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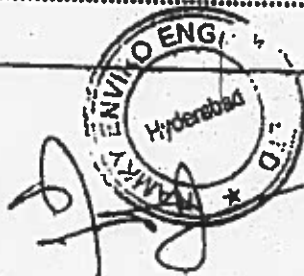
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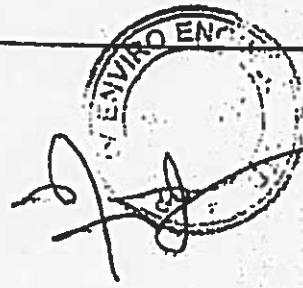
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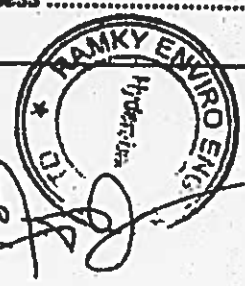
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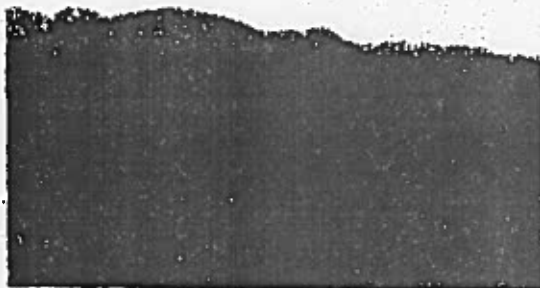
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CHAPTER - 1 INTRODUCTION

1.1 BACKGROUND

Growth and development of economy triggers expansion in urbanization. This often induces migration of population from rural & semi urban areas to big towns and cities. Unless a proper planning is undertaken well ahead of time, the uncontrolled growth in urbanization could cause a strain to the municipal infrastructures like water supply, sewage and solid waste disposal causing public health problems.



Like most urban cities Guwahati, the capital of Assam and the biggest city in North East India, is facing these problems. The geographical location and the topographical features (i.e. hilly terrain with heavy rainfall throughout the year) of Guwahati City have further compounded these problems.

In India, it is now mandatory for all urban and local bodies to comply with the 'Solid Waste Handling & Management Rules, 2000'. Solid Waste Management (SWM) includes all activities that seek to minimize the health, environmental and aesthetic impacts of solid wastes.

In order to implement an integrated approach to Solid Waste Management Practices in Guwahati, Guwahati Municipal Corporation (GMC) awarded the consultancy to IL&FS Ecosmart Ltd., New Delhi to undertake a study of the existing collection, transportation, processing and disposal activities of solid waste management and suggest an appropriate strategy for optimal service delivery keeping in view the economic, environmental, social and institutional dimensions.

Ecosmart conducted a comprehensive study, carried out the waste quantification and quality surveys & held discussions with different stakeholders in order to prepare a comprehensive integrated solid waste management system for the Guwahati City.

1.2 OBJECTIVES

The broad objective of this project is to prepare a Detailed Project Report (DPR) for Integrated Solid Waste Management of Guwahati City. The outputs of the DPR include:



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- a) Technical Feasibility
 - b) Preliminary Designs and Cost Estimations
 - c) Financial Projections for Project Finance, Phasing of Costs and Financing Plan for Financial Feasibility
 - d) Cost Benefit Analysis and Sensitivity Analysis
 - e) Economic and Environmental Analysis
 - f) Operations Costs Projection and Analysis

1.3 SCOPE OF WORK

The Scope of the DPR is as follows.

- Survey and analysis of MSW generation of the city to determine the source, quantity, quality and composition.
- Projection of MSW generation and formulation of guidelines.
- Detailed field survey for design and recommendation of MSW collection system with transit routes for transportation.
- Identification of technically viable MSW treatment methodology based on MSW analysis.
- Preparation of conceptual and preliminary design of the treatment plant.
- Preparation of conceptual and preliminary design of the landfill site and its infrastructure.
- Prepare cost estimate for the entire project.
- Suggestions on phasing of implementation of the project along with cash flow.
- Suggestions on action plan for regular MSW management and quality monitoring.
- Suggestion on suitable implementation mechanism of the project.
- Recommendation on organisational set up including manpower requirement.
- Preparation of detailed Notice Inviting Tender for execution of the scheme

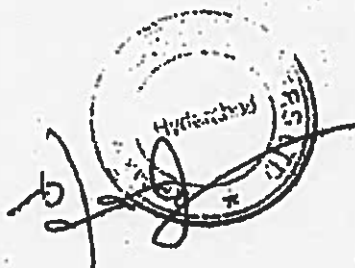
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1.4 THE UNDERLYING CONCEPTUAL DESIGN OF THE DPR

Though some studies have been carried out in past to address isolated issues for the solid waste management systems for the city, there has been no study to understand the problems in an integrated manner. The present DPR is an attempt to address various issues faced by GMC on SWM in an integrated and practical manner. IL&FS Ecosmart Limited also intends to help GMC to implement various elements of the findings in an integrated and sustainable manner through Public-Private Partnership (PPP).



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CHAPTER - 2 PROFILE OF STUDY AREA

2.1 INTRODUCTION

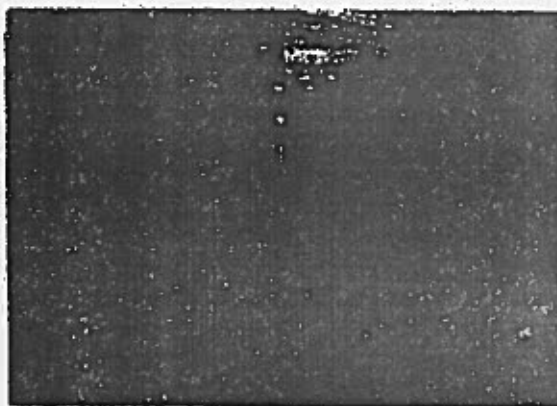
This section covers the regional setting, physical growth, demographic and socio-economic profile of the Guwahati City. The profile is based on the information collected from the various government agencies and the Guwahati Municipal Corporation. The salient features of the city are based on the discussions with the concerned officials, stake holders and field surveys.

Secondary information from various earlier studies and other resource persons was collected for this purpose. Sections below summarise the analysis of the information collected.

2.2 SOCIO - ECONOMIC PROFILE

2.2.1 Regional Setting

Guwahati city, the capital of Assam is located on the south bank of river Brahmaputra towards the south eastern side of Kamrup district. The city area is located in 26°5' N to 26°12' N Latitudes and 91°34' E to 91°51' E Longitudes. The metropolitan area of the city is 264 sq km of which an area of about 216 sq km is within the municipal corporation's limit. Location map of the Guwahati city is shown in Annexure 2.1



The southern bank of the river rises up from an average ground elevation of 51.3m and except in certain central portion of the area and the western portion, the area stretches up to the hill ranges namely, Kharghuli and Nabagraha Hill range rising to maximum of 303 m in the central portion. Then, it falls down to a valley having an average ground level of 49 m and a minimum elevation of 41.16 m, after which it gradually rises again to Meghalaya Hill ranges to a maximum elevation of 575 m which constitutes the southern boundary of the city. In the east, the area slopes down from a hill range having a general elevation of 182 m to a valley having elevation of 49 m inside the area there are (1) Patasil range

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(elevation average 358 m) (2) Sarania hills (elevation average 250 m). In between the hills, there are pockets of low lying areas with an average elevation of 49 m. On the west is a valley land including a vast low lying area named Dipar Beel, which occupies more than 54 sq km.

2.2.2* Significance of the City

Guwahati experienced phenomenal growth after becoming the state capital in the year 1972. Establishment of the Guwahati Oil Refinery, opening of major institutions of higher education like the Guwahati University, Engineering College, Medical College etc., construction of Saraighat bridge, has been some of the major factors to make Guwahati one of the most developed cities in the North Eastern states. It is also the central hub for all the commercial activities in the North East. It is at the junction of National Highways 31, 37 & 40. A broad gauge railway line connects Guwahati with the rest of the country. Super fast trains including Rajdhani Express connect Delhi, Kolkata and Chennai to Guwahati. It has the biggest airport in the entire North East region. It provides link to all the other state capitals. Recently, it has been upgraded to an international airport by the Ministry of Civil Aviation, Government of India. It is the service centre for the oil industry and tea plantations; the world's largest tea auctions are held here.

Guwahati has a population of around 8.2 lakhs based on the Census 2001. The population has grown manifold in the past few years. The ward wise population, number of households, and major localities are presented in the Annexure 2.2.

2.2.3 Climate and Weather

Climate of the Guwahati city is sub tropical humid. Climatically the whole year can be divided into three periods. From February to May, the weather is dry and moisture less. In the month of March, the North East wind carries dry sand from the river and makes the atmosphere very cloudy.

The wind direction is predominantly from the North-East to South-West during winter season and South-West to North-East during summers. The temperature varies from 31° to 22° in this region.

In April and May local rain along with thunderstorm are common features. The monsoon period is from June to October, with maximum rainy months being June and July. The average rainfall in Guwahati is 166.22 cm. From November to January, the weather is cool and foggy, with minimum temperature during the month of December.

Guwahati is a flood prone area. In the river Brahmaputra, at Guwahati station, the danger level is 49.68 m. High flood level ever recorded here was 51.37 m in the



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year 1988. Information of maximum flood levels reached in the river in Kamrup district is provided in the table below:

Table 2.1 Flood Level

Year	Max. Flood Level (m)
2001	49.65
2002	51.05
2003	50.98

Based on the analysis of satellite data of July, 2002, flood inundated area in Kamrup district was 157.57 sq. km, out of total area of 4345 sq. km.

2.2.4 Soil Characteristics

The soil strata are underlain by hard bedrock at variable depth. Heavy encroachment and the deforestation of the high lands in the Brahmaputra catchment have resulted into high soil erosion and caused heavy silt load in the drain water from the hill slope.

Alluvial soils are common in the area and vary in characteristics. The colloidal can be observed along the hill slopes. However, these soils get mixed well with alluvium soils during the floods. The soils are generally fertile and with high rainfall in the area, it is covered with a layer of vegetative cover. The organic matter content in the soil is high.

2.3 PROJECT AREA - GUWAHATI MUNICIPAL CORPORATION


Guwahati city achieved its municipal corporation status in the year 1974. The metropolitan area of the city is 264 sq km of which an area of about 216 sq km is within the municipal corporation's limit. Table 2.2 presents the main features of the GMC Area. The figures in the table have been taken from the data of Census Board, 2001.

Table 2.2 Main Features of GMC

Parameter	Description
Area, in km ²	216
Population - 2001 Census	809,895
No. of Households	184454
No. of Municipal Zones	20
No. of Wards	60
Population Density, persons/km ²	3750
Number of Slums	26
Slum Population	160371
Percentage Slum Population to total Population	19.8 %

Source: Comprehensive Master Plan for Guwahati Metropolitan Area: Data Base Report (Draft)

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2.4 DEMOGRAPHIC CHARACTERISTICS OF PROJECT AREA (GMC)

2.4.1 Population Growth



Guwahati is the largest urban centre in Assam comprising of 24% of the total urban population of the state. The maximum growth in the population of Guwahati has been registered during the period 1971-2001, after it became the state capital in 1972. The city has the status of Class I town in Assam, as per Census of India, 2001. It contributes to 55% of the combined population of the Class

I towns of Assam. The geometric growth rate (Compounded Annual Growth Rate) model has been used to estimate the future population in Guwahati, since the population has a tendency to grow in Geometric Progression.

The population within GMC area is 809,895 as per 2001 census, projected to be 946,487 for the year 2005 based on geometric progression model. Table 2.3 given below provides the population growth trends of GMC area.

Table 2.3 Population Growth Trends of GMC Area

Year	Guwahati Municipality	Decadal Growth (%)
1961	100,707	130.90
1971	123,783	22.91
1981*	No census	-
1991	584,342	117.27
2001	809,895	38.60

Source: Census of India; Modified Final Master Plan and Zoning Regulations for Guwahati

The following table gives the Compounded Annual Growth Rates (CAGR) of population of GMC area with respect to 2001 population.

Table 2.4 Compounded Annual Growth Rates (%) of Population of GMC Area

Year	Guwahati Municipality
1961-2001	4.038
1971-2001	3.973
1991-2001	3.318

Source: Comprehensive Master Plan for Guwahati Metropolitan Area: Data Base Report (Draft)

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Based on CAGR, the low, medium and high projections of population of GMC area are as follows:

Table 2.5 The Future Population Estimate in GMCA

Year	Estimated Population		
	Low	Medium	High
2005	922,855	946,487	948,832
2010	1,086,461	1,150,065	1,156,486
2015	1,279,072	1,397,430	1,409,585
2020	1,505,829	1,698,000	1,718,075
2025	1,772,787	2,063,218	2,094,078

Source: Comprehensive Master Plan for Guwahati Metropolitan Area: Data Base Report (Draft)

In the master plan for Guwahati (Draft report), the medium projection of 20.63 lakhs has been adapted for the year 2065. This value has been used for population distribution in the area in the master plan and this report too.

2.4.2 Sex Ratio

As compared to the overall sex ratio of 932 of Assam, the Guwahati city has slightly lower sex ratio of 839 in 2001. From Table 2.6, it can be observed that in 1901, the city had a very low sex-ratio of 500, which actually started increasing after 1971, when the city became the state capital. Since then, there has been continuous rise in the sex ratio with the highest 839 in 2001.

Table 2.6: Change in Sex Ratio in GMC Area

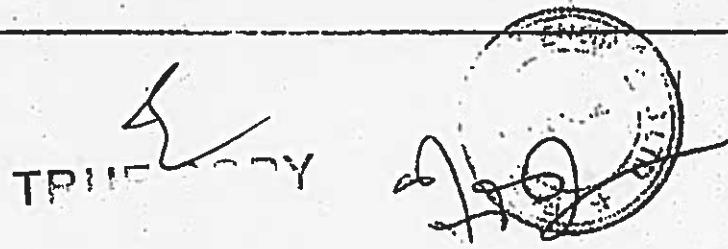
Year	Guwahati City
1901	500
1911	534
1921	528
1931	503
1941	567
1951	558
1961	497
1971	638
1991	783
2001	839

Source: Comprehensive Master Plan for Guwahati Metropolitan Area: Data Base Report (Draft)

2.5 LAND USE

The digital satellite imagery data (IRS-P6 LISS-III data) of Guwahati city and the adjoining areas, obtained from NRSA and processed through ERDAS by the

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Environmental Information Centre (an initiative of Ministry of Environment and Forests, Government of India) software is presented in Annexure 2.3. The map shows several layers of information including agriculture, fallow land, grass land, marshy land, marshy vegetation, open / barren land, sand settlement, vegetation (low, medium and high density), water bodies etc.

Water bodies: The water bodies include all the rivers, lakes and reservoirs, and ponds in Guwahati City.

Open and barren land: The land devoid of vegetation is included in this category. This includes the rocky surfaces. The areas that have been stripped of vegetation are included in this class.

Vegetation: Vegetation includes forests as per the Forest Conservation Act and non forest areas with close tree cover. For the analysis, the vegetation has been considered under three categories of crown cover density, namely, < 10% (low density vegetation), 10-40% (medium density vegetation) and > 40% (high density vegetation).

The landuse categories and the area of each category within the municipal limits are given in the Table below.

Table 2.7: Land use Categories and Area of Each Category

S. No.	Landuse Categories	Area (sq km)	Percentage of Total Area
1	Water Bodies	1.3	0.6
2	Open /Barren land	8.64	4
3	Agriculture land	8.6	4
4	Barren Land	8.6	4
5	Vegetation Low Density	64.8	30
6	Vegetation Medium Density	8.64	4
7	Vegetation High Density	4.32	2
9	River bed	0.54	0.25
10	Built Up Area	79.92	37
11	Marshy Vegetation	23.76	11
12	Marshy Land	4.32	2
13	Miscellaneous (unclassified)	2.48	1.15
	Total	216	100

It can be seen that the major development in the Guwahati city has taken place in a concentrated cluster. The area of the city was only 1.68 sq km in 1951 and 14 sq km in 1961 and now extends up to 216 sq km.

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As the city is constrained by the river Brahmaputra in the north and hills in the south, the residential expansions sprawl up to the top of the various hills situated within the city landscape. Such expansions have created problems like deforestation, reduction of grass land, soil erosion and have led to the flow of topsoil downward during the rainy season

2.6 ADMINISTRATION & MANAGEMENT

The Guwahati Municipal Corporation is the creation of the Guwahati Municipal Corporation Act, 1971. The Corporation was duly constituted in 1974 in the first meeting of the elected councilors as per provision of Sec. 45 of this Act.

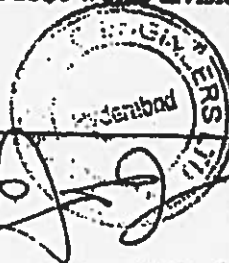
The Corporation has the following major branches:

1. Conservancy
2. Water Works Tax Division
3. Public Works
4. Building Permission
5. Street light and Electrical Section
6. Municipal Markets
7. Sanitation & Health
8. Veterinary
9. Enforcement
10. Property Tax
11. Mutation Branch
12. Trade License
13. Advertisement
14. Slow Moving Vehicle Branch
15. Dead body and Night Soil Removal Branch
16. Poverty Alleviation
17. Birth and Death Registration
18. Garage Branch
19. Accounts Branch

The Corporation is headed by a Council of 60 elected Ward Commissioners. The council is headed by a Mayor and then a Deputy Mayor. There are five standing committees of the council to supervise various works.

The Commissioner is the executive head of the corporation. He is assisted by Additional and Joint Commissioners.

The water and public works divisions are headed by a Chief Engineer. The garage branch is headed by a Superintending Engineer. The accounts branch is headed by a Financial Advisor and Chief Accounts and an Audit Officer. Each revenue zone is headed by a Deputy Commissioner. Each Public works division is headed by an Executive Engineer.



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The Engineering Department of GMC is responsible for collection and transportation of Solid Waste generated in the GMC Area. For operational purposes the entire area of the corporation is divided into 20 zones (23 Engineering zones out of which 20 zones have SWM responsibilities) consisting of 60 wards, with each zone having 3 to 5 wards. Each zone is headed by a Zonal Engineer (Assistance Engineer). Inspectors and supervisors who oversee the daily activities assist the Zonal engineers. The Zonal Engineers work under Divisional engineers, each division having 4-5 zones. The Engineering Department address major programmes such as -- construction and maintenance, building licensing, and SWM activities including drain cleaning.

2.6.1 Staffing Details

The Engineering Department of Guwahati Municipal Corporation has at present total employee strength of 2800 out of which 1173 are working on solid waste management. The Chief Engineer is assisted by five Executive Engineers each in charge of one division. Organogram of GMC staff involved in SWM activities is shown in Figure 2.1.

Table 2.8: Staffing -- GMC--Engineering & Conservancy Departments

Designation	No. of posts	Duties
Chief Engineer	1	Responsible for management of all engineering & sanitation.
Superintending Engineer	1	Overall engineering and sanitation operations
Executive Engineer	5	Construction & maintenance of roads, drains, municipal buildings and SWM operations
Zonal Engineers	20	Supervision of the construction works, street sweeping, collection, transportation and disposal of wastes
Supervisors	60	Supervision & monitoring of SWM operations
Workers	800	Street sweeping, nalla cleaning, assisting loading unloading operation
Drain Cleaners	270	Cleaning of drains
Drivers	16	Operation of collection drain cleaning vehicles & equipments

Source: GMC

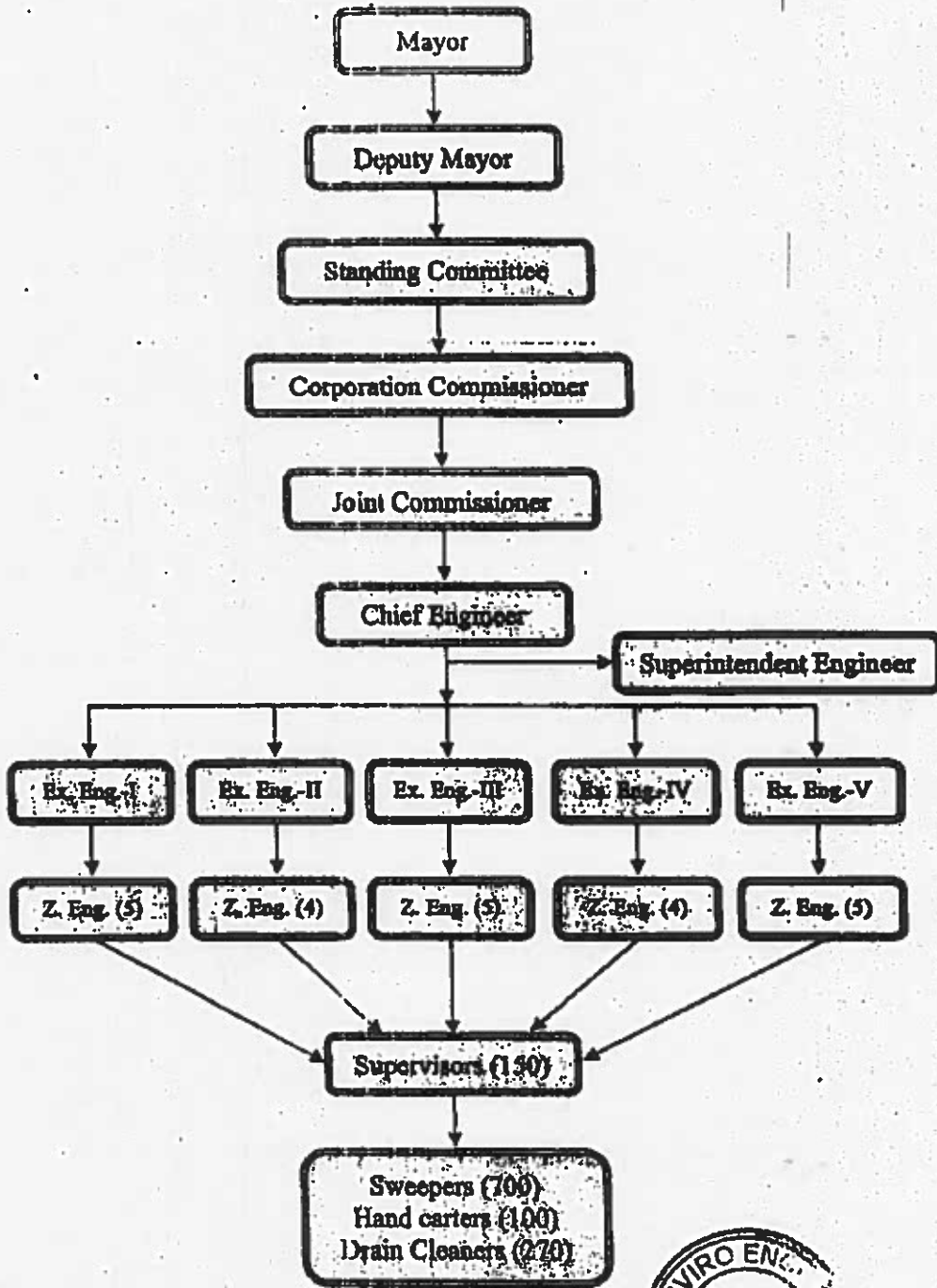


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Figure 2.1 Organisation Chart of GMC for SWM



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2.6.2 Structure of the Department

Each division is headed by Executive Engineer and there are 5 Divisional Executive Engineers and 1 Executive Engineer (Project & Planning). Table 2.9 below shows the details of each division.

Table 2.9 Division wise details of Staff of GMC

Division no	Staff	Wards
Division-1	Executive Engineer -1	1-16,18,19 &29
	Zonal Engineer 1	13-16
	Zonal Engineer 2	7-12
	Zonal Engineer 3	18,19,22
	Zonal Engineer 4	1-6
Division-2	Executive Engineer	31 to 33-39
	Zonal Engineer 1	31,33
	Zonal Engineer 2	34,35
	Zonal Engineer 3	36,39
	Zonal Engineer 4	37,38
Division-3	Executive Engineer-1	40-50,52
	Zonal Engineer 1	42
	Zonal Engineer 2	43,44
	Zonal Engineer 3	45
	Zonal Engineer 4	46-49, 52
	Zonal Engineer 5	40,41
Division-4	Executive Engineer-1	2033,25-28, 30, 32
	Zonal Engineer 1	28,32
	Zonal Engineer 2	22,23,30
	Zonal Engineer 3	25,26
	Zonal Engineer 4	20,21,27
Division-5	Division V	17,24,51, 53-60
	Executive Engineer-1	
	Zonal Engineer 1	17,24,57,58
	Zonal Engineer 2	57,60
	Zonal Engineer 3	53,54
	Zonal Engineer 4	51
Division-6	Zonal Engineer 5	55,56
	EE (Planning and Projects)	1

2.6.3 Zonal Engineers

Under each zonal engineer there are supervisors and workers for sweeping & drain cleaning, cart men collect the waste and deposit the waste in the secondary collection points.

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**CHAPTER-3
PRESENT SOLID WASTE
MANAGEMENT SCENARIO**

3.1 SALIENT FEATURES OF SOLID WASTE MANAGEMENT

3.1.1 Introduction

In this section review and analysis of the data collected on the present solid waste management practices of the GMC area are discussed. A detailed field survey has been conducted to assess the quality and quantity of the solid waste generated in the Guwahati city as discussed in this and the subsequent chapters. To substantiate the survey, detailed discussions with the concerned officials & resource persons have also been carried out.

3.1.2 Salient Features

Municipal Solid Waste is generated by the domestic sources, commercial establishments, hotels and restaurants, markets, street sweeping, drain cleaning and other sources.

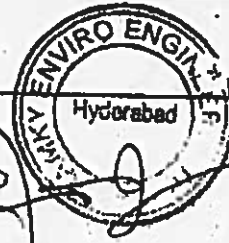
The primary collection in the city is mainly 'bring in system' where the generators i.e. households, hotels, restaurants, commercial establishments, markets, temples, etc. bring and deposit the waste in secondary collection points - dustbins / open collection points/ drains/ road margins/ river etc. GMC presently has a network of community collection points and a significant number are open points. Subsequently, the waste from the collection points is collected by trucks manually and finally dumped in unsecured landfill site at Sachhal.

Wastes are segregated and picked up for recycling by the rag pickers at the collection points as well as the dumping site.

It is observed that the existing system in the city is not in compliance with the MSW Rules, 2000. Health & Environmental aspects are not integrated as can be seen from the Table 3.1 below:

Table 3.1 Salient Features of Solid Waste Management in the GMC Area

Elements		Features
Generation	Generators	Households, Hotels, Restaurants, Commercial Establishments, Markets, Temples, Institutions, Drain Silt, Street Sweepings.
Segregation & storage at source	Generally absent. News papers, cartons, glass are segregated at source.	



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Collection	Primary Collection	Collect from households and bring to GMC collection points, drains/ road margins/ river; Limited private initiative for door to door collection.
	Drain cleaning	270 workers engaged. Material removed by GMC vehicles.
	Street sweeping	Approximately 800 sweepers and workers engaged for sweeping and collection of sweepings in the streets.
	Collection Points:	RCC / Metallic/Masonry Enclosures - 318 nos., size - 0.3, 0.5, 1.0, 1.2, 1.5, 2, 3, 5 m ³ Open ground level points - 460 nos.
	Average spacing of collection points	Highly varying (200 m -1000 m)
	Transfer	Manual, by scraping from ground
Transport		Private transporters contracted by GMC through trucks (47 private and 16 GMC owned trucks)
Frequency of waste removal		Scheduled daily, from city centre, occasionally from other places- Night Lifting, 2 trips on an average per truck per day from GMC collection points. Irregular except from major city points.
Processing		No processing at city or local level except a 50 Tons per month private vermi compost initiative at Panikheti.
Disposal	Land Fill Site	Crude unsafe dumping at Sachhal, Express Highway VIP Road, Size - 9 ha.
Recycling		Separation by rag pickers for non-organic matter / recyclables including plastics, paper, metals, bottles, etc. at generation and collection points and the land fill site.

It would be prudent to mention that there is no sewerage and drainage system in the Guwahati city.

It is observed that GMC provides services in only 70% of the area under their jurisdiction. No services are available on Sundays and holidays. Detailed analysis of the present system is carried out in this chapter to assess the component wise service levels and deficiencies. The overall city looks dirty with rampant disposal of waste all over the streets and river Brahmaputra.

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3.2 SOURCES OF MUNICIPAL SOLID WASTE

The primary generators of solid waste generation in the Municipal area are the local households, markets and commercial establishments such as hotels, restaurants, shops etc. As Guwahati is a centre of commercial activity not only in Assam but also in the entire North East, there is a considerable floating population in Guwahati. Inventory of sources and source wise assessment of generation is not available with GMC. Based on preliminary observations and GMC records the following major groups of waste generators were identified. Table 3.2 below shows the major sources of MSW and the number of corresponding units:

Table 3.2 Sources of MSW

S. No	Source	No of units
1.	Domestic Sources (Households)-2001 Census	1,84,454
2.	Commercial Establishments	38,871
3.	Hotels & Restaurants	596
4.	Markets	14
5.	Temples (major)	06

Source: GMC

Annexure 3.1 shows a map with major localities, roads, major commercial establishments and other features & Annexure 3.2 gives a matrix of zones, wards and major localities in GMC area.

3.2.1 Domestic Households

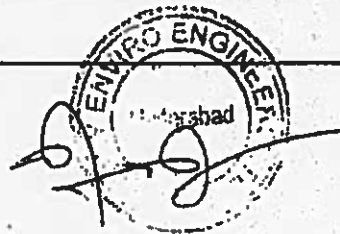
Various categories of households are major generators of waste. The households in the Guwahati city may be categorised based on the income range, number of family members, socio economic profile, owned / rented, size of the house, house affordability and economically weaker section dwellings. The quantity of solid waste generated is directly proportional to the consumption pattern and therefore the income levels of population. There is no particular category specific cluster / colony in the city. There has been a spurt in multi storey buildings in the recent past. However, these are not planned and they are scattered all over the city.

Most of the houses in the newly developed residential areas such as Kahailipara, Hengrabari, Panjabari, Khanspara, Kalapahar, Fatasil, Ambari, Gotanagar, Bamunimaidan etc. are single storied. Most of the buildings in these areas are designed for provisions for vertical extension up to G + 2 as per GMC. Comparatively older areas have already been developed and the high rise buildings have sprung up in these areas.

Based on a recent assessment (Census 2001), it is estimated that there are 1,84,454 households with in the GMC Area (Reference: Annexure 2.2 - shows the ward-wise number of households) and the average family size is 4.4 persons.

The middle income group forms the largest economic strata with 46.5% of the total households having the monthly income of Rs 7500 - 15000. Table 3.3 shows the percentage distribution of households classified by average monthly income.

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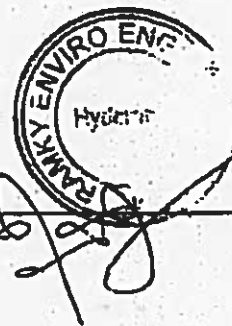
Table 3.3 Distribution of Households by Average Monthly Household Income

Average Monthly Household Income (In Rupees)	Percentage of Households
Upto 3000	6.5
3001-7500	37.8
7501-15000	46.5
Above 15000	9.3

Source: Comprehensive Master Plan for Guwahati Metropolitan Area: Data Base Report

Apart from the income levels, the socio-cultural practices also influence the generation practices of the solid wastes. Guwahati has its own typical practices and some of them which influence the quantity and the quality of wastes are as given below:

- Emphasis on ritualistic prayers in every household, thus daily usage of coconut, flowers (marigold), banana leaves and flowers, areca nut (tambul) and betel leaves irrespective of the class or income of the household
- Bananas and Sal leaves are used as packaging material for eatables and disposable plates in local Dhabas.
- In comparison to other cities of similar size relatively lesser use of plastic bags because of availability of jute, bamboo and choir materials.
- Maximum expenditure of all the households from various income groups is incurred on food items (44% - Source: Comprehensive Master Plan for Guwahati Metropolitan Area: Data Base Report)
- Ratio of working women is high
- Eating out is generally restricted to the weekends.
- People are primarily non vegetarians. Fresh water varieties of fish, rice, chicken are major components of the meals.
- Low awareness on the proper disposal of solid waste.
- Pan and supari consumptions are very high.
- No estimations on the house hold generation of the waste.



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3.2.2 Markets & Commercial Establishments

The major contributors of solid waste after households are markets and commercial establishments within the GMC area. These include fancy and novelty items shops, stationery shops, grocery stores, electrical shops, bakeries, hardware shops, food grain shops, fruit and vegetable shops, job working stations, office complexes and offices, malls and others. There are around 40,000 commercial establishments in the Guwahati city.



There are four main wholesale markets in the city. Important features of these markets are as follows:

1. Machkuan-Fancy Bazaar area:

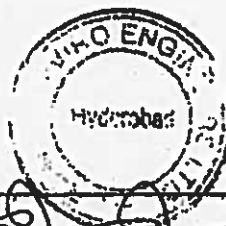
- Location: right within the heart of the city facing the river Brahmaputra;
- Planning: random / haphazard locations of the shops in approx. 75 ha area;
- Commodity: mainly potato, onion & other vegetables (40 shops), foodgrains & mustard oil (90 shops), other commodities (170 shops) including crockery, tea, cattle feed items, plastic, salt, biscuits, masala, mineral water, handlooms, sugar, garments, paint, consumer durables etc.
- No. of Shops/stalls: 179 rooms and 123 stalls

2. Along AT Road- Paltan Bazaar area:

- Location: Along 1 km stretch of AT Road starting from fire station near ASTC to Athgaon railway crossing
- Commodity: Hardware and spare-parts
- No. of Shops/stalls: 96 rooms and 143 stalls

3. Maligaon Timber market area

- Location: At Maligaon along half km stretch of AT Road in the foothills of Kamakhya, starting from Maligaon Rail Overbridge (ROB) to Maligaon Chariali
- Commodity : Timber
- No. of Shops/stalls : 47



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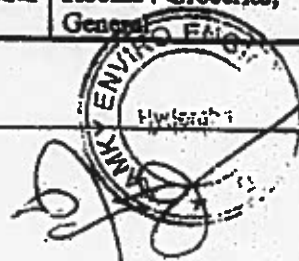
4. Fish market in Paltan Bazaar area

- Location : Near Paltan Bazaar area on the back of Meghdoot cinema
- Commodity : Fish
- No. of Shops/stalls : 52 stalls

In addition to the wholesale markets, there are twelve major markets under the GMC jurisdiction in the city. Details are shown in Table 3.4.

Table 3.4 Details of Major Markets in GMC Area

S. No.	Market	No. of Rooms/Stalls Operating	Zone	Commodity
1	Dispur Super Market	128 rooms	Zone-5, Central	Rooms : General, Stationeries, Groceries
2	New Market Bazaar	30 rooms 52 stalls	Central	Rooms : Pooja Items Stalls : Fish
3	Ganeshguri Market	152 rooms 74 stalls	Zone-19	Rooms : General, Stationeries, Groceries Stalls : Fish, Vegetable
4	Uhubari Market	51 rooms 68 stalls	South	Rooms : Groceries, General Stalls : Fish, Vegetable Chicken, Mutton
5	Tarun Ram Phukan Market	35 rooms	Central	Rooms : Groceries, Vegetable, General
6	Chandmari Flyover Market	21 stalls	Zone-10	Stalls : General
7	Fatasil Market	49 rooms 63 stalls	Zone-3	Rooms : Groceries, General Stalls : Fish, Vegetable, Pan, Mutton
8	Uzan Bazaar Market	28 rooms 32 stalls	Central	Rooms : Groceries, General



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				Stalls : Fish
9	Chandmari Colony Market	44 rooms 7 stalls	Zone-10	Rooms : Groceries, General Stalls : Pan
10	Kacharighat Market	54 stalls		Stalls : Fish, Vegetable
11 (a)	Belhola Bi-weekly Market	44 stalls	Zone-19	Stalls : Vegetable, Fruit, Chicken, mutton, Clothes, Stationeries.
11 (b)	Belhola Evening Market	33 stalls	Zone-19	Stalls : Vegetable

Source: GMC

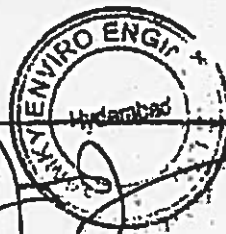
The salient features of the markets are as follows:

- None of the markets in the city have been planned specifically for wholesale trade, hence basic infrastructure facilities are missing.
- Almost all the markets are congested & dirty.
- No garbage dumping locations and improper drainage network
- Commercial establishments/ offices are not concentrated in any specific area of the city.
- Except for fish and vegetable markets, none of the markets are dedicated to single type of commodity in the entire city.
- There are no dedicated bins or collection system for the commercial establishments or the markets.
- Spurt in multi storey malls and shopping complexes in the last few years. There are 3 - 4 such malls on the G. S. Road and office complex in Oriant Towers on the same road

3.2.3 Hotels & Restaurant

Hotels and restaurants have been considered as a separate category due to the high rate of solid waste generation by this category. The organic content in the solid waste of this category is generally high. According to the secondary data from the Tourism Department and GMC there are 32 hotels, 210 lodges, 391 restaurants and tea stalls, 173 messes and 30 bars in Guwahati. A list of hotels in Guwahati, as per the Department of Tourism, is given in Annexure 3.4. There are numerous small hotels which are not listed in records.

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2800**Sallent Features:**

- There are no 5-Star category hotels in Guwahati.
- There are numerous Dhabas scattered in the city. There is no estimate of the numbers of Dhabas in the city. Most of them are located near the bus terminus at Paltan Bazaar and Adabari, railway stations at Paltan Bazar, Ganeshguri and Kalapahar.
- There is no separate-direct system for collection of waste from hotels and restaurants in the city. Further, none of the hotels and restaurants pay for the collection of their waste. They simply dump their waste in the GMC designated collection points and often litter the wastes. A list of Hotels in Guwahati as per the Department of Tourism, is given in Annexure 3.3.

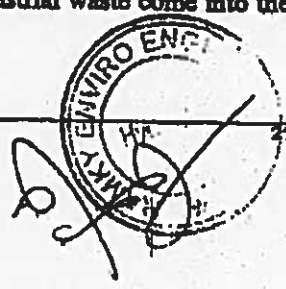
3.2.4 . Others

There are several other generators which contribute to the total waste generation in Guwahati. Some of the major ones are:

- Institutions like the schools, university and colleges- Guwahati University, Guwahati Engineering College, Guwahati Agricultural University, Commerce College, Handique College, Polytechnic, B. Barua College, Dispur College, Aryavidyapeeth College
- Temples – Kamakhya, Sukreshwar, Vashishtha, Navagrah, Latasil, Ganesh
- Parks and Exhibition Grounds – Nehru Park, Engineering College Ground- Chandmari, Sona Ram School Ground – Bharalmukh, Kalakhetra, Punjabari, State Text Book Publication Ground – Pan Bazar
- Hospitals and Nursing Homes -- (Non Biomedical waste) – Down Town, Guwahati Medical College, Good Health Institute of Neurological Science, B Barua Cancer Institute.
- Industries – Bamuni Maidan Industrial Area, IOC - Guwahati Refinery
- Marriage Halls – Radhika Bhawan, Shalini, Bibah Bhawan, Asian Palace, Aashirwad, Decora Bibah Bhawan.

Sallent Features:

- Although the industrial waste is not included in the MSW stream, there are a very few industries in the city which are contributing to the total MSW in the city.
- Bigger units like the IOC, Guwahati Refinery and others have their own treatment system. Only the treated and the non-industrial waste come into the main solid waste stream of the city.



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- Although the Railway Colony and the cantonment fall within the GMC area, they are not under the jurisdiction of GMC.
- No slaughter houses within the city limits. However, there are a number of butcher shops and meat shops.
- No major dairies in the city. However, there are a few cowsheds in the city. Few of the bigger houses keep 1-2 cows or buffaloes.
- Negligible amount of construction and demolition waste generated in the city.
- Presence of the drain cleaning waste and silt in the MSW stream.
- No organised sewerage system in Guwahati. There are open drains spread all across the city. The waste and the silt tend to get mixed with the solid waste stream.
- Presence of Bio-medical waste in the MSW stream. As per Government of India's directives in 1998 for Bio-Medical Waste (Management & Handling) Rules, 1998, it has been made mandatory that the treatment and disposal of Bio-Medical waste is responsibility of the respective medical institutions. Despite this regulation the biomedical waste finds its way in to the MSW to some extent in Guwahati. Bio-medical waste of the hospitals and nursing homes which is generated from their cantens, mort, offices and others is considered as a part of the MSW.

3.2.5 Street Sweeping

With a total road length of 639.032 km, street sweeping waste is the other major component of the solid waste in GMC Area. There are 2022 numbers of roads in the GMC area. As presented in Table 3.5, a significant 44 per cent of the roads are cement concrete roads and over 34 per cent are black topped.

Table 3.5 Details of Roads in GMC Area (length in km)

Category of Road	GMC					Total (kms)
	Division I	Division II	Division III	Division IV	Division V	
Black Top	68.124	69.743	37.931	32.110	59.613	267.521
WBM	40.619	5.368	35.197	11.330	58.618	151.132
Barthen / Gravel	62.031	14.904	47.154	17.440	78.850	220.379
Total	170.774	90.015	120.282	60.880	197.081	639.032

Source: GMC



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Salient Features:

- While one worker sweeps the road, a second worker picks up the sweepings, which are kept in heaps by the former. However, these activities are not done simultaneously.
- The sweeper uses a long broom, while the cartmen go round with the handcart and dust-collecting pan. Time lag leads to spreading of these heaps.
- The sweepings are collected in traditional hand carts (Box type-wooden / metallic), are taken to the secondary waste collection points and put on ground to be manually transferred to the trucks.
- There are around 700 sweepers and 100 drain cleaning workers distributed in the five divisions (100-150 workers in each division).
- The sweepings are carried out daily once in a day in one shift from 0430 am to 1100 am in summers and 0500 am to 1200 noon winters.

3.2.6 Drain Cleaning Waste

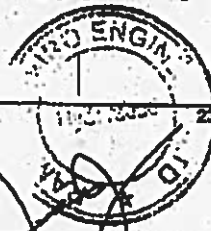
The total length of the drains is estimated to be double of the road length (1,278 km) in the GMC area as reported by GMC. As there is no proper drainage in the city the solid waste gets mixed in the open drains. There is also a high content of silt in the water which settles in the drains and becomes a part of the solid waste stream when dredged. The drains are cleaned by GMC drain cleaners who are separate from the

sweepers with the help of long forks and shovels. This waste is dumped on the sides of the drains and is picked up by the hand carts. Separate piles of this waste are made near the secondary waste collection bins and are lifted by the GMC trucks (own). Majority of this waste is disposed off in the low-lying areas. However, it is seen that this waste is also mixed with the waste at the collection points and finds its way to the land fill site. It is extremely difficult to estimate the quantity of this waste.

3.2.7 Floating Population

People from almost all the neighbouring states, visit Guwahati for their commercial pursuits. Since no formal data is available on the floating population, reconnaissance surveys at commercial areas and Focused Group Discussions with the resourceful persons and local authority officials were conducted to estimate the floating population. As a result it is estimated that the floating population per day of Guwahati city is around 30,000 - 40,000.

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3.3 COLLECTION AND TRANSPORTATION

3.3.1 Primary Collection

In some of the housing societies, door to door collection systems exist mainly through private initiatives of the Resident Welfare Associations. For example, few of the colonies where such an initiative is being taken are: Rahawari, Uzan Bazaar, Chandmari, Silpukhri and Pan Bazaar. Residents pay Rs. 20 - 40 per house for door to door collection of the waste.

The MSW strewn around is mainly collected through street sweepings. The municipal sweeper collects the waste in heaps along the road sides and the cartman deposits the waste in secondary collection points.

3.3.2 Secondary Collection Points / Waste Storage Depots / Waste Receptacle / Dhallas

GMC presently has 778 secondary waste storage collection points as reported by the GMC. Majority of these points are open ground sites. The break up of varieties of waste storage depots in the city is as below.



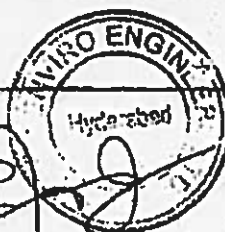
Type of waste storage depot	No.
Open waste storage depots	460
Masonry/RCC/Metallic waste collection points	318

The masonry enclosures are three sided construction with a height of 100-120 cm. The waste is scraped out from the open side for loading to trucks. Similar kind of metallic enclosures are also seen.

The workers use traditional handcarts and deposit the waste on the ground instead of putting in the containers and create unsanitary conditions around the bin. The situation attracts stray cattle, pigs, rats & rodents.

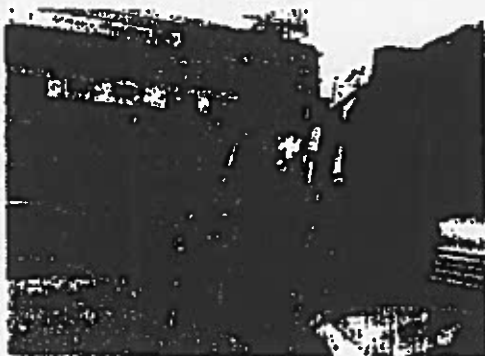
None of the waste storage depots have an arrangement of a platform. Generally the premises of containers are found with over flowing and decomposing waste. Some of the locations are on footpaths and on narrow road margins causing obstructions to traffic and movement of the people.

The responsibility of the collection and transportation of the waste from the secondary collection points is with GMC. Divisional and zonal engineers, supervisors and then the sweepers manage the collection of the solid waste in the city. Annexure 3.4 gives the zone-wise list of secondary collection points in the city.

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GMC has let out the transportation of the solid waste to 20 private contractors. They collect the waste from the secondary collection points and dispose off at the dumping sites. These transporters have annual contracts with the GMC and are paid according to the clearing of the waste from the area assigned. If the GMC supervisors find that the area allocated to the contractor has not been cleared then he has to pay a fine of 3 times of the fee he gets. The trucks make on an average 1-2 trips to clear the waste from their respective allocated areas. GMC has its own fleet of 16 trucks, which are being used for drain cleaning and on special occasions e.g. during festivals of Diwali, Durga Puja, Ambu Basi Mela and Dignitary Visits.



If the GMC supervisors find that the area allocated to the contractor has not been cleared then he has to pay a fine of 3 times of the fee he gets. The trucks make on an average 1-2 trips to clear the waste from their respective allocated areas. GMC has its own fleet of 16 trucks, which are being used for drain cleaning and on special occasions e.g. during festivals of Diwali, Durga Puja, Ambu Basi Mela and Dignitary Visits.

The vehicles involved in the solid waste transportation are ordinary uncovered non tipping type trucks. They are manually loaded by scraping waste from the ground into conical shaped bamboo basket (thapa) and tilting the same to the truck holding the bottom handle. The workers are not using any personal protection equipments for this job.

Recently, GMC has restricted the collection and transportation of the waste during the night time. The lifting of the waste starts at 7.00 pm in the evening and carries on till 8.00 am in the morning. The GMC supervisors and engineers go for supervision during these hours. However, the street sweeping is done during the day time.

Table 3.6 Solid Waste Collection and Transportation Infrastructure with GMC

Vehicle	GMC
Hand Carts	104
Trucks	16
Brooms	700 brooms in a month

Source: GMC

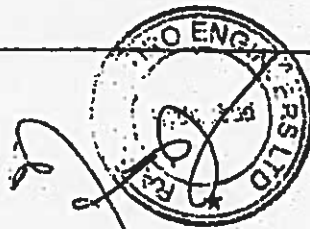
3.3.3 Vehicle Maintenance

Private transporters maintain their own vehicles. GMC has its own workshop which is used for all the vehicles owned by GMC. The vehicles used for MSW transportation are maintained in this workshop only.

3.4 PROCESSING & DISPOSAL OF MUNICIPAL SOLID WASTE

At present, GMC is not practicing any scientific and safe solid waste processing

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and disposal methods. However, there is a small successful private initiative of 50 Tons / month for vermi composting in the outskirts of the city at Panikheti. This unit is owned by M/s North East Green Tech.



GMC has no sanitary landfill site per say. Organized dumping in Guwahati started with the disposal site at Versapada. After a Public Interest Litigation (PIL) this site was abandoned and disposal was shifted to Amin Gaon. After that it was shifted to Adebhari and then finally at Sachhal, the current disposal site. This site was developed nearly 2 years back.

The disposal site at Sachhal, 10 km away from city centre, is a low-lying area. This site is a government owned land and was transferred to the GMC. Only a part of this site is being used. It is a developing area and many new constructions have come up in recent years. Few of these are close to the site. Being low-lying area, during monsoon flooding occurs and landfill operations become difficult in the absence of properly developed roads and the approach gets flooded. The disposal is crude dumping where the waste is not covered and no specific steps are taken for controlled filling. A dozer is used to compact the waste. Bird, cattle nuisance, burning of waste, water logging and leachate contamination are the major issues of the site.

It was reported that in 2004, there was public protest against the generation of odour and the insect menace in this site. To combat this problem GMC is doing some remediation exercise. Insect repellent and de-odouriser is sprayed at regular intervals at the site. This job has been awarded to a private contractor.

3.5 RECYCLING

There is a prominent role played by the rag pickers/ scavengers in the MSW system. They contribute to the segregation and sorting of the recyclables in the MSW. Their role begins right at the generation sources including residences, offices, shops, markets and others from where they collect paper, plastic bottles, buckets, metals and other recyclable items and sell them for reuse. Then they also pick up recyclables from the secondary collection points, roadsides, open sites and the land fill site. This unorganised sector affects the final quantity of the waste reaching the land fill site significantly.



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These rag pickers generally stay in the slums, pavements and at the dumping area. It is common to see a rag picker with a huge bag at all odd hours of the day and night in the city especially these days when the waste is being collected and disposed during the night hours. Generally, these rag pickers are strewn over in busy places like Fancy Bazar, Paltan Bazar, Pan Bazar, Ganeshguri, Chandmari, Maligaon and others. They collect the recyclable waste and sell to contractors who again sell in whole sale markets. Some of the selling points are at Lakhotia (under the over bridge), Beltola Charali, Khanapara, Lakhotai, Fatasil, Dhirenpara and Chatribari.

There are about 100 rag pickers staying at the land fill site at Sachhal and they collect the recyclables from the waste. They are reported to sell recyclables around Rs 100/ day each. They also burn the waste for metal recovery at the site.

Few of the findings of a profile study done by Assam Science Technology & Environment Council as part of their Survey of Urban Garbage in Guwahati are:

- Highest number of these rag pickers are found to be below 15 years of age
- Total number of rag pickers those who operate in Guwahati area has not been estimated
- Total lack of hygiene and sanitation in their living and their work
- Unorganised sector
- Very low income levels
- No civic amenities or facilities available to them
- High rate of occurrence of skin diseases, injuries and infections

At present there is no NGO or any other organisation working on the improvement of the rag pickers. However this is a humanitarian problem and needs to be addressed in a significant way

3.6 QUANTITY & CHARACTERISTICS OF MSW GENERATED

Quantity

Few studies have been conducted in the past on the MSW management of Guwahati city. Estimates on the quantity of MSW as reported in these studies are as follows:

- As per the "Municipal Solid Waste Management Plan (Collection & Transportation) of Guwahati Municipal Corporation for 2005-07 (Draft)", the quantity of MSW generated in the city is estimated around 467 TPD in the year 2005.
- According to "Report on a Survey on Urban Garbage in Guwahati Prepared by

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Assam Science Technology and Environmental Council, 1994-95", the waste generated per capita has been estimated around 0.315 kg per day. This translates to 184 TPD.

- According to the study conducted by NEERI "Project Report on Mechanical Composting Plant at Guwahati" in the year 1976, the quantity of refuse generated in the Guwahati city was estimated around 98 TPD.
- Comprehensive Master Plan for GMA: Data Base Report (Draft) reports a generation of 325.52 TPD of MSW in the year 2001. This report refers to a document prepared by the Assam Pollution Control Board (APCB) and Society for Research Development and Communication in the year 1999.

Characteristics

The composition of MSW, as reported in various reports, has been summarized in Table 3.7.

Table 3.7: Composition of MSW in GMC area

Waste Composition (%)	GMC Report, 2003	Report by Assam Science Tech. and Env. Council, 1994-95	NEERI, 1976	Master Plan (Draft)
Organic Matter	64.6	78.0	57.0	71.0
Paper	5.4	14.0	-	13.0
Plastic	3.5	6.2	0.2	8.0
Rubber & Leather	2.8	-	0.2	-
Inerts	15.9	-	8.0	-
Ash & Fine	-	-	33.7	-
Others	7.8	1.8	0.9	8
Total	100	100	100	100

3.7 OPERATIONAL EXPENDITURE & ECONOMIC DETAILS

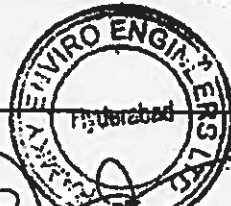
The average GMC expenditure towards SWM for year 2004-05 is Rs. 954 lakhs. The expenditure for the last three years is given in Table - 3.9.

As there is no single costing system for SWM, and the expenditure heads maintained in Accounts carry other activities. Hence the figures available may not cover all the expenditure on SWM. However it is observed that O&M expenditure is steadily increasing.

Table 3.8: SWM Operating Expenditure-GMC

Year	2002-03	2003-04	2004-05
Expenditure in Rs. lakhs	1487	1379	1261

Source: Accounts Dept, GMC



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The major item of expenditure is salaries, which in Indian cities are 70-80% of the total expenditure. It is around 60% here as the transportation is privatised. The expenditure on Landfill is low as no sanitary operation is done.

Table 3.9: Breakup of expenditure (2004-05)

Item of Expenditure	% to the total
Salaries	76.0
Collection & Transportation	22.0
Landfill	0.5
Fuel & Maintenance	1.5

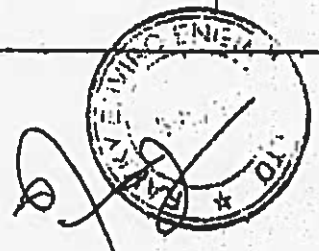
3.8 DEFICIENCY ANALYSIS

Table 3.10 below sums up the deficiency analysis in the MSW management system existing currently

Table 3.10: Deficiency Analysis

Component	Indicator	Remarks
Regulatory Compliance	SWM Rules 2000	<ul style="list-style-type: none"> No compliance of rules
Generation	Mixed Waste	<ul style="list-style-type: none"> Waste from all categories including households, hotels, restaurants, commercial establishments, markets, temples, institutions, drain silt, street sweepings is mixed. No separate system for big generators like hotels & markets. Drain silt is treated as a part of MSW. Rampant disposal of waste all over the streets and river Brahmaputra leading to diseases and epidemic. Community cleaning is totally absent
Segregation at source	Difference in organic levels at generation and collection points	<ul style="list-style-type: none"> No segregation of waste at the source of generation. Recyclables (20% of MSW) including newspapers, plastics and metals are collected by ragpickers.
Primary Collection	Door to door collection	<ul style="list-style-type: none"> No door to door collection in most of the localities Most of the waste is dumped in open areas No dustbins at public places. Unhealthy and unhygienic waste

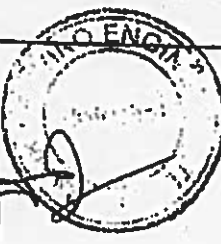
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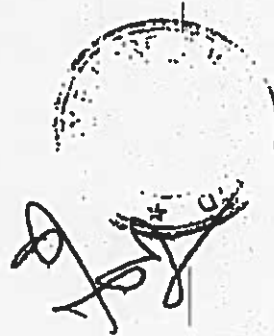
		disposal practices followed by the big generators.
Secondary Collection	Unmanaged and insutic ent collection points	<ul style="list-style-type: none"> • Insufficient number of collection points, at more than the desirable spacing of 50-500 m. • Based on population norms, no. of collection points should be at least 1000 against the existing 318 points. • Most of the collection points are open points and unhygienic. • No provision to dump the waste in separate biodegradable (green)/recyclable (blue) containers. • Poor maintenance of collection points by GMC. • Infrequent and erratic clearing of waste from collection points • Erratic capacities of the collection points • No separate collection points for various streams of waste • Mixing of drain silt at this level • Manual lifting of the waste from the collection points leading to spilling of waste • No personal protection equipments used by the workers clearing the waste
Street Sweeping		<ul style="list-style-type: none"> • Absence of need based sweeping • Inefficient street sweeping operations. • On an average 20% workers are on leave or absent. • 639 km of roads are to be swept on need based frequencies. The current schedule does not cover all the roads and streets. • Workers are entrusted 800-1000 metre road length for street sweeping. This is on higher side considering MoEF manual recommending beat lengths per worker for sweeping, collection from sources along the road stretch.
Transportation	Unmanaged and unscientific	<ul style="list-style-type: none"> • Although privatised, the basis for contract value and terms is arbitrary • Open non-tipping trucks are used which are highly unhygienic and non-productive. • No arrangement for lifting of waste from congested by lanes of markets and remote areas of the city.

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Community participation		<ul style="list-style-type: none">Community participation is absent except very small initiative at one or two places.
Public Awareness		<ul style="list-style-type: none">No significant educational programs, campaigns, NGO activities for public awareness on solid waste management, significance of recycling, reuse and segregation of MSW.
Disposal		<ul style="list-style-type: none">No waste processing practices.No scientific disposalUnmanaged landfill site



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CHAPTER - 4 QUANTITY & CHARACTERISTICS OF SOLID WASTE GENERATED

4.1 INTRODUCTION

An estimation of the quantity and characteristics of solid waste generated in GMC is discussed in this section. An accurate assessment of the quantity and characteristics of the solid waste generated is very important for a city in formulating the solid waste management plans. On the other hand, the characteristics of solid waste are strongly influenced by the climate of the region, seasonal variation, the economy of the region, the physical characteristics of the city and the social and religious customs of the society.

Considering the above aspects the following surveys were carried out in Guwahati City to assess the exact quantity and characteristics of the waste generated.

- sample surveys for estimation of quantity of solid waste generated
- solid waste sampling for the analysis of physico-chemical characters

Details of these surveys and the results of the same are discussed in the subsequent sections of this chapter.

4.2 SAMPLING METHODOLOGY

For Guwahati direct measurement techniques were adopted to estimate the quantity of waste generated from each source and the per capita quantity of the waste generated.

4.2.1 Sample Survey

A sample survey was conducted in the city with the following objectives:

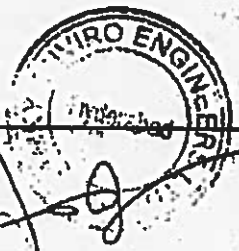
- Assess the quantity and quality of waste generated by various generators and
- Collect and collate information relevant to design of an integrated waste management program for GMC

The scope of the survey was as follows:

Part A : Waste quantification and quality assessment:

Coverage : All the zones in Guwahati Municipal Area

Sample Size : 390 Samples


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Sample Duration : 3 Days & 1 day as specified in Table 4.1

A list of samples selected in all categories of waste generators is shown in Annexure 4.1.

Part B: Secondary information collection and compilation

Base data and secondary information was collected from various sources. A list of secondary data sources is given in Annexure 4.2.

Apart from quantity/ quality assessment, limited number of group discussions [with Resident Associations, Chamber of commerce and other trade associations] on the quality of services of GMC, expectation and willingness to pay/ participate in the SWM program of the city were also conducted.

4.2.2 Approach and Methodology

Of the 390 samples, the proportion of residential samples was 350. This sample size was chosen as the best compromise between economy and precision. This number is higher than the suggested number in the CPHEEO Manual. Environment Protection Agency (EPA), U.S.A. has also established some norms for effective sampling. According to the norms for precision vs sample size for the waste stream components, to get a precision level of $\pm 5\%$ in the estimates, a sample of 300 is near perfect. This correlation is for a waste stream with high organic/putrescibles. An assumption has been made based on the secondary research that the Guwahati MSW has a high content of organics.

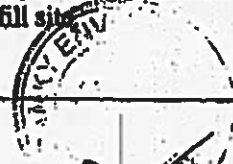
Table 4.1 provides the break up of the sampling done in various categories of generators.

Table 4.1 Sample Break Up

Categories	Sample for Waste Quantification & Physical Analysis	Sample for Chemical Characterisation	
		Partial	Full
Households	350 X 3*	12	3
Commercial Establishments - Dhalaos	20 X 1*	5	2
Hotels & Restaurants	10 X 1*	3	2
Others - Dhalaos	10 X 1*	8	3
Total	1090	28	10

*No of days

To assess the physico-chemical characteristics of the MSW, on site physical analysis and lab testing for chemical parameters were carried out. Physical analysis was carried out for all the samples and partial chemical analysis for 28 samples and full for 9 samples. Sample for physical analysis was collected by coning and quartering method at the dhalaos and the land fill site.



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The parameters measured in quality are shown in Annexure 4.3.

Additionally, to the secondary waste collection and final disposal. All 6 samples for chemical analysis. Sampling was also carried out at Schachhal. For before noon and afternoon for 3 days.

4.2.3 Domestic Households Sampling

The 350 Economically Weaker Income Group (MIG) and Higher Income Group (HIG) households. This break up has been derived from the expert discussions and secondary data from the Master Plan Document (Draft) and the 'The Indian Market Demographics Report', 2002 by NCAER.

Table 4.2 Break up of the Household Samples

House Hold Category	Number of Samples		% to the Total Samples	
	Households	Population	Households	Population
EWS	87	365	25	25.62
LIG	145	575	40	40.41
MIG	87	362	25	25.94
HIG	29	121	10	8.50
Total	348	1423	100	100

It was also made sure that the sampling was evenly distributed all over the city.

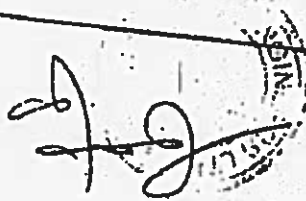
The household surveys were carried out for three consecutive days i.e. on 23rd (Friday), 24th (Saturday) and 25th (Sunday) of September 2005. The days were selected to represent the waste generation trends of the households on a weekend and two normal weekdays. Out of the 350 households selected, 348 gave samples.

4.2.4 Sampling of Other Sources

To finalise the number of samples for other sources of generation of MSW such as commercial establishments, hotels & restaurants, markets, and others field reconnaissance surveys, discussions with experts and GMC were carried out. However, as the number of samples in this category was small, to get a fair representation, the samples were collected from the dhalkos having the dedicated catchment of the waste generators including commercial establishments, markets and others. The survey in these categories was done for a day.

Broad methodology adopted for testing the chemical parameters is given in

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Annexure 4.4.

4.3 QUANTITY OF DOMESTIC SOLID WASTE GENERATED

4.3.1 Domestic Households

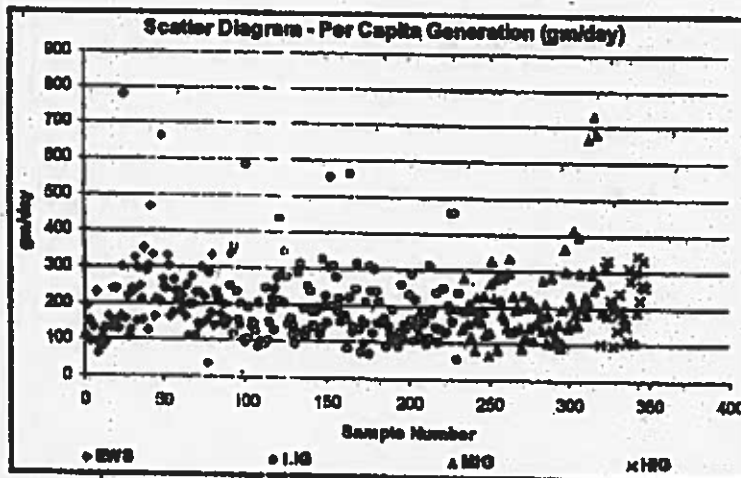
Out of the 350 households selected for sampling purposes, as presented in table 4.2, 348 responded and over the three days, the response to the surveys has been around 84 per cent (292 households responded) on the 1st day, 92% on the 2nd day (319 households responded) and 96 per cent (333 households responded) on the 3rd day. Almost all the households responded at least for one day. Annexure 4.5 presents the type, size, income group and average solid waste generation of sample households.

Table 4.2 Sample Response to the Per capita Assessment Surveys

House Hold Type	Responded Households		
	Day 1 (Weekday)	Day 2 (Weekday)	Day 3 (Weekend)
EWS	75	80	83
LIG	120	133	139
MIG	73	80	83
HIG	24	26	28
Total	292	319	333

As illustrated in the figure below a wide variation in generating trends ranging from a minimum of 40 gm per capita per day to a maximum of around 779 gm per capita per day is observed across the households.

As presented in the figure, about 78 per cent of the samples are in the per capita range of 50 to 250 gm and around 22 percent samples are outside this range (50 - 250



gm/day). This is authenticated by standard deviation of 103.48. Since the deviation is high, average per capita generation for the days of sampling has been calculated by eliminating extreme 10 per cent values.

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Table 4.3 Category Wise Waste Generation Trends in Guwahati

Category	Per Capita Generation, gm/day			Average Per Capita Generation, gm/day
	Day 1 (Weekday)	Day 2 (Weekday)	Day 3 (Weekend)	
EWS	189	167	159	175
LIG	186	146	128	161
MIG	180	157	175	170
HIG	208	196	153	195

Source: Analysis

Average Per Capita Generation, gm/day =	$\frac{(6 \times \text{Average Weekdays Per Capita Generation} + (\text{Weekend Average Per Capita Generation}))}{7}$
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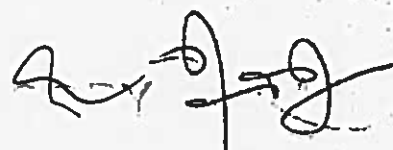
Therefore from the above analysis it is concluded that the average per capita generation of solid waste in Guwahati ranges from 161 to 195 gm/day in EWS, LIG, MIG and HIG categories. Thus the average per capita generation works out to 175 gm/day. The per capita generation values are applied to the population of different wards to arrive at the total waste generated by households. As presented in the table 4.4 total waste generated by households in Guwahati works out to 172.21 tons/day (for 2006).

Table 4.4 Zone Wise Waste Generation Trends of Households in Guwahati

Zone	Waste Generated, Tons/day	Zone	Waste Generated, Tons/day
Zone 1	15.11	Zone 11	4.99
Zone 2	19.48	Zone 12	9.28
Zone 3	14.49	Zone 13	8.38
Zone 4	1.57	Zone 14	16.09
Zone 5	9.19	Zone 15	9.61
Zone 6	1.80	Zone 16	6.19
Zone 7	1.19	Zone 17	6.55
Zone 8	2.24	Zone 18	1.61
Zone 9	6.01	Zone 19	16.11
Zone 10	4.82	Zone 20	23.05
Total Waste Generated		172.21 tons/day	

4.3.2 Commercial Establishments

There are around 40,000 commercial establishments operating in Guwahati, majority of them are general Shops, grocery shops, bakeries and juice shops, hardware and electrical shops, wholesale and retail stores and others. The major waste generating sources are bakeries, juice shops, *pan* shops, snacks shops, vegetable stalls, coconut vendors, etc.

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In order to assess the waste generated by these establishments, field visits and field assessment surveys were carried out in all the major commercial areas of Guwahati. Discussions were also held with the shop owners on the amount of waste generated by each of them and disposal practices. Commercial establishments in the markets have not been considered in this estimation.

Since no information was available with the Corporation on category wise inventory of commercial establishments, 20 collection points were selected in commercial areas and their catchment area was demarcated. The total waste received by the collection points (maximum of 100 kgs was considered) apportioned to the number of establishments contributing to it. Based on the survey it was concluded that commercial establishments in Guwahati generate 56.53 tons of solid waste everyday with unit generation rate of 1.49 kg / day, as presented in table 4.5. Annexure 4.7 presents the details of commercial establishments and results of the survey.

Table 4.5 Solid Waste Generated by Commercial Establishments

Description	Value
Number of Commercial Establishments in City	38,871
Number of Commercial Establishments in Markets	872
Number of Commercial Establishments in City other than Markets	37,999
Solid Waste Generation Rate, kg/unit/day	1.49
Total Solid Waste Generated by Commercial Establishments, tons/day	56.53
* Note: Waste Generated by Commercial Establishments in the Markets has been considered under the Markets Category	

Source GMC, Field Assessment Surveys and Analysis

4.3.3 Restaurants

Restaurants are one of the main sources of solid waste generation in Guwahati, which contributes organic waste. Field assessment surveys at open collection points were conducted to estimate the unit generation rates by restaurants. There are 564 restaurants, tea stalls and dhabas of various types in Guwahati and a sample size of 1 per cent (a sample of 6) has been considered to conduct the assessment surveys, details of which are presented in Annexure 4.8.

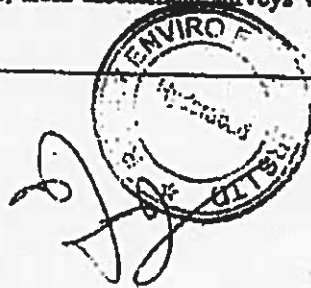
Based on the field assessment survey the unit generation rate of restaurants is estimated as 16.67 kgs / day. At this rate the total solid waste generated by restaurants in Guwahati works out to 9.40 tons / day.

4.3.4 Hotels

Waste generated from hotels, depends on the occupancy rate at any particular time. Estimation based on such details will need longer time period for analysis.

Similar to the commercial establishments, field assessment surveys were carried

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out in Hotels of Guwahati and average waste generation trends are estimated. Parameters such as capacity, occupancy rate were also evaluated during the surveys. There are 32 hotels in Guwahati (including all types). Out of these 5 were selected to conduct the assessment surveys.

Table 4.7 Solid waste Generated by Hotels in Guwahati

Description	Value
Number of Hotels	32
Solid Waste Generation Rate, kg/unit/day	83.89
Total Solid Waste Generated, tons/day	2.68

Source: Field Assessment Surveys and Analysis

These surveys as analysed in table 4.7 indicate that the waste generation rates of hotels in Guwahati range from 60 kg/unit/day to 100 kg / unit / day. After considering the occupancy rates and capacities of the hotels, it is estimated that the average waste generation rate in hotels is around 83.89 kg per day. Thus the total waste generated by hotels in Guwahati is 2.68 tons per day.

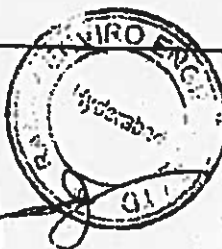
4.3.5 Markets

Vegetable, fruit, mutton, chicken & fish stalls and general establishments like stationery, electrical, pharmaceuticals, general stores, grocery, PCO, tea stalls, etc. are the potential sources of waste generation in markets in Guwahati. The generation trends of these areas are totally different from any other sources. However, major generation from these markets are coming from fruits, vegetables and fish shops and stalls.

There are 14 major markets (listed in table 4.8) in the Guwahati under the jurisdiction of GMC. Apart from these markets there are few small markets located roadside at residential colonies. List of markets with details of stalls and generation trends has been presented in table 4.8.

Table 4.8 Waste Generation in Markets in Guwahati

Name of Market	Vegetable / Fruit Stalls	Mutton / Chicken Stalls	Fish Stalls	Commercial Establishments	Total Stalls
Dispur Super Market	7	6		115	128
Ganeshpuri Market	10	24		192	226
Tarun Ram Phukan Market	5			30	35
Fatahill Market	21	4	33	54	112
Uzan Bazar		3	32	25	60
Pancy Bazar	69		36	177	302
New Market			52	30	82
Uhubari Bazar	30	45	15	29	119
Paltan Bazar	91	9		139	239
Beltois Market	68	5		9	82
Kacharighat Market	31		23		54
Wholesale Fish Market			52		52
Chanmari Flyover Market				21	21


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Chanmari Colony Market				51	51
Total Stalls	33.1	96	263	872	1563
Unit Generation, kg/day	12.00	15.00	20.00	1.49	
Total Generation, kg/day	3984.00	1440.00	5260.00	1299.28	11983.28

Source: GMC, Field Assessment Surveys and Analysis

In order to assess the waste generated by the markets field assessments surveys were carried out and discussions were held with the vendors of the markets. As presented in the Table 4.8, vegetable and fruit wholesalers and retailers generate around 12 kg of waste per stall everyday, whereas the fish vendors generate only 2 kg per vendor. Similarly mutton and chicken vendors / stalls generate on an average 15 kg of waste everyday. Based on these assessments, it is estimated that the markets in GMC generate around 11.98 tons of waste everyday.

4.3.6 Schools & Institutions

The waste generated by schools and other institutions will depend on the size of the school or institution. The activities of these institutions generally do not contribute much to the solid waste of the city. However, Guwahati being the capital city of the state, large number of central and state government institutions function in the city. These include Guwahati University, Assam Engineering College, Guwahati Polytechnic and others as mentioned in Chapter 3.

The specific number of schools and institutions and the number of students / people working in these places in the city were not available. Based on the judgement of the consultants and discussions with the zonal engineers it is estimated that schools and institutions in Guwahati generate around 3 tons of solid waste.

4.3.7 Street Sweepings & Drain Cleanings

GMC has engaged about 16 trucks for lifting of street sweepings and drain cleaning waste generated in Guwahati. It was observed that 12 trucks on an average make 2 trips everyday to lift the street sweepings and drain cleaning wastes. Considering a vehicle capacity of 50 m³ and an efficiency of 50 % the total waste collected by GMC vehicles are about 48 tons per day.

Table 4.12 Details of Solid Waste Generated by Street Sweepings and Drain Cleanings

Description	Value
No. of Trucks Engaged for Lifting of Street Sweeping & Drain Cleaning Waste	12
Average No. of Trips per day	2
Capacity of Vehicle	5 m ³
Bulk Density	0.8 t/m ³
Efficiency	50 %
Total Street Sweeping & Drain Cleaning Generated Waste per Day	48 TPD

Source GMC and Analysis



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4.3.8 Other Sources

The other sources of waste generation in Guwahati comprise domestic waste generated from temples, parks, exhibition halls, marriage halls, hospitals and other medical institutions etc.

Based on the discussions with the trust authorities, GMC officials and sample survey it is estimated that these temples generate around 1.2 tons of solid waste every day.

Based on the norms specified by the CPHEEO the waste generated by hospitals will be around 1.5 kg / bed / day, of which 75 per cent will be non bio medical waste and 25 %, will be bio-medical waste. With this unit generation rate and total bed strength of 3650, the total waste generated by hospitals is estimated as 5.48 tons/day of which 4.11 tons/day will be domestic waste.

Similarly, the contribution from construction and demolition activities could not be quantified exactly. Based on expert opinion, it is estimated that on an average 2.5 tons of construction waste is generated from various places of the city everyday.

Apart from the sources considered there are other sources like marriage/function halls, unorganised dairies guest houses, hostels, cottage industries, exhibition halls and others. Contribution from these sources can not be assessed exactly due to their nature and variation in generation trends. To take care of the quantity of the waste contributed by these sources around 3 tons per day has been taken into account based on the understanding and previous experience of the consultants.

On the whole the waste generated from other sources is thus estimated as 6.61 tons per day.

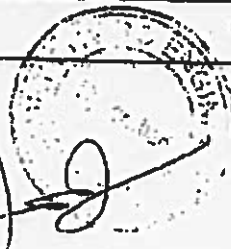
4.3.9 Total Quantity of Waste Generated

A summary of quantification surveys discussed above, conclude that the total quantity of waste generated in Guwahati to be around 300 tons per day. While around 172 tons is generated by the domestic sources around 57 tons is generated by the commercial establishments and around 48 tons from street sweeping and drain cleaning activities.

Table 4.13 Total Quantity of Solid Waste Generated in Guwahati

S. No	Source	Unit Generation/day	Total Waste, tons/day	% to Total
1.	Domestic Sources	175 gm/cap/day	172.21	54.39
2.	Commercial Establishments	1.49 kg/unit	56.53	17.85
3.	Restaurants	8.33 kg/unit	9.40	2.97
4.	Hotels	83.89 kg/unit	2.68	0.85

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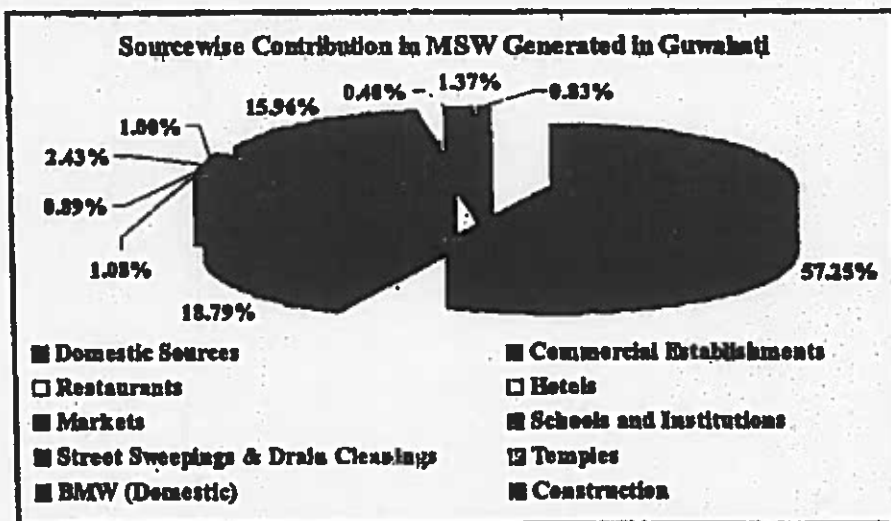
5.	Markets	2.25 to 15 kg/unit	11.98	3.78
6.	Schools and Institutions	LS	3.00	0.95
7.	Street Sweepings & Drain Cleanings		48.00	15.16
8.	Temples	LS	1.20	0.39
9.	BMW (Domestic)	1.13 kg/unit	4.11	1.30
10.	Construction	LS	2.50	0.79
11.	Others	LS	5.00	1.58
	Total Waste Generated, tons/day		316.61	100.00
	Combined Per Capita Generation		321.73 gm/cap/day	

Source Survey Analysis
LS - Lump Sum

Per Capita Generation (PCG) is defined as the ratio between the total quantity of waste generated by all sources and population (projected for 2006) of Guwahati.

$PCG = \text{Total Quantity of Waste Generated (gm) by all sources} / \text{Population of the city}$
 $= 31661000 / 984083 = 321.73 \text{ gm/day}$

In terms of percentage contribution, as summarised in table 4.13, domestic waste generated from the households account for a substantial 54 per cent of the total waste generated. Street sweepings & drain cleanings and commercial wastes contribute 15 and 18 per cent respectively. The per capita generation (PCG) for Guwahati thus works out to 321.73 gm/day.



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Table 4.4 Zone Wise Waste Generation Trends in Guwahati

Zone	Waste Generated, Tons/day	Zone	Waste Generated, Tons/day
Zone 1	31.23	Zone 11	10.32
Zone 2	40.25	Zone 12	19.17
Zone 3	29.93	Zone 13	17.32
Zone 4	3.25	Zone 14	33.25
Zone 5	6.60	Zone 15	19.86
Zone 6	3.72	Zone 16	12.80
Zone 7	-2.47	Zone 17	13.53
Zone 8	4.63	Zone 18	3.32
Zone 9	12.41	Zone 19	33.29
Zone 10	9.96	Zone 20	47.62
Total Waste Generated	321.73 tons / day		

4.4 QUANTITY OF WASTE COLLECTED BY GMC

The Engineering Department of Guwahati Municipal Corporation as presented in earlier sections is responsible for collection and transportation of waste from open collection points and dustbins to the landfill site. As discussed in the earlier chapter, the collection and transportation of MSW has been privatised by GMC, except for street sweepings and drain cleaning wastes. As information provided by the GMC there are 20 private operators responsible for the collection and transportation of waste from 20 zones. These operators have engaged 47 trucks for waste transportation apart from this GMC also has engaged 16 trucks for transportation of street sweeping and drain cleaning waste.

Movement of these vehicles and their collection capacities are critical to assess the actual waste collected by the GMC as against the 300 tons waste generated by the citizens of Guwahati. In order to assess this, the vehicle movement data maintained at the landfill site by GMC was collected and analysed for three months (July, August and September 2005) for total number of vehicles on road and amount of waste collected on a particular day, etc.

Table 4.19 Vehicle Movement Analysis of Solid Waste Collection Vehicles

Period	Average No. of Vehicles on Road	Average Trips / Day	Average Trips / Vehicle	Average Quantity of Waste Collected, Tons / Day
July, 05	33	64	1.93	153.03
Aug, 05	42	81	1.94	193.75
Sept, 05	43	82	1.91	196.50
Average	38	73	1.92	175.71

Source: Vehicle Movement Register & Analysis

As analysed in table 4.19, on an average around 38 vehicles collect the solid waste everyday from 20 zones. In order to assess the waste carrying capacity of the

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vehicles, the dimensions of the vehicles were measured. the volume of the vehicles was calculated and the waste density factor was applied to arrive at the actual carrying capacities of each vehicle. These carrying capacities were then applied to the corresponding vehicle trips on the particular day of vehicle movement analysis and the total waste collected is estimated. Based on this analysis, it is estimated that on an average 175.71 tons (59 % of the 300 tons of waste generated) of waste is being collected. Details of vehicle movement analysis and quantity of waste collected are presented in annexe 4.6.

4.4.1 Waste Collected by the Rag Pickers

In order to estimate the quantity of waste recycled, the street collectors, rag pickers, raddiwalas, sub-dealers and main dealers in the city were interviewed. Generally street collectors and ragpickers collect the waste and sell to the raddiwalas. These raddiwalas buys the material from ragpickers and sell to sub-dealers once in every 15 days after accumulation of considerable quantity of material. It is estimated that around 100 ragpickers are operating at land fill site at Schachhal. The sub-dealers do cleaning and segregation of waste into different categories like plastics (bottles, covers, cassette covers, wires, large articles, etc.), glass (broken glass and bottles), metal, tins, rubber, cartons, paper, etc. The sub-dealers again sell the recycled material to main dealer who generally handle the material in bulk and supply to recycling plants.

Based on the discussions and filed surveys it is estimated that in Guwahati about 14 tons of waste is being recycled everyday. A significant portion of these recyclables is contributed from metal scrap, card board and glass bottles, etc.

Table 4.21 Estimated Quantity of Recycling in Guwahati

Recyclable	Quantity Collected, tons / day
Plastic (hard poly bags, films, bottles, packing materials, cans, cassette covers, etc.)	1.50
Glass including Bottles	2.00
Rubber	0.80
Wire and cable	0.30
Tin	0.70
Iron	4.00
Paper	3.00
Cartons	1.50
Water bottles (plastic)	0.20
Total	14.00

Source Field Surveys and Analysis



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