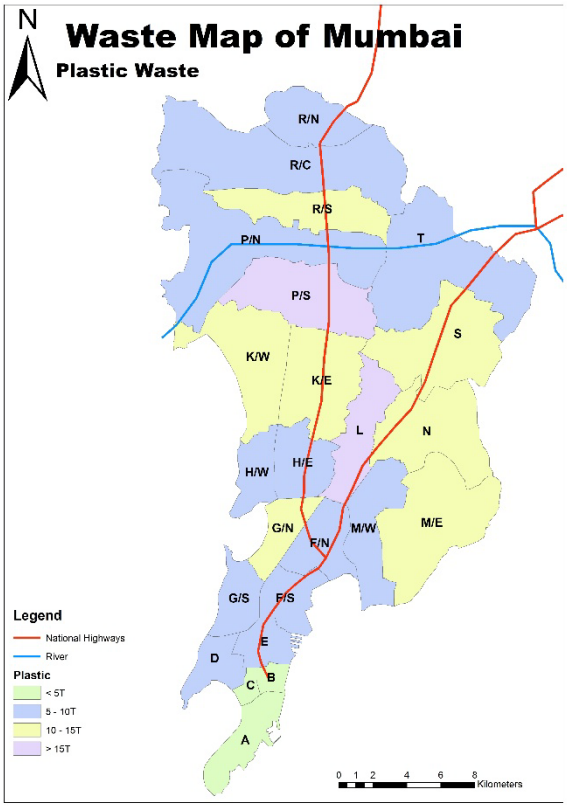


Figure 9: Plastic Waste Generation in Mumbai

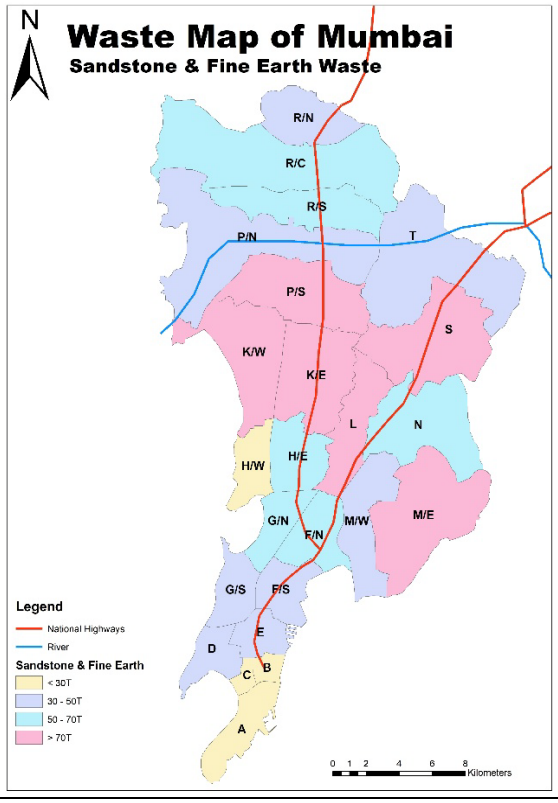


Figure 10: Sandstone & Fine Earth Waste Generation in Mumbai

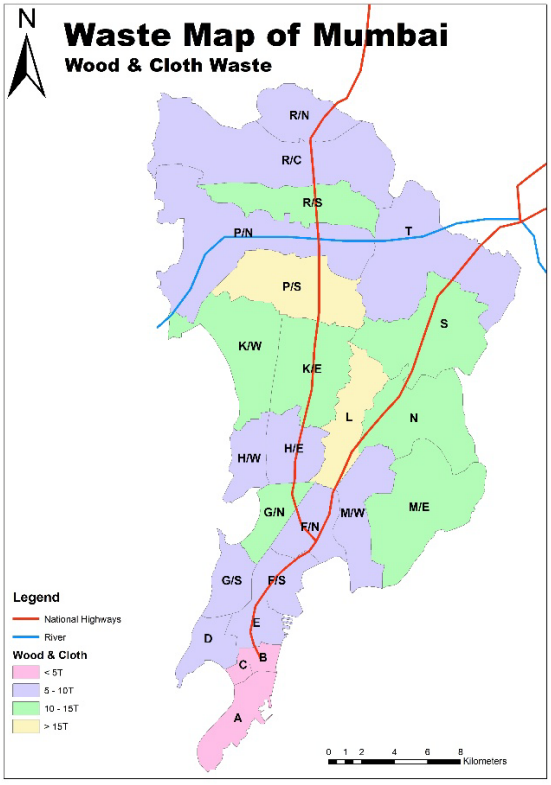


Figure 11: Wood & Cloth Waste Generation in Mumba

2.1.3 Household Waste

Social Economic level plays a vital role in generation of household plastic waste. Three social economic levels are identified as follows:-

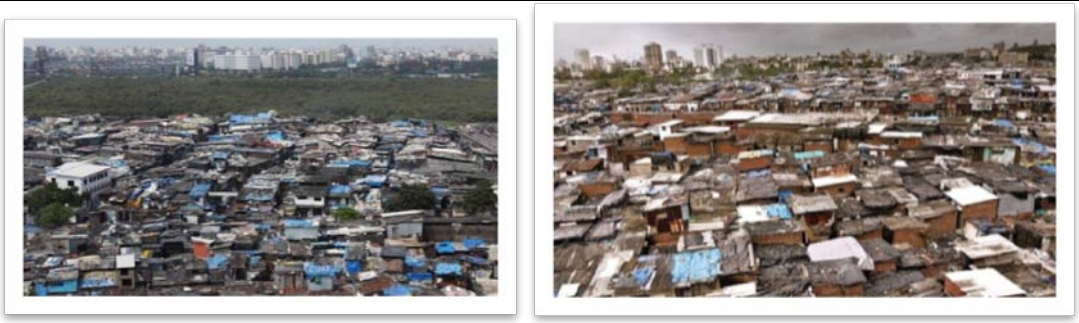
1. Higher Income Group
2. Middle Income Group
3. Low Income Group or Slum Establishment

The percentage of people living in slums **(Refer Figure No. 12)** is estimated to be as high as 40-50% of total population in Greater Mumbai, meaning that over **9 million** people live in these areas.

Table 6: Details of Households in Greater Mumbai:

S. No.	Particulars	Quantities	Reference/Remark
1.	Area	6,355 square kms	Greater Mumbai
2.	Population(2011)	1,24,42,372	Census Report 2011
3.	Household	658,359	Census report Mumbai
4.	No. of Wards/Sanitation Zone	24 wards	DPR (Each Ward includes 5-6 areas depending upon the population)
5.	Total waste generation	6959 MTD	BMC Report
6.	Household Waste (Dry)	789 MTD	BMCReport
7.	Slums	03 major Slums exist in Greater Mumbai (40-50% of city population lives in slums	
8.	Slum House holds	283095(Approx)	40% of total Households

Household waste is generated from a number of sources which include households (kitchen and yard). Generally, household waste constitutes biodegradable, recyclable and domestic hazardous waste such as used batteries, containers for chemicals plastics pesticides, discarded medicines and other toxic or hazardous household waste. The biodegradable waste (wet waste) is made up of vegetable and fruit remainders, leaves, spoiled food, eggshells, cotton, etc. Recyclable (dry waste) consists of newspapers, thermocol, plastic, battery cells, wires, iron sheets, glass, etc. Debris includes construction waste, renovation waste, demolition waste, etc. Silt comprises earth and clay from drains and road corners.



Photos show largest slum area in Mumbai-Dharavi

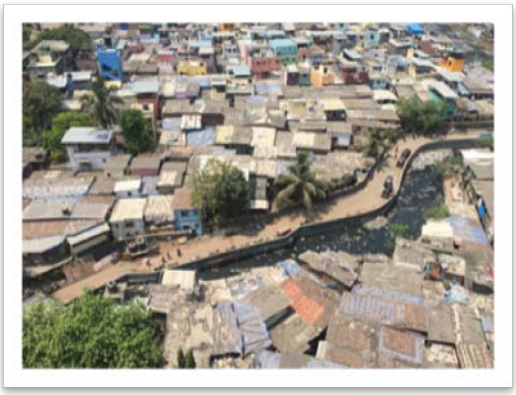


Photo indicates that this area is densely populated so, it is inaccessible for BMC Waste collection vehicles to reach out in these Slum Areas

Photo indicates that no Proper door to door collection Facility Available in Slum Areas So People Dump Waste directly into Water Bodies

Photo indicates that thin Layer of Plastic Litter Clogged into drainage passing through slum areas

Photo indicates that Railway Track near Mahim area where slum dwellers throw Dry waste directly

Figure 12: Some identified Slum Areas in Mumbai

2.1.4 Market Waste

Generally, Market waste constitute waste from vegetable & Fruit Shop, Meat & Fish Shop, Bakery & Sweet Shop, Shop/Tea Shop and Juice Shop. Prominent market areas in greater Mumbai are Crawford Market (Mahatma Jyotiba Phule Market) near CSMT Station, Dadar, Byculla vegetable market etc where all biodegradable waste as well as dry waste is generated on a daily basis. It has been observed that maximum waste generated from market places is prominently biodegradable waste **(Figure 13).**

Photo shows biodegradable waste sighted near Dadar Vegetable market

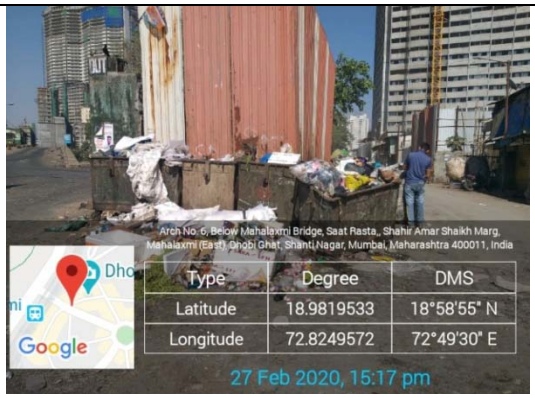
Photo of Dhobi Ghat Area where Plastic has been collected by Rag pickers which has Economic value

Picture depicting prominent Polythene Bags (Black, Blue Colour), multi-layered Plastic used in Market to carry Vegetables and other stuff

Figure 13: Photos depicting prominent Market areas and Waste in Greater Mumbai

2.1.5 Commercial waste

As discussed with BMC Executive Engineer about Commercial waste Scenario in Mumbai, It was observed that nearly about 280 shopping malls functional in Greater Mumbai and approx 200 shops and single brand retailers like restaurants like Dominos, McDonald, Burger king, Pizza hut etc in each wards and Retails Brands Like Bata, Pantaloons Trends etc., are functional in city. Also it was informed that the waste collected from the Mall premises is given to waste collector approved by BMC. Prominent waste generated in Commercial area consists of Polythene Bags, Multi layered plastic, Wrapping Material, Toys Waste, silver foil, thermocol, cardboards etc.

 **Photo at Dhobi Ghat indicate that maximum number of Woven Bags have been found in this area**	 **Photo at Infinity mall, Kandivali (West) indicate Polythene used as carry bags (2-3 %)**

2.1.6 Public Cleansing

Street Sweeping comes under secondary collection of waste. Trash Booms have been installed and operated for preventing the pollution of sea and mangroves from floating trash.

 **Prabhadevi Area: Mechanised Dust Collection Vehicle for Small Roads cleaning**	 **High Water pressure road Cleaning Vehicle**
 **Mini Street Dust Collection Van**	 **BMC Workers Cleaning Street manually**

Side Loading Compactor- introduced for first time in India by MCGM

Trash Boom Machine for collection of Floating trash in rivers and mangroves

2.1.7 Industrial Waste

Mumbai is the commercial and entertainment capital of India, it is also one of the world's top 10 centres of commerce in terms of global financial flow, generating 5% of India's GDP, and accounting for 25% of industrial output, 70% of maritime trade in India (Mumbai Port Trust & JNPT), and 70% of capital transactions to India's economy. The city also houses India's Hindi (Bollywood) and Marathi film and television industry. As informed by the officials of BMC during field visit, all the Industrial area comes under the jurisdiction of Maharashtra Industrial Development Cooperation (MIDC), so as such no waste collection data was available with the BMC officials as no industrial area is covered by BMC in Greater Mumbai. MIDC caters to waste management services in industrial areas through their own vendors. During field visit to some Industrial areas nearby to Mumbai city (Thane, Panvel which includes areas like Marol, Dombivali, Airoli Knowledge Park etc.) packaging material and woven bags were found to be littered in significant amount near River side.

2.2 Collection and Transportation of Municipal Solid Waste

Collection of municipal solid waste is carried out through door to door collection and community bins placed near residential areas. As discussed with the officials of Municipal Cooperation of Greater Mumbai (BMC), there are 24 existing wards. Each ward includes 5-6 areas depending upon the Population and managed by BMC. Each ward has door to door Collection as per Waste management rule 2016. Some of the waste collection mechanism is shown in **Figure 14.** Each ward has its separate vehicles for collection of Wet (biodegradable) and Dry (Non-biodegradable) waste. Transport facilities provided in each ward for waste collection are given below.

1. For Wet Waste: Compactor with Capacity 2.5 tonnes.
2. For Dry Waste: Small Tempo.

Table 7 shows different types of transport vehicle used by BMC for collection of waste in different areas.

Table 7: Transport Details for Primary and Secondary collection of waste

Sr. No.	Type of vehicles	Municipal	Private	Total
1	Compactor (Large)	137	452	589
2	Compactor (Small)	76	322	398
3	Small Tipper 1 Ton	0	350	350
4	Skip Vehicles	42	0	42
5	Tipper 8 Ton	58	0	58
6	Stationary Compactors	110	0	110

Slum Area in Greater Mumbai

Waste Collection Centre in Grant Road Area

Waste Segregated near Waste Collection point

Community Dry Waste Collection Centre in Prabhadevi (G-South Ward)

Figure 14: Photos depicting Household areas and Community Bins in Greater Mumbai

The collected waste is transported to Dry Waste Collection and Sorting Centres (DWCS) and transfer stations from where it is transported to treatment and dumping sites.

2.2.1 Dry Waste Collection & Sorting Centers

About 98.69% of total garbage is collected through House-to-House collection. The daily Municipal Solid Waste (MSW) is collected and transported by deploying various types of vehicles. There are 2574 no. of 1.1-cubic meter containers and 7 Dumper Placer containers kept at 941 community collection points in Mumbai. MCGM has set up 37 dry waste collection & sorting centers in 24 cluster wards. Other than these, MCGM has decided to set up 24 more dry waste collection & sorting centers and at some places work of setting up of additional dry waste centers is in progress. Separate 96 vehicles are deployed for collection and transportation of dry waste to dry waste sorting centers, in all the 24 wards of MCGM. Waste / Rag Pickers' Associations are appointed to carry out the collection and segregation of dry waste. Dry Waste is segregated into paper, cardboard, thermacol, plastic, metal & glass and then sent to the recyclers for recycling directly by the rag pickers' associations. Details of municipal dry waste collection in different wards are given below.

- Under BMC's (Mumbai Municipal Corporation) control there are 46 DWSCs.
- Currently, the DWSC are operated by associations of Rag pickers. They are provided 94 numbers of dedicated dry waste collection vehicles by MCGM for house to house collection and transportation of dry waste.
- The new compactors having separate provision for collection of Dry Waste unload the segregated dry waste at centres.
- Daily 200 MT of dry waste is received at DWSC.

- In some dry waste sorting centres, there are baling, compressing and shredding facilities of paper and plastic.
- The revenue generated from the activity is kept by the rag pickers.

Examples of waste collected at DWSCs are given below.

1) Ghokhale Road Segregation Centre (Near Prabhadevi Area, Ward G-South): As It is a household area, so maximum amount of cardboards and plastic Bottles are identified at this Centre, after Segregation. list of Dry Waste Identified at this Centre is given in **Table 8.**

Table 8: waste generation identified from Dry Waste Segregation Centre (DWSC) in Mumbai

Sr. No.	Type Of Waste	Total Collection Per Day (in Kgs)	Recyclable Value In Rs/Kg
1.	Plastic Bottles	12-15	Rs.11
2.	Mix Plastic	-	-
3.	Single layered Plastic	5-6	Rs.5-6
4.	Multilayered Plastic	2-3	Rs.5-6
5.	Milk Pouches	5-6	Rs.3-4
6.	Hard Plastic(Shampoo etc)	1-2	Rs.3-4
7.	Metal	10-11	Rs.15
8.	Cardboards	15-20	Rs.11
9.	Waste Paper	5-6	-
10.	Disposal Waste (Cups, Plates etc.)	2-3	-
11.	Woven Bags (Cement)	5-6	Rs.5 (each bag)
12.	Packaging Bags	5-6	Rs.4

2) Sayani Road, Near ST bus Stop, Prabhadevi Area (Ward G-South): List of Dry Waste Identified at this centre is given in **Table 9.**

Table 9: Waste generation identified from Dry Waste Segregation Centre (DWSC) in Mumbai

Sr. No.	Type of Waste	Total Collection Per Day (in Kgs)	Recyclable Value In Rs/Kg
1.	Plastic Bottles	18-20	Rs.12
2.	Mix Plastic	12-15	Rs. 8
3.	Milk Pouches	5-6	Rs.3-4
4.	Hard Plastic (Shampoo, Oil bottles etc)	10-12	Rs.3-4
5.	Metal	2-5	Rs.15
6.	Cardboard Boxes	12-15	Rs.10
7.	White Paper	12-15	Rs. 8
8.	Mixed Paper	10-12	-
9.	Tissue paper	10-15	Rs.10
10.	Disposal Waste(Cups, Plates etc.)	2-3	-
11.	Packaging Bags	5-6	Rs.4
12.	Oil Cans	20-22 Piece	Rs.25

Dry Waste Segregation Centre (DWSC) Report showing the quantity and composition of municipal solid waste for the month Nov-2019 for (46 Centres) in BMC area is given in **Table 10** and shown in **Figure 15. Table 10,** indicate that glass bottles followed by paper including newspapers and cardboard and plastics both bottles and other recyclable recyclables constitute the maximum amount of waste, which gets segregated.

Table 10: Dry Waste Generation and composition in Mumbai at DWSC (November 2019)

Dry Waste Generation in Mumbai (Monthly Report -November 2019) in - MT													
Plastic Bottles	Other Plastic Recyclables	News Paper	Mixed Paper	Boxes/Card Board	e-waste	Thermocol	Glass Bottles	Tins	Metals	Cloths	Other Recyclables dry waste	Reject sent to Dumping Ground	Total Dry Waste
321	657	666	592	532	64	71	3410	94	188	181	636	861	8274

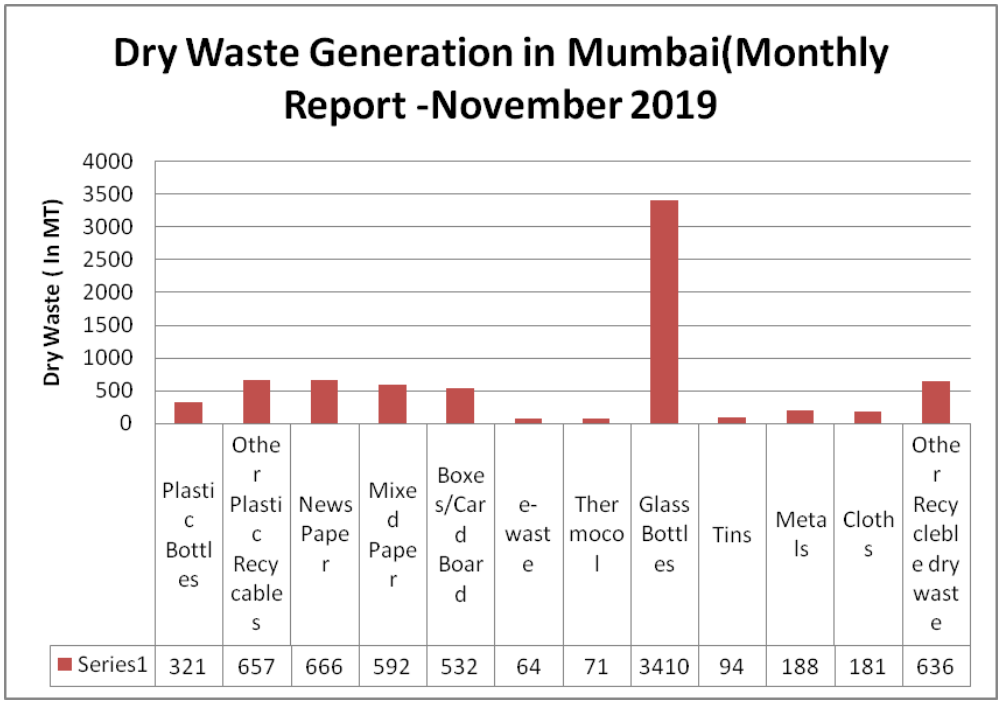
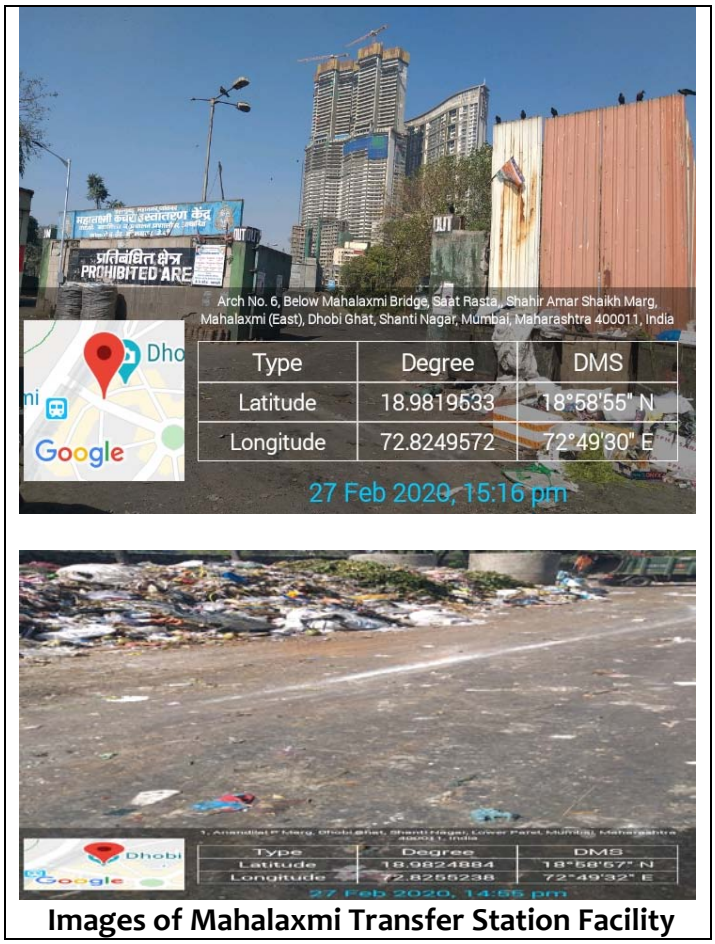


Figure 15: Dry Waste Generation in Mumbai (November 2019)

2.2.2 Transfer Station (ST)

At present, there are four Refuse Transfer Stations viz. Mahalaxmi Refuse Transfer Station, Kurla Refuse Transfer Station, Versova Lagoon Transfer Station & Gorai Refuse Transfer Station in Mumbai. The MSW collected from nearby MCGM wards through small refuse vehicles are unloaded at Refuse Transfer Station and the said MSW is loaded in Big Close body Refuse vehicles and transported to Dumping Grounds / Landfill site for final disposal.

a. **Gorai Refuse Transfer Station**: It is having area of approx. 10000 sq.mt. and MSW of approx. 500 MT is handled daily.
b. **Kurla Refuse Transfer Station**: It is having area of approx. 3000 sq.mt. and MSW of approx. 700 MT is handled daily.
c. **Versova Lagoon Transfer Station**: It is having area of approx. 8000 sq.mt. and MSW of approx. 400 MT is handled daily.
d. **Mahalaxmi Refuse Transfer Station**: It is having area of approx. 14700 sq.mt. with modernized machinery and MSW of approx. 750 MT is handled daily **(Figure 16)**



Images of Mahalaxmi Transfer Station Facility

Figure 16: Images of Mahalaxmi Refused Transfer Station at Mahalaxmi area

2.3 Disposal & Treatment

The garbage from all over Mumbai is collected and disposed off at the 2 dumping sites at Deonar and Mulund by simple dumping and leveling method. Deonar, the oldest dumping ground of Mumbai has been operating since 1927.The site is situated in the Eastern Suburbs of the City, adjacent to Thane creek, in an area of about 120 ha. of land. It is surrounded by creek on three sides and a slum on the fourth side. At present, daily fresh MSW of an average 3200-3500 TPD and ward debris of an average 700-900 TPD & debris from various Municipal dept. of an average 1000-1200 TPD is received at Deonar Dumping Ground. The debris received at Deonar Dumping Ground is used for daily covering and preparing loop roads inside dump and operated by MCGM. Scientific Closure Project of Gorai dumping site has been completed and operation and maintenance of the site is in progress. Deonar dumping ground is the largest dumping ground, receiving approximately 32.40% of the garbage. Kanjur receives 42.25% & Mulund receives 25.35% of the total garbage. Mulund and Deonar dumping grounds have nearly exhausted their capacity to receive the garbage. Area of different dumping grounds is given in **table 11** Input loads of MSW at various dumping sites are given in **Table 12.**

Table 11: Capacity of Various Dumping Sites in Mumbai

Sr. No.	Disposal Site	Area (Ha)
1	Deonar	120
2	Mulund	24
3	Kanjur	65.96

Table 12: Input Load of Waste

Sr. No.	Dumping Ground	Classification of Waste	Tonnes/day (approx.)
1	Deonar	Municipal Solid Waste	2200-2500
2	Mulund	Municipal Solid Waste	1700-1800
3	Kanjur	Debris	600
		Municipal Solid Waste	3000

MCGM is responsible for operating the landfills and has emphasized on implementing a PPP framework for the landfill maintenance.

Kanjur processing facility and landfill site (Figure 17) is the newest in Mumbai, with a developed Bioreactor landfill facility. The garbage is treated at Kanjur processing site using Bio-methenation Technology. It is also located along the Thane creek and has an area of 121 Ha. The site was handed over to the MCGM in 2003. The site has a capacity of 5000 to 5500 tonnes per day.

Figure 17: Google map showing Kanjur Landfill Site (Lat- 19.072055, Lomg-72.930054)

Kanjur facility has 1000 TPD of MSW treatment by windrow composting and 4000-4500 TPD of MSW treatment by way of bioreactor technology and composting. It is the first time a Bioreactor landfill Facilty (BLF) will be used in India. Currently, about 60% of the waste is being treated for producing RDF, while 30% is going for composting and the remaining 10% is being recycled under various streams. The process flow diagram is shown in **Figure 18** and details of all the process steps involved are presented below:

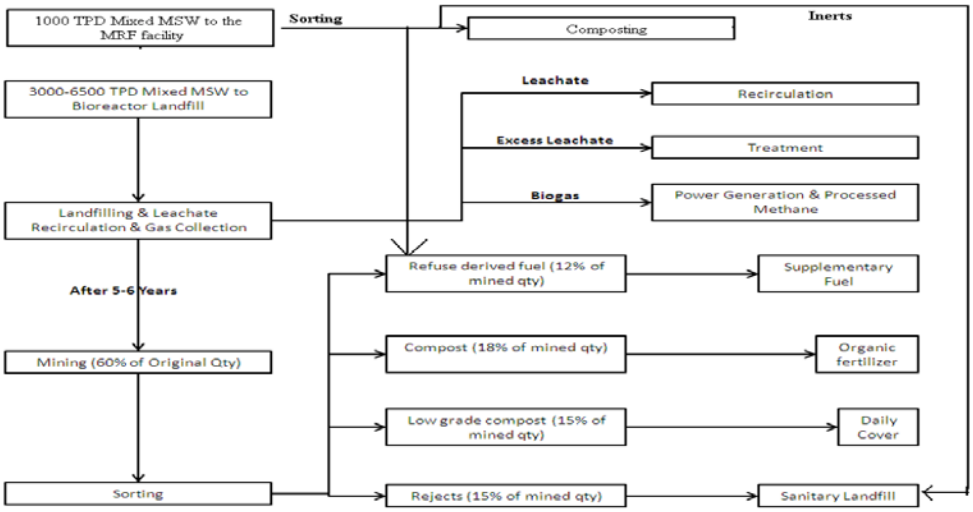


Figure 18: Processing details for the ISWM Plant

Source:http://environmentclearance.nic.in/writereaddata/FormB/TOR/Brief_Summary/0_0_22_Feb_2016_160150260 1Chapter9KNES10022016.pdf

Step 1: Material Recovery facility (MRF)

As a preliminary step to the aforesaid composting facility, the private operator (ALESPL) will be installing and commissioning a sophisticated Material Recovery Facility (MRF). The MRF will have two different screening stages for sorting out pure organic waste: by using trommel and by using disc screen. The 1000 TPD incoming waste will be segregated into rich bio-degradable fraction, recyclable fraction, RDF and rejects. The biodegradable fraction will be sent to compost plant for processing. The recyclable materials like plastic, metal, etc will be sold to recyclers. The inert fraction will be sent to SLF and material with high/ moderate calorific value shall be sorted out as RDF and cold to open market.

Photo Plate No.4.26 Material Recovery Facility (MRF) at Kanjur Processing Plant.

Step 2: Composting system

The composting unit at Kanjur site will process segregated organic waste transported from MRF system. The technology proposed is negative/positive aeration with bio-filter. Windrows of waste of appropriate dimensions will be constructed and air will be sucked or blown in through these windrows Leachate and condensate will be collected from the windrows which will be directed to leachate collection pond and leachate treatment plant thus minimizing the emissions to the

environment and thus also aerating and controlling odors. The windrows will be turned regularly to further aid aeration. The entire composting process is expected to take about 7 - 8 weeks (depending on the weather conditions and waste characteristics).

Step 3: Bioreactor landfill facility (BLF)

About 3000 TPD to 6500 TPD of mixed municipal solid waste will be transported to the seven cells of the bioreactor landfill sequentially. The base of bioreactor landfill is constructed in a similar way as of a sanitary landfill with layers of Geosynthetic clay liners, HDPE liners, protection geotextile and drainage layer. A series of permeable trenches with blankets of geotextile and gravel will be laid at every 6-7 m of waste fill through which leachate will be recirculated into the cells using a specially designed network of pipes, valves and hydrant stations.

3.1 Plastic Waste Generation in Greater Mumbai

3.1.1 Source of Plastic Waste

Plastic waste is found in the collected mixed municipal waste as shown in **Figure 19.**

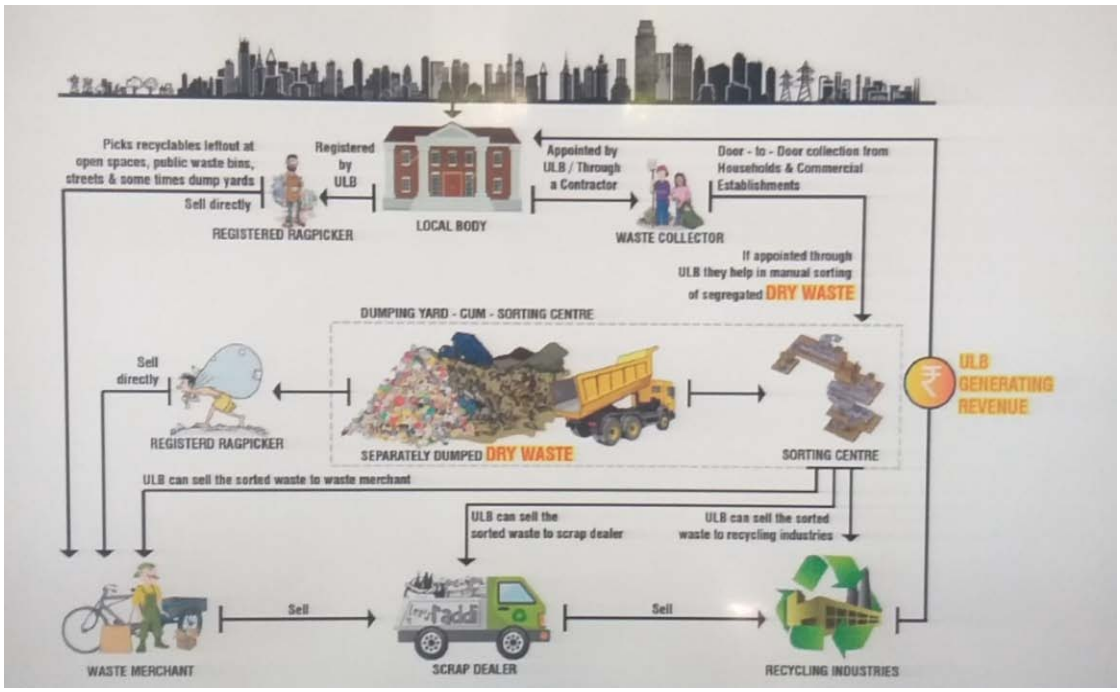


Figure 19: Municipal dry waste collection in Maharashtra

Source: report on identifying market potential for recycle solid waste in Maharashtra

Different Source of Plastic Waste Generation in Greater Mumbai are: **(i) h**ousehold Waste; **(ii)** Market Waste; (iii) Commercial waste; (iv) Public Cleansing and (v) Industrial Waste. As per secondary data, the Plastic Waste (PW) contribution in the total solid waste is approx. 3.24%. Earlier a study was carried out by CPCB "Assessment & Characterisation of Plastic Waste Generation in 60 Major Cities of India" in January 2015. As per the CPCB study report, Plastics-waste generation in Mumbai was about 62.81 Kg/MT out of total MSW waste of about 6500 MT/day. This was based on the field study in Mumbai, which was carried out in two dumpsite located at Mulund and Deoner and samples were collected on six days at these sites. The Average PW studied at the both dumpsites is reported in the **Table 13** given below. Huge numbers of Rag pickers collect the valuable plastics waste like Polybags, PET Bottles, Sacks, Milk Pouches, rubber & Foam slippers etc at the dumpsite. Metalized pouches were not collected by

rag pickers. The CPCB's annual report indicates that the percentage of plastic contributing to the total solid waste is about **6.28** % in Mumbai. The various categories of plastic in the waste stream examined by CPCB is indicated in the following **Table 13** and shown in **Figure 20.**

Table 13: Categories of plastic in the waste stream in Mumbai Study of Mumbai City: PW (Kg/MT)

SERIAL OF DAYS	PET	HDPE/LDPE	PVC	PP	PS	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**

Source: Assessment and Characterisation of plastic waste generation in 60 cities report, CPCB

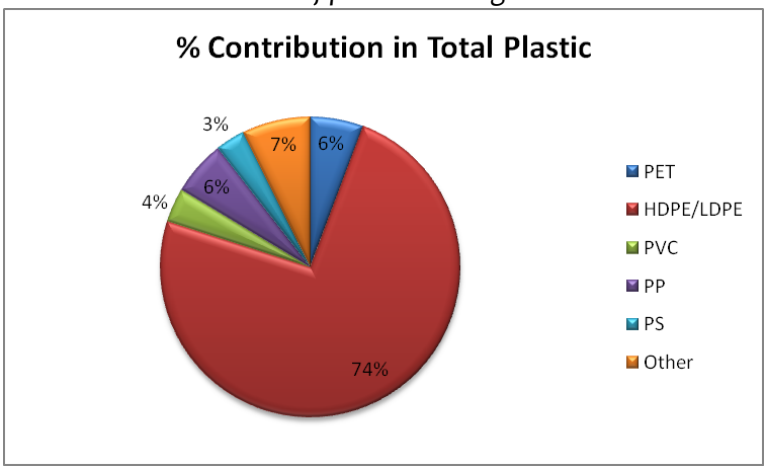


Figure 20: percentage contribution of total plastic in Mumbai

As per BMC's dry waste collection monthly report for the month of November 2019, it can be inferred that the amount of plastic that gets collected and attempted to bring back into the value chain is approx. 32.6 MT per day out of 275.76 MT per day which is 11.82% of the Total dry waste generated in Mumbai City. The maximum and minimum amount of plastic waste generated has been computed and summarized in **Table 14** so, approximately plastic waste generation in Mumbai city is in the Range of 84 TPD to 433 TPD. Images of Segregation Centre at Ward Level with Prominent type of Plastic and Paper Waste is shown in **Figure 21.**

Table 14: Plastic Waste generation and leakage estimation in Mumbai

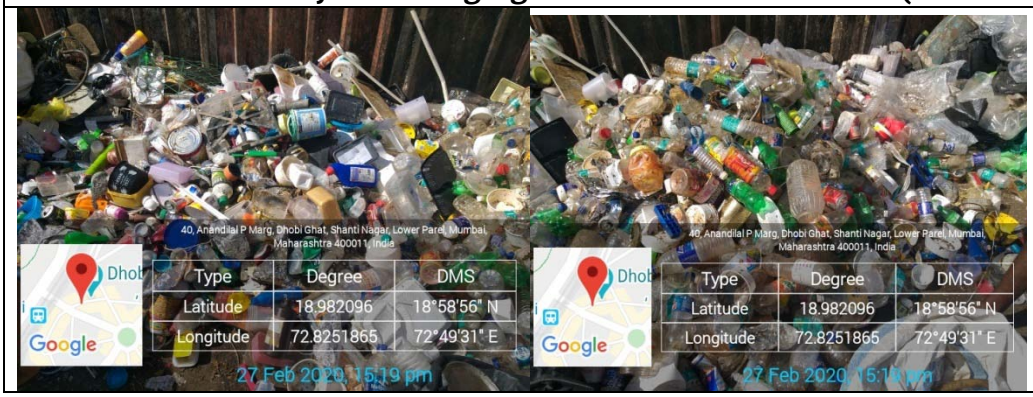
Plastic Waste Details			Remarks	
	Minimum (As Per BMC Dry Waste Collection Report)	Maximum		
Plastic waste generation	86.79	433.32	Min generation value assuming 100% collection of waste	Max value based on estimate using plastic content indicated in CPCB, 2015 report
Plastic leakage	50.616	110	Estimation as per PCRA Energy report Oct 2019	

The summary of plastic waste generation based on the secondary and primary data sources is described in **Table 15.**

Table 15: Summary of estimates pertaining to waste generation

Particulars	Values as per available secondary data		Values as per primary data collected on organized waste collection
	CPCB	Research paper(s)	
Solid waste generation (MT/d)	6500	7000	6959
Per capita solid waste generation (kg/c/d)	-	0.45	0.39
Plastic waste generation (MT/d)	433	210	86.79(11% of Dry Waste 789MTD)
Per capita plastic waste generation kg/c/d	-	-	-
% plastic waste in total solid waste	6.28%	3%	11%

Dry Waste Segregation Centre at Prabhadevi (G-South Ward)



Picture depicts segregation of dry waste which Contain 2-3 % plastic with and types of plastic waste

Waste Paper and Used Tissue papers which has economic value

Figure 21: Images of Segregation Centre with Prominent type of Plastic and Paper Waste

3.2 Identification of Hotspots

A step wise approach has been adopted to identify the hotspots, which serve as source of plastic leakage into the river. This is based on IUCN's approach for defining the plastic leakage as a function of loss rate and leakage rate. The various steps include identification of vulnerable areas using fuzzy logic approach adopted by GIC, AIT Thailand **(Figure 21)** and identification of leakage points **(Figure 22**) followed by field reconnaissance & verification **(Figure 23)** and cleanup activities. During the field survey at Mumbai, littering of solid waste comprising majority of plastic waste was observed in abundance. This was followed by discussion with MCGM/ BMC, which suggested hotspots, which were in line with predicted vulnerable areas. The major hotspots in Mumbai include:

- direct disposal of plastic waste into drains or into Mithi River from nearby slum residents,
- Littered on streets, nearby community bins in market area, on railway tracks etc. finally finding its way into riverine ecosystem (Mithi River) and at last into the ocean (Arabian Sea) by various means.
- There are 186 outfall to the Arabian Sea which drains plastic mixed waste from the city.
    - 5 major outfalls in city which drain sewage mixed with plastic to Arabian Sea directly,
    - 8 at Mahim creek and 12 at Mahul creek.
    - 29 outfalls in western suburbs draining directly into sea
    - 14 drain into Mithi River which ultimately joins Mahim creek.
    - In eastern suburbs, 14 outfalls discharge in Thane creek while six discharge in Mahul creek and 8 into Mahim creek.
- Out of 186 outfalls in Mumbai, 135 are above mean sea level but below the high tide level, 46 outfalls below mean sea level. In addition, there is a 2,000km roadside open drain systems that are mostly clogged with plastic and waste. Only 6 outfalls are above high tide level.

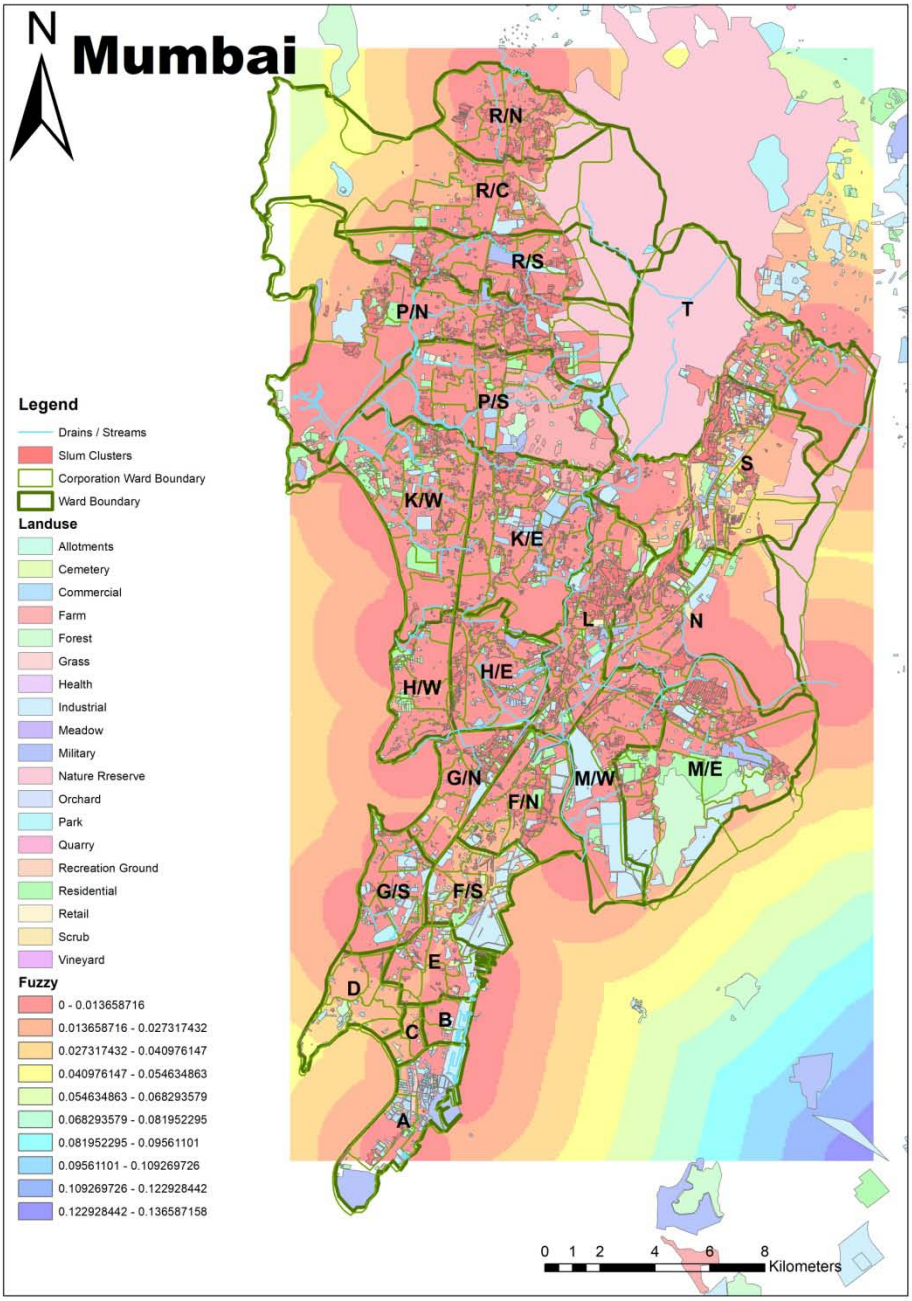


Figure 22: Plastic Leakage Vulnerable Areas identified using Fuzzy Logic Approach

Figure 23: Location of Probable Hotspots in Mumbai

Number of outfalls in Mumbai is described in Table 16.

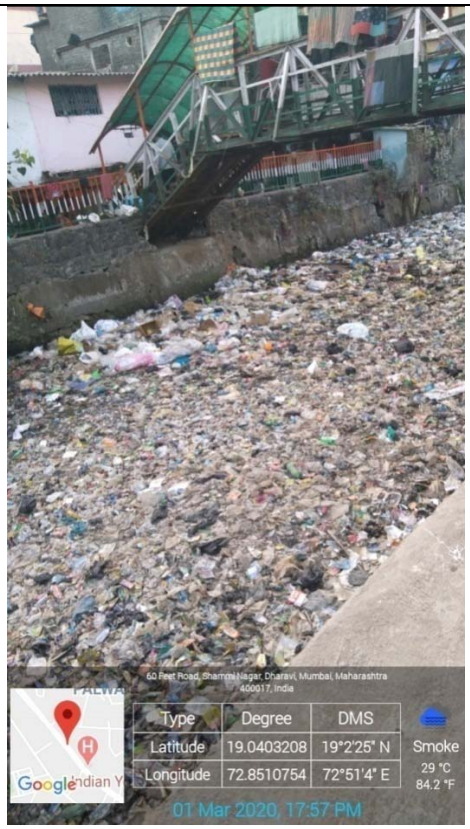
Table 16: No. of leakages (Outfalls) in Mumbai

Sr. No	No. of Outfalls	Area /Place	Remarks
1	85	-	Drain sewage mixed with plastic to Arabian Sea directly
2	8	Mahim Creek	Via Creek to sea
3	12	Mahul Creek	
4	29	Western Suburb	Drain directly into sea
5	14	Mithi River	-
6	14	Thane Creek	Via Creek to sea

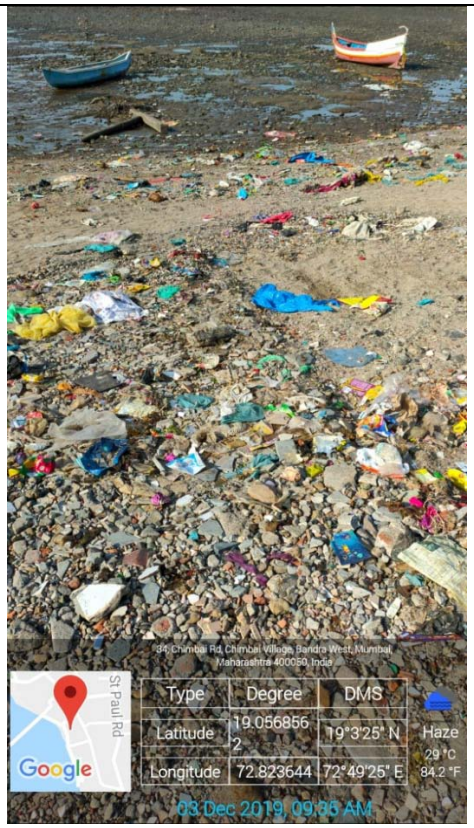
Source: Energy News-Oct 2019 By Petroleum Conservation research Association (PCRA), New Delhi.

NPC's team have Identified some hotspots showing plastic litter in various areas which are depicted below in **Figure 24** and **Figure 25.**

Figure 24: Picture Depicts Plastic Waste Littered directly near Mithi River



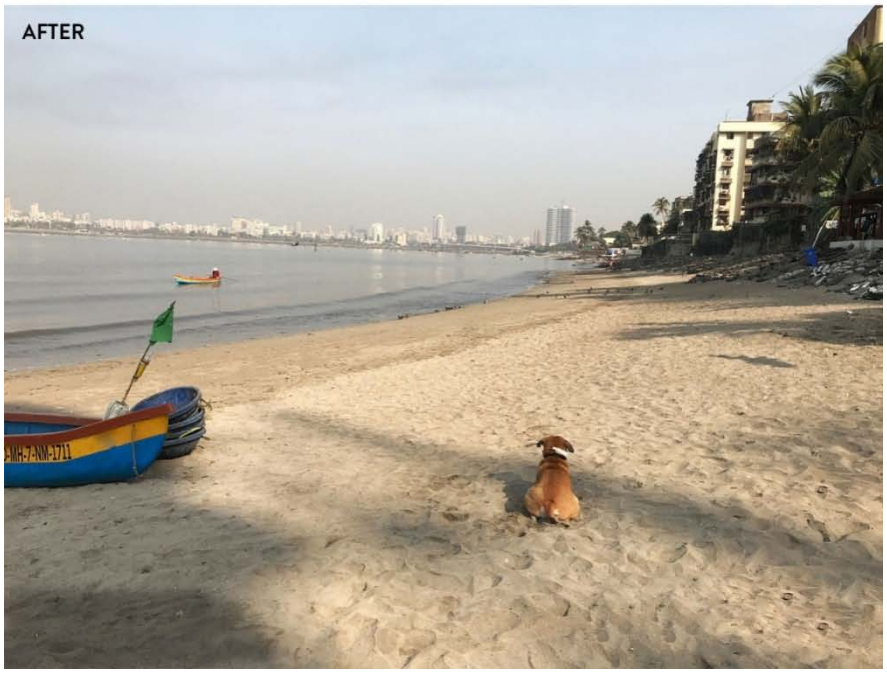
Plastic Dumped directly into Channel



Chimbai Beach showing Plastic Bags Scattered on Beach

Gorai Clean-up Site-50% of Plastic found during the activity

Total beach Area taken for clean-up: 1000m
Duration of Clean-up: 2 years
Total Waste Collected: 9,50,000kgs
No. of dumpers of Waste:95
Most Prominent Waste Category: Plastic Bags, Milk Packets, Footwear, Diapers
Most prominent type of plastic was Plastic packaging and single use Plastic
% of Plastic Waste: 90%



Before After Scenario at Mahim Beach Clean-up where huge amount of Plastic Settled down during High Tides

Figure 25: Plastics found during Beach Cleanup Activities

3.3 Assessment of categories of plastic in the total plastic waste

As per CPCB's assessment, LDPE/HDPE and PP were most prominent categories of plastic prevalent in the plastic waste in Mumbai. As per NPC's assessment the following observations were made with regard to the category of plastic in the plastic waste stream. Clean up activities were carried out by NPC's team at three hot spots of plastic litter in Mumbai as given in **Table 17 and Figure 26, Figure 27 and Figure 28.**

Table 17: List of Hotspots with date

S. No.	Name of Hotspot	Date of Clean-up activity undertaken
1	Gorai Creek (Near Gorai Bridge)	2nd march 2020
2	Chimbai Beach	3rd December 2019
3	Vashi Mangroves	2nd November 2019

The cleanup activities indicated that amount of plastic that gets collected is approx. **25-35**% of the total Trash collected during clean-up activity at various location in Mumbai City. The classification of plastics Waste collected during clean up drives is shown below. It can be inferred that majorly found plastic category in Mumbai clean-up site is Polythene bags and Multilayer packaging such as packaging of chips, namkeen, snacks etc.

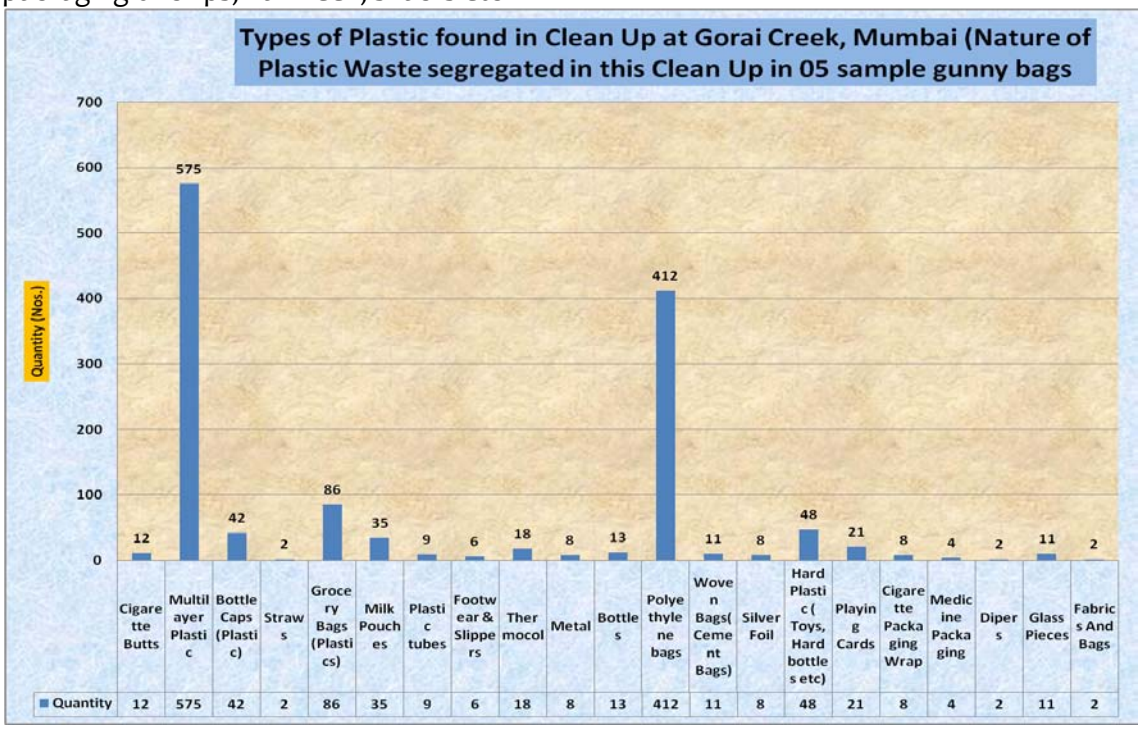


Figure 26: Types of Plastic found in Clean-up at Gorai Creek, Mumbai

Figure 27: Types of Plastic found in Clean-up at Chimbai beach, Mumbai

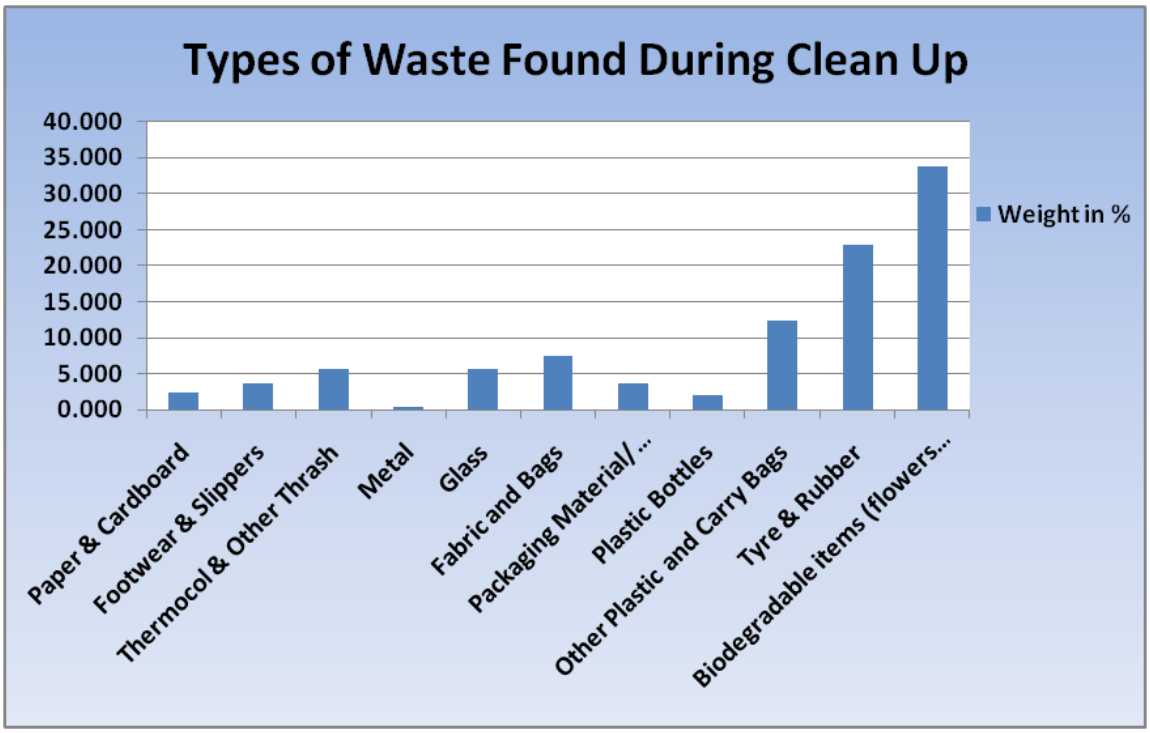


Figure 28: Types of Plastic found in Clean-up at Vashi Mangroves, Mumbai

During physical observation at various hot spots the prominent plastic categories, which were found include Polythene Bags, Multilayer Plastic, Bottles and Disposable Cups and Plates (Figure 29).

Prominent Plastic Observed during Physical Observation at various hotspots

Figure 29: Prominent plastic waste as per physical observation at various hotspots

3.4 Plastic leakage scenario in Mumbai

Plastic leakage scenario is shown in **Figure 30,** while plastic leakage from Households and commercial and market area is shown in **Figure 31** and **Figure 32.** Salient features of plastic leakage into riverine and seas in Greater Mumbai area are given below.

- Mumbai dumps 50–110 TPD of plastic waste into drains and water channels, Main reason to plastics leakage into sea or river in Mumbai is government failure to install nets across storm water drains to collect waste from drain (nallahs) before they empty out.

- The Maharashtra Pollution Control Board (MPCB), in a follow-up affidavit, said creeks, rivers and the sea along 21 Mumbai's 437.71sqkm coastal stretch is under threat with plastic waste as a major source among municipal solid waste.

- Plastic directly enters into drain by the general public mainly from slums areas. Discharge of untreated domestic waste accounts for 93% of the source of pollution for these water bodies.

- The unconcerned attitude of Mumbai people, especially those living near drains and creeks has resulted in massive amounts of plastic waste, majority of which is single use plastic, being dumped into the natural water courses.

- Experts said the 2005 floods were as much a result of clogged open surface drains with solid waste including plastic, storm water drains and its channels as it was due to significant changes in land use across the city and illegal construction and encroachments along natural drains and the Mithi river **(Figure 33).** City authorities should take measures to ensure that when heavy rainfall occurs, adequate drainage systems are in place and these are unclogged so that flooding does not occur in the vulnerable areas.

- A recent analysis by the Mumbai-based Veermata Jijabai Technological Institute (VJTI) spanning 45 years showed that changing rainfall patterns, extensive concretisation, open

drains along roads choked with plastic and other waste together with more than-a-century-old storm water drain system has led to an increase in the quantum of rain water turning into run-off, thereby causing frequent inundation in Mumbai.

- Darshan Sansare, principal investigator and research scholar, VJTI said of the total 186 outfalls in Mumbai, 135 are above mean sea level but below the high tide level, 46 outfalls below mean sea level and 2000km roadside open drain system that are mostly clogged with 22 plastic and waste. Only 6 outfalls are above high tide level.

- Flash floods and high tides therefore, cause most of the outfalls to submerge under the sea water leaving it useless for disposal of city water.

- These satellite images of Mumbai shows stunning story of vanishing of water bodies and mangroves over 3 decades. Mangroves maintain the integrity of shorelines, but Mumbai has lost its largest part of mangroves cover to rampant construction. also Mumbai`s natural storm water drains and wetland and Mithi river are being mercilessly encroached upon. The Mithi River is the dividing line between the city and suburbs which drains into Arabian Sea (Ocean), But the Mithi rivers catchment area has narrowed down over a period of time due to reclamation of land for construction so huge amount of plastic debris left in Mithi river.

- Mumbai`s man made water drainage system is very poor as over 400 kms of underground drain and laterals are chocked with garbage and plastic so in heavy rainfall season flow Mumbai gets flooded **(Figure 34).**

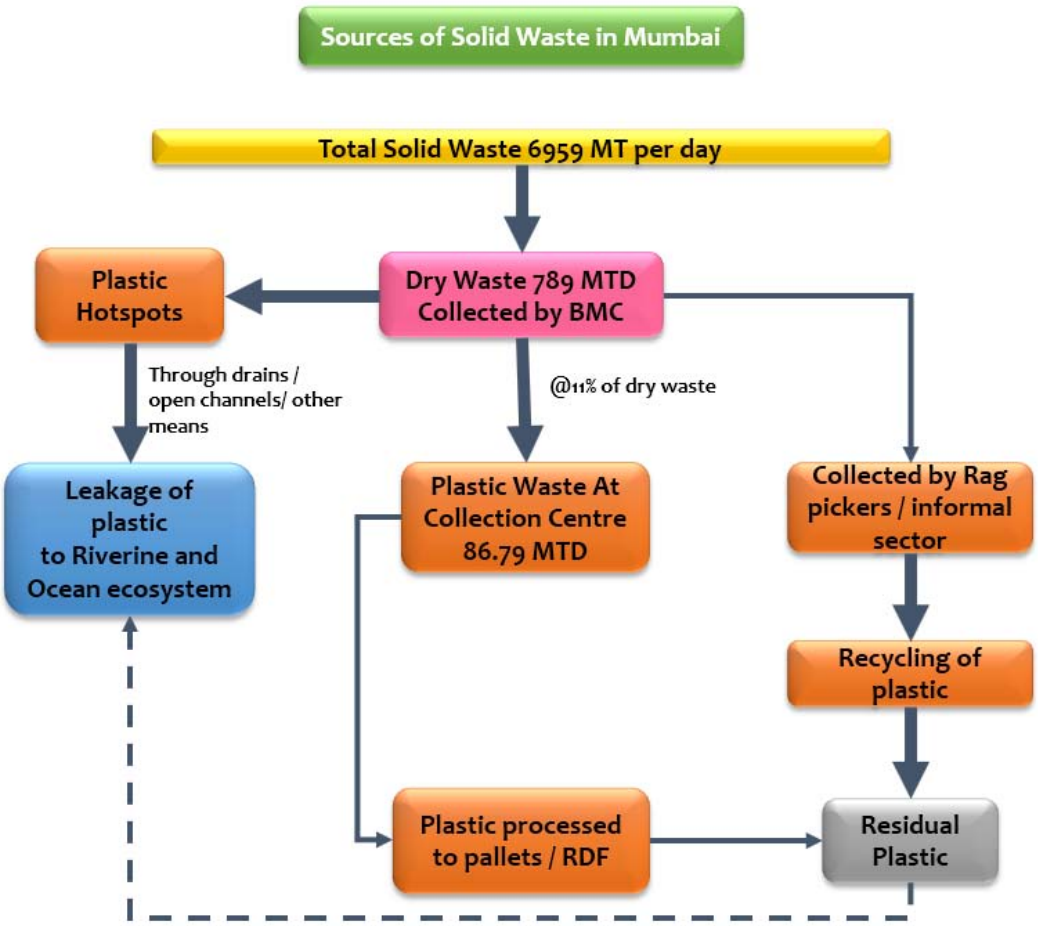


Figure 30: Leakage Scenario in Mumbai

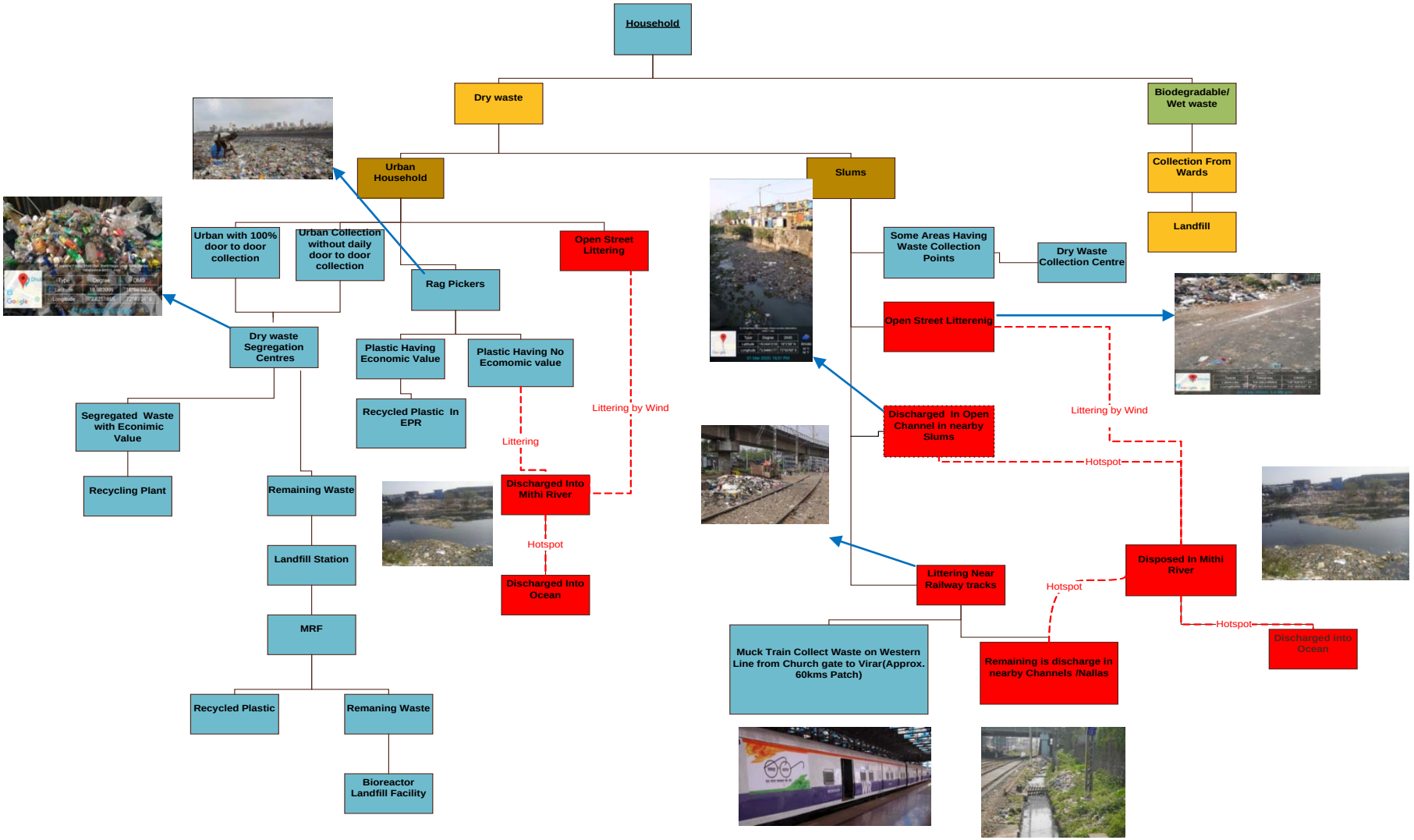


Figure 31: Plastic Leakage Scenario from Households

Figure 32: Plastic Leakage Scenario from Market and Commercial Area

Figure 33: Picture depicting shrinking catchment area of Mithi River

Drain Near Mankhurd Station (19°02'54.7"N 72°55'57.1"E)-Picture depicting plastic Clogged into Drain

At Wadala Station (19°00'57.8"N 72°51'31.9"E) - Plastic Littered near Railway Track with prominent Polythene Bags

At Govandi Station (19° 03' 17" N and 72° 54' 56")- Plastic Clogged into Small Drain

OFD,Sion (19° 03' 14" N and 72° 51' 56" E)- Woven Bags Littered near Mithi River

Figure 34: Plastic littered and leakage into drains and Mithi river

3.5 Impact after Plastic Ban in Maharashtra

Government of Maharashtra has banned plastic on 23rd June 2018. It has been over two years since Maharashtra banned single-use plastics in a bid to make the state cleaner and greener. Government of Maharashtra has announced penalty norms for not following the plastic Ban in Maharashtra. State have reported reductions in plastic waste of up to 20%.

This study stepped out to assess how the city is adapting to the implementation of the ban **(Figure 35).** According to the Brihanmumbai Municipal Corporation's Environment Status Report 2017-18, plastic accounted for 3.2% of the approximately 7,500 tonnes of waste generated daily in Mumbai. Banned plastics seized from 23.06.2018 to 76,000 Kgs and are auctioned to authorized recyclers (BMC data). Hotels and restaurants are struggling to implement the ban. While some have added paper and aluminium foiled containers, lack of cheaper alternatives has led to higher production costs. The change has been the most difficult for unorganised players like the recycling industry operating out of the slums of Dharavi. Dharavi units recycle all types of plastic before sending it to different manufacturing units around the city. The ban has meant a direct hit on employment of the daily wagers in these recycling units with no job alternatives.

Figure 35: A fruit stand in Mumbai displays a plccard informing shoppers about the new single-use plastics ban that went into effect June 23, 2018

Reference:

- Assessment and Characterisation of plastic waste generationin 60 cities report, CPCB
- Brihanmumbai Municipal Corporation (BMC) official Website
- Development Plan for Greater Mumbai 2014-2034, Report on Preparatory Studies
- District Census Handbook-Mumbai (Census Report -2011)
- Environment Clearance report for BMC by Fine Envirotech Engineers ltd
- Energy News-Oct 2019 By Petroleum Conservation research Association(PCRA),New Delhi
- Greater Mumbai Municipal Cooperation-Environment Status report 2016-17
- Greater Mumbai Municipal Cooperation (MSW monthly reports)
- Maharashtra Pollution Control Board annual report
- Municipal Solid Waste Management manual by CPHEEO
- report on identifying market potential for recycle solid waste in Maharashtra
- Urban Solid Waste Management in Mumbai- Minor Field Study by Yuri Joelsson and Rebecca Lord