4.5 PHYSICO-CHEMICAL ANALYSIS OF SOLID WASTE

Field investigation surveys by collecting the samples and segregating them into different categories like plastic, Paper, rubber, leather, metals, inert and organics has been carried out to assess the physical characteristics of the MSW. Samples were collected from different sources and analysed for their physical characteristics. As presented in table 4.23 households, hotels, temples and markets contribute high organic waste. Similarly institutions, bus stands and commercial sources contribute inorganic waste. The inert waste is mainly contributed from street sweeping and drain cleaning activities.

Table 4.23 Physical Characteristics of the Guwahati MSW

Source	Percentage by Weight (w/w, %)						
	Plastics	Paper	Rubber, Leather & Synthetics	Glass	Metals	Inert	Organic
HIG	7.32	6.75	5.24	6.22	3.05	5.68	66.88
MIG	6.30	7.19	4.33	5.75	2.17	4.64	68.69
LIG	6.57	6.23	4.23	6.61	2.50	7.05	66.81
Slums	6.59	6.45	4.38	4.11	1.65	7.82	68.29
Households (Average)	6.70	6.65	4.55	5.67	2.34	6.30	67.67
Markets & Commercial	10.60	10.62	6.17	2.40	3.32	3.30	63.60
Hotels	8.12	7.16	1.58	1.99	0.57	0.97	77.61
Institutions	16.35	16.77	3.67	4.89	2.45	2.49	53.38
Temples	11.88	10.29	3.76	4.60	0.16	0.00	69.32
Adabari Bus Stand	11.35	9.60	10.40	6.50	2.40	6.85	52.90
Nehru Park	18.00	11.00	2.20	0.75			28.05
Secondary Collection Points	6.13	5.28	3.66	1.95	0.45	1.68	80.85
Landfill Site	4.50	8.39	9.14	2.90	1.63	12.54	61.45

Source Sample Analysis

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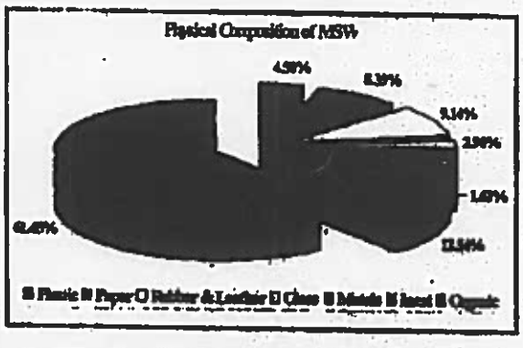
It can be observed from the table 4.2 that the physical characteristics of waste reaching secondary collection points have a high organic content as majority of recyclables are collected by the rag pickers and street sweeping and drain cleaning waste does not get mixed at this stage. The low percentage of plastics and paper can also be attributed by the fact that there is usage of carry bags made of bamboo and coir and low usage of paper which is replaced with banana leaves for wrapping and packaging.



The analysis of waste reaching landfill again reveals that not all the street sweeping and drain cleaning waste and construction and demolition waste reaches the landfill. Majority of this waste is being disposed off in the low-lying areas there by indicating low percentage of inert waste. Thus the composition of waste coming out of the Guwahati consists of substantial organic component of more than 60 per cent mixed with inerts (12 %).

Annexure 4.9 Detailed Sheets of Physical Characteristics Sourcewise.

Chemical properties analysed for the MSW included moisture, Carbon to Nitrogen Ratio, Calorific Value and heavy metals. These were done to make a decision in finalising the waste processing technology. The moisture content of the tested samples is in the range of 44-88%, C/N ratio is in the range of 9 – 32 and the calorific value is in the range of 1000 – 1400 kcal/kg. C/N ratio is a direct indicator of the conversion of MSW into compost. Calorific Value is the indicator for waste to energy technologies. However to compute the calorific value of MSW is complex because of the various constituents in it. It is extremely difficult to test the accurate calorific value of the MSW. Normally, in the testing laboratory the calorific value of the organic fraction is tested and then the values of other constituents are also taken into account. The heavy metals are also well within the desirable ranges. These are shown in the Table 4.24 below.

Table 4.24: Content of Heavy Metals

S. No.	Elements	Value (in ppm)
1	Se	0.92
2	Cr	0.02
3	Pb	0.11
4	Cd	0.03
5	Cu	0.12
6	Zn	0.42
7	Ni	0.11

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4.6 FUTURE GENERATION TRENDS

Population Growth

Population growth in the Guwahati City has already been discussed in Chapter- 2. It can be seen that maximum growth in the population of Guwahati has been registered during the period 1971-2001, after becoming the state capital in 1972. Based on the geometric growth rate (Compounded Annual Growth Rate) in the model as discussed the master plan for Guwahati (Draft report), the medium projection growth rate of 3.97 per cent per annum has been adapted and used for population distribution in the area.

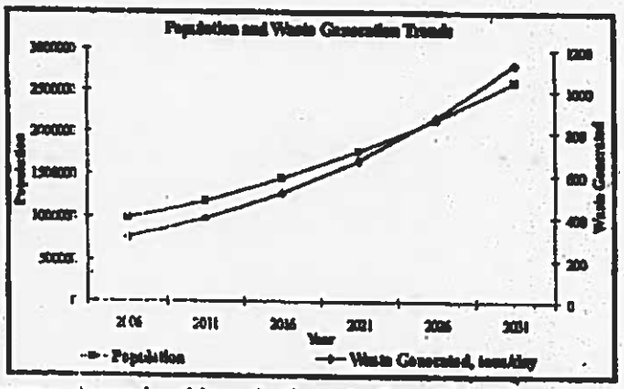
The population of Guwahati is expected to grow from the 9.84 lakhs in 2006 to 26.06 lakhs by the year 2031.

Future MSW Generation Trends

The consumption of raw materials and finished product by the community is directly proportional to the Gross National Product (GNP) of the country. The solid waste quantities are directly proportional to the quantity of material consumed and thus the increase in per capita solid waste quantities would be directly proportional to the per capita increase in GNP. Accordingly, solid waste generation per capita has been calculated as follows.

Table 4.25 Generation Trends of Solid Waste in Guwahati

Year	Population	Per Capita Generation, gm/day	Waste Generated, tons/day
2006	9,84,083	305.68	300.81
2011	11,95,734	327.47	413.34
2016	14,52,905	351.62	510.87
2021	17,65,388	377.12	665.76
2026	21,45,078	404.47	867.61
2031	26,06,429	433.80	1130.66



Based on a study conducted by Urban Development Section Unit, East Asia and Pacific Region of The World Bank, the relation between GNP and per capita waste generation rates will grow at an exponential rate of 1.41 per cent per annum. Assuming this projection rates is projected that the per

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capita generation (PCG) in Guwahati will increase from 305.68 gm / day in 2006 to 433.80 gm / day by the year 2031, and similarly the total waste generated increases from 300.81 tons / day to 1150.66 tons / day.

4.7 INTERPRETATIONS AND INFERENCES

1. The Guwahati city is generating 317 TPD of MSW equivalent to 321 gms / capita / day currently. This quantity of the waste generated is lower than the one estimated by other studies and as reported in secondary data available. The collection of the waste is also lower than the reported one. Table 4.26 below depicts the waste balance of the city.

Table 4.26 Waste Balance

S. No.	Description	Quantity
1.	Total Waste Generated (2006)	317 TPD
2.	Per Capita Generation	322 gm/cap/day
3.	Total Waste Generation (2011)	413 TPD
4.	Total Waste Collected (2006)	176 TPD
5.	Collection Efficiency	59%
6.	Organic Levels	65 – 81%
7.	Bulk Density	0.4 MT/m^3
8.	C/N Ratio	9 - 32
9.	Moisture Levels	64%
10.	Calorific Value	1000 – 1400 kcal/kg

Source: Summary of various Ecosmart Surveys

2. The unaccounted waste not reaching the land fill is because of recycling activity by the rag pickers at the various locations or left unattended at various stages of generation, collection and transportation.

3. It is observed that the organic levels vary at the generation sources, at the secondary waste receptacles / *dhalaos* and at the land fill site. They are the highest at the *dhalao* level. This is plausible as the wastes were not sorted or segregated at the generation sources. The waste reaching the secondary collection points / *dhalaos* is sorted and segregated by the rag pickers for recyclables like plastics – bags, bottles, containers, buckets, metals, cans, etc and finally the waste at the land fills is further segregated by the ragpickers. Also, the inerts increase at the land fills as the construction and demolition and drain silt.

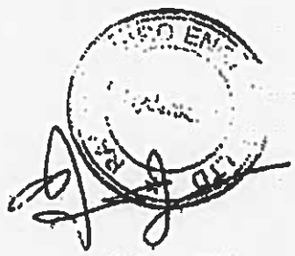
4. There is not much difference in the quality of the waste in the various categories of households (HIG, MIG, LIG, EWS & slums). The organic levels are in the range of 67- 68%. As expected the waste from hotels and temples has high organic content.

5. Maximum waste is being generated in the Zone 2, followed by Zones 19 & 3.

6. There is a correlation between the net calorific value and the moisture content

of MSW. As there is high moisture content additional energy is required to convert the wet mass into dry mass. This would ultimately reduce the total amount of energy that can be derived from MSW. Therefore, the option of waste to energy is not technically viable for Guwahati MSW.

7. The organic levels, moisture and the C/N ratio indicate that the waste is best suited for composting.



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CHAPTER – 5
COLLECTION & TRANSPORTATION (C&T) PLAN

5.1 INTRODUCTION

The analysis and discussions in the earlier chapters bring out the fact that the solid waste management in GMC will require modifications for more effective management. Despite spending substantial efforts, SWM services falls short of a 'desired level' -a level required to meet the prescribed standards and coverage as indicated in the chapter three. The comprehensive programme to address the issues are framed considering the need to comply with the Municipal Solid Waste (Management & Handling Rules) 2000.

The broad framework under which the management plan is prepared emphasises the following:

- Progressively encourage and enhance source segregation and storage of bio-degradable and non bio-degradable wastes separately at all premises
- Encourage primary collection of waste with community participation
- Abolition of secondary open collection points /static bins with mobile storage covered containers
- Regular street sweeping on a need base schedule
- Not to allow waste to reach the ground at primary and secondary collection stages
- Transportation of waste in covered vehicles. Dispense with manual loading of waste.
- Avoiding multiple handling of waste and its exposure during collection, transport, and minimising the exposure during disposal
- Resource recovery as near to the source as possible (4R's Principle – Recover, Reduce, Reuse, and Recycle)
- Set up waste treatment facilities
- Construction of sanitary landfill
- Enhancement of capacity building for staff and workers for effective management

- Building meaningful and effective partnership with Community, NGOs and private entrepreneurs
- Developing effective cost recovery system for financial viability
- Developing MIS and regular monitoring mechanism

The options for improvement in physical, organisational and financial terms are discussed in the subsequent chapters This chapter is organised to detail out the collection and transportation plan

5.2 OVERVIEW OF THE RECOMMENDED C&T PLAN

Collection and transportation, probably the most expensive component of the SWM operation requires active involvement of the citizen, NGOs and CBOs. Besides introduction of equipment and vehicles for minimum handling and exposure of waste, awareness creation is the key in developing meaningful partnerships. The suggestions in this section focus mainly on the mode of operation, choices of vehicle and equipments and estimation of the requirements. The suggestions are mainly for:

- Promotion of the practice of segregation and storage of waste at source in two bins- for biodegradable waste and another for recyclable waste, so as to facilitate an organised and hierarchical system of waste collection and disposal, without letting the waste to reach the ground in the primary and secondary collection stages.
- Organization of door to door / kerbside collection with community participation on cost recovery basis and minimize the multiple handling of waste, improvement in the productivity of labour and equipment
- Containerized secondary storage facilities phasing out open storage
- Daily transportation of organic waste /mixed waste to the treatment site
- Need based transportation of inorganic and other dry wastes to landfill site
- Container transportation using simple hydraulic system mounted vehicles
- Awareness creation for segregation, storage at source
- Monitoring system to increase the productivity

The proposals are discussed in detail in the subsequent sections in this chapter

5.3 SEGREGATION AND STORAGE OF WASTE AT SOURCE

Source segregation and storage is not the primary responsibility of the Municipal Corporation. However, if this can be achieved, the waste quality will improve substantially and the waste processing will be easy and effective. It is realized that in a heterogeneous society with several layers of stratification, it is difficult to achieve complete source segregation. Though GMC does not have a direct role to play in this regard, it can induce and facilitate segregation practices to a large extent. It is therefore desirable to prioritize Segregation & Storage of wastes at the source irrespective of the area of generation so as to facilitate an organized and environmentally acceptable waste collection, processing and disposal system. Source segregation of recyclables and biodegradables (organic waste) will not only provide an efficient way for resource recovery, but will also substantially reduce the pressure and pollution in Landfill sites. It is understood that implementation of such practices takes time and requires significant cooperation from the public. However, initiation should be made and efforts should be diverted to progressively increase the segregation practices. Chapter on Community Participation indicates various actions that could be taken by GMC to increase the public participation for the management of SWM. The sections below deal with issues that need to be considered for source segregation and various options available to GMC to implement the system.

5.3.1 Segregation at source

Segregation of the two different fractions of waste could be undertaken with out mixing them, but directly depositing to the separately bin / bag as and when generated

Table 5.1: MSW Source Segregation - categories

Category 1. Food & Green waste (wet waste)
Cooked/uncooked food, vegetable, fruit, meat, bone, fish waste, leaves, grass
Category 2. Recyclable & Non-bio-degradable (dry waste)
Paper, Plastics, glass, metal, ceramic, rubber, leather, rags, used cloths, wood, stone, sand, ash, thermocol, straw & packing materials

However, it is not easy to implement source segregation practices immediately. A prolonged campaign by GMC will be required with adequate budgetary provisions to impress the citizens that source segregation will provide them a healthy environment and a better lifestyle.

5.3.2 Storage at source

Citizens could be encouraged to have separate storage facilities for food/bio-degradables and recyclables/non-bio-degradables so as to ensure that no waste goes to ground and a system of 'Single handling' is developed.

A 3-bin system of storage of waste is suggested by MoEF in its guide lines of solid waste management. However, such a system of segregation in the initial

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stages of waste management is difficult for the community to practice. However, a single bin system could be encouraged which can be upgraded to a 2-bin system progressively. In the single bin system all the wastes are to be kept in a single bin.

As per the '2 Bin system of Solid Waste Storage at source', each of the household is encouraged to keep separate 2 bins / containers for Food/Green waste and Recyclables/Non-bio degradables.

The household bin for food & green waste could be of 10-15 liters capacity made of plastic / reinforced plastic / LDPE or metal. Bin or plastic bags may be used for recyclables, non bio-degradables and domestic hazardous storage requirements. Bins are preferred options as it is often difficult to separate the plastic bag during the waste processing and disposal. Moreover, plastic bags have a recurring expenditure, which is often difficult to overcome in a long run.

Multi-storied residences, commercial complexes, in addition to storage facilities in individual residences/shops, could also keep containers within their premises matching to collection system of the city.

Hotels, offices, shops and restaurants need to keep adequate number of bins with a capacity of about 60 litres to facilitate easy handling and transfer of waste to Municipal collection system. Plastic HDPE or reinforced fibre-glass bins are recommended for this purpose. Large premises generating quantities of 500 lit or more may keep containers matching to the collection system in the area.

Hospitals and Nursing homes could use colour coded bins/bags for storage as specified in the Bio-medical Waste (Management & Handling Rules)-1998. Hospitals should deposit only the food & bio-degradable waste in the Municipal System.

Construction & Demolition (C&D) waste has to be stored at the premises of the construction either in skips or suitable containers and has to be directly emptied to the notified disposal site/sites or by transported by availing Municipal facility. However, in Guwahati, the C&D wastes are in much demand for filling up the low lying flood prone area. Not much of C&D wastes find its way to the municipal MSW system.

Garden or other bulk waste has to be stored at premises and disposed directly to skips / containers for the purpose or should be directly handed over to the Municipal vehicle arriving on pre-notified days.

Meat, Chicken and fish stalls should store waste in non-corrosive bin / bins of about 60 litre capacity each and transfer contents to large container for bio-degradable to be kept at the market just before lifting of such large containers or handover to collection crew directly.

Each stall in vegetable and fruit market should store waste in bins and transfer to a large container / skip stationed for secondary storage.

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Street / food vendors will have to keep bins to store waste and transfer to municipal container. Marriage halls/function halls should keep large container matching the Municipal system.

Provision of suitable containers at source is the responsibility of individual generators. The role of SMC will be mainly to create awareness amongst the people with the support of NGOs. As segregation and storage require a high degree of human awareness on the health and environment perils of throwing waste on ground, a continued and concentrated effort is required top create this awareness.

Table 5.2: Specifications for 2-Bin System of Waste Storage at Source

S No	Source	Storage of Segregated waste	
		Food & Green waste	Recyclable & non-bio-degradable
		Green Color Bin	Yellow Bin/Bag
1.	House Holds	10-15 litres capacity plastic/reinforced plastic/ LDPE/metal bin with lid	A bin or bag of suitable size
2.	Hotels & Restaurants	60 litres capacity-LDPE/HDPE bins	A bin or bag of suitable size
3.	Shops, offices & institutions	Suitable container not exceeding 60 litres	A bin or bag of suitable size
4.	Market Stalls	40-60 litres bin-LDPE/HDPE for stalls	A bin or bag of suitable size
5.	Marriage/town halls	Wheeled Bin / Skip matching to Municipal Collection system	A bin or bag of suitable size
6.	Hospitals, nursing homes	60 litres capacity bin for non-infectious food & bio-degradable waste	Store waste as per Bio-medical Waste Mgmt Handling Rules 1998
7.	Construction/ Demolition waste	Store in containers /skips of size and capacity specified by municipality	Store with in premises and deposit in the notified Site by the local body or to the municipal Vehicle
8.	Garden Waste	Store with in premises/Synchronize trimming of gardens with the schedule of municipal collection	Deposit in large community bin or to the municipal vehicle arriving on pre-determined days

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Note:

1. Food & Green waste collection bins to have 100% spare capacity where a daily collection system is employed
2. Recyclables and non bio-degradables are generally dry, therefore the storage capacity is to be decided based on generation & frequency of collection of individual generators
3. Newspapers, magazines, glass bottles, plastics, metals, etc to be stored separately and sold /handed over to vendors directly. Municipality can engage vendors at secondary storage facility for procuring these materials from the generators

Since at present no source segregation is being practiced, to start with initially a single bin system can be adopted and GMC shall create awareness amongst the generators about the advantages of source segregation. The awareness could bring the attitudinal changes and two-bin system could be implemented as presented above.

5.4 PRIMARY COLLECTION

The job of primary collection is to be entrusted to private operator under PPP format.

It was observed that there is negligible organized primary collection system in Guwahati except in a few residential colonies which have their own initiative.

Different modes of improved collection systems being practiced in other cities are briefly discussed below. Recommendations have been made on suitable system considering the need & willingness of the people to pay for improved services

5.4.1 Options of primary collection

The work of primary collection is to be entrusted to private operator.

Door to door Collection system: In this system the collection vehicle stops as close as possible to the entrance of the house/establishment and individual household bin is picked up by a refuse collector from the premises, empties and places the bin back at the same location

It is preferable to have this system working under the management of neighborhood community where the community group employs refuse collection crew and oversees the operation.

Kerb Side Collection –Each householder puts out the waste in bin/bag at the edge of the pavement and later retrieves the bin. The collection vehicle passes at a set time; collection crew empties it into collection vehicle.

Block Collection – Block collection reduces stops for collection vehicle which comes at a pre set time and place to collect the waste from dwellers that bring

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their bins and empty in the vehicle. The system requires coordination between the people and collection service because the refuse is not left at the roadside as in kerb side system .The crew may use a bell or horn to inform the people around of the vehicle arrival. Householder delivers the waste at the time of collection

Bring System (Community Bin System)

In this the householder carries and deposits the waste in the community bin / facility. It requires the community bins to be placed at closer intervals, usually 100 m. The bins may have to be of 100 liter size if manual collection is employed which will cover only 20-25 households. Large containers could be used in markets and commercial complexes. Small container system may have to be discouraged due to possible theft of container or tilting by rag pickers or stray animals.

The organization of waste collection can be greatly simplified by the use of large community containers to receive the waste from primary collection employing short range transfer vehicles- containerized hand carts, tri-cycles, direct tipping three wheelers- operating door to door, kerb-side or block collection. The system will work efficiently provided the people are willing to pay for door to door system, to observe time schedule for Kerb / block collection. It is also equally important that the primary collection crew sticks to time schedules and the GMC organizes the timely removal of waste from the containers.

The bring system can not be totally eliminated as low income communities may not be willing to pay for door to door service, while other problem may be lack of access for vehicles. However considering the problems in placing small community bins, these communities may be served by block collection employing crew with auto trailer.

5.4.2 *Primary collection vehicles*

Collection of waste requires different kinds of vehicles depending on the quantities involved, and the distances waste has to be transported, access & terrain conditions. The general criteria for the design of collection vehicles are:

- The vehicle must be able to reach at the reception points- at house, kerb side, storage area.
- Loading height from the standing position to the container on the vehicle should not be more than 1.5 m for ease of hand loading.
- Tipping should be possible for fast emptying unless portable containers are used
- Transfer should not involve dumping of waste on the ground.
- Provision for covering the load in the vehicle to prevent the load from being blown off by the high
- Improved productivity by reducing loading, unloading time

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- Indigenous production, low maintenance, service, spare availability are other important considerations

5.4.3 *Choices of Primary collection vehicle*

Hand carts: Suitable for high density areas with only small quantity of waste generated per inhabitant. It is suitable for small residential neighborhoods as the radius of operation is limited to around 1 km. For the daily house to house collection of waste, one number of six bin hand cart of 40-50 lits will be equivalent to 50 dwellings at 8 lits/dwelling/day .One collector with a hand cart of containers can serve bout 200 dwelling units. Hand cart is a suitable choice for all locations having gentle terrain.

Tri-cycles Pedal tricycles with six bin facility (as in hand carts) can operate on a larger radius than hand cart. This system is suited for medium density residential area where the terrain is gentle. Coverage of more than 200 houses can be expected from a wider area with lesser effort by the collector. A three men crew can be engaged to cover 500-600 houses a day. In block collection the daily collection can range from 800 to 1000.

Auto Trailers/tippers Three wheeled power driven Auto is the third option. It can be fitted with high level tipping body (< 1.2 m) of 2 m^3 capacity retaining the low loading line. An alternate arrangement is to provide two tiers carrying 16 bins of 50-60 lits capacity or a bottom tier of 8 bins and top box of about 1 m^3. The top box can be used to collect garden or bulky waste, which can be transferred directly to skip/dumper. Its relatively high speed gives an operating radius of 8-10 kms but not suitable in rough and steep roads. An auto trailer can cover about 1500 premises in one shift four-member crew and a driver.

Dual tray Auto loader: Auto three wheeler with two trays (bins) of 0.75 m^3 size. The bins can be directly lifted and emptied to collection vehicle. By directly emptying to collection vehicle, Secondary storage may be eliminated. (Bin less system)

5.4.4 *Options for door-to-door collection system*

While door-to-door collection is the most ideal solution, it requires manpower, collection vehicle and community participation. The cost of service depends on the community participation.

Options are:

a) GMC could identify a Private operator for door-to-door collection and prescribe monthly collection charges for different categories of households, shops and establishments and notifies the same. The community pays prescribed monthly collection charges to agencies .who operates on an agreement with GMC.

b) Resident Welfare Associations (RWA) and other user groups (Hotel owners

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Association, etc) directly engage crew and pay directly. This is typical Community managed system and is in practice in many towns in our country, but requires a committed approach from the community. The major advantage will be the feel of ownership by the community. At present there are a few community based initiatives and survey reveals that there is an interest in the community members to organise community managed collection system.

5.4.5 *Community preferences and willingness to pay*

Findings based on a study conducted in 1994-'95 on community preferences are shown in the Table 5.3 given below.

Table 5.3: Community preferences

Area	% preferring community bin at accessible distance	% preferring door step collection
Henrabari	54	46
Professors Colony	20	80
Mahura Nagar	62	38
Beltola	30	70
Chenkuti Hill Side	7	93
Dihrenpara	93	7
Kanwachal	18	82
Pension para	80	20

Source : Report on survey of Urban Garbage in Guwahati- Assam Science Technology & Environment Council.

Table 5.4 below shows the results of the findings of the survey s done by picking representative samples from households falling under different social economic groups including slum dwellers apart from the survey of commercial establishments and large & medium hotels by Ecosmart

Table 5.4: Community willingness to pay

Category	Willingness to pay	
	Yes	No
HIG	73%	27%
MIG	54%	46%
LIG	38%	62%
Slum	14%	86%
Commercial	70%	30%
Hotels	92%	08%

Source : Survey & Analysis

As per the survey, 60% of domestic generators mainly HIG and MIG are currently interested in door step collection though it would be desirable to provide doorstep collection service even in the slums so as to ensure that no waste comes on the streets the However, the willingness to pay amongst the LIG and slum population is the lowest.. Moreover, the slum population comprises of the economically weaker section of the population and may not be able to pay the collection

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charges. Therefore is it recommended that the though the collection is to be undertaken by the private operator, GMC will pay collection charges to the operator on a negotiated basis.

70 % of the respondents from hotels, commercial establishments and shops are willing to pay for door step collection and hence they may be targeted through door to door/kerbside collection. For such establishments, the private operator will collect the wastes from generators and will collect the charges directly from them. GMC will notify the collection charges to the generators.

Auto trailers and tippers are not recommended for collection considering the higher capital and operating costs compared to carts & tricycles. Hand carts/tricycles with a capacity of 40 lit bins, six numbers will be operated. The former would be operated in the denser areas and latter in the medium / low density areas.

The suggested collection system and the storage facilities are given in table below.

Table 5.5: Primary collection from residential areas

Mode of collection	Area of collection	Primary Collection Vehicle	Secondary storage
Door to Door	Residential colonies high density in gentle terrain	Tri-cycle with 6 nos 40 lit capacity bins - 4 green color bins for Bio-degradable waste, 2 yellow color bins for recyclables	1.Bio-degradable in dumper container 2. Non-biodegradable- Sell or dispose in for the same
Community bin collection	Slums/LIG colonies	Tricycles would collect waste from the community bins	Transfer of waste collected by tricycles to dumper containers
Direct Collection System	Hotels / restaurants / Hospital-non infectious	Closed vehicle to collect biodegradable.	Direct transport to treatment yard/landfill

It is proposed that the capital investment for the procurement of the vehicles including carts, tri-cycles, trucks etc and other tools (brooms, trays etc.) would be borne by GMC. The collection service through door to door /kerb side collection can be done by the private operator on cost recovery basis

5.4.6. *Direct Collection System*

A direct and separate collection system is recommended for Large and Medium Hotels and Restaurants, Hospitals (non-infectious component of hospital waste only). Waste from these sources should be collected from the source and transported to the treatment/disposal site directly. The objective of the system is to eliminate this waste at the secondary storage area. In this system also, the

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necessary capital investment would be borne by GMC and all the operations shall be carried out by private operator. This system would operate on a user fee basis.

The hotels and restaurants may be directed to use two-bin system for the storage of food waste and other recyclable material. Both the wastes should be collected separately in two compartments in the vehicle. (The existing vehicle will be modified accordingly). The biodegradable waste should go to the treatment plant/landfill site and recyclable waste may be sold out to recycling industry directly. These operations will be done on a cost recovery basis.

5.4.7 *Direct Collection of bulk Garden waste.*

Several households generate garden waste on account of trimming of lawns, gardens etc. A weekly program may be prepared for providing service to those who have private lawns for collection of garden waste on a cost recovery basis by the private operators. Each ward may be served on one day in a fortnight from Monday to Saturday.

5.4.8 *Handling of construction debris*

As it is difficult for the citizens to dispose of construction waste generating in small quantities they generally tend to engage a cart puller or a mule to take away the construction debris who generally dispose of such waste surreptitiously anywhere on the streets or in open spaces. To control this situation, at least 1 location may be identified in wards where there are construction activities for disposal of construction debris is generated by the citizens in small quantities whereas the citizens who generate large quantities of construction debris may be directed to deposit their construction debris at the disposal site that may be notified by GMC. GMC may also notify that the construction and demolition waste would also be collected from contractors and builders premises. The C&D waste will be collected by the private operators at a cost notified by GMC.

5.4.9 *Tools for primary collection*

Based on the slum households and income levels as presented in earlier chapters and the willingness pay survey results it is estimated that about 70 % households could be covered under door to door collection system and 30 % households under community bin system. In door to door collection system a tricycle would collect waste from households and deposit the waste in dumper container. In case of community bin system the existing metal bins (0.3 m^3) would be placed at different locations from where waste would be transferred to dumper containers through tricycles. The Commercial sources will be covered by Sweepers and dedicated kerb-side collection crew. Out of the total 2,24,125 households 1,57,000 will be covered by door to door collection and 67,000 households by community bin system

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Table 5.6: Primary Collection Vehicles / Implements Estimated

Item	Quantity
A. Door to door collection by tricycles-House holds	
Capacity of Collection Tricycle	6 bins of 40 litre capacity
Total Number of Households to be covered by door to door collection system	157000
Number of households covered by one tricycle	600
Total tricycles Required	262
B. Community Bin Collection	
Total Number of Households to be covered under Community Bin Collection	67,000
Number of 0.3m³ Bins Required	60
Number of Bins Covered by One Tricycle	6
Number of tricycles Required	10
C. Commercial area – Collection by sweepers	
Collection by Sweepers in sweeper carts	Estimated in Sweeper cart requirements

Source : Analysis

5.5 STREET SWEEPING

The whole street sweeping operation will be entrusted by GMC to a private operator and the cost of the operation will be paid by GMC on a negotiated rate.

The two-tier system followed at present is less productive and leads to issues like synchronization of the activity of sweeping and collection of sweepings. The work norms have to be modified, since on an average the beat distances now allocated are not in tune with those prescribed in MoEF Guidelines, nor need based. Secondly, the wheelbarrows and box type carts used by sweepers have to be replaced by multi bin carts for direct transfer of waste to containers.

In order to improve the system, all the roads and lanes having habitation or commercial activities may be covered on a day to day basis. This may be done by employing one person per 350 m in highly congested areas, 500 m in medium density area and 750 m in low density areas and on an average one man may be allocated for 500 mtr of road length which will enable the sanitation worker to clean the streets and the drains conveniently. If most of the households, shops and establishments are covered through door to door collection, hardly any domestic waste is expected to be on the streets to be picked by the street sweepers.

The total road length (including BT, WBM and Earthen) in Guwahati is about 639 kms. The roads are categorized in to those in city center and busy area, in medium density area, low density and fringe areas and the requirement of sweepers are worked out as per the MoEF norms as presented in table 5.7.

The worker engaged in street sweeping could be given a long handle broom, metal plate and tray, and one containerized handcart with 4 bins of 40 litre capacity

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each, so that the waste is transferred easily to dumper containers.

The sweepers should work individually in the beats allotted to them as per the yardstick prescribed. But if this arrangement is not feasible, they may be allowed to work in pairs, carrying out the following:

- Sweeping two 'single beat' lengths
- Collecting the sweeping in handcart or tricycle
- Cleaning the drains which are less than 60 cm wide in the premises
- Carrying the drain cleanings
- Depositing the sweeping & drain cleanings in the nearby container
- Cleaning the container stations with in the beat length
- Emptying litter bins in the area
- Kerbside collection from shops/establishments along the road/street

Daily sweeping is also required along the main roads, commercial centres, markets in high density wards – 25, 20, 18, 19, 29, 28, 30, 31, 32, 33, 27, 20, 21, 34, 35, 37, 38, 39, 36, 40, 41 and 4. Wards of medium density – 14, 12, 11, 15, 16, 22, 23, 43, 24, 55 and 49 may be served with alternate day sweeping, while schedules for remaining wards may be once in three days/once in a week.

Street cleaning needs to be undertaken on all days including Sundays and public holidays with special focus on busy centres, markets, and tourist spots as under.

(1) Parks & open spaces

(2) City centres - commercial area & markets

(3) Bus terminals

(4) Roads around Railway stations

- In order to improve the system carryout inventory of all the main roads, streets and by-lanes and identify the beats for street sweeping and drain cleaning.
- Based on the road length data available and the norms set out by MoEF and Government of India, it is estimated that Guwahati could have around 485 beats to be attended daily, 194 beats on alternate days, 200 twice in a week and 27 once in a week and this schedule will require around 654 workers
- Market areas and busy commercial areas (city centre and dense areas) shall be swept at least twice a day and sweeping could be undertaken on Sundays and holidays also.

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Table 5.7 Distribution of Road Length & Beat Allocation for Street Sweeping Activity

Location	Road Length, km	Beat Length, m	No. of Beats	Frequency of Sweeping	Sweepers required
City Centre, Commercial and Market Area and Other Important Areas	170	350.00	485	All Seven Days	485
Medium Density Areas & Housing Colonies	97	500.00	194	Alternate day	97
Low Density Areas	150	750.00	200	Twice a Week	67
Fringe areas	262	1000.00	262	Once a week	47
Total	679		1141		696

In addition to the above, 14 market / commercial areas, six major temple premises, parks & bus stations require sweeping twice a day. 34 numbers of additional sweepers are proposed to meet the requirements. The total estimated requirement works out to 730 sweepers.

As mentioned earlier, the entire task of street cleaning would also be awarded to the private contractor with necessary capital investment by GMC. GMC would pay the contractor suitable fee for the carrying out the operation of street cleaning.

5.5.1 *Requirement of carts and implements for street sweeping*

As mentioned earlier 485 beats are to be operated daily and 194 beats every alternate day. It is proposed that a team comprising two men crew shall handle two beats. The crew has to be provided with one containerised cart with 4 numbers of 40 lit bins, for collection of sweepings and for kerb side collection from shops/offices. In addition to the cart, long handle broom, shovel and metal tray, should be provided.

Table 5.8: Requirement of vehicles for street sweeping

No of sweepers & Teams	No of sweepers cart required	No of Other Implements
730 Sweepers and 365 Teams	365	Long Handled Brooms – 365 Shovels – 365 Metal Trays – 365

The requirement is worked out at the rate of one containerised cart for each team (work in pair) with other implements. As presented in third chapter 800 workers are already involved in street sweeping activities so the proposed crew of 730 can be involved in street sweeping and the rest could be involved in direct collection system.

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5.5.2 *Provision of Dustbins*

There is a significant floating population in and around Kamakhya temple and other major temples, markets like Fancy bazaar and in the city centres. Litter bins are proposed in these locations. Litter bins at a spacing of 100 meters.

Table 5.9: Requirement of litter bins

Area	No of bins
Major temple premises	60
Open spaces, parks, bus stations	40
Market area	50
City centre area	50
Total	200

Emptying of litterbins can be undertaken by the sweepers in the respective areas.

5.5.3 *Drain cleaning*

At present drains are cleaned by engaging departmental workers. There is no detailed inventory of the drains with GMC. However from secondary information it is gathered that the drains in the municipal area covers roughly about 1280 kms and 270 workers are currently employed for the job. The drain cleaning job needs to be split in to:

- Small drains up to 60 cm wide and 45 cm average depth (road side drains) which have to be attended by the sweeping crew. They will use shovels and wheel barrows
- Large drains – The task of cleaning of primary and secondary drains is be attended by currently engaged drain clearing team and the departmental vehicles and equipments. Shovels, excavators could be used for the purpose of drain cleaning
- Pre-monsoon clearing of major (primary) drains, canals - This task is be undertaken through contract arrangement. Mechanised cleaning could be carried out. Clearing of silt and debris will be the responsibility of contractors.

Each division may prepare detailed inventory of drains falling under the above category and may develop cleaning schedule. The material cleared from the drains by the drain cleaning squad will be directly transported to the disposal site. This job would also be assigned to the private contractor at a suitable contract fee.

The entire primary collection operation would be contracted to a private operator. The private operator will recover the collection cost partially from the generators

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and partially from GMC as given in the table below.

S.No.	Component	Collection cost per annum (Rs. in Lakhs)	To be recovered from
1	Door to Door from Houses and Colonies	284.93	Households as user fee
2	Door-to Door from Slums	7.28	GMC
3	Major Markets	6.28	Generators
4	Street Sweeping	266.50	GMC
5	Drain Cleaning	8.95	GMC
6	Direct Collection from Hotels, Restaurants, Marriage hall, Institutions etc.	25.00	Generators as User fee
	Collection Cost borne by Generator	316.21*	
	Collection cost borne by GMC	282.73*	

The collection cost shown above has been estimated based on the expenditure on O&M and manpower per annum. This cost does not include any profit margin of the private operator.

5.6 SECONDARY COLLECTION

In order to promote single handling system, it is desirable to discontinue the current open and static collection system. The available options are:

- Bin-less system by transferring the waste directly from primary collection vehicles to transport vehicles. High level of synchronization is required to operationalise this option to achieve timely arrival of transport vehicle at pre-determined locations for transfer. Failure in timing often results in idling of primary collection vehicle or open throwing of waste collected by primary collection crew

- Providing movable containers at regular intervals – containers which can be emptied by a mechanical device fitted to transport vehicle (refuse collectors) or which can be loaded to vehicle chasis (dumper placer).

The options for secondary collection and transport are:

- Primary collection vehicle – transfer to container at secondary storage area (Container station), container transportation to process / disposal site

- Primary collection vehicle – transfer to transport vehicle, transportation to the disposal site.

In latter system, secondary collection points would be eliminated through a direct vehicle to vehicle transfer. Though this is an ideal system, implementing the same

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will encounter the following issues

- Loading to secondary collection vehicle is manual and time consuming. Hence vehicle idling will result in low productivity
- Tipping vehicles used for secondary collection will have to be with dual tray facility for segregated collection.

Hence vehicle to vehicle transfer system is not recommended. For secondary storage facilities are to be developed are:

- Wheeled containers of 0.5 m^3 to 2 m^3 capacity and refuse collectors –side or rear loader of 6m^3-15 m^3 capacities.
- Dumper containers of 2.5 m^3 to 7 m^3 and dual or single dumper lifting vehicles

Capital & operating costs are higher for former system, while the latter is a cheaper and reliable alternative. Hence the option recommended is dual loader and 3.5 m^3 containers at all collection points. Since the bulk waste generation in most of the markets and commercial centres are in the range of 1- 1.5 tons/day, large single containers of capacity 5-7 m^3 are not required.

Table 5.10: Zone wise container requirements

Zone	Waste Generated, Tons/day	Containers required	Zone	Waste Generated, Tons/day	Containers required
Zone 1	31.23	32	Zone 11	10.32	11
Zone 2	40.25	41	Zone 12	19.17	20
Zone 3	29.93	30	Zone 13	17.32	18
Zone 4	3.25	4	Zone 14	33.25	34
Zone 5	6.60	7	Zone 15	19.86	20
Zone 6	3.72	4	Zone 16	12.80	13
Zone 7	2.47	3	Zone 17	13.53	14
Zone 8	4.63	5	Zone 18	3.32	4
Zone 9	12.41	13	Zone 19	33.29	34
Zone 10	9.96	10	Zone 20	47.62	48
Total	144.45	149		210.48	216 ✓

If an area based estimation is done, the requirement will workout to around 800 containers. Since the population densities are low and there is a large extent of agricultural land / low lying area with in the city coverage based on total area is not required.

The total container requirements works out to the tune of 365 numbers assuming that the container will be loaded to 80% capacity on average (Table 5.10).This estimation is based on the total generation and assuming 100% collection. But in

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practice there will separation for recycling and there will be other modes of disposal. Hence the requirement is further broken down in to requirements for organic and inorganic fractions to be collected from sources separately excluding sources where direct collection is recommended. At Fancy Bazaar (2 bins), New Market (1 bin), Ulubari Market (1 bin), Beltola Market (1 bin), Paltan Bazaar (1 bin), Kacharighat Bazaar (1 bin) and wholesale fish market (1 bin). Extra container requirements to the tune of 15% are added to meet contingencies and stand by requirements. Accordingly the estimated requirement is 333 containers of 3.5 cubic meter capacity.

5.6.1 *Container locations*

All the existing waste storage bins / open points may be abolished and replaced by neat dumper containers of 3.5 m^3 capacity. There are 768 numbers secondary collection points in the city. Some of the collection points receive only small quantities of wastes and some others are located at narrow road margins and without proper access. By filtering out the collection points found not suitable, the locations have been identified for dumper bins placement. The lists of identified zone wise locations for dumper bin location/containerized stations are listed in Annexure 5.1. These locations have been finalized in consultation with GMC. However, it is felt that these numbers need to be further screened and reduced, especially for the zones marked in red. None of these sites are now provided with platform and drainage facility. The site has to be improved with such facilities.

The containerised stations shall be provided with raised, paved platform (with drainage facility) having space for two/three containers and constructed with proper drainage arrangements. The specifications and drawing of containerised station is presented in Annexure 5.2.

In order to avoid container over flow the following measures are to be taken:

- Sufficient capacity (in case one container not enough two or more may be provided in places like market) should provide as per the estimated waste arrival of waste.
- Notify the container facilities and community bin facilities available so that public are aware and deposits the waste in the facility only
- Bring strict imposition by penalizing those who deposit out side
- To keep the container premises clean, entrust responsibility to the sweeper in the area.

5.7 TRANSPORTATION

The strategies for improvement of waste collection and transportation for GMC will be to follow an independent transport system for each of the following:

- Daily transportation of organic waste loaded in the containers to the processing plant.

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- Transportation of Non Bio-degradable waste at regular intervals to the landfill site based on waste accumulation at every containerised station
- Direct transportation of Construction and Demolition waste and Drain Cleaning Waste to the landfill site/ for land reclamation
- Direct transportation of hotel, hospital (non infectious), and diary waste to the processing plant
- Direct transportation of garden waste on pre-notified days from premises to the compost plant
- Direct transportation of street sweeping and drain cleaning waste to landfill site

Table 5.11: Container & Vehicle Requirements for Proposed Collection and Transportation System

Sources	Quantity, tons/day	No. of Containers	Extra Containers	Vehicle Type
Domestic biodegradable	105	105	15	Dual Dumper placer
Domestic non-bio degradable	57	67	10	Dual Dumper placer
Commercial & Institutional	65	65	10	Dual Dumper placer
Small restaurants	6	46	1	Dual Dumper placer
Large Markets	10	10	2	Dual Dumper placer
Street Sweepings & Drain Cleanings	48	48	8	Dual Dumper placer
Total		301	46	

Source: analysis

Estimated total requirement is 347 containers out of which 215 containers will be coloured green and 132 coloured yellow to receive organic and inorganic / inert fractions respectively.

Table 5.12: Lifting Schedule of Dumper Containers

Source	No. of Containers	Number of Containers to be Lifted						
		Sun	Mon	Tues	Wed	Thu	Fri	Sat
Domestic Biodegradable	105	105	105	105	105	105	105	105
Domestic Non-Biodegradable	67	20	40	40	40	40	40	40
Commercial,	65	65	65	65	65	65	65	65

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Restaurants & Institutional								
Street sweeping	48	24	48	36	36	36	36	36
Markets	10	8	10	10	10	10	10	10
Total	295	232	268	256	256	256	256	256
Vehicle trips		[illegible]	134	128	128	128	128	128

Source: Analysis

The number of containers to be lifted would be around 295 per day. The proposed landfill / treatment site is 14 km from city center .Assuming average distance to be covered by vehicle as 14 km, the number of trips which can be operated in an eight hour shift is worked out.

Unloading first empty container : 3 mins

Loading first loaded container : 5 mins

Unloading second empty container : 10 mins
(Including travel time to nearest location)

Loading second loaded container : 5 mins

Traveling time to landfill site : 40 mins

Time for unloading two containers
at treatment/disposal site: : 10 mins

Return to the city for second trip operation: 40 mins

In total 113 mins, 4 trips are possible in one shift.

Transportation of containers as per lifting schedule in Table 5.12 at the rate of 8 (4 trips) containers per shift @ one shift per day would require 37 vehicles. Since night shifts are possible this practice is recommended for city centre areas where day time operations will be hindered by heavy traffic. Around 118 containers (40%) and another 177 during the day time. 15 vehicles will be required for night operation. Those vehicles along with another fleet of 7 will be in service for day time operation. This system operation will reduce the vehicle requirement to 22 numbers. Another 20% vehicles need to be kept as standby to ensure reliability of service. This will necessitate additional procurement of 4 vehicles and 26 dual dumper placer vehicles.

5.7.1 Vehicle requirement for direct collection system

- A direct and separate collection system is recommended for large and medium Hotels and Restaurants, Hospitals (Domestic Component of BMW only), Marriage and Function halls, Construction Waste, Hazardous Waste, and waste from tourist and other places.

- Waste from these sources should be collected directly from the source and

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transported to compost plant. This system will require 6 hydraulic tipping trucks for direct collection and 2 commercial tippers for construction & demolition waste from existing fleet.

Table 5.13: Container and Vehicle Requirements for Proposed Direct Collection System

Source	Quantity, tons/day	Requirement
Hotels	12.08	4 covered tipping trucks
Hospitals	4.11	2 covered tipping trucks
Construction	2.50	2 commercial tippers

Source: analysis

Table 5.14: Summary of vehicle & equipment requirements

Description	Number
Tricycles with 6 numbers 40 lit bins (Door to Door Collection)	262
Tricycles with 6 numbers 40 lit bins (Collection from Slums)	10
Containerised Carts with 4 numbers 40 lit bins (Street Sweeping)	340
Dumper Containers of 3.5 m^3 capacity	347
Paved Container stations	215
Dumper placers	26
Modified tipping trucks Tipping trucks for Direct Collection	46
Tipping truck for construction waste collection	2

Source: Analysis

5.8 VEHICLE MAINTENANCE

Workshop is the backbone of the solid waste management system. Generally, workshops run by the municipal authority are not in a position to maintain 80% vehicles on the road. It would be desirable to outsource this service for repairs and maintenance of the vehicle. Alternately, the workshop has to be upgraded with facilities to attend:

- Preventive maintenance of vehicles, land fill equipments hand carts, bins & containers. A schedule shall be prepared for daily checking, monthly checking and periodic checking and repairs, replacements as specified by the manufacturers of vehicles.
- Recovery vehicle for attending break downs
- Stock of essential spares, tyres, oil, auto electric items, hoses and pipes of hydraulic systems

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- Battery chargers, tyre inflators, vulcanising facilities
- Welding units, both electrical and gas welding
- Air compressor & water servicing facilities
- Trained staff

Since the fleet contains hydraulic vehicles & earth moving machineries, the staff should be well trained to repair and maintain those or such works have to be contracted out to manufacturers' authorised persons. However workshop technical staff should have basic training to handle repairs of all type of vehicles. As there is enough staff except auto electricians, no additional man power is necessary.

In order to maintain the condition of these vehicles, a day to day service and upkeep of vehicles is also being recommended. Fort this purpose a small workshop along with the necessary tools and equipments that perform the following functions is to be established. The driver of each vehicle has to submit a report in a prescribed format at the end of every shift. Regular preventive maintenance programs have to be attended even if drivers' report contains no specific complaint. It is important to keep stock of spares required for the preventive maintenance.

- Washing, greasing, servicing as per schedule
- Water topping in the radiator
- Engine oil level
- Air pressure in tyres
- Checking oil level of the hydraulic system
- Check leakage of oil and change oil seal if required
- Check hydraulic operation, check pressure
- Minor auto electric works,
- Battery checking, charging etc.

The working of the preventive maintenance should be devised on the recommendations of the vehicle manufacturers (daily, fortnightly, after 2000 km, after 4000 km). Each vehicle /equipment should have its own history of document, providing details of purchase, specification, deployment and use, maintenance work done, all costs.

Major repairs and vehicle periodical servicing works have to be contracted out to

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private agencies or to the authorised vehicle dealers/service centre.

The containers made of mild steel if not kept clean and regularly painted (twice in a year) preferably with anti corrosive paint will get corroded in the humid and wet climate of Guwahati.

It is proposed to upgrade the facilities in the garage in terms of both equipments and civil infrastructure. The O&M operations including the maintenance of garage is responsibility of the Private Operator at its own cost.

5.9 MANPOWER REQUIREMENTS

The manpower requirements estimated here are for the following categories:

Table 5.14: Sweepers, drain cleaners, drivers, helpers, primary collection crew

Category	Workers required	Nature of work	Remarks
Primary collection			
Tricycle @ 3 persons/vehicle	726	Door to Door Collection	Capital cost to be borne by GMC, collection to be carried out by private operator who in turn would recover the cost from the generator
Tricycle @ 2 persons/vehicle (Collection from Slums)	20	Collection from Community Bin	Capital expenses to be borne by GMC. The O&M cost to be borne by the private operator, which will be recovered from GMC.
Sweepers	730	Road and open space sweeping and kerb side collection	To be contracted out by GMC to the private operator at suitable fee.
Drain cleaners 15 in each Zone	150	Clearing of drains	To be contracted out by GMC to the private operator at suitable fee.
Direct collection			
Hotels / hospitals @ 3 men / vehicle	18	Collection from premises and loading to vehicles	Capital cost to be borne by GMC, collection to be carried out by private operator who in turn would recover the cost from the generator
Construction waste	6		To be provided by

collection			the private operator, cost recovery from the generator.
Secondary storage			
Workers @ 1 worker /4 stations	58	Clean the container stations and keep with out spilling and overflow	To be provided by the private operator, cost recovery from GMC
Total	1704		978 workers to be provided by the private operator, cost recovery from GMC
Transportation			
Drivers			
Dumper placer	37	Operate night/day trips	The capital cost of equipment to be provided by GMC. O&M and man power cost by the private operator who in turn would recover the cost from GMC.
Direct collection vehicles	8		The capital cost of equipment to be provided by GMC. O&M and man power cost by the private operator who in turn would recover the cost from GMC.
Total -Drivers	45		Private operator
Helpers for Drain cleaning of Large Drains	5		Private operation
Helpers – Dumper Placers	37		Private operation
Total helpers	42		Private operation

- The total operation is to be privatised and the man power is to be provided by the private operator.
- By privatizing the operation of transportation as being done now. However the contract has to be modified with provision for containerised transportation.

5.10 COST ESTIMATES

The total capital cost for proposed collection and transportation system in the city includes the costs of primary collection, street sweeping, secondary storage, and transportation as shown in Table 5.16 given below. This capital cost would be

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entirely borne by GMC and the collection works would be contracted out to private operator. The private operator will bear the O&M cost for the life time of the equipment as decided by GMC

Table 5.16: Cost Estimates for Proposed Collection and Transportation System

S No	Item of expenditure	Quantity required (numbers)	Cost per unit (Rs)	Total expenditure (in Rs lakhs)
1.	Containerized tricycles (Door to Door Collection)	262	15,000	39,30,000
2.	Containerized tricycles (Collection from Slums)	10	15,000	1,50,000
3.	Containerised Carts (Street Sweeping)	365	12,000	43,80,000
4.	Wheel barrows for drain cleaning	150	8,000	12,00,000
5.	Litter bins	200	2,000	4,00,000
6.	Dumper placer containers of 3.5 cu m	347	45,000	1,56,15,000
7.	Concrete flooring under the bins	215	5,376	1,15,58,40
8.	Dumper placer vehicles (twin container lifting device)	26	12,50,000	3,25,00,000
	Costs to be borne by GMC			593,30,840

In addition to the above, 46 trucks will be required to transport the waste (drain cleaning, from commercial places etc) directly to the processing facility site. The trucks could be hired by the operator from the market. This cost has not been included above. However, it has been proposed that GMC will pay transportation fee to the operator and the cost of hiring of the trucks is included in that. Summary of the collection and transportation scheme for the Guwahati city is presented below:

Capital Cost for collection and transportation (Primary + Secondary) to be borne by GMC	Rs. 593.30 Lakhs
Collection Cost to be recovered from generators by the operator (Primary + Direct Collection)	Rs. 316.20 Lakhs
Collection cost to be recovered from GMC by the operator (Primary + Direct Collection)	Rs. 282.70 Lakhs
Collection Cost to be recoverd from GMC by the operator (Secondary Collection and Transportation)	Rs. 199.17 Lakhs

The detailed specifications and the drawings for the C&T equipments and vehicles are given in Annexure 5.2.

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CHAPTER – 6
IDENTIFICATION OF MUNICIPAL SOLID WASTE PROCESSING TECHNOLOGIES

6.1 MSW MANAGEMENT TECHNIQUES

There are several MSW management technologies, which are being followed in various parts of the world. Besides source reduction, reuse and recycling, broad categories of available technologies for processing MSW are mentioned below:

- Thermal Processing Technologies
- Biological Processing Technologies
- Physical Processing Technologies

Table 6.1 shows the technologies expressed in terms of the three major groups (thermal, biological & physical) that have been considered for evaluation purpose for processing MSW of Guwahati.

Table 6.1: List of Identified MSW Processing Technologies

Waste Processing Technology Group	Waste Processing Technology
Thermal Processing Technologies	
	Incineration (Mass burn)
	Pyrolysis
	Pyrolysis / Gasification
	Plasma Arc Gasification
Biological Processing Technologies	
	Aerobic Digestion (Composting)
	Anaerobic Digestion (Biomethanation)
	Landfill as Bioreactor (Bioreactor Landfill)
Physical Processing Technologies	
	Refuse-Derived Fuel (RDF)
	Densification / Pelletisation
	Mechanical Separation
	Size reduction

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6.2 THERMAL PROCESSING TECHNOLOGIES

Thermal technologies are those technologies that operate at temperatures greater than 200°C and have higher reaction rates. They typically operate in a temperature range of 375°C to 5,500°C. Thermal technologies include advanced thermal recycling (a state-of-the-art form of waste to-energy facilities) and thermal conversion (a process that converts the organic carbon based portion of the MSW waste stream into a synthetic gas which is subsequently used to produce products such as electricity, chemicals, or green fuels).

These technologies are briefly described below.

6.2.1 Incineration

Mass-burn systems are the predominant form of the MSW incineration. Mass-burn systems generally consist of either two or three incineration units ranging in capacity from 50 to 1,000 tons per day; thus, facility capacity ranges from about 100 to 3,000 tons per day. It involves combustion of unprocessed or minimally processed refuse. The major components of a mass burn facility include: (1) Refuse receiving, handling, and storage systems; (2) Combustion and steam generation system (a boiler); (3) Flue gas cleaning system; (4) Power generation equipment (steam turbine and generator); (5) Condenser cooling water system; and (6) Residue hauling and storage system.

6.2.2 Pyrolysis

In Pyrolysis, at high temperatures of 700°C to 1200 °C, thermal degradation of organic carbon-based materials is achieved through the use of an indirect, external source of heat, in the absence or almost complete absence of free oxygen. This thermally decomposes and drives off the volatile portions of the organic materials, resulting in a syngas composed primarily of hydrogen (H_2), carbon monoxide (CO), carbon dioxide (CO_2), and methane (CH_7). Some of the volatile components form tar and oil, which can be removed and reused as a fuel. Most Pyrolysis systems are closed systems and there are no waste gases or air emission sources (if the syngas is combusted to produce electricity; the power system will have air emissions through a stack and air emission control system). After cooling and cleaning in emission control systems, the syngas can be utilized in boilers, gas turbines, or internal combustion engines to generate electricity or used as raw stock in chemical industries.. The balance of the organic materials that are not volatile, or liquid that is left as a char material, can be further processed or used for its adsorption properties (activated carbon). Inorganic materials form a bottom ash that requires disposal, although some pyrolysis ash can be used for manufacturing brick materials.

6.2.3 Gasification

In the Gasification process, thermal conversion of organic carbon based materials is achieved in the presence of internally produced heat, typically at temperatures of 660°C to 1800°C, and in a limited supply of air/oxygen (less than stoichiometric, or less than is needed for complete combustion) to produce a

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syngas composed primarily of H_2 and CO. Inorganic materials are converted either to bottom ash (low-temperature gasification) or to a solid, vitreous slag (high temperature gasification that operates above the melting temperature of inorganic components). Some of the oxygen injected into the system is used in reactions that produce heat, so that Pyrolysis (endothermic) gasification reactions can initiate; after which, the exothermic reactions control and cause the gasification process to be self-sustaining. Most gasification systems, like Pyrolysis, are closed systems and do not generate waste gases or air emission sources during the gasification phase. After cooling and cleaning in emission control systems, the syngas can be utilized in boilers, gas turbines, or internal combustion engines to generate electricity, or to make chemicals.

6.2.4 *Plasma Arc Gasification*

In Plasma Arc Gasification process, alternating current (AC) and/or direct current (DC) electricity is passed through graphite or carbon electrodes, with steam and/or oxygen/air injection (less than stoichiometric), to produce an electrically conducting gas (a plasma) typically at temperatures greater than 2,200°C. This system converts organic carbon-based materials, including tar, oil, and char, to syngas composed primarily of H_2 and CO and inorganic materials to solid, vitreous slag. Like Pyrolysis and conventional Gasification, Plasma Arc Gasification is a closed system; therefore there are no waste gases and no emission sources in the Plasma Arc Gasification process. After cooling and cleaning in emission control systems, the syngas produced by plasma arc gasification can be utilized in boilers, gas turbines, or internal combustion engines to generate electricity or to make chemicals. The final emission products are CO_2 and water. The furans and dioxins in the emissions are extremely low and lower than the recommended USEPA or EU emission norms

6.3 BIOLOGICAL PROCESSING TECHNOLOGIES

Biological technologies operate at lower temperatures and lower reaction rates. Biological processing technologies are focused on the conversion of organics in the MSW. MSW consists of dry matter and moisture. The dry matter further consists of organics (i.e., whose molecules are carbon-based), and minerals, also referred to as the ash fraction. The organics can be further subdivided into biodegradables or refractory organics, such as food waste, and non-biodegradables, such as plastic. Biological technologies can only convert biodegradables component of the MSW. Byproducts can vary, which include: electricity, compost and chemicals.
Various biological processing technologies are briefly described below.

6.3.1 *Composting*

Composting is a natural micro-biological process where bacteria break down the organic fractions of the MSW stream under controlled conditions to produce a pathogen-free material called "Compost" that can be used for potting soil, soil amendments (for example, to lighten and improve the soil structure of clay soils), and mulch. The microbes, fungi, and macro-organisms that contribute to this

biological decomposition are general y aerobic. A mixture of organic materials is placed into one or more piles (windrows), and the natural microbial action will cause the pile to heat up to 65-30°C killing most pathogens and weed seeds. A properly designed compost heap will reach 70°C within 6 to10 days, and slowly cool off back to ambient temperatures as the biological decomposition is completed. Systematic turning of the material, which mixes the different components and aerates the mixture, generally accelerates the process of breaking down the organic fraction, and a proper carbon/nitrogen balance (carbon to nitrogen or C/N ratio of 20:1) in the feedstock insures complete and rapid composting. The composting process takes from 17 to 180 days.

There are two fundamental types of composting techniques: open or windrow composting, which is done out of doors with simple equipment and is a slower process, and enclosed system composting, where the composting is performed in some enclosure (e.g., a tank, a box, a container or a vessel).

6.3.2 *Anaerobic Digestion*

In anaerobic digestion (AD), biodegradable material is converted by a series of bacteria groups into methane and CO_2. A first group breaks down large organic molecules into small units like sugar. This step is referred to as hydrolysis. Another group of bacteria converts the resulting smaller molecules into volatile fatty acids, mainly acetate, but also hydrogen (H_2) and CO_2. This process is called acidification. The last group of bacteria, the methane producers or methanogens, produce biogas (methane and CO_2) from the acetate and hydrogen and CO_2. This biogas can be used to fuel boilers or reciprocating engines with minimal pretreatment. In addition to biogas, anaerobic bioconversion generates a residue consisting of inorganics, non-degradable organics, nondegraded biodegradables, and bacterial biomass. If the feedstock entering the process is sufficiently free of objectionable materials like colorful plastic, this residue can have market value as compost. AD process is also referred to as Biomethanation process.

6.3.3 *Bioreactor Landfill*

A bioreactor landfill is a wet landfill designed and operated with the objective of converting and stabilising biodegradable organic components of the waste within a reasonable time frame by enhancing the microbiological decomposition processes. The technology significantly increases the extent of waste decomposition, conversion rates and process effectiveness over what would otherwise occur in a conventional wet landfill. Stabilisation in this context means that landfill gas and leachate emissions are managed within one generation (twenty to thirty years) and that any failure of the containment system after this time would not result in environmental pollution. There is better energy recovery including increased total gas available for energy use and increased green house reduction from reduced emissions and increase in fossil fuel offsets. These factors lead to increased community acceptance of this waste technology. Management of a bioreactor landfill requires a different operating protocol to conventional landfills. Liquid addition and recirculation is the single most important operational variable to enhance the microbiological decomposition processes. Other strategies

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can also be used to optimise the stabilization process, including waste shredding, pH adjustment, nutrient addition and temperature management.

6.4 PHYSICAL PROCESSING TECHNOLOGIES

Physical technologies involve altering the physical characteristics of the MSW feedstock. The MSW is subjected to various physical processes that reduce the quantity of total feedstock, increase its heating value, and provide a feedstock. It may be densified or palletized into homogeneous fuel pellets and transported and combusted as a supplementary fuel in utility boilers. These technologies are briefly described below.

6.4.1 Refused Derived Fuel

The RDF process typically includes thorough pre-separation of recyclables, shredding, drying, and densification to make a product that is easily handled. Glass and plastics are removed through manual picking and by commercially available separation devices. This is followed by shredding to reduce the size of the remaining feedstock to about eight inches or less, for further processing and handling. Magnetic separators are used to remove ferrous metals. Eddy-current separators are used for aluminum and other non-ferrous metals. The resulting material contains mostly food wastes, non-separated paper, some plastics (recyclable and non-recyclable), green wastes, wood, and other materials. Drying to less than 12% moisture is typically accomplished through the use of forced-draft air. Additional sieving and classification equipment may be utilized to increase the removal of contaminants. After drying, the material often undergoes densification processing such as pelletizing to produce a pellet that can be handled with typical conveying equipment and fed through bunkers and feeders. The RDF can be immediately combusted on-site or transported to another facility for burning alone, or with other fuels. The densification is even more important when RDF is transported off-site to another facility, in order to reduce volumes being transported. RDF is often used in waste to energy plants as the primary or supplemental feedstock, or co-fired with coal or other fuels in power plants, in kilns of cement plants, and with other fuels for industrial steam production.

6.4.2 Mechanical Separation

Mechanical separation is utilized for removing specific materials or contaminants from the inlet MSW stream as a part of the pre-treatment process. Contaminants may include construction and demolition (C&D) debris, tires, dirt, wet paper, coarse materials, and fine materials. Generally, MSW reaching the dumping sites is unsegregated and mixed containing C&D debris and other contaminants. Therefore, it is essential to remove these contaminats from the incoming MSW by mechanical separation before processing the waste further by either biological, physical and thermal technologies (except Plasma Arc Technology).

However, in the Guwahati city, most of the C&D debris (more than 90%) is reused, and the ragpickeres take away most of the recyclable material at the collection points only. Therefore, the MSW reaching the dumping grounds does not require the elaborate mechanical separation process. This MSW has high

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organic content, fit to be directly used for various technologies after manual sorting only.

6.4.3 *Size Reduction*

Size reduction is often required to allow for more efficient and easier handling of materials, particularly when the feed stream is to be used in follow-on processes. Sizing processes include passive moving, and vibrating screens and trommels. In order to reduce the size of the entire stream, or portions of it, mechanical equipment, such as shredders, is utilized. This allows for other physical processes, such as dryers, magnetic and eddy current separators, and densification equipment to work more efficiently. Magnetic and eddy current separators may be installed both up- and down-stream of shredders to increase the recovery of metals.

6.5 SELECTION OF THE MOST SUITABLE TECHNOLOGY FOR GUWAHATI

While identifying and selecting the technologies for Guwahati, following considerations have been kept paramount:

- The technology is suitable to treat the waste characteristics of Guwahati, in an environmentally sustainable manner;
- The technology meets the regulatory requirements (i.e., confirms to the MSW Rules, 2000 requirements) and is socially acceptable with minimum impacts to the environment and citizens; and
- The technology is economical and commercially available.
- Land availability and its suitability

6.5.1 *Technology Screening Criteria*

A brief technology screening methodology is presented in **Figure 6.1**. As shown in the figure, three main screening criteria have been used to identify potential technologies that could meet the GMC objectives.

The following technology screening criteria / filters have been established:

- **Technology Reliability Criteria**: Technologies that are proven internationally for large scale application for MSW and could be considered without reservations for Guwahati
- **Environmental and Social Acceptability Criteria**: Technologies that have minimum environmental and social impacts, and conforms to the regulatory requirements (MSW Rules, 2000)
- **Waste Suitability Criteria**: Technologies that are suitable for MSW characteristics of Guwahati.

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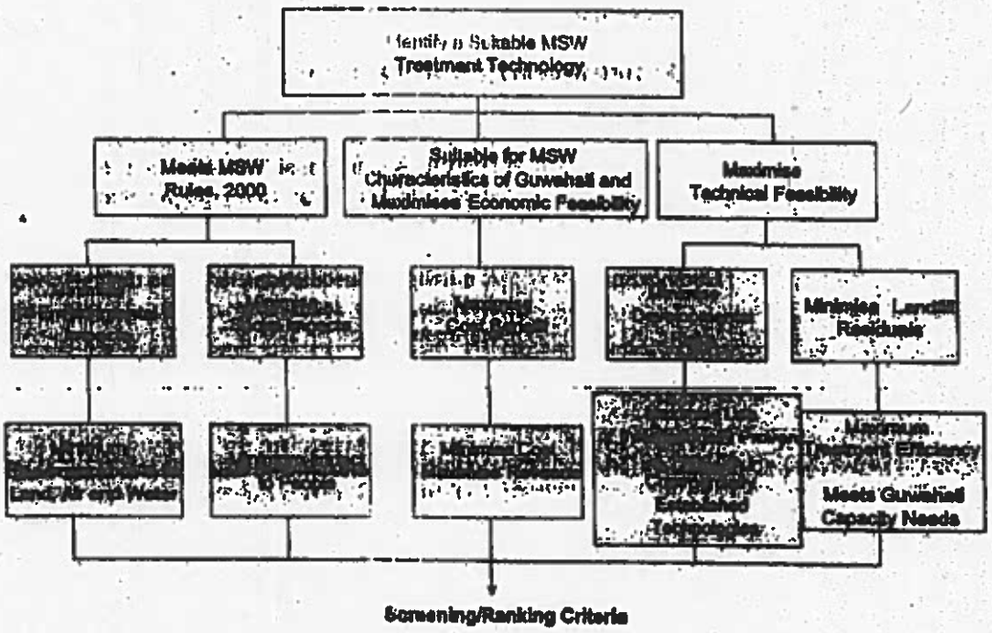
Figure 6.1: Waste Process Technology Selection Objectives for Treating Guwahati Waste



The criteria described above have been applied to each of the identified technologies (except mechanical separations and size reduction) to determine which would be carried forward for final selection. Physical Technologies like mechanical separations and size reduction technologies are considered pre-processing technologies and therefore have not been considered for evaluation and screening.

6.5.2 *Technology Reliability Criteria*

As a first step towards technology selection, the identified technologies have been evaluated for their reliability for MSW treatment internationally. The reliable technologies without reservations for large scale application for MSW for Guwahati have been assigned Category 1. The internationally proven technologies that require some caution for use in Guwahati from the point of view of sophistication of the technology or scale of application have been assigned category 2. The technologies that do not have adequate track record internationally and can not be considered for Guwahati have been assigned Category 3.

The results of this evaluation are presented on Table 6.2.

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Table 6.2: MSW Treatment Technologies with respect to Potential Reliability of Operations

S. No.	Technology Category	Comments
Category 1 – Internationally Proven and Easy to Implement in India		
1.	Bioreactor Landfill	A number of installations with capacities over 5000 tons per day are in operation in US. Though no such landfill is functional in India the technology is simple and can be easily implemented in India. However the existing MSW rules specify that only inerts will have to disposed in the landfills.
2	Composting	A number of installations have satisfactorily worked in India. The technology is simple and easy to implement.
Category 2 – Internationally Proven but Require Higher Levels of Sophistication		
1	Refuse Derived Fuel	Large scale plants are in operation in US. The technology is relatively simple and two medium scale plants are in operation in India. However, these plants utilize significant amount of agricultural wastes and not MSW alone.
2	Anaerobic Digestion of mixed MSW (Biomethanation)	Plants are operational in Europe, however Biomethanation is applicable only to organic fraction of MSW and requires very high level of source segregation and pre-processing of mixed waste. No successful demonstration of technologies in India.
3	Incinerator	Large plants have been in operation in US and Europe and parts of Asia. The technology, however, requires higher sophistication and process control. No MSW incinerator plants in India
Category 3 – Insufficient successful experience		
1	Plasma Arc Gasification	Medium scale mixed waste (MSW+ASR) plants are operational in Japan. The technology, however, requires high degree of sophistication and process control and is expensive. No Plasma Arc gasification plant in India
2	Gasification and Pyrolysis	Although the technology is well proven with woody biomass, there is insufficient operational experience with MSW. No plant in India is under operation at present.

Since the current MSW rules do not permit the disposal of MSW containing organic substances in a landfill, the Bioreactor Landfill component has not been considered here. In Category 3, the technologies of Gasification and Pyrolysis have been eliminated from further considerations, as these technologies have not

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boilers for generation of steam and / or power. The air pollution could be an issue. The RDF combustion generates dioxins and furans which are toxic and therefore the emissions needs adequate control which increases the cost of the process. RDF as a part of integrated facility could be considered for the management of GMC in combination with Biomethanatic.

6.5.7 *Incineration*

Air emissions are likely to be a key environmental issue for Incineration facilities. In incineration, combustion of MSW is achieved in the presence of a direct flame and an over-abundance of combustion air to promote the complete oxidation of the incoming waste to form primarily carbon dioxide and water vapor that are emitted along with the excess combustion air (the portion of the incoming air that is not required for oxidation). In addition, a wide range of volatiles are formed. Depending on the composition of the initial waste (and sometimes of the fuels used to support combustion), compounds containing halogens, sulfur, nitrogen and metals may be produced. The possibility of formation of dioxins and furans is high if the temperature of combustion is not adequately controlled. Incineration may not be suitable for Guwahati wastes in view of the low calorific values.

6.5.8 *Regulations Affecting MSW Processing Technology Implementation*

The development of any solid waste management processing facility will require a variety of permits before a plant can be established and operated.

The broad legislative framework that would guide developmental activities including installation of processing and disposal facilities for handling municipal solid wastes have been summarised below.

(a) Water (Prevention & Control of Pollution) Act, 1977 (as amended up to 1988)

(b) Water (Prevention & Control of Pollution) Cess Act, 1977 (as amended up to 1991)

(c) Air (Prevention and Control of Pollution) Act,1981 (as amended up to 1987)

(d) Hazardous Wastes (Management and Handling) Rules, 1989 (as amended up to 2003)

(e) Municipal Solid Wastes (Management and Handling) Rules, 2000

(f) Recycled Plastics (Manufacture and Usage) Rules, 1999

(g) Environment (Protection) Act,1986

(h) Environment (Protection) Rules, 1986 (as amended up to 2003)

(i) Coastal Regulation Zone Notification,1991 (as amended up to 2003)

been attempted in India and are known to be expensive also. For the remaining technologies, next level evaluation has been done, using environmental and social acceptability criteria.

Environmental and Social Acceptability Criteria

In this section, environmental and social impacts of various technologies have been discussed. In addition the requirements as per MSW Rules, 2000 have also been considered.

Composting

Amongst the MSW processing technologies, the composting process probably has least number of environmental issues to cause any serious concerns. However, issues like noise, dust, odor, leachate generation, aesthetic and litter nuisances at the receiving end of the plant need to be carefully considered. . Waste turning process also leads to odour problems during initial weeks of operation. However, with proper process design and moisture management, the negative impacts can be minimized to levels acceptable or eliminated altogether.

Further, product compost is high in essential nutrients like nitrogen, phosphate and potash. Compost can is used as organic fertilizer and as soil amendment agent .In addition, compost reduces erosion, increases the air penetration to soil and help to suppress plant diseases.

6.5.5 *Anaerobic Digestion (AD)*

The AD is considered one of the suitable technologies for treatment of high organic fraction of MSW. The MSW of Guwahati has higher organic content but would need adequate segregation before processing which could often be expensive. Though the land requirement for AD system is lesser than that of compost, a better foundation is required for placing the turbines. The current land that has been made available requires soil filling up to 8 m above existing ground level and may not be suitable for placement of turbines. If alternate land is made available with more robust foundation possibilities, the AD options in coordination with RDF could be considered for an integrated facility. The methane produced through AD is generally used for generation of power. NOx control could be an environmenral issue but it can be handed with proper design of the burners.

The technical details of the 100 TPD biomethanation plant is given in Annexure 6.1. Guwahati needs 2x100 TPD biomethanation plant.

Refused Derived Fuel

The production of RDF is largely a mechanical process. The processing facility itself would not be a source of combustion emissions. The major issues of concern would be the control of fugitive dust (PM10) generated from the mechanical equipment during the materials separation process and the generation of potential odors. The environmental issues related to RDF arise when the RDF is used in

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(j) Indian Electricity Act 1910

(k) Policies and Guidelines of MNES, issued from time to time

(l) State Level Policies, issued from time to time

(m) The 77th Constitutional Amendment, 1992

(n) Indian Penal Code, 1860

(o) Code of Civil Procedure, 1908

(p) Constitution of India, 1950

(q) Code of Criminal Procedure, 1973

Based on the environmental impacts of various technological options for MSW, they may be categorised as environmentally and socially acceptable and environmentally and socially suspect. Table 6.3 summarises the environmental impacts of all the technologies discussed in previous sections.

Table 6.3 MSW Treatment Technologies with respect to Environmental and Social Acceptance

S. No.	Technology Category	Comments
1	Composting	Environmental impacts are negligible. The product is beneficial for agriculture and plantations.
2	Refuse Derived Fuel	Requires significant air pollution control measures when RDF is used as fuel.
3	Anaerobic Digestion (Biomethanation)	Environmental Impacts are negligible. However, segregation of the waste is required before AD process.
4	Mass Burn/Incineration	Requires strict process control and significant air pollution control measures.

The basic problem with incinerators relates to its environmental acceptability. Unless carefully designed and operated, MSW combustion could results in the emission of toxic gases like mercury, hydrochloric acid gas, PCBs, PAHs, dioxins, and furans which makes incinerators non acceptable. In addition, the plant will have a chimney, high enough for the dispersion of the flue gas. Due to the nearness to the airport, obtaining clearances for such plant will be difficult. The incinerator ash could be hazardous (depending on the variations in the composition of the MSW) and may need special disposal arrangements. The pollution control measures are often expensive. In view of the above, the incinerators all over the world are not a highly preferred option for MSW treatment.

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In addition to causing boiler corrosion and slagging problems, RDF combustion has come under strict scrutiny because of concerns over the emission of mercury, hydrochloric acid gas, PCBs. PAHs dioxins, and furans generated from the combustion of certain components in an oxidizing environment and in the presence of chlorine

6.5.9 *Waste Suitability Criteria*

The above technologies have been evaluated for their suitability to treat MSW of Guwahati.

Table 6.4 presents the salient average characteristics of the MSW reaching the existing landfill site of Guwahati based on pre-monsoon sampling.

Table 6.4: Average MSW at Landfill Site during Pre-Monsoon Sampling

Parameters	Desirable Range		MSW reaching the dumping site Ranges by wt.
	Thermal Processing	Biological Processing	
Average Moisture	<45%	>50%	44-88 %
Organic matter (Food, Vegetable, Fruit waste, Dry grass/straw, rags, wood)	-	>70%	62-81 %
Recyclable Fraction (Rubber & Leather, Plastics, Metals, Cardboard, Glass)	-	-	16-31%
Inert (Sand / Soil / Earth / Stone)	<35%	-	3-7 %
Gross Calorific Value of MSW (wet basis)(Kcal/kg)	>1200	-	1000-1446
C/N Ratio	-	25-30	9-32

Based on the physical and chemical properties of the MSW of Guwahati, its suitability for thermal and bioconversion technologies has been discussed below.

6.5.10 *Thermal Technologies*

As documented in the World *Bank's Technical Guidance Report on Municipal Solid Waste Incineration,* once ignited, the ability of waste to sustain a combustion process without supplementary fuel depends on a number of physical

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and chemical parameters including, the calorific value and moisture content and inert content of the waste. These parameters determine the suitability of waste for energy recovery by thermal technologies. Guwahati's MSW contain > 44% moisture and > 64% biodegradables. High moisture content is a critical determinant in the economic feasibility of waste treatment by incineration or RDF technology. Additional energy must be supplied to the waste to evaporate excess water content to make it dry before the waste can be used for thermal processing. If the energy produced during incineration is consumed for captive consumption (for drying needs) this will have direct effect on the economics of the plant as there will be less energy that will be available to sell commercially. In comparison, in Taiwan and other western countries where incineration plants have been established, the MSW is mostly dry and consists of 16-27% biodegradable and the rest mostly incinerables.

Energy balance, therefore, may not be sustainable for commercial operations. Hence, mass burn technology and RDF are not technically feasible options for MSW of Guwahati.

6.5.11 Bio-conversion Technologies

Bioconversion processing is mainly dependent on the presence of biodegradable matter, moisture content and C/N ratio of MSW. From the Table 6.3, it has been observed that MSW of Guwahati is suitable for bioconversion.

It is possible to treat the segregated Guwahati MSW through biomethanation technology. However, the segregation process could be expensive and it often makes the biomethanation process commercially non-viable. Moreover, the disposal of the sludge could be a problem. Though the sludge could have compost value, it could be rich in pathogens and needs to be treated before use, which again adds up to the cost.,

The simplest and most economical technology to treat the MSW of Guwahati is Composting. Because of high organic content (> 65%) and very less inerts (< 7%), composting can be undertaken easily without waste segregation, with the good efficiency of more than 25% . It is a proven technology for Indian wastes and several plants are running successfully.

6.6 RECOMMENDED TECHNOLOGY FOR PROCESSING OF MSW IN GUWAHATI

As detailed above, after applying the above-mentioned technology screening criteria, the technology of composting has been found to be the most preferred option for treatment of MSW in Guwahati. Composting process has least environmental problems amongst waste treatment technologies. Compost is considered as a slow release fertilizer where nutrients are released slowly and over the years. The chemical fertilizers, on the other hand, are fast acting and therefore give better crop yields. However, soils undergo stress and degradation due to prolonged fertilizer use. Compost is a good soil amendment agent and helps to enrich the soil quality by increasing the oxygenation rates and organic content. It

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also improves the texture of the soil. In non-harvesting agricultural practices like plantations, the compost is most useful and the benefits can be maximized by duel application of chemical fertilizers and compost. Assam has extensive tea gardens where compost can be effectively and economically used. Assam already has a good demand for organic fertilizers and it will not be difficult to market the compost, provided it meets the required quality in a consistent manner.

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CHAPTER – 7
SITE SUITABILITY & DEVELOPMENT STRATEGY FOR INTEGRATED FACILITY

7.1 INTRODUCTION

The selection of a site for developing landfill is one of the long pending issues with GMC. For several years, GMC has been requesting the government to provide a suitable site for the disposal of MSW. The current site at Sacchal is utterly unsuitable and GMC has received notice from the Pollution Control Board to shift the existing site. Guwahati is located on the Brahamputra flood plains. A significant area in and around Guwahati gets occasionally flooded during the monsoon and the water often stands for about 8 months along the low lying tracts. Because of expansion of the city over the years, the entire high level area within the Guwahati municipal limits has been fully occupied. In view of the above, selection of a suitable site, conforming to the MSW rules is difficult. However, in spite of the non availability of a suitable land for engineered landfill, Guwahati still needs land for disposal of the MSW. It is apparent that, populated areas can not be acquired for the disposal of MSW as it is not politically and socially sustainable.

Earlier two lands pieces were considered; one was in Panikheti on the banks of Brahamputra and the other at Garchug on the foothills. The Panikheti land is unsuitable for SLF as most of the time this land is submerged under water. Moreover, due to the vicinity of the river, the hydraulic force of the flood water is enormous and the cost of making the land suitable with be very high. The Garchug land is very small in size (about 3-4 Ha) and spending money to make the site suitable which will last only for a few years is not economical. In addition, this site also has rehabilitation and resettlement problems.

After considerable deliberations, the present site in Boragaon has been earmarked by the Government for the MSW disposal. Though this site is also not particularly suitable for MSW disposal, GMC indicated in several meetings that no other suitable site is available for this purpose. The constraints of finding a suitable high-level land free of habitation are appreciated and under these constraints, IL&FS Ecosmart has attempted to design the engineered integrated facility at the present site in Boragaon. The land needs to be protected from the flood waters and adequate measures are to be adopted for a safe and environmentally sustainable disposal of MSW.

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7.2 DESCRIPTION OF THE PROPOSED SITE

The proposed site for integrated facility development is located at Badagaon in GMC area with survey numbers 1112, 1113, 1117, 704 and part of 1114. The site is observed to be open land with seasonal agricultural activities. It has also been observed that fishing activities are predominant in and around the site. The site is within Brahamputra flood plain. The site is located at a distance of around 15 km from the Guwahati City and is 1 km from the NH-37.

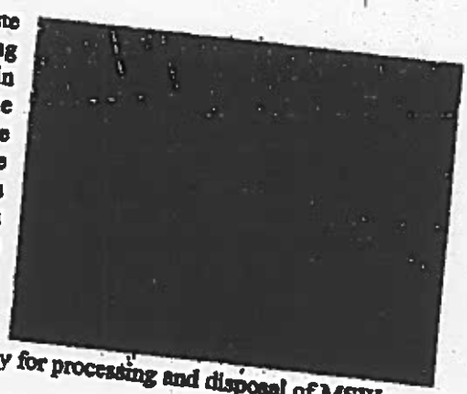
An approach road of length around 0.5 km originating from NH-37 provides access to the site. A railway track passes adjacent to the site on western side.

The land use around the site is observed to be agricultural and residential with a hill on north western side. No major trees have been observed within and around the site. Only aquatic flora has been observed within the site as it is water logged throughout the year.

The type of soil in the site has been observed to be dark grey silty and clayey soils. The terrain is low lying plain with mild undulations. The ground water levels at the site are observed to be very shallow with ground water only few feet below the ground. Drawings 7.1 R1 and 7.1 (a) present the details of land allocated for integrated facility development.

7.3 SITE SUITABILITY ANALYSIS

In India, recently, solid waste management systems are assuming larger dimensions especially in keeping the guidelines issued by the committee appointed by the Honorable' Supreme Court on the subject of Municipal Solid Wastes (Management and Handling) Rules 2000. Many of the municipalities are taking appropriate actions to improve collection and transportation of solid waste (MSW) from the generation areas, and opting for suitable technology for processing and disposal of MSW.



In India, normal practice of open dumping is obviously causing public nuisance, pollution of air, water and land environment along with a constant source of hazard to the adjoining habitation. An extensive study has been carried out to delineate the health hazards of open dumping. Based on this review, a site

selection criterion has been developed considering environmental conditions, hydro geological characteristics, accessibility etc.

7.3.1 *Proposed Site Features*

The proposed site for sanitary landfill development is located at Boragaon. The Garchug village is approximately 3 km away from the proposed site. Initially GMC had provided two isolated pieces of land. One was 9.38 Ha piece of land and the other was 2.8 Ha land at a distance of 200-300 m from each other. After the presentation of the project to the Chief Minister, additional land area has been allocated for the integrated facility. Total area for the development of integrated facility for the management of MSW of Guwahati is now 24.12 Ha (180 Bigha). The features of the site are presented in Table 7.1. Schematic Map Presenting Integrated Facility Site and Location Aspects have been presented in Annexure 7.1.

Table 7.1: Features of Proposed Site

Features	Details
Latitude & Longitude	Lat. 26°5'0" to 26°8'0", Long. 91°38'0" to 91°41'0"
Land use	It is on Brahmaputra flood plain. The land is generally lies idle, but occasionally used for minor cultivation and for fishing
Major crops in the study area	Reported some occasionally paddy cultivation around the site but often gets washed away in floods. However, there is no indication that the site is being cultivated.
Nearest Highway	National Highway-37 is 1 km away
Access Road detail, if any	The road is metalled and paved upto IASST, while about 0.5 km road leading to the site is unpaved
Nearest Railway Station	Guwahati – ~15 km
Nearest Airport	Guwahati air port ~10 km
Nearest Town/City	Maligaon village towards North about 6 km from the site
Major Settlements	On the other side of NH-37 about 1.5 km and in Gorchug about 2.5 to 3 km from the proposed site; settlements in Paschim Boragaon (houses as well as school) within the 1 km of the site including proposed.
Minor settlements	Harapur (Harapara / Hirapara, ~5km), Chakard (~3km), Devchatal (~1.5 to 1.75 km), Maghawpara (~1 to 1.25 km), Teteliya (~2.5km) Villages
Water bodies and dams, canals	Mora nalha which, originate from the Garchuk, passing right through the site and joining the dipar beel (within 200 to 300 m from the site).
Hills and Mountains (within or around the area)	Meghalaya Pahad behind the Maghurwpara about 1.5 to 2 km from the site; behind that Rani reserve forest starts while on the other side towards north Phatasil reserve forest about 4 km from the site
Reserve forests	Rani reserved forest about 1.5 km from the site
Ecologically sensitive zones(within 10 km)	Deepar beel about 1.5 km from the site

Features	Details
Monuments (within 10 km)	Not observed any
Sensitive Receptors	Shiv temple within 1 km from the site.
Socio-economic	Since the area remains waterlogged, some minor fishing activities have been observed. Occasional paddy farming has also been reported in some patches. No lands at and in the vicinity of site is used for residential purposes except the proposed lands of LIC and tea industry in between the compost and landfill. Moreover, hardly any identify the site as of scenic importance.
Major important industries within 10 km	There are tea warehouses, small-scale textile (weaving) mill, salt factory and stone crushing factory near the site.

7.3.2 *Site Evaluation Criteria*

Attributes are divided in to four categories and these are given below.

1. Receptor related
2. Pathway Related
3. Waste characteristics related
4. Waste management practice related

A set of 34 attributes has been considered for ranking exercise. The attributes are listed below:

1. Accessibility related
2. Environmental related
3. Socio-economic related
4. Waste Management Practice related
5. Climatology related
6. Geological related

Table 7.2: Sensitivity Index (As per CPCB)

S. No.	Attribute	0.0-0.25	0.25-0.5	0.5-0.75	0.75-1.0
Accessibility Related					
1.	Type of road	National highway	State highway	local road	No road
2.	Distance from collection area	< 10 km	10-20 km	20-25 km	> 25 km
Receptor Related					
3.	Population within 500 m	0 to 100	100 to 250	250 to 1000	> 1000
4.	Distance to nearest drinking water source	> 5000 m	2500 to 5000 m	1000 to 2500 m	< 1000 m
5.	Use of site by nearby Residents	Not used	Occasional	Moderate	Regular
6.	Distance to nearest building	> 3000 m	1500 to 3000 m	500 to 1500 m	< 500 m
7.	Land use/Zoning	Completely remote (zoning not applicable)	Agricultural	Commercial or industrial	Residential
8.	Decrease in property value with respect to distance	> 5000 m	2500 to 5000 m	1000 to 2500 m	< 1000 m
9.	Public utility facility within 2 km	Commercial and industrial area	National heritage	Hospital	Air port
10.	Public acceptability	Fully accepted	Acceptance with suggestions	Acceptance with major changes	Non acceptance
Environmental Related					
11.	Critical environment	Not a critical environment	Pristine natural areas	Wetlands, flood plains, and preserved areas	Major habitat of endangered or threatened species
12.	Distance to nearest surface water	> 8000 m	1500 to 8000 m	500 to 1500 m	< 500 m
13.	Depth to ground water	>30m	15 to 30 m	5 to 15 m	<5m
14.	Contamination	Air, water or food contamination	Biota-contamination	Soil contamination only	No contamination
15.	Water quality	Highly polluted	Polluted	Potable	Confirming to standard

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S. No.	Attribute	0.0-0.25	0.25-0.5	0.5-0.75	0.75-1.0
16.	Air quality	Highly polluted	Polluted	Confirming to industrial standards	Confirming to residential standards
17.	Soil quality	Highly contaminated	Contaminated	Average	No contamination
Socio-economic Related					
18.	Health	No problem	Moderate	High	Severe
19.	Job opportunities	High	Moderate	Low	Very low
20.	Odour	No odour	Moderate odour	High odour	Intensive foul odour
21.	Vision	Site not seen	Site partly seen (25%)	Site partly seen (75%)	Site fully seen
Waste Management Practice Related					
22.	Waste quantity/day	< 250 tonnes	250 to 1000 tonnes	1000 to 2000 tonnes	> 2000 tonnes
23.	Life of site	> 20 years	10-20 years	2-10 years	< 2 years
Climatology Related					
24.	Precipitation effectiveness index*	<31	31 to 63	63 to 127	>127
25.	Climatic features contributing to Air pollution	No problem	Moderate	High	Severe
Geological Related					
26.	Soil permeability	> 1 X 10^{-3} cm/sec.	1 X 10^{-3} to 1 x 10^{-7} cm/sec.	1 X 10^{-1} – 1 X 10^{-5} cm/sec.	< 1 X 10^{-7} cm/sec.
27.	Depth to bedrock	>20 m	10 to 20 m	3 to 10m	<3m
28.	Susceptibility to erosion and run-off	Not susceptible	Potential	Moderate	Severe
29.	Physical characteristics of rock	Massive	Weathered		Highly weathered
30.	Depth of soil layer	>5m	2-5 m	1-2 m	<1m
31.	Slope pattern	< 1%	1-2%	2-5%	> 10%
32.	Seismicity	Zone I	Zone II	Zone III	Zone IV & V

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