S. No.	Indicators	Existing Situation	Standards according to SWM Rules, 2000, CPHEEO Manual and Service Level Benchmarks	Observations from Consultant's Team
	(102,395 from Total 1,15,957)			and 47 -total 13,562 Households.
3	Segregation at source	Nil	According to service level benchmarks, it should be 100%	Waste segregation at primary collection is practiced but that is wasted as there is no segregation of waste at secondary collection point.
4	Waste collection frequency	Daily	Bio degradable waste is to be collected for disposal on a daily basis. Recyclable waste may be collected when the bin becomes full.	Daily collection is in practice throughout the town.
5	Collection Type	Covered vans/Uncovered tractors/ truck	Wastes from secondary dustbins are to be collected through covered tractors or auto tippers.	Covered tractors or auto tippers are not used to transport wastes to the open dumping site. However, SMC has got some new machinery and compactors for collection and transportation of solid waste.
6	Disposal	Open dumping.	100% of Segregated inert waste should be disposed in the identified sanitary land fill.	Wastes Collected are dumped to the dumping ground without any treatment.
7	Cost Recovery in SWM Services (Rs. 0.3 Crores collected against expenditure of Rs. 17 Crore)	3%	According to service level benchmarks, it should be 100%	Ward wise Household and shops SWM Charge collection by Ward Committee. SMC only get revenue from Hotels, Hospitals etc.

Source: Rapid Baseline Assessment – Siliguri Draft Report (MOUD)

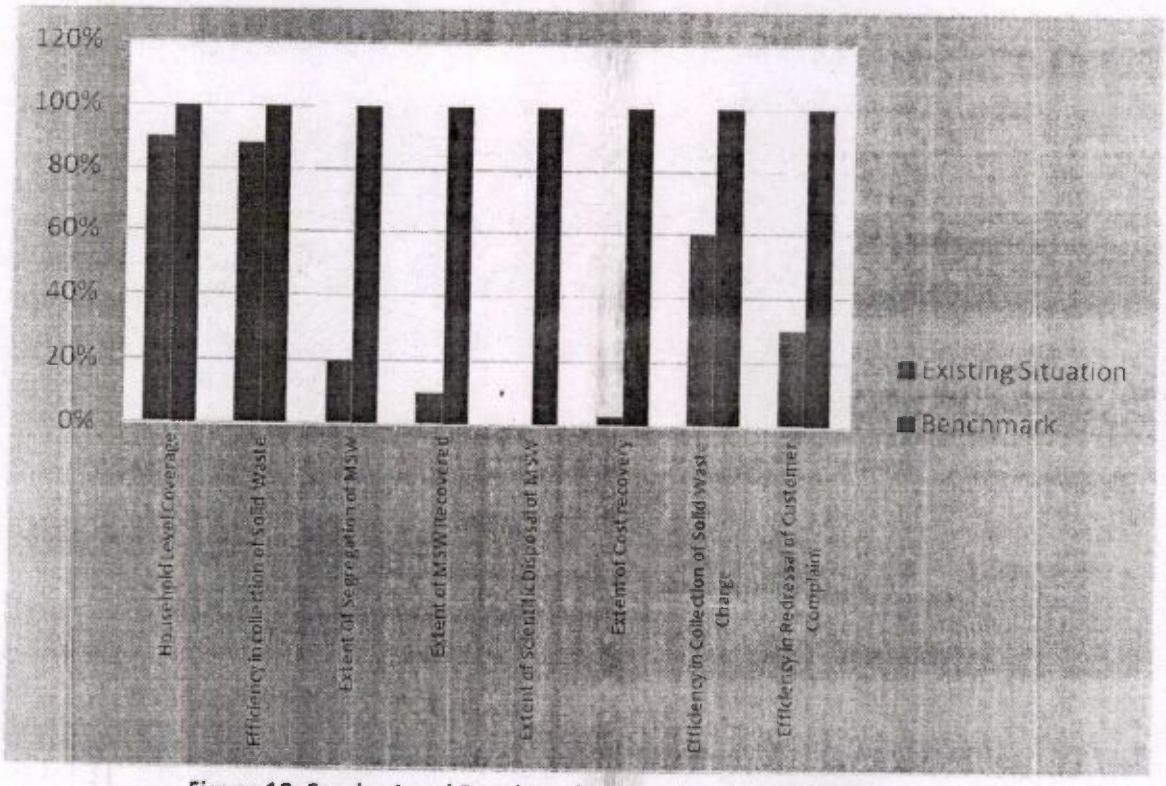


Figure 10: Service Level Benchmarks vis-a-vis existing situation

NUSP Rank of the City

The MoUD, GoI, commissioned agencies, to carry out sanitation rating exercises for 436 Class-I cities of India. Under National Urban Sanitation Policy (NUSP). The overall goal of this policy is to transform Urban India into community-driven, totally sanitized, healthy and livable cities and towns.

The first rating of cities with regard to their performance in sanitation improvements, based on a set of objective indicators of outputs, processes and outcomes, was carried out in 2010 to set the baseline ranking. Based on the scores cities were divided into four colour codes

Colour	Indicator	Marks
Red	Cities needing immediate action	<33
Black	Needing considerable improvement	34 - 66
Blue	recovering	67 - 90
Green	Healthy and green city	91 - 100

Siliguri ranked 132 out of 423 with 38.597 points and falls in the black category in the baseline survey requiring immediate intervention for improvement of sanitation conditions.

4. SOLID WASTE QUANTIFICATION AND CHARACTERIZATION FOR SILIGURI

4.1 Introduction

Quantification of solid waste is necessary in order to develop proposed plans and also it helps for designing purpose of the whole system and characterizations of the waste samples are necessary to arrive at an appropriate technology of reusing the waste materials.

4.2 Quantification of waste

4.2.1 Sources of Waste

Various sources of waste generation were identified in Siliguri Town through field survey and stakeholder discussions. During discussions it was highlighted that major sources of waste generation in Siliguri town are Households, Regulated Market, other Main Markets Malls, Hospitals and Hotels etc.

Primary Survey

Procedure:

The methodology used for calculating the per capita waste quantification for Residential areas at Siliguri is given below.

The per capita survey at residential area has been calculated. The 53 houses have been identified comprising of high income, low income and poor group of people. Plastic bags have been supplied to the identified households for collecting waste from the each individual house. After 24 hours the waste is collected and weighed with weighing machine.

The quantified waste has been divided with the number of family members to get the individual contribution of waste. The survey was carried out for 3 days continuously in all the wards. The average per capita has been considered for further calculations. The data format used while carrying the survey at Siliguri is given in **Error! Reference source not found.**29.

Table 15: Per Capita Average waste generation per household

Sr. No.	Household Size	Total Waste Collected (gm)	Per Capita Generation (gm)	Category	No. of Persons	Avg. of Per Capita Waste (gm)
1	10	7640	764	HIG	27	517.8
2	4	3590	898			
3	4	420	105			
4	9	2330	259			
5	3	1720	573	MIG	250	432.1
6	5	1830	366			
7	8	2330	291			
8	4	1360	340			
9	8	4900	613			

Sr. No.	Household Size	Total Waste Collected (gm)	Per Capita Generation (gm)	Category	No. of Persons	Avg. of Per Capita Waste (gm)
10	3	1580	527			
11	8	3730	466			
12	6	2530	422			
13	4	2950	738			
14	28	6040	216			
15	4	3470	868			
16	30	17495	583			
17	24	11335	472			
18	10	5350	535			
19	7	1490	213			
20	4	1850	463			
21	6	2740	457			
22	26	11220	432			
23	3	850	283			
24	4	940	235			
25	3	650	217			
26	3	2940	980			
27	4	440	110			
28	7	3270	467			
29	5	2180	436			
30	3	1170	390			
31	3	1160	387			
32	2	360	180			
33	6	3042	507			
34	6	530	88			
35	5	2090	418			
36	3	1410	470			
37	5	3080	616			
38	8	3120	390	LIG	65	245.4
39	6	2100	350			
40	6	600	100			
41	6	1000	167			
42	3	1130	377			
43	3	1020	340			
44	5	930	186			
45	4	670	168			
46	3	1000	333			

Sr. No.	Household Size	Total Waste Collected (gm)	Per Capita Generation (gm)	Category	No. of Persons	Avg. of Per Capita Waste (gm)
47	3	330	110			
48	2	330	165			
49	4	320	80			
50	2	690	345			
51	5	1150	230			
52	3	790	263			
53	2	770	385			
			384			

From the above table it is seen that the average per capita generation for HIG group is 0.517 kg/capita/day, MIG is 0.432 kg/capita/day and LIG group of people is 0.245 kg/capita/day. Hence overall average per capit waste generation of Siliguri is about 0.403 kg/capita/day.

Per-capita waste generation from Previous Studies

Several studies were conducted by the CPCB, NEERI over the last two decades to arrive at waste generation details and solid waste composition of waste generated in the country. Summaries of the several findings are listed below:

Table 16 : Per-capita waste generation rates as per SWM Manual

Sr. No.	Year	Population Range (In Millions)	No. of Cities Surveyed	Average per capita value (kg/capita/day)	Source
1	1996	0.1 to 0.5	255	0.21	NEERI
2	1999-2000	Above 0.1	210	0.34	CPCB
3	2011-2012	0.2 to 0.5	34 States and UT's	0.35-0.4	SPCB/PCC

Source: Draft MSW Manual 2014 & MSW Manual 2000

So based on the above mentioned initial estimate total solid waste generated by the City is calculated by considering 384 gram/capita/day by residential population.

Total Waste generation

Total quantum of waste generation has been estimated based on the above per capita generation and is calculated as below.

Table 17: MSW Generated per day in Siliguri

S. No.	Source of Waste	MSW Generated (TPD)
1	Domestic Source @ 384 gm per person per day	215
2	Marriage Hall - 50 Nos. @ 200 kg/unit/day	10
3	Hotels - 500 nos. @ Avg. 20 kg./unit/day	10
4	Markets (Regulated Markets, Malls, etc.)	49
5	Construction and Demolition Waste	10
6	Street sweeping/Drain silt 800 Km Roads @ Avg. 30 Kg./Km/day	16
7	Hospital and nursing Homes- all waste except biomedical waste 1100 Nos. Beds @ 2 Kg per bed + 80 Nos. Pathology Labs @ 10 kg./lab	3
	Total	**313**

4.2.2 Quantification of MSW by Weighing of Vehicles

Our team has done waste quantification to know the quantity of waste generation in Siliguri. The quantity of waste varies day by day because of collection frequency. Waste carrying Capacity of each vehicle has been calculated and given in Table 27. Based on the carrying capacity of secondary vehicle and the number of trips made in a day to the dumpsite, total waste generation has been estimated. The necessary details were collected and the waste quantity reaching the dumpsite is found to be about 253 MT for Siliguri.

Table 18: Weight of MSW carried by Vehicles

S. No.	Vehicle Model	Sample No.	Empty Weight of Vehicle(Kg)	MSW Filled Weight of Vehicle (Kg)	Net Weight Carrying per Trip (Kg)	Average Weight Carrying per Trip (Kg)
1	Tata Xenon	1	3280	4370	1090	613
		2	3280	3660	380	
		3	3280	3650	370	
2	Tata 407 Covered Van	1	2580	3640	1060	1060
3	Tata 407 (Tata Truck)	1	3120	5230	2110	2110
4	Tata Tipper - 1613	1	7120	16020	8900	5600
		2	7120	9420	2300	
5	Tata 909	1	4350	6710	2360	2360
6	Compactor -14 CUM	1	11500	22070	10570	10570

Source: (Weight of the filled and empty vehicles measured at a weigh bridge near site – Refer Annexure 2)

Table 19: MSW Weight Carrying per day by MSW Vehicles:

S. No.	Vehicle Type	No. of Vehicles	Avg. Trips Per Day	Average Weight Carrying per trip in KG	Total Weight Carrying per day in KG
1	Tractor	11	2	1000	22000
2	Tata Truck	4	3	2100	25200
3	Tata DI	4	8	500	16000
4	Tata Xenon	6	8	613	29424
5	Tipper - 909	5	3	2360	35400
6	Tipper - 1613	10	2	5600	112000
7	Compactor - 7 CUM	2	2	5000	20000
8	Compactor - 14 CUM	1	2	10570	21140
	Total MSW Carrying (Tons.)				281
	Considering 90% of the total load based on the vehicle efficiency and no. of trips of vehicles. Total MSW carried per day (MT)				253

As per above calculation it is clear that around 250 MT of Solid waste is transported to the Landfill site based on the number vehicles and trip information provided by SMC authorities. It is clear from the Table no28 and 31 given above, that around 313 MT of waste is generated from the City and around 80% of the waste is daily transported to the Landfill Site.

4.3 Waste Characterisation

4.3.1 Physical Composition of Waste

Bio-degradable Wastes

Biodegradable waste is something that can be decomposed naturally by microorganisms and other biological processes. Biodegradable waste products can also be called green waste, food waste, or organic waste. When biodegradable products are exposed to nature, including oxygen and moisture, they break down relatively efficiently.

Recyclable Wastes

Recyclable waste can be processed by chemical action and other processes. Non- Biodegradable waste products can also be called plastic bags, rubber, textile, woolen and tires or inorganic waste. It can be processed chemically with different technologies like pyrolysis, Refuse Derived Fuel (RDF), Plastic Granular Technology etc.

Non-Recyclable Wastes

Construction and demolition (C&D), debris, soil and ashes waste constitutes Non-Recyclable waste. This waste is nonhazardous, uncontaminated material resulting from construction, remodeling, repair, or demolition of utilities, structures, and roads.

4.3.2 Chemical Composition of Waste

Moisture Content

Moisture content plays a big role for survival of the microorganism. Most micro-organisms including bacteria require a minimum of approximately 12% moisture for growth. In Siliguri moisture content is high 29.1 %. High moisture content is a drawback because it have high transportation cost. It and be dried by solar drying according to requirement.

Gross Calorific Value

Gross Calorific Value is found to be 942 Kcal/ Kg in Siliguri. The content of calorific value indicates that waste can be used for RDF technology. But there is some limitation with this technology.

Carbon Content

Currently 29.6% carbon content is present in Siliguri. It is good for composting process, only 12% - 15% required for the process. It can be reduced by decomposing process.

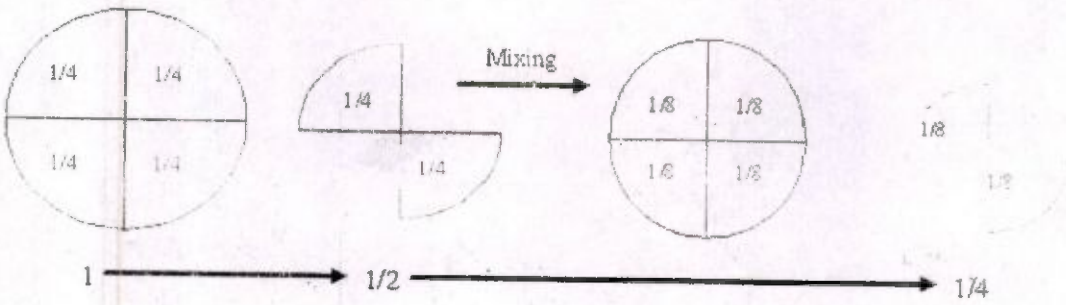
4.3.3 Survey of Characteristics of waste generated

4.4 Quartering system of waste sampling

For Characterization of waste sample procedure was followed as per CPHEEO manual.

After waste collection from major sources at different locations, this waste is accumulated for waste sampling to know the characteristics of waste.

- Collected approximate 80-100 kg of mixed waste at a point.
- This waste is divided in to 4 equal parts, and selected two diagonal parts and they are mixed together. We got approximately 40-50 kg quantity of waste.
- Further this waste is divided again into 4 equal parts and then two diagonal parts were mixed. We got approximately 20-25 kg quantity of waste.
- This exercise is repeated with same procedure and a final sample of 10-12 kg is collected.
- Finally this waste is sent to laboratory for analysis of physical and chemical characteristics of the waste.



The MSW 6 Samples were collected from Secondary collection bins at Ward 34 (Residential), Ward 2 (Hotels and Commercial), Ward 11 (Sabji mandi and market), Ward 23 (Slum) Regulated Market Area and Dumping Ground. The wastes were mixed and sample of around 10-12 Kg was collected through quartering process which was further sent to the laboratory for physical and chemical analysis. Besides this 3 leachate samples were also collected from Dumping Ground, Regulated market and Secondary Collection bin and sent for further analysis

4.5 Waste Characteristics

The samples were analyzed to arrive at bulk density and segregated into constituents for physical composition and were recorded. Components of all the waste sample were segregated in various categories like Food/fruit, Leaves/hay/straw, Paper/cardboard /packaging, Rubber/leather, Plastic/polythene, Textile, wood, Glass and crockery, Tin cans, Stone/brick, Coal ash/fine earth/dust and metals. (Classifications of waste are shown in table below).

Average of the six samples is given in the table below:

Constituent	Value
Biodegradable in %	65.2
Non-Biodegradable - Recyclable Glass in %	13.6
Inert in %	12.1
Plastic in %	1.6
Unusable - Like Leather etc. in %	7.5
Moisture (Random basis at 33 degree Celsius) in %	29.1
Gross Calorific Values in kcal/Kg	942.0
pH	5.9
C/N Ratio	29.6
Test Reports of all the tests is Attached as Annexure 1	

The waste samples were analyzed for organic bio degradable waste, inert waste and recyclable waste.

5. POPULATION PROJECTION AND WASTE PROJECTION

5.1 Population Projection

Population projection for the City has been projected based on the following methods:

i) **Arithmetic Increase Method:** This method is based on the assumption that the population increases at a constant rate; i.e. the rate of change of population with time is constant.

ii) **Geometric Increase Method:** In this method, per decade percentage increase or percentage growth rate is assumed to be constant, and the increase is compounded over the existing population every decade.

iii) **Incremental Increase Method:** In this method, per decade growth rate is not assumed to be constant as in arithmetic or geometric progression methods but it is progressively increasing or decreasing, depending upon whether the average of incremental increase in the past data is positive or negative.

Table 20: Population Projection for Siliguri

Year	2017 as base year			
	Arithmetic	Incremental	Geometric	Average (Incremental + Arith.)
2015	561189	558061	578183	559625
2017	585152	579789	613659	582470
2022	645058	632154	712168	638606
2027	704965	681726	826490	693345
2032	764871	728505	959164	746688
2037	824778	772491	1113136	798634
2042	884684	813683	1291824	849184
2047	944591	852083	1499197	898337

FIPL proposes that **average of the Arithmetic and Incremental Increase** population projections shall be used for the calculation of the solid waste generated as City had seen about 9% growth in previous decade which is quite less as compared to the growth in previous decades, Secondly the population projected as per Geometric Increase method is generally considered for the developing City's. As the City has seen decrease in growth rates over past years so an average of Arithmatic and incremental increase method has been considered.

5.2 Present Municipal Solid Waste Generation

Present Municipal Solid waste Generation per day in MT from different sources, Per capita waste generation in grams and percentage of waste from Different sources in Siliguri is as below:-

Table 21: MSW Generation per day from different Sources

Sr. No.	Source of Waste	MSW Generated (TPD)	MSW Generated Per Capita per Day (Gram) 2015	Percentage of waste
1	Domestic Source	215	384	68.68
2	Commercial, Hotels, Hospitals (Except Bio Medical) and Markets (Including Tourists/Floating Population)	82	147	26.21
3	Street sweeping/Drain silt	16	29	5.11
	Total	**313**	**560**	**100**

5.3 MSW Projection

Municipal Solid Waste projection is done based on the increase in per capita waste generation due to change in lifestyle and Population increment of the city.

MSW Projection of Siliguri has been shown in tables below:-

Table 22: Projection of Per Capita per day Municipal Solid waste generation in gram

Sr. No.	Source of Waste	MSW Generated PCPD (Grams)						
		2017	2022	2027	2032	2037	2042	2047
1	Domestic Source	394	419	444	469	494	519	544
2	Commercial, Hotels, Hospitals (Except Bio Medical) and Markets (Including Tourists/ Floating Population)	151	161	170	180	190	199	209
3	Street sweeping/Drain silt	30	32	34	36	38	40	42
	Total	575	612	648	685	722	758	795

Table 23: Projection of MSW Generation in Siliguri City in Tons per day

Sr. No.	Source of Waste	MSW Generated Tons per Day						
		2017	2022	2027	2032	2037	2042	2047
1	Domestic Source	229	268	308	350	395	441	489
2	Commercial, Hotels, Hospitals (Except Bio Medical) and Markets (Including Tourists/ Floating Population)	88	103	118	135	152	169	188

Sr. No.	Source of Waste	MSW Generated Tons per Day						
		2017	2022	2027	2032	2037	2042	2047
3	Street Sweeping/Drain silt	18	21	24	27	31	34	38
	Total	**335**	**391**	**450**	**512**	**577**	**644**	**715**

Table 24: Projection of Household Municipal Solid Waste Generation per Borough

Borough	Household Waste (MT)						
	2017	2022	2027	2032	2037	2042	2047
No. I	57	67	77	88	99	110	122
No. II	24	28	33	37	42	47	52
No. III	32	38	43	49	55	62	69
No. IV	51	59	68	77	87	97	108
No. V	65	76	87	99	112	125	139
	229	**268**	**308**	**350**	**395**	**441**	**489**

Table 25: Projection of Commercial Municipal Solid Waste Generation per Borough

Borough	Commercial, Markets Waste (MT)						
	2017	2022	2027	2032	2037	2042	2047
No. I	22	26	29	34	38	42	47
No. II	9	11	12	14	16	18	20
No. III	12	14	17	19	21	24	26
No. IV	19	23	26	30	33	37	41
No. V	25	29	33	38	43	48	53
	88	**103**	**118**	**134**	**152**	**169**	**188**

Table 26: Projection of Construction and Demolition waste Generation per Borough

Borough	C & D and Drain Silt Waste (MT)						
	2017	2022	2027	2032	2037	2042	2047
No. I	5	5	6	7	8	9	10
No. II	2	2	3	3	3	4	4
No. III	3	3	3	4	4	5	5
No. IV	4	5	5	6	7	7	8
No. V	5	6	7	8	9	10	11
	18	**21**	**24**	**27**	**31**	**34**	**38**

6. POLICIES PROGRAMS AND LEGAL FRAMEWORKS

The country has awakened to the pathetic sanitation and wastes management situation existing in India as in the last few years, there has been lots of pressure due to international events concerning better environment and human settlements. As a result, several initiatives were taken at the national, state and local government level to go deep into the flaws in the existing situation and suggest remedies. The central and state governments initiated efforts to develop policies and programmes in this regard. The Strategy Paper on Solid Waste Management in India by the National Environmental Engineering Research Institute (NEERI) in August 1995 is one of the most exhaustive evaluations of the problem at the national level. The J. L. Bajaj Committee constituted by the Planning Commission in 1994 immediately after the Plague outbreak, also reviewed the prevalent conditions and made specific recommendations to deal with the situation. The Interim Report of the Committee on Solid Waste Management in Class I Cities in India constituted by the central government at the apex court in June 1998 is a valuable document which contains detailed recommendations for the removal of solid waste.

6.1 National and State level Initiatives

6.1.1 Swachh Bharat Mission, 2014

Swachh Bharat Mission is Prime Minister Mr. Narendra Modi's dream project intended to create a 'Clean India'. Mr. Modi had urged citizens, government institutions to dedicate 100 hours every year towards cleanliness. It's a clean India initiative by our present Prime Minister. The mission will be in force till 2nd October 2019. Among other objectives related to sanitation, one major objective is to modernize Solid Waste Management System. The mission also lays emphasis upon creating effective behavioral changes regarding healthy sanitation practices and creating general awareness about sanitation.

The report of the expert (J .L. Bajaj) committee of planning commission may 1995:- The committee suggested large-scale public private partnership in garbage management after reviewing some major innovative pilot projects on urban SWM through private and public initiatives. The main conclusion of the report was a situational analysis of the existing state of waste management in the Indian Cities and towns. The inevitable conclusion was that better sanitation standards could have been achieved in most of our cities and towns by prudent and planned allocation of available resources. Develop and support the application of appropriate low cost, eco-friendly technologies.

Interim report of the committee on solid waste management in the class I cities in India, constituted by the supreme court of India, June 1998:- It explains the present scenario in garbage management and detailed recommendations on technical, institutional and social aspects of storage, collection, transportation and disposal of garbage in class I cities. Its recommendations include steps for strengthening the institutional set-up, management information system and financial and legal provisions. The committee also recommended

certain specific responsibilities not only for the local, state and central governments, but also for the citizens and the community. The Interim Report of the Committee includes crucial recommendations meticulously categorized mandatory and discretionary with delineated work responsibilities for three categories of stakeholders i.e. the citizens, local bodies, state and central government. Several norms have also been specified for each function. Besides setting goals with a specific time frame to achieve the same, the Committee has also emphasized the role of community participation which are being followed in some of the cities can ensure long term sustainability of the system and structure of municipal solid waste disposal developed by the local bodies.

Bio-Medical Waste (Management and Handling) Rules, 1998:- The biomedical waste management rule directs biomedical waste incineration ash to be disposed into municipal landfills. Also, the municipal body must be a member of the 'Advisory Committee' in the state to advice on steady implementation of biomedical waste management and handling in their area.

Hazardous Waste (Management and Handling) Rules, 1998:- These Rules are applicable to hazardous waste which specifies the obligations of the occupier generating the hazardous waste, the process for grant of authorization for handling such wastes from the State Pollution Control Board (SPCB) or Pollution Control Committees (PCC). Requirements for packaging, labeling and transport of hazardous wastes are also mentioned in the Rules. The process for suspension/cancellation of licenses to generators and restrictions on the import of these wastes are also specified. The responsibility of the State Government to inventorize all hazardous waste generators and the requirements for record keeping and reporting by the operator and the SPCB/PCC are mentioned.

Battery (Management and Handling) Rules, 2001:- These Rules are for regulating the recycling of lead acid batteries after use. The Rules specify responsibilities of manufacturers, importers, assemblers, dealers and re-conditioners of lead acid batteries, which are a source of electrical energy and contain lead metal. Requirements for registration of recyclers are prescribed under the Rules. It also provides a control on the imports of substances by OEMs (original equipment manufacturers) and other equipment manufacturers.

National Urban Sanitation Policy (NUSP) (2008):- In order to address the sanitation issues in a holistic manner National Urban Sanitation Policy (NUSP) has been formulated by the Government of India in 2008 with a vision to provide appropriate sanitation facilities in all cities/ towns. States have to prepare state sanitation Strategies and Cities/ towns are required to prepare city Sanitation Plans (CSPs) as per NUSP guidelines, so as to improve health and environmental outcomes. The CSP is a vision document on sanitation with 20 to 25 years horizon with short term town level action plans for five years to achieve sanitation goals. CSP envisages achieving the following outputs:

- Open defecation free cities.
- Elimination of manual scavenging and safety of sanitary workers.

- Proper disposal of municipal wastewater and storm water drainage.
- Recycle and reuse of treated wastewater for non-potable applications.
- Solid waste fully collected and safely disposed of scientifically.
- Serving the un-served with basic minimum services.
- Measures for improved public health and environmental standards.

The Plastic Waste (Management and Handling) Rules, 2011:- The manufacture, stocking, distribution, sale and use of plastic carry bags and sachets is regulated by this Rule. Requirements for management of plastic wastes are also specified in this Rule. Norms for labeling plastic bags and recycled plastic products; recycling, recovery or disposal of plastic waste is to be carried out as per the Rules and standards notified by the central government.

The E-waste (Management and Handling) Rules, 2011:- These Rules are based on the principles of Extended Producer Responsibility (EPR) wherein the producer engaged in the manufacture, sale, purchase of electric and electronic equipment is responsible for the end of life management of the electrical and electronic products. Procedures for handling e-waste as applicable to all stakeholders such as collection centers, dismantlers and recyclers of e-waste are provided. Stipulations for reducing the hazardous substances in electrical and electronic equipment are also prescribed. Procedures and formats for registration of facilities for recycling e-waste are specified.

Municipal Solid Waste Management (Management & Handling), Rules, 2000 and revised draft 2013- Revised draft of Rules circulated in the year 2013 by MoEF Designates Urban Local Bodies responsible for MSWM and lays down the mandatory functions to be performed by various stakeholders.

The Rule designates the Urban Local Bodies as sole responsible to manage solid waste in their area and dictates that "within the territorial area of the municipality, be responsible for the implementation of the provisions of these rules, and for any infrastructure development for collection, storage, segregation, transportation, processing and disposal of municipal solid wastes". It prohibits waste to be exposed to open atmosphere; It also prohibits waste disposal by burning (garbage, dry leaves) in open.

Regarding Collection of MSW the rule identifies the following features:

- Mandates collection of waste from slums and open squatter areas, hotels/restaurants/office complexes and commercial areas;
- Avoid Manual handling of waste, and ensure that the waste is collected and removed from the municipal area daily;
- Vehicles used for transportation of wastes to be covered;
- Bio degradable waste and non-bio-degradable waste must be collected in separate bins from source. Waste bins for biodegradable waste shall be painted 'Green', those for storage

of recyclable wastes shall be printed 'White' and those for storage of other wastes shall be printed 'Black';

- Construction/demolition wastes/debris to be separately collected and disposed off following proper norms,
- Stray animals are to be kept out from the waste storage facilities;

Regarding Processing of MSW the rule identifies the following features:

- Recover recyclables from the waste mass before treating for biodegradable portion of the waste;
- Treatment of organic waste through biodegradation such as Vermi-composting, Mechanical composting by windrow method or any other suitable methods such as anaerobic digestion etc. as approved by Central Pollution Control Board (CPCB) may be adopted;
- In case the municipal body is engaged in any other treatment technology, such as incineration, energy recovery from waste etc. it must be duly approved by CPCB;
- Chlorinated plastics should not to be incinerated;

Regarding Disposal of MSW the rule identifies the following features:

- Municipal body to develop scientifically designed landfill as disposal facility for residues out of waste processing facilities, as well as pre-processing rejects or unprocessed mixed waste (applicable if the waste is not fit for any treatment) in a scientifically designed sanitary landfill for a long term of 20 – 25 years.
- Site suitability criteria to be ensured for selection of landfill sites
- Land filling of mixed waste must be avoided, unless the waste is found unsuitable for waste processing. Under unavoidable circumstances or till installation of alternate facilities, land-filling shall be done following proper norms.

Regarding Monitoring of Pollution the rule identifies the following features:

- Municipality to take adequate pollution prevention steps for all its waste management and handling units.
- Measures to reduce air pollution typically in case the unit has a waste to energy units.
- Environment Monitoring (ground and surface water, air quality) for waste handling site.

Regarding Awareness Programs the rule identifies the following features:

The Municipality to be engaged in encouraging citizens, by organizing awareness programs for segregation of waste at source and promote recycling or reuse of segregated materials through community participation programs involving representatives of local resident welfare associations, community based organizations(CBOs) and nongovernmental organizations.

MSW Rules Requirements on Street Cleaning: - As per MSW Rules 2000/2013, littering of municipal solid waste is prohibited in cities, towns and in urban areas notified by the state government. Manual handling of wastes is prohibited. However, if unavoidable due to constraints, manual handling should be carried out under proper precautions with due care for

safety of workers. Workers should be provided with uniforms, shoes, gloves and other implements etc., for their safe and easy working. They should be subjected to periodic health checks and should be provided with social security benefits including health insurance.

Manual on Municipal Solid Waste Management by Central Public Health & Environmental Engineering Organization (CPHEEO), May, 2014 - With a view to assist and guide the Urban Local Bodies for managing the solid waste in an efficient manner, the Ministry of Urban Development, Government of India issued Municipal Solid Waste Management Manual in May, 2014. It includes all aspects such as Composition and Quantity of Solid Waste, Storage of waste at source, primary collection of waste, transportation of waste, composting, energy recovery from Municipal Solid Waste, emerging technologies, sanitary land fill site, bio-medical waste, economic & financial consideration, environmental & health impact assessment, institutional aspects and capacity building, prospects of private sector participation community participation and legal aspect etc. The revised Manual also includes new technologies and approaches available in the MSWM sector ; improved institutional approaches and planning tools such as a combined planning for MSWM and Urban Sanitation: a fresh understanding of "Integrated Solid Waste Management", newly emerging issues/themes such as climate change, relevance of informal sector to MSWM as well as its links to gender equity and gender related issues; the need for state and regional strategies and handholding support for MSWM.

6.2 West Bengal Solid Waste Management Mission

The Government of West Bengal has launched a 'West Bengal Solid Waste Management Mission' registered under the West Bengal Societies Registration Act 1961 on 18 May 2005. The mission has been set up under the chairmanship of the Chief Secretary to Government and a technical committee headed by the Secretary, Department of Environment. Regulations have been framed and the powers, duties and functions of the mission as well as technical advisory committee have been laid down. The objective of the mission is to promote modernization of collection and transportation of MSW and facilitate development of cost-effective technology for treatment and disposal of the same in the state. Provision of technical and financial support to municipal bodies, PRIs, and authorities of the statutory area for setting up of regional or common solid waste management facilities is proposed.

The technical committee has prepared an action plan for implementing MSW Rules 2000 in the state. It has been envisaged that 25 to 30 regional facilities would be constructed in the state to cover 126 ULBs including six corporations. One regional facility would serve about five ULBs and each city would share the O&M cost in proportion to the waste delivered for treatment and disposal. On March 7, 2006, the WBPCB issued a circular restricting plastic carry bags in specific areas in the state. All manufacturers, stockiest and users were directed to comply with the guidelines of the Board regarding use of plastic carry bags to avoid regulatory order as provided under Section 5 of the Environment(Protection) Act, 1986, and also legal actions as warranted under Section 15 of the Environment (Protection) Act, 1986. All concerned persons and authorities were asked to ensure strict compliance of this circular.

6.3 Initiatives taken at under Swatch Bharat Mission

To achieve the target no defecation, house hold survey is completed. Following are the details of Insanitary Laterine/No Laterine Facilities :

- Total No. of Household Surveyed : 87374
- Total No. of households having Insanitary Laterine as per present Survey : 164
- Total No. of households without laterine facility : 3029

6.4 Initiatives taken at Local Level

SMC is distributing two Bins for Organic and Inorganic waste to households. SMC has already implemented Citizen Charter and formed Grievance redressal Cell. However, no separate staff is designated for redressal. The existing system of addressing the complaints needs to be improved.

6.5 Initiatives taken by CBUD, GOI

In order to provide an effective solid waste management system, CBUD, MoUD has awarded Consultancy Contract for preparation Detailed Project Report for Municipal Solid Waste Management with focus on innovative technologies for 8 ULBs all across the country namely Kurukshetra, Gangtok, Vishakhapatnam, Kollam, Siliguri, Bharuch, Siliguri and Solapur.

IRG Systems South Asia Pvt Ltd in association with Feedback Infrastructure Services Pvt Ltd; Cogent Training Research Consultants Pvt Ltd; and Green Origin Ventures Pvt Ltd, has been assigned this task.

After signing the Contract on 27th August 2014; a kick-off meeting was held under chairmanship of Director (N-IV), Urban Development, MoUD, Govt of India wherein Consultants team made a presentation on proposed approach and methodology, timelines for deliverables. The list of persons attended the kick-off meeting are attached at end of this Chapter.

The key outcome of the discussions held in the meeting is under:-

- MSWM Plan and DPR shall be prepared in consultation with ULB and other stakeholders with focus on improving sanitation conditions in an integrated manner;
- Implementation of project/MSWM Plan shall be designed to attract private sector participation partnering with local NGOs/CBOs; and
- Consultant shall explore all the possible options including innovative ones for techno-economically feasible solution for waste treatment/processing.

7. COLLECTION AND TRANSPORTATION PLAN

7.1 Introduction

This chapter provides Solid Waste Management Plan (SWMP) for primary and secondary waste collection system and transportation system for Siliguri City. The proposed plan includes the planning, infrastructure requirements for the collection and transportation systems and corresponding cost estimates were made in the end of the DPR. The proposed SWM system is broadly based on the following major aspects which form the core of the detail plan described in this & subsequent chapters:

1. Compliance with Municipal Solid Waste Management & Handling Rules of 2016. The entire MSW management plan is in compliance with these rules right from door step collection to final disposal i.e. sanitary landfill.
2. Compulsory segregation at source. Segregation at source is major component in MSW management system.
3. Provision of segregation infrastructure at all stages of collection and transportation. Proposed infrastructure is designed with separate collection and transportation of segregated waste *viz.*. wet and dry waste (2 bin system).
4. Waste to be covered at all stages of handling. The vehicles and equipments handling MSW should be covered at all stages of collection and transportation.
5. Reduction of manual handling of waste by providing of proper personal protection equipments (PPE's) to the workers. Safety and effective waste management go hand in hand hence workers should be provided with suitable PPEs like gloves, masks and safety boots etc. during all stages of waste handling.
6. 100% collection and transportation of the generated waste and to transport the same for treatment and disposal.
7. Maximum recovery of resources by segregation of recyclables and biodegradable waste. Treatment technology should be so designed so as to achieve maximum recovery of resources from the waste. Details of Proposed treatment technology are discussed in subsequent section.
8. Advocate *3 R's* i.e. Reduce, Reuse and Recover materials in MSW management. Waste hierarchy of *3 R's* is the order of priority of actions to be taken to reduce the amount of waste generated and to improve overall waste management and create a sustainable system.
9. Promote information, education and communication across the stakeholders to ensure system efficiency and sustainability. Detailed IEC methodologies are discussed in subsequent chapters.
10. Ensure economic sustainability of the proposed system by introducing public private partnership in MSW management.
11. Adequate health and safety provisions for workers at all stages of waste handling. Manpower is backbone for the MSW management system, hence their health and safety is an important aspect for successful operation of the any project.

12. Regular environmental monitoring at waste processing and disposal facilities. Detailed Environmental monitoring system is discussed in subsequent chapters.
13. Have robust complaint-handling system in place. For effective operations of MSW management, development of a complaint redressal cell is a must. This will enhance the quality of operations.
14. Conduct regular internal and external independent audits on the efficiency of entire SWM system. Conducting audits at regular intervals at every stage of MSW management will help to identify the deficiencies in the system, which enhances the quality of implementation.

7.2 Overview of the recommended C&T Plan:

Collection and transportation, probably the most important component of the SWM operation requires active involvement of the citizen, NGOs and private entrepreneurs. 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 & equipment 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 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 waste to the integrated MSW disposal facility.
- Container transportation using simple hydraulic system mounted vehicles.
- Awareness creation for source segregation and storage at source.
- Monitoring system to increase the productivity

Based on the existing Collection and transportation system, the comprehensive collection and transportation plan depicted below.

7.3 Primary Collection

7.3.1 Door To Door Collection

Door to door collection services includes collection of waste from households and commercial establishments, markets and other waste generating sources. The vehicles used for door to door collections in general are tricycles/pushcarts, autotippers, and sometimes small compactors depending on the area.

It is necessary for SMC to provide a daily service to all households, shops and establishments for the collection of putrescible organic/food/bio -degradable waste from the doorstep because of the hot climatic conditions in the City . This service must be regular and reliable – recyclable material can be collected at longer regular intervals as may be convenient to the waste producer and the waste collector, as this waste does not normally decay and need not be collected daily.

Option 1: Manual Tricycles: Door-to-door collection of waste to be done through containerized cycle rickshaws. Waste collectors will collect waste on a day-to-day basis in two types of bins - green bins for biodegradable and blue / black bins for non-biodegradable. The number of vehicles required and its basis of calculation has been shown in the table below.

Table 27: Number of Vehicles required from option -1 for DTDC

Sr. No.	Description	Qty.	Unit
1	Cycle Rickshaw with 6 bins of 40 Litre capacity each (Total 240 Litre - 0.24 cum Cap.)	240	Litre
2	Density of Waste	500	Kg/Cum
3	One Vehicle Load (Qty. of Waste)	120	Kg
4	Total Working Time Schedule	9	Hours
5	Lunch Time	1	Hour
6	Unloading Time Duration	2	Hour
7	Total Working Hours	6	Hours
8	Total Working Seconds	21600	Seconds
9	Estimated Time taken for HH Waste collection	90	Seconds
10	No. of Households covered in a day	240	HH
11	Approx. Waste Generated per Household (Family Size 4.5 Persons;	1.551	Kg
12	Covered Households in one trip	77	Nos.
13	**Number of Trips**	**3**	
14	Waste Collected in One Trip	120	Kgs
15	Waste Collected in Whole Day	372	Kgs

Option 2: Auto Tipper LCV with 1.8 cum capacity: - The Auto Tipper LCV to collect wastes from households. The Auto Tipper LCV would blow horn at a particular time in day, and the residents would come up from their house to dump their wastes, the tipper truck would be having two compartments. One will consist of bio degradable waste while the other will be having non bio degradable waste. The number of vehicles required and its basis of calculation has been shown in the Table below.

Table 28: Number of Vehicles required from option-2 for DTDC

Sr. No.	Particulars	Qty.	Unit
1	Capacity of one Vehicle	1800	Litres
2	Density of Waste	500	Kg/Cum
3	Capacity of one Vehicle	900	Kgs
4	Total Working Time Schedule	9	Hours
5	Lunch Time	1	Hour
6	Unloading Time Duration	0.75	Hour
7	Total Working Hours	7.25	Hours
8	Total Working Seconds	26100	Seconds
9	Estimated Time taken for HH Waste collection	45	Seconds
10	No. of households covered in a day	580	HHs
11	Approx. Waste Generated per Household (Family Size 4.5 Persons;	1.55	Kgs
12	Covered Households in one trip	580	Nos.
13	**Number of Trips**	**1.0**	
14	Waste Collected in One Trip	900	Kg
15	Waste Collected in Whole Day	900	Kg

Table 29: A comparison between the two options of Door to door collection is shown below:

Sr. No.	Particulars	Tricycle	Auto Tippers
1	Household Coverage	250	1400
2	Vehicles Required	510	76
3	Worker Required	464	138
4	Salary Per Person (including ESI, PF etc.)	5564	6682
5	Capital Cost	Low	High (3- 4 times higher than Tri Cycle Cost)
6	Life Time of Vehicles	2-3 Year	More than 5 year
7	O & M Cost	High	Low
8	Impact on Environment and Health	No Impact and Eco Friendly	Eco Friendly (in case of BS-4, Electrical Motor and CNG)
9	Segregation	Possible	Possible
10	Time required	More	Less
11	Efficiency	Low	High

As shown in above table capital cost of tricycles are lesser than the auto tippers. But, the O&M cost is found to be lesser and the life cycle is found to be higher for the auto tippers. Even the auto tipper is able to cover more households in lesser time period.

Collection of waste shall be done on a day-to-day basis between 6:00 AM and 3:00 PM (Time may change according to weather conditions). The ULB shall ensure that infrastructure is made available for undertaking this activity in compliance with the MSW Rules 2000.

Based on above discussions and comparison tables, it is proposed to provide Manual Rickshaws where roads are narrow whereas Auto Rickshaws have been provided where roads are wide. It is proposed to collect 80% of waste by Tricycles and 20% by Auto Tippers.

Table 30: Projected Tricycle requirement Borough wise for Household DTDC

Borough	Total No. of Wards	Tri Cycle Req. (Nos.)							
		2015	2017	2022	2027	2032	2037	2042	2047
No. I	8	127	136	158	182	207	233	261	289
No. II	10	54	57	67	77	87	99	110	122
No. III	10	71	76	89	102	116	131	146	162
No. IV	10	112	119	139	160	182	205	229	254
No. V	9	144	154	179	206	235	265	296	328
	47	**508**	**543**	**633**	**728**	**828**	**933**	**1042**	**1155**

Table 31 : Projected Tricycle Pullars requirement Borough wise for Household DTDC

Borough	Total No. of Wards	Tri cycle Pullar Req. (Nos.)							
		2015	2017	2022	2027	2032	2037	2042	2047
No. I	8	127	136	158	182	207	233	261	289
No. II	10	54	57	67	77	87	99	110	122
No. III	10	71	76	89	102	116	131	146	162
No. IV	10	112	119	139	160	182	205	229	254
No. V	9	144	154	179	206	235	265	296	328
Total	**47**	**508**	**543**	**633**	**728**	**828**	**933**	**1042**	**1155**

Table 32: Projected Auto Tippers requirement Borough wise for Household DTDC

Borough	Total No. of Wards	Motor Vehicle Req. (Nos.)							
		2015	2017	2022	2027	2032	2037	2042	2047
No. I	8	13	14	16	19	21	24	27	30
No. II	10	6	6	7	8	9	10	11	13
No. III	10	7	8	9	11	12	14	15	17
No. IV	10	12	12	14	17	19	21	24	26
No. V	9	15	16	19	21	24	27	31	34

Borough	Total No. of Wards	Motor Vehicle Req. (Nos.)							
		2015	2017	2022	2027	2032	2037	2042	2047
Total	47	53	56	65	75	86	96	108	120

Table 33: Motor Vehicle Driver Requirements

Borough	Total No. of Wards	Motor Vehicle Driver Req. (Nos.)							
		2015	2017	2022	2027	2032	2037	2042	2047
No. I	8	13	14	16	19	21	24	27	30
No. II	10	6	6	7	8	9	10	11	13
No. III	10	7	8	9	11	12	14	15	17
No. IV	10	12	12	14	17	19	21	24	26
No. V	9	15	16	19	21	24	27	31	34
Total	**47**	**53**	**56**	**65**	**75**	**86**	**96**	**108**	**120**

Table 34 : Projected Motor Vehicle Collector Requirements

Borough	Total No. of Wards	Motor Vehicle Collector Req. (Nos.)							
		2015	2017	2022	2027	2032	2037	2042	2047
No. I	8	13	14	16	19	21	24	27	30
No. II	10	6	6	7	8	9	10	11	13
No. III	10	7	8	9	11	12	14	15	17
No. IV	10	12	12	14	17	19	21	24	26
No. V	9	15	16	19	21	24	27	31	34
Total	**47**	**53**	**56**	**65**	**75**	**86**	**96**	**108**	**120**

Table 35: Total Workers Required for Household MSW Collection

Borough	Total No. of Wards	Total Workers Req. (Nos.)							
		2015	2017	2022	2027	2032	2037	2042	2047
No. I	8	153	164	191	220	250	281	314	349
No. II	10	65	69	81	93	106	119	133	147
No. III	10	86	92	107	123	140	158	177	196
No. IV	10	135	144	168	193	220	248	277	307
No. V	9	174	186	217	249	283	319	357	396
Total	**47**	**613**	**655**	**763**	**878**	**999**	**1126**	**1257**	**1394**

Table 36:Required Tools and Equipment's

Years	Worker	Dust Pans	Gloves (Pair)	Boots	Uniform	Helmet	Safety Mask
2015	599	1198	7185	1198	1198	1198	62272
2017	640	1280	7678	1280	1280	1280	66542
2022	747	1494	8965	1494	1494	1494	77693

Years	Worker	Dust Pans	Gloves (Pair)	Boots	Uniform	Helmet	Safety Mask
2027	859	1717	10303	1717	1717	1717	89290
2032	976	1951	11709	1951	1951	1951	101477
2037	1101	2201	13207	2201	2201	2201	114461
2042	1228	2457	14741	2457	2457	2457	127753
2047	1361	2722	16332	2722	2722	2722	141546

Gloves	1 Pair of Glove per Month
Boots	(2 Pair of boots per year)
Uniform	(2 Pair s in a year)
Helmet	(2 Helmet per year)
Dustpans	2 Dust Pans per Worker
Masks	(Two masks in a week)

Waste Collection from other Areas

In internal areas of wards many shops are part of the houses from such shops primary collection of waste to be done through manual Rickshaws. In Commercial Areas, Groups of shops, vegetable vendors, Hotel and Hospitals SMC shall collect through Auto Tippers. Most of the wastes from commercial areas are recyclable. Therefore it is proposed that waste collectors shall collect recyclable waste from shops and commercial establishments as soon as they open up. There will be a secondary waste collection point in every market area. Therefore, SMC Staff/ shopkeepers themselves shall dispose off their waste in these collection points.

It is proposed to collect 30% of waste collected by Manual Rickshaw, 20% by Auto rickshaw and rest 50% from secondary collection point through Compactor.

Sr. No.	Source of Waste Generation	Proposed Methodology
1	Commercial Markets	SMC will provide one 240 liters Two wheel HDPE Bins for each five shops or shop keepers will arrange dustbins of standard quality of their own.
2	Landmarks (like Bus stand, Outside of Railway station, DMC etc.)	MS refuse compactor bins have been proposed with a capacity of 4.5 cum each near the landmarks. Pair of dustbins is to be kept at a single location. One for Bio-degradable and other for Non-bio degradable waste.
3	Vegetable Market / Meat market	MS Refuse compactor bins of 4.5 cum capacity each at vegetable markets are to be placed. Pair of bins is too kept in a single location. One for Bio-degradable and other for Non-bio degradable waste.
4	Hotels and restaurants	SMC will provide 240 liter HDPE Bins (2 Nos.; 1 for

Sr. No.	Source of Waste Generation	Proposed Methodology
		Biodegradable and 1 for Non-Biodegradable) for each hotel and restaurants. A total of 310 bins will be required for this purpose.
5	Religious Places	The wastes generated from religious places are to be managed by their own.

For large size MS bins wastes will be cleared by Refuse Compactors and Dumper Placers. In case of Hotels and commercial shops using 240 Litre HDPE bins may dump their waste to the nearest secondary collection bins or may handover the waste when the Vehicle arrives.

Table 37: Tri Cycle Requirement for Commercial Waste Collection

Borough	Total No. of Wards	Tri Cycle Req. (Nos.)							
		2015	2017	2022	2027	2032	2037	2042	2047
No. I	8	18	19	23	26	30	34	37	42
No. II	10	8	8	10	11	13	14	16	18
No. III	10	10	11	13	15	17	19	21	23
No. IV	10	16	17	20	23	26	30	33	37
No. V	9	21	22	26	30	34	38	43	47
	47	**73**	**78**	**91**	**104**	**119**	**135**	**150**	**166**

Table 38: Tri Cycle Pullers requirement for Commercial Waste Collection

Borough	Total No. of Wards	Rickshaw Pullar Req. (Nos.)							
		2015	2017	2022	2027	2032	2037	2042	2047
No. I	8	18	19	23	26	30	34	37	42
No. II	10	8	8	10	11	13	14	16	18
No. III	10	10	11	13	15	17	19	21	23
No. IV	10	16	17	20	23	26	30	33	37
No. V	9	21	22	26	30	34	38	43	47
	47	**73**	**78**	**91**	**104**	**119**	**135**	**150**	**166**

Table 39: Motor Vehicles requirement for Commercial Waste collection

Borough	Total No. of Wards	Motor Vehicle Req. (Nos.)							
		2015	2017	2022	2027	2032	2037	2042	2047
No. I	8	5	5	6	7	8	9	10	11
No. II	10	2	2	3	3	3	4	4	5
No. III	10	3	3	4	4	5	5	6	6

Borough	Total No. of Wards	Motor Vehicle Req. (Nos.)							
		2015	2017	2022	2027	2032	2037	2042	2047
No. IV	10	4	5	6	6	7	8	9	10
No. V	9	6	6	7	8	9	11	12	13
	47	**20**	**22**	**25**	**29**	**33**	**37**	**41**	**46**

Table 40: Motor Vehicle Driver requirement for Commercial Waste collection

Borough	Total No. of Wards	Motor Vehicle Driver Req. (Nos.)							
		2015	2017	2022	2027	2032	2037	2042	2047
No. I	8	5	5	6	7	8	9	10	11
No. II	10	2	2	3	3	3	4	4	5
No. III	10	3	3	4	4	5	5	6	6
No. IV	10	4	5	6	6	7	8	9	10
No. V	9	6	6	7	8	9	11	12	13
	47	**20**	**22**	**25**	**29**	**33**	**37**	**41**	**46**

Table 41: Total Workers requirement for Commercial Waste collection

Borough	Total No. of Wards	Total Workers Req. (Nos.)							
		2015	2017	2022	2027	2032	2037	2042	2047
No. I	8	25	27	31	36	41	46	51	57
No. II	10	10	11	13	15	17	19	22	24
No. III	10	14	15	17	20	23	26	29	32
No. IV	10	22	23	27	31	36	40	45	50
No. V	9	28	30	35	41	46	52	58	64
	47	**99**	**107**	**124**	**143**	**162**	**182**	**204**	**226**

Table 42: Personal Protection Equipment requirement for Commercial MSW Collectors

Years	Worker	Dust Pans	Gloves (Pair)	Boots	Uniform	Helmet	Safety Mask
2015	99	199	1192	199	199	199	10328
2017	107	213	1279	213	213	213	11083
2022	124	248	1486	248	248	248	12882
2027	143	286	1717	286	286	286	14879
2032	162	325	1948	325	325	325	16879
2037	182	365	2188	365	365	365	18967
2042	204	409	2453	409	409	409	21261
2047	226	452	2714	452	452	452	23520

7.3.2 Street Sweeping

Street to be cleaned per Day:

Total Street length of Siliguri city is 977 Km, It has been assumed that daily sweeping will be done in city core area, market areas, minor streets, sub urban shopping streets and residential streets. Roads and streets having no households/establishments on either side would be swept once in a week. The highways and peripheral areas would be swept twice in a Month while open spaces are to be swept once in a month.

Table 43 : Road to be Cleaned Per Day

Sr. No.	Road Type	%age	Length (KM)	Beat Length (KM)	%age	Cleaning Criterion	Road Cleaning per Day
1	Arterial	4.4	43	86	7.6	25% Daily, 25% Weekly, 50% Bi Monthly	27
2	Sub-arterial	3.2	31	63	5.5	25% Daily, 50% Weekly, 25% Bi Monthly	21
3	Sub-arterial Collector	8.1	79	158	14.0	50% Bi Weekly, 50% Weekly	23
4	Local	84.3	824	824	72.9	50% Daily, 25% on Alternate Days, 25% Weekly	544
Total		100	977	1130	100.0		615

It has been proposed that 90% of the road to be swept manually while 10% of the road by Mechanical sweeping.

<u>Manual Sweeping:</u>

To ensure that street sweeping is done properly and there is accountability at individual level, it is proposed that team of two sweepers shall be made responsible for a stretch of road. Each sweeper will clean approximately 500 m of road stretch, therefore two sweepers between themselves are responsible for cleaning 1 km of road. One wheelbarrow shall be shared by a team of two sweepers.

The sanitary supervisors will be having the complete road map with them for monitoring of the activities. The sanitary supervisor will be responsible for making surprise checks to check the quality of the work being implemented in the area.

Table 44: Borough wise Sweepers required for cleaning of roads

Borough No.	Population Density (PPH) of the borough	Length Swept per Sweeper per Day (M)	Road Length (Km)	Road to be swept Daily (Km)	Roads Swept Manually (Km)	Sweepers Req. 2015
1	137	600	274	172	155	259
2	196	500	73	46	41	82
3	245	450	77	48	43	97
4	173	550	196	124	111	202
5	135	600	358	225	203	338
			977	**615**	**554**	**978**

Table 45: Sweepers required for street sweeping

Borough No.	Roads Swept Manually (Km)	Sweepers Req. 2015	2017	2022	2027	2032	2037	2042	2047
1	155	259	264	277	290	303	316	328	341
2	41	82	84	88	92	96	100	104	109
3	43	97	99	103	108	113	118	123	128
4	111	202	206	216	226	236	247	257	267
5	203	338	345	362	379	396	413	429	446
	554	**978**	**997**	**1046**	**1095**	**1144**	**1193**	**1242**	**1291**

Mechanical Sweeping

3 types of mechanical sweeping have been explored. Mechanical Sweeping Machine, Regenerative Air Sweeping Machine and Vacuum Sweeping Machine. It has been assumed that these vehicles would sweep at the rate of approximate 3.5 Km per liter. Two shifts for each vehicle have been assumed. One shift will be from 6 AM to 3 PM while the other will be from 9 PM to 6 AM.

Mechanical Broom Sweeper: A mechanical broom Sweeper is used to remove standard road waste, using various kinds of circulating brushes that sweep material onto a conveyer belt and then into bins. Mechanical broom Sweeper uses a gutter broom which displaces debris from the kerb into the path of the main broom, which is attached to a conveyer belt. Mechanical brooms have an ability to pick up large debris such plastic bottles, canes, wet vegetation, gravel and coarse sand. They are also effective in removing packed dirt from roadways. However, they are ineffective in picking up fine material. A mechanical broom has lower energy demand than regenerative sweepers and vacuum sweepers.

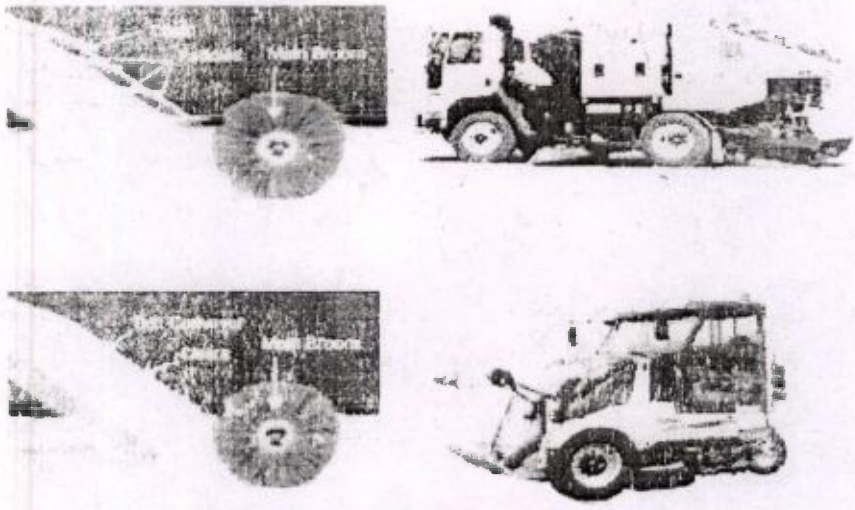


Figure 11 : Mechanical Broom Sweeper

Regenerative Air Sweeping Machine: The regenerative air sweeper uses a broom to collect large debris/ wastes; it also uses forced air and high power vacuum for the collection of fine material. The sweeper blows high pressure air onto the road to loosen very fine sediment. A vacuum suction lifts all particles and captures them in a hopper. Regenerative air sweeper can remove fine sand and dust, provided the surface is dry. Regenerative air sweepers contribute to preventing air pollution by capturing fine sand particles. They have relatively higher energy consumption compared to the mechanical broom sweeper and are quite expensive. They however can clean a wider path, and limit the amount of dust-laden air that is exhausted back into the atmosphere. They are also able to pick up large sized debris, since the blast of air is able to dislodge material and get them into the airflow stream that is created by the suction.

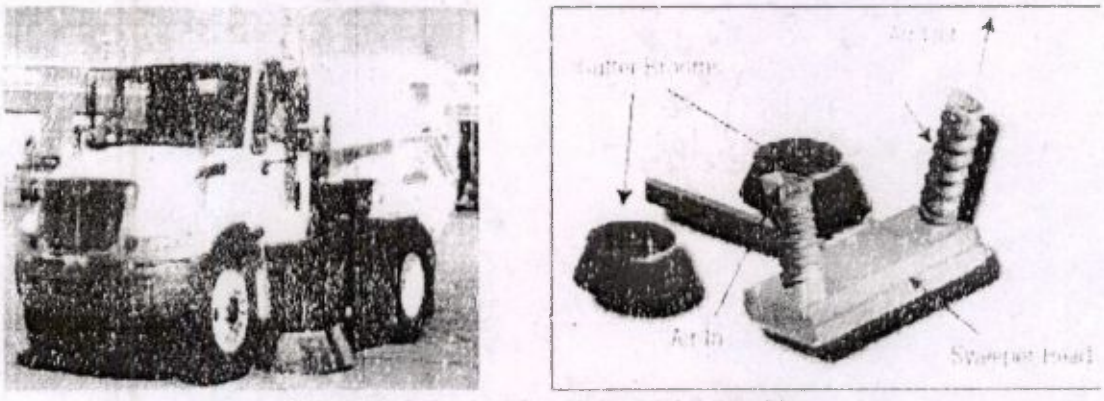


Figure 12: Regenerative Air Sweeping Machine

Vacuum Sweeping Machine: A vacuum sweeper uses a broom to move debris towards the vacuum nozzle. Typically, there is a suction inlet on one side of the sweeping head, and the "used" air is constantly exhausted during the sweeping process .There are various types of

vacuum sweepers based on the location of the vacuum nozzle. Vacuum sweepers utilize a fan that exhausts its air directly to the atmosphere and uses water for dust suppression. They can vacuum material from channels and gutters and collect fine particles from within cracks also, but cannot pick up large debris like tree trimmings and disposed packaging. However, since there is no vacuum suction beneath the broom, the area of the road under the broom may still retain fine material. Vacuum sweepers use water-based dust suppression systems.

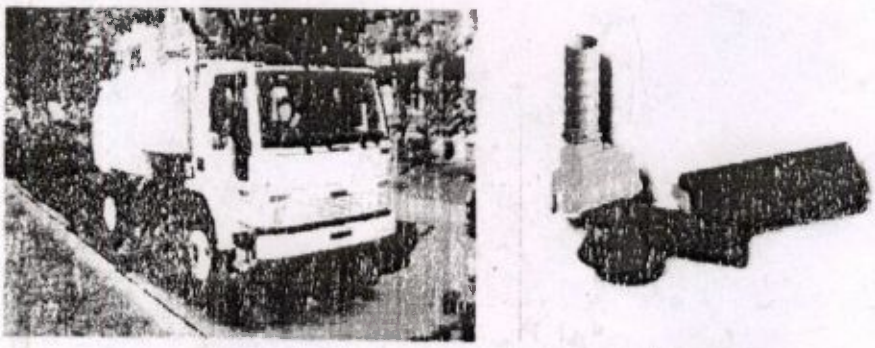


Figure 13: Vacuum Sweeper and Vacuum Nozzle

Table 46: Comparison in between different Types of Mechanical Sweeping Vehicles

Sr. No.	Particulars	Mechanical Sweeper	Regenerative Air Sweeper	Vacuum Sweeper
1	Working Capacity	10-15 Km per 8 hours	10-15 Km per 8 hours	15 Km per 8 hours
2	Number	2	2	2
3	Life cycle	7 Years	7 Years	7 Years
4	Capital Cost in Rs.	26,00,000	44,00,000	70,00,000
5	O & M Cost in Rs.	12,00,000	15,00,000	18,00,000
6	Workers Required	6	6	6

It has been assumed that one sweeping machine would be able to sweep about 15 Km in 8 hours. Thus in morning shift of 8 hours from 6 AM to 2 PM, 11-13 Km of road would be swept while in the night shift, which is from 10 PM to 6 PM the same sweeping machine would sweep another 11-13 KM of road. Thus, one sweeping machine in a span of 24 hours is able to sweep 25 Km

Table 47: Mechanical Sweeping Vehicles Requirement

Borough No.	Roads length (Km)	Mech. Vehicle Req.							
		2015	2017	2022	2027	2032	2037	2042	2047
1	17	1	1	1	1	1	1	1	1
2	5	0	0	0	0	0	0	0	0
3	5	0	0	0	0	0	0	0	0

Borough No.	Roads length (Km)	Mech. Vehicle Req.							
		2015	2017	2022	2027	2032	2037	2042	2047
4	12	0	1	1	1	1	1	1	1
5	23	1	1	1	1	1	1	1	1
	62	**2**	**3**	**3**	**3**	**3**	**3**	**3**	**3**

One Driver and one Collector are required for one Mechanical Sweeping Machine.

Table 48: Total Workers required for sweeping (Manual and Mechanical)

Borough No.	Roads length (Km)	Total Workers Req.							
		2015	2017	2022	2027	2032	2037	2042	2047
No. I	8	261	266	279	292	305	318	331	344
No. II	10	83	84	89	93	97	101	105	109
No. III	10	97	99	104	109	114	119	123	128
No. IV	10	204	208	218	228	238	248	259	269
No. V	9	341	348	365	382	399	416	433	450
	47	**985**	**1005**	**1054**	**1103**	**1153**	**1202**	**1251**	**1300**

Table 49: PPE Required for Street Sweeping

Year	Worker	Brooms	Shovel	Gloves (Pair)	Boots	Uniform	Helmet	Safety Mask	Wheel Barrow
2015	783	18783	391	783	1565	1565	1565	81392	391
2017	798	19158	399	798	1597	1597	1597	83019	399
2022	837	20097	419	837	1675	1675	1675	87089	419
2027	877	21037	438	877	1753	1753	1753	91159	438
2032	916	21976	458	916	1831	1831	1831	95228	458
2037	955	22915	477	955	1910	1910	1910	99298	477
2042	994	23854	497	994	1988	1988	1988	103367	497
2047	1033	24793	517	1033	2066	2066	2066	107437	517

Brooms	1 broom of lifecycle 15 Days
Shovel	1 Shovel for two workers
Gloves	1 Pair of Glove per Month
Boots	(2 pair of boots per year)
Uniform	(2 pairs in a year)
Masks	(Two masks in a week)
Helmet	(2 Pair of Helmet per year)
Wheel Barrow	1 among two workers

7.3.3 Drain Cleaning:

The silts and dirt collected from drain cleaning constitutes a major source of inert solid waste. Cleaning of drains is needed to keep the storm drainage system in good condition.

As per CPHEEO Manual on Solid waste guidelines – The drains up to 60 cm depth shall be cleaned by Sweepers along with the street sweeping.

- ***Considering 50% of the drains having a depth up to 60 cm.***

So, separate staff required for drain cleaning is based on the assumption that 40% of the total length of the drains to be cleaned manually and rest 10% is to be cleaned using jetting machine.

Table 50: Details of drain cleaning proposed is given below

Sr. No.	Road Type	%age	Length (KM)	Beat Length (KM)	Cleaning criterion	Drain Cleaning per Day (Km)
1	Arterial	4.4	39	78	25% Daily, 25% Weekly, 50% Bi Monthly	25
2	Sub arterial	3.2	28	56	25% Daily, 50% Weekly, 25% Bi Monthly	19
3	Sub arterial Collector	8.1	71	143	50% Bi Weekly, 50% Weekly	20
4	Local	84.3	744	744	50% Daily, 25% on Alternate Days, 25% Weekly	491
Total		100	882	1020		556

Table 51: Manual Drain Cleaners Requirement

Borough No.	Drain to be cleaned Daily (Km)	Drain Cleaned Manually (Km)	Drain Cleaners Req. 2015	2017	2022	2027	2032	2037	2042	2047
1	156	62	104	106	111	116	121	127	132	137
2	41	16	33	34	35	37	39	40	42	44
3	44	17	39	40	41	43	45	47	49	51
4	112	45	81	83	87	91	95	99	103	107
5	204	81	136	138	145	152	159	166	172	179
Total	**556**	**222**	**392**	**400**	**420**	**439**	**459**	**479**	**498**	**518**

Table 52: Mechanical Drain Cleaning Machine Requirement

Borough No.	Drain Cleaned Mechanically (Km)	Drain Cleaning /Sweeping M/c Req.							
		2015	2017	2022	2027	2032	2037	2042	2047
1	16	2	2	2	2	3	3	3	3
2	4	1	1	1	1	1	1	1	1
3	4	1	1	1	1	1	1	1	1
4	11	1	1	1	2	2	2	2	2
5	20	3	3	3	3	3	3	3	3
	56	**8**	**8**	**8**	**8**	**9**	**10**	**10**	**10**
Road Sweeping Machine for Road Sweeping		3	3	3	3	3	4	4	4
Jetting Machine Required		5	5	5	5	6	6	6	6

7.4 Secondary Waste Collection and Transportation

In the proposed system, storage of waste in open dumps has been totally eliminated. The indicators used in order to decide the location of the proposed dustbins are as follows:

i) Identified open dumping locations
ii) Major Landmarks
iii) Existing secondary collection points
iv) Slums

The capacities of proposed secondary dustbins are decided on the basis of:

i) Frequency of collection.
ii) Quantity of waste generation

The following aspects also are taken care off while deciding the type of vehicles to be used:

i) Proposed vehicles are covered and water tight
ii) Having hydraulic attachment for loading and unloading of waste
iii) Can adjust and rotate in the existing junction points.

The following table shows the total number of bins required for the city along with their capacity during the base year:

Table 53: Bin Location and Capacity

Sr. No.	Item	Capacity	Nos.	Location
1.	MS Bins	1.1 Cum		Peripheral areas of the city
		2.5 Cum		Core City
		4.5 Cum		Major Landmarks
2.	Skipper	4.5 Cum		Places of origin of C & D waste
3.	Two Wheel HDPE Bins	120 L		Commercial Areas
		240 L		Hotels and Restaurants
4.	Litter Bins (Two Bin Set)	20 L Each		Places of high pressure of floating population

Sr. No.	Item	Capacity	Type of Vehicles	Frequency	Remarks
1.	MS Bins	1.1 Cum	Refuse Compactor	Daily and alternative days	It has been assumed that dustbins located in the peripheral areas would be cleared on every alternate day basis. City core to be cleared daily.
		2.5 Cum	Refuse Compactor Twin Bin Dumper Placer	Daily	RC could carry both 1.1 cum and 2.5 cum dustbins.
		4.5 Cum	Single Bin Dumper Placer	Daily	Its area of coverage is decided according to the density of population.
2	Skipper	4.5 Cum	Single Bin Dumper Placer	Daily	At locations where C & D wastes are generated.
3	Two Wheel HDPE Bins	120 L	Refuse Compactor	Daily	Shop keepers may dump their waste in the nearest secondary collection bin or may handover the waste when the refuse compactor arrives.
		240 L			
4	Litter Bins (Two bins Set)	20 L each			

However, lime should be sprayed after lifting of the bins. The bins also need to be washed once in a week.

Transportation

As SMC has purchased some new MSW Carrier recently, therefore there is no immediate need to purchase new vehicle.

MSW carried by SMC vehicles was checked at a Weigh bridge near SMC Lanfill Site. It has been observed that Compactor is carrying highest weight 10,570 Kg per trip while Tata Xenon is carrying only 613 Kg per trip.

The Analysis of Weight carried by different types of vehicles is given in the table below:-

Table 54: Total weight carried by vehicle per trip

S. No.	Vehicle Model	Sample No.	Empty Weight of Vehicle(Kg)	MSW Filled Weight of Vehicle (Kg)	Net Weight Carrying per Trip (Kg)	Average Weight Carrying per Trip (Kg)
1	Tata Xenon	1	3280	4370	1090	613
		2	3280	3660	380	
		3	3280	3650	370	
2	Tata 407 Covered Van	1	2580	3640	1060	1060
3	Tata 407 (Tata Truck)	1	3120	5230	2110	2110
4	Tata Tipper - 1613	1	7120	16020	8900	5600
		2	7120	9420	2300	
5	Tata 909	1	4350	6710	2360	2360
6	Compactor -14 CUM	1	11500	22070	10570	10570

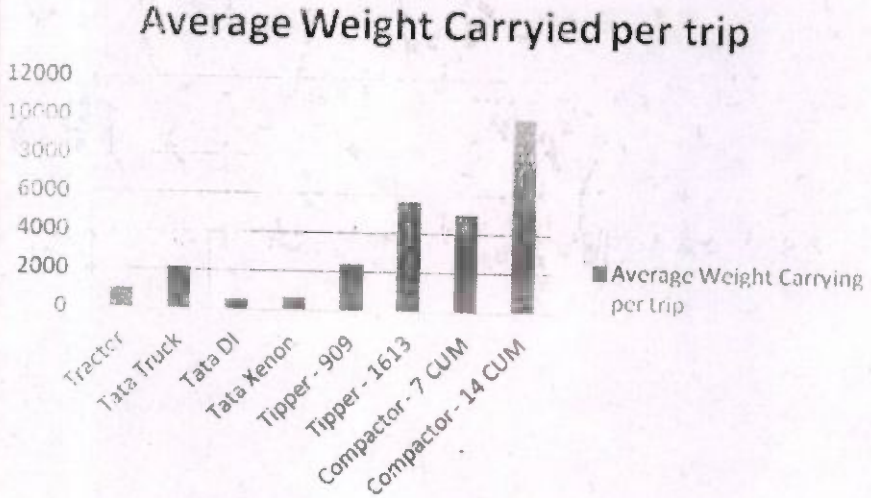


Figure 14: Average weight carrying by vehicles per Trip

Efficiency of each type of vehicle has been calculated by dividing total weight carried by vehicle to fuel consumed per day by each vehicle.

Sr. No.	Vehicle Type	No. of Vehicles	Avg. Trips Per Day	Average Weight Carrying per trip	Total Weight Carrying per day	Avg. Fuel Consumption per Trip	Fuel Consumption per Day	Efficiency of Vehicle
1	Tractor	11	3	1000	33000	3	99	333
2	Tata Truck	4	3	2100	25200	4	48	525

Sr. No.	Vehicle Type	No. of Vehicles	Avg. Trips Per Day	Average Weight Carrying per trip	Total Weight Carrying per day	Avg. Fuel Consumption per Trip	Fuel Consumption per Day	Efficiency of Vehicle
3	Tata DI	4	8	500	16000	2	64	250
4	Tata Xenon	6	8	613	29424	1.5	72	409
5	Tipper - 909	5	3	2360	35400	7	105	337
6	Tipper - 1613	10	3	5600	168000	7	210	800
7	Compactor - 7 CUM	2	2	5000	20000	6	24	833
8	Compactor - 14 CUM	1	2	10000	30000	7	21	1429

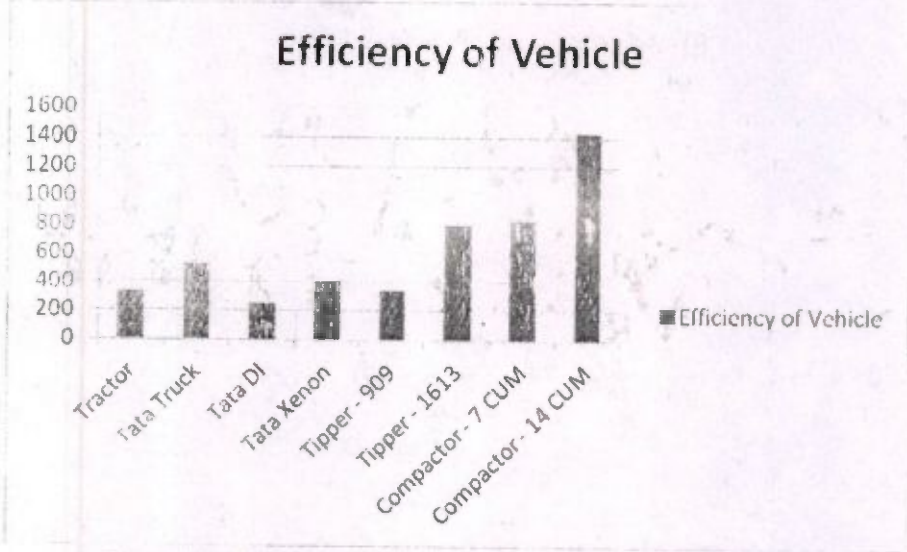


Figure 15 : Efficiency of Vehicle Load Carrying per liter of Fuel

It has been observed that Tractor, Tata 407 Truck, Tata Di, Tata Xenon are having low efficiency therefore these should be used to collect waste from Internal Roads of wards and dump the waste to Secondary collection points from where Compactors shall be used to collect and carry MSW to Landfill Site.

Proposal for Secondary Waste Collection Vehicles: SMC has procured quite large number of vehicles for transportation of Solid Waste to dumping ground. As it is explained above paragraphs that the dumper placer's of Tata – LCV make are less efficient as compared to the Compactors. Secondly, SMC has bought 15 numbers of tippers but the tippers are generally provided to carry C and D waste using a Backhoe.

So in a nut shell if tippers are only used to carry the construction and demolition waste then the existing fleet of vehicles is on lower side. So, 2 numbers of 14 CUM and 1 number of 7 CUM compactors are proposed in addition to the existing vehicles to transport the 120% of the present day waste. The solid waste carrying capacity of the existing and 3 proposed vehicles is given in the table below:

Table 55: Proposal for Secondary Waste Collection Vehicles

S. No.	Type of vehicles	Use	Capacity in CUM	Carrying capacity in MT	Number of vehicles	Number of trips	Total capacity in MT
1	Compactor - 7 CUM	Waste Collection	7	4.9	3	4	59
2	Compactor - 14 CUM	Waste Collection	14	9.8	3	4	118
3	LCV Dumper Placer - 4.5 CUM	Waste Collection		0.6	14	8	67.2
4	Tractor with Covered Refuse trailer	Waste Collection	2MT (Considering 2 Trailers pulled by single tractor)	2	10	4	80
5	Tipper - 9 T	C and D, Drain silt and other Miscellaneous wastes	9	3	2	3	18
6	Tipper - 16 T	C and D, Drain silt and other Miscellaneous wastes	16	6	2	3	36
7	Payloader/BackHoe	Drain Silt and C & D	One each for tipper		2		377.6

Washing of Vehicles: The vehicles also need to be washed daily at the workshop proposed in the campus of the landfill site. After washing of these vehicles, proper hygienic spray shall be applied on it to make it free from harmful bacteria's.

7.5 Biological Processing Technologies

Biological technologies operate at lower temperatures and lower reaction rates, this technology is mainly used for the conversion of organic waste. MSW consists of dry mater and moisture. The dry matter further consists of organic (i.e. whose molecules are carbon –based) and minerals also referred to as the ash fraction. The organic can be further subdivided into bio degradable or refractory organics such as food waste and non-biodegradable such as plastic. Biological technologies can only convert bio-degradable component of the MSW. Byproducts can vary, which include electricity compost and chemicals. Various biological processing technologies are briefly described below.

7.5.1 Composting

Composting is a natural process that turns organic material into a dark rich substance. This substance, called compost or humus, is a wonderful conditioner for soil. There various method of composting described in following section.

7.5.1.1 Windrow Composting

A turned windrow system builds windrows with a front-end loader and then periodically turns or mixes these windrows to maintain air within the pile. The size of the windrow is determined by the type of equipment used to turn the pile. If a front-end loader is used, the pile is usually 8 – 12 feet high because the loader can easily reach to that height to mix the materials. If a specially built machine for turning windrows is used, like a scarab, the windrow is usually only 4 – 6 feet in height in order to accommodate the equipment. The width of these windrows is determined by the size of the equipment being used; usually twice the height. The length is determined by the space available for making the piles.

The aeration of the pile in this method is controlled by the nature of the materials being composted and by the equipment that is used to turn and mix the material every few days. Because no additional effort to maintain air in the pile is expended, the regular mixing of the material to maintain adequate oxygen in the pile is essential. The other parameters of moisture, C:N ratio, and heat are also closely managed. The proper C:N ratio is calculated at the beginning of the process, water is added if needed at the beginning and again along the way if too much moisture has been lost, and the temperature of the pile is constantly measured to help determine how the process is proceeding.

7.5.1.2 Vermi Composting

Vermi composting involves the stabilization of organic solid waste through earthworm consumption which converts the material into worm castings. Vermi composting is the result of combined activity of microorganisms and earthworms. The worm species that are commonly considered are Pheretima sp, Eisenia sp & Perionyx excavatus sp. These worms are known to survive in the moisture range of 20-80% and the temperature range of 20-40oC. The worms do not survive in pure organic substrates containing more that 40% fermentable organic substances. The incoming municipal waste has to be composted aerobically for about 2 to 3 weeks to ensure partial decomposition. The fresh waste is mixed with partially or fully stabilized waste before it is subjected to vermi composting. The earthworms would eat the waste and convert them to casting over 4-6 weeks. The castings have to be collected manually at regular intervals. Earthworm requires shade and protection from rain and predators. A pit over ground is preferred for storing the partially decomposed waste and the worms. The pits have to be covered to provide protection from sun and rain. The inorganic portion of waste, which is not eaten by the worms, is sent for landfill and the organic portions are fed back to the worms. The adult worms and the young worms from each cycle are collected back and used again in the next cycle. The worms are also known to be adversely affected by high concentrations of heavy metals.

7.5.1.3 In Vessel Composting

This system encloses the feedstock in a chamber or some kind of enclosure that mixes, and supplies air and moisture to the material. A large pipe is designed to slowly rotate and move the material along from one end to the other mixing and processing the material at optimum conditions in as little as one week. Another method uses a static aerated pile but covers it completely with a nylon fabric cover. This cover allows the compost manager to more effectively control the moisture and air and most of the odors. Sealing over the aerated windrow results in an in-vessel system. Even though all of these methods are expensive, they have the advantage of being able to compost food wastes much better than some of the other pile methods. While the potential for pathogens and odors is generally higher in food wastes, pathogen reduction, and odor control is easily attained with these in-vessel systems.

7.5.2 Bio Methanation

When municipal solid wastes with a large proportion of organic matter is subjected to anaerobic decomposition, a gaseous mixture of Methane & Carbon di-oxide (CH4 & CO2) known as biogas could be produced under favorable conditions. The process is quite stable and do not upsets easily occur. The gas production ranges from 0.29 m3 /kg of Volatile solids added/day to 0.16 cubic metre (m3)/kilogram of Volatile solids added/day in different seasons. The sludge has good manure value of Nitrogen, Phosphorous; Potassium (NPK: 1.6: 0.85: 0.93) and is observed to drain easily. The process gives a good performance at detention time of 25 days. Anaerobic digestion to produce biogas (then power) is feasible with food wastes free of plastics & ash. Successful solutions to this option will only develop if they are basically self-sustaining and economically viable.

As stated earlier biomethanation is anaerobic digestion of organic materials which is converted into biogas, a gaseous combustible mixture, of methane (CH4). Biomethanation is a biological treatment method that can be used to recover both nutrients and energy contained in biodegradable municipal waste. Biomethanation of organic wastes is accomplished by a series of biochemical transformations - which include in the first stage hydrolysis, acidification and liquefaction followed by a second stage where acetate, hydrogen and carbon dioxide are transformed into methane. The process generates biogas with high content of methane (55–70%) which can directly be used as fuel and by employing gas engines can also generate electricity. One of the most promising methods of treating the organic fraction of MSW and other organic wastes is anaerobic digestion which is well adapted for high-moisture wastes. This technology has dual benefits. It gives biogas as well as manure as end product. Fibre fraction of waste can also be recovered for use as a soil conditioner after biomethanation. The fibre fraction tends to be small in volume but rich in phosphorus, which is a valuable and scarce resource at global level. Apart from methane (55-75%), biogas contains significant amounts of carbon dioxide CO_2, (30-45%), which is non-combustible, along with smaller quantities and traces of Nitrogen (0-5%), Oxygen(<1%) Hydrogen sulphide (0-0.5%) hydrocarbon (<1%), Ammonia (0-0.05%), water vapour (1-5%) and Siloxanes ($CnH_2n+1SiO$, 0-50 mg/m^3).

The complete combustion of $1m^3$ of CH_4 (methane gas) provides about 9000 kcal of heat and after proper pre-treatment, in internal combustion engines electric energy can be produced (or both heat and electricity if a cogeneration engine is used). This technology can be conveniently employed in a decentralized manner for biodegradation of segregated organic wet wastes such as wastes from kitchens, canteens, institutions, hotels, and slaughter houses and vegetable markets. This technology can also be used to manage MSW in a centralized manner in small towns and decentralized manner in large cities provided the municipal authorities collect segregated biodegradable wet wastes from households and establishments. Currently, this technology has been successfully employed in 172 locations in India ranging from 100kg/day to 10 TPD. Commercially available digesters range from 70 m^3 to 2000 m^3 reactor capacity. The smaller digesters make use of the generated biogas (i.e. mixture of CH_4 and CO_2) for heating the digester while larger units generate up to 2 MW of electricity. Biogas produced through bio methanation technology can be upgraded into biomethane which can also be used as a transportation fuel. Alternatively, upgraded biomethane can substitute natural gas (a non-renewable fuel) in variety of domestic and industrial applications. Carbon dioxide is typically removed from biogas only when the target is to upgrade it into biomethane.

Thermal Processing Technologies

Thermal technologies are those technologies that operate at temperature greater than 200°C and have higher reaction rates. They typically operate in a temperatures greater than 200° 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). The calorific value of garbage will help to identify the treatment technologies like Waste-to-Energy and other thermal processes. These technologies are briefly described below.

7.5.3 Pyrolysis

Pyrolysis uses heat to break down combustible polymeric materials in the absence of oxygen, producing a mixture of combustible gases (Primarily methane, complex hydrocarbons, hydrogen, and carbon monoxide), liquids and solid residues. The products of Pyrolysis process are: (i) a gas mixture; (ii) a liquid (bio-oil/tar); (iii) a solid residue (carbon black). Relatively low temperatures (400-9000ºC, but usually about 6500ºC) are employed compared to gasification. The proportion and composition of the various fractions depends on a variety of parameters. Two technologies exist and differ on the method of heat transfer: fast pyrolysis for production of bio-oil and slow pyrolysis for production of charcoal called carbon black. The calorific values of pyrolysis gas typically lie between 5 and 15 MJ/Nm3 based on composition of MSW and between 15 and 30 MJ/Nm3 on RDF.

Low-temperature pyrolysis can also be used to produce a synthetic liquid fuel from waste plastic packaging materials and polymeric wastes. A beneficial byproduct of pyrolysis is a kind of charcoal called "carbon black," which can be used as catalyst, filler material and can also be

7.5.5 Incineration and Mass Burning

Incineration technology is complete combustion of waste with the recovery of heat to produce steam that in turn produces power through steam turbines. Figure 7.2 describes the thermal conversion of municipal solid wastes into electricity.

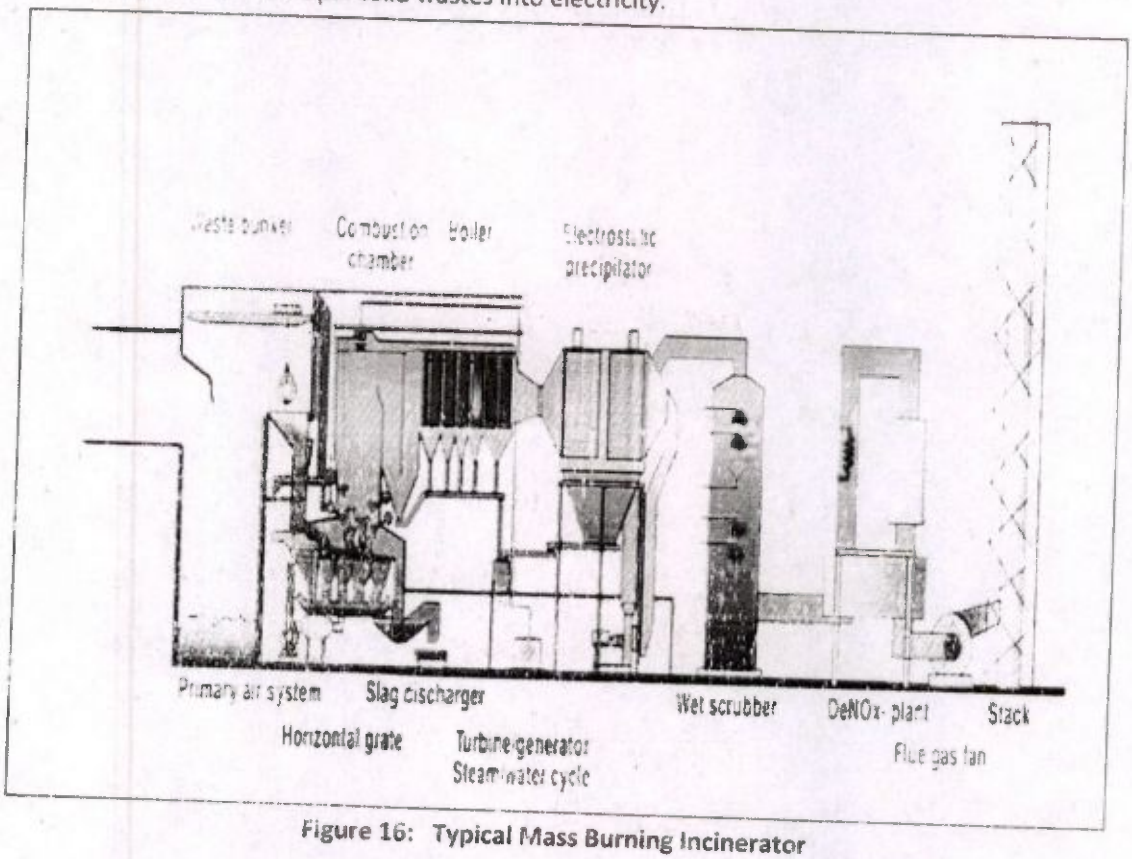


Figure 16: Typical Mass Burning Incinerator

There are a number of combustor designs used to burn combustible fraction of MSW. Complete combustion optimally involves a two-stage transformation of fuel, in this case solid waste, into CO_2 and water vapour

The secondary phase of incineration (combustion) takes place as the combustible materials (e.g., paper, plastics and organic materials containing carbon, hydrogen and oxygen) combine with oxygen to form carbon dioxide and water vapour (oxidizes). But in incinerators, since the waste stream is so heterogeneous, other compounds are also formed and buoyed upward off the grate by the heat of combustion. There are unburned carbon particles, incompletely burned carbon-based compounds, and incombustible elements such as heavy metals, sulphur, nitrogen, and chlorine, which combine with oxygen and hydrogen in the furnace to form compounds such as HCl, SO_2 and oxidized metals.

In most mass burn plants the grate system moves the solid waste through the drying, burning, and burnout zones, while promoting combustion. This is done by ensuring that adequate (but

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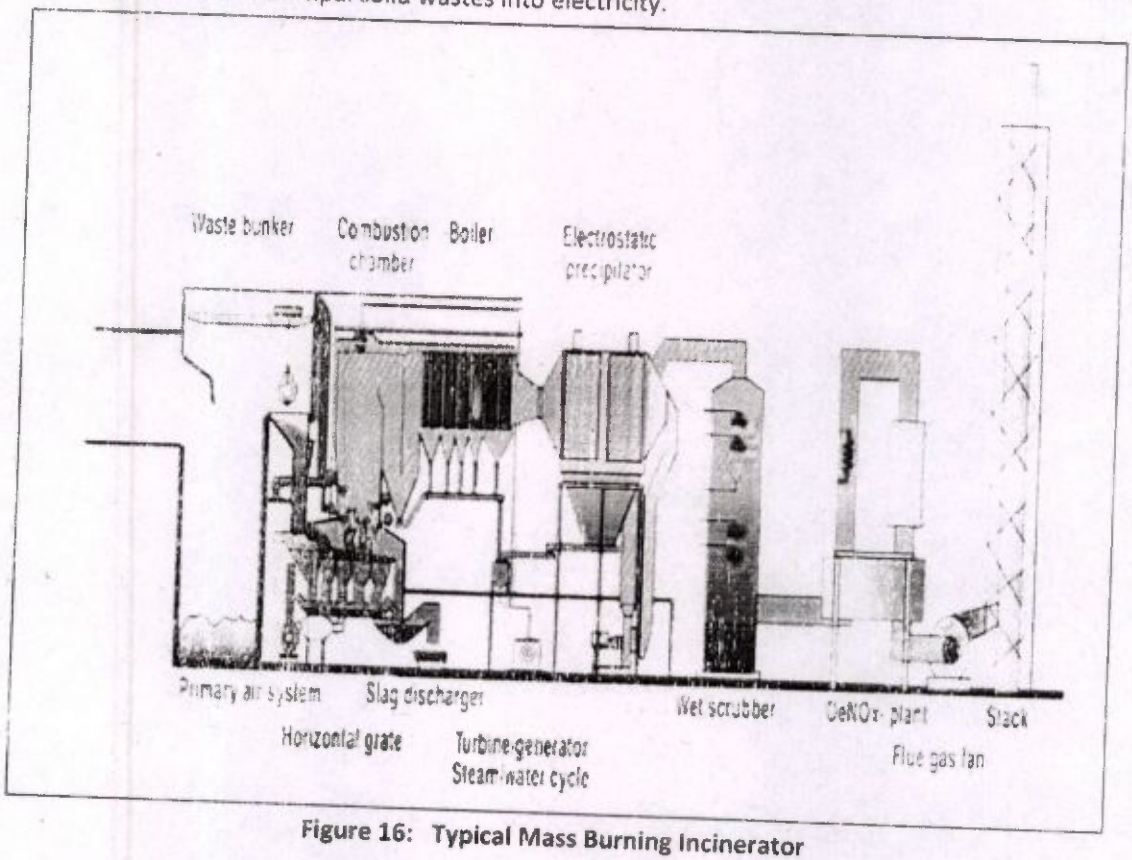

Figure 16: Typical Mass Burning Incinerator

There are a number of combustor designs used to burn combustible fraction of MSW. Complete combustion optimally involves a two-stage transformation of fuel, in this case solid waste, into CO_2 and water vapour.

The secondary phase of incineration (combustion) takes place as the combustible materials (e.g., paper, plastics and organic materials containing carbon, hydrogen and oxygen) combine with oxygen to form carbon dioxide and water vapour (oxidizes). But in incinerators, since the waste stream is so heterogeneous, other compounds are also formed and buoyed upward off the grate by the heat of combustion. There are unburned carbon particles, incompletely burned carbon-based compounds, and incombustible elements such as heavy metals, sulphur, nitrogen, and chlorine, which combine with oxygen and hydrogen in the furnace to form compounds such as HCl, SO_2 and oxidized metals.

In most mass burn plants the grate system moves the solid waste through the drying, burning, and burnout zones, while promoting combustion. This is done by ensuring that adequate (but

not excessive) quantities of air enter from below via holes in the grates. The efficiency of the combustion process, and therefore incineration, is characterized by the "three T's": temperature, time and turbulence. To achieve the temperature requirement, an adequately high and uniform temperature profile must be maintained throughout the furnace volume at all times in order to destroy PICs reliably. In order to optimize combustion of these gases, it is generally considered that the temperature profile (or the secondary chamber) should not fall outside the range of about 1800-2000° F. This means that the temperature should be uniform with no cool spots or short cuts for the gases to exit. Considering the heterogeneous nature of municipal solid waste, with some components highly combustible and others not, strict maintenance of at least a minimum temperature throughout the furnace is necessary.

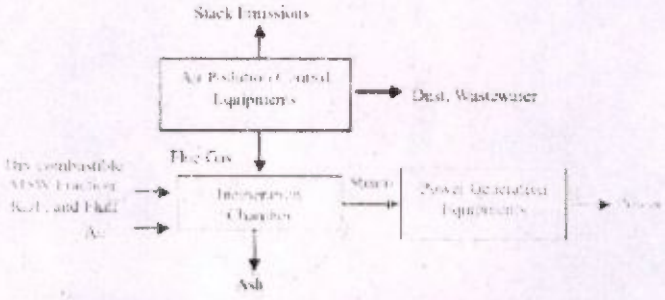

Figure 17: Incineration and Mass Burning Process

RDF and pre-processed MSW are used as fuel in the specially designed boilers and for generation of electricity through steam turbines. RDF being low density fuel generates more fly ash during combustion. Fly ash acts as catalyst for de-novo synthesis (at 200-450ºC) for production of dioxins and furans. In order to reduce formation of dioxins and furans, it is imperative that maximum fly ash is removed before gases cool to the range of 200-450ºC. This requires multiple passes in radioactive section of boiler and results in much bigger boiler for W to E plants. The flue gases produced in the boilers have to be treated by an elaborate air pollution control system. The resultant ash from incineration of solid waste can be used as construction material after necessary processing while the residue can be safely disposed of in a landfill.

Using RDF as a fuel in incinerators is a better option because it is typically formed by augmenting calorific value of combustible wastes with the help of some high calorie-rich industrial wastes or biomass and through application of pressure and/or heat and with the help from binders physical shapes of pellets or briquettes are extruded. It is a possible solution for making W to E a success in India because RDF is easy to transport, has adequate shelf life and it can be prepared in small and medium scale de-centralized facilities and conveniently transported to a regional W to E facility in a radius of 100 km catchment zone. Some of the challenges in applying combustion technologies and their status are as follows:

i) Meeting emission standards (Particulates, NOx, etc.) - Technologies are available for meeting strict pollution control norms
ii) High water consumption – Air-cooled condensers used in India have largely overcome this constraint Multi-fuel capability – being used in some cases

With the above challenges the major research trends in the area of incineration has been towards:

i) Improving the efficiency of low power capacity steam turbines by achieving higher pressures,
ii) Issues related to super heater tube,
iii) Material life, etc.,
iv) Co-firing,
v) Reduce the fossil fuel consumption,
vi) Emission control techniques and
vii) Hybridization.

7.5.6 Syngas

Syngas is a mixture of carbon monoxide (CO) and hydrogen (H_2) or very little quantity of CO_2, which is the product of high temperature steam or oxygen gasification of organic material such as biomass and MSW. In the gasification reactors, the feedstock is converted into a mixture of H_2, CO and CO_2, which produces a variety of downstream energy carriers. Bio-automotive fuels and chemicals can be produced from high-quality syngas (mainly H_2 and CO) which is obtained by gasification of biomass and wastes. Syngas plays an important role as an intermediate in the production of several industrial products, such as methanol and ammonia. Currently, syngas is produced from fossil fuels, mainly coal, natural gas and naphtha. Syngas from renewable resources, such as biomass, exhibits a promising prospective.

7.5.7 Catalytic conversion of waste plastic to liquid fuel

Besides conventional W to E technologies, new technologies are emerging in India for converting polymeric wastes to liquid fuel. Catalytic conversion and pyrolysis are the two technologies currently used for converting plastic waste to liquid fuel. Large size conversion plants are based on pyrolysis while catalytic conversions are used in small batch / cyclic operation. Similarly, soiled plastic wastes are being used for strengthening roads by blending chopped polymeric waste with molten bitumen which reported enhancing the life of the road by 30%.

These emerging technologies appear to be promising and need to be explored in conjunction with other MSW processing technologies to create viable alternatives.

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 and increase its heating value. It may be dandified or palletized into homogeneous fuel pellets and

transported and combusted as a supplementary fuel in utility boiler. These technologies are briefly described below.

7.5.8 Pelletization and Fluff as an RDF to Support Combustion Technology

Refuse Derived Fuel (RDF) is a segregated combustible fraction of MSW. The combustible fraction of the waste is transformed into fuel pellets by the compaction of waste or shredded and converted into fluff, enriched in its organic content by the removal of inorganic materials and moisture. Due to reduction in fuel particle size non-combustible material, RDF fuels are more homogeneous and easier to burn than the gross MSW feedstock. The RDF burning technology includes spreader stroker fired boiler, suspension fired boilers, fluidized bed units, and cyclone furnace units. In order to derive optimum advantage from RDF towards saving fossil fuel; secondary fuel like biomass, rice husk and other agro wastes can be used in small proportions for co-burning to generate energy.

Combustion of the RDF from MSW is technically sound and is capable of generating power. RDF can be fired at temperature above 900ºC along with the conventional fuels like coal without any ill effects for generating heat. Operation of the thermal treatment systems involves higher costs and a relatively higher degree of expertise.

7.5.9 Eco Bricks

So far in India, there is very little effort to manage and utilize C&D waste. There is potential to recycle and reuse C&D waste. The crushed concrete can be used for making pre-cast products like Eco Bricks, Kerbstones, Pavement blocks, square tiles etc. or can be sold as such in the construction industry. As per studies conducted by the Central Road Research Institute (CRRI), there is enormous possibility of using processed C&D waste aggregates for road works and embankment construction.

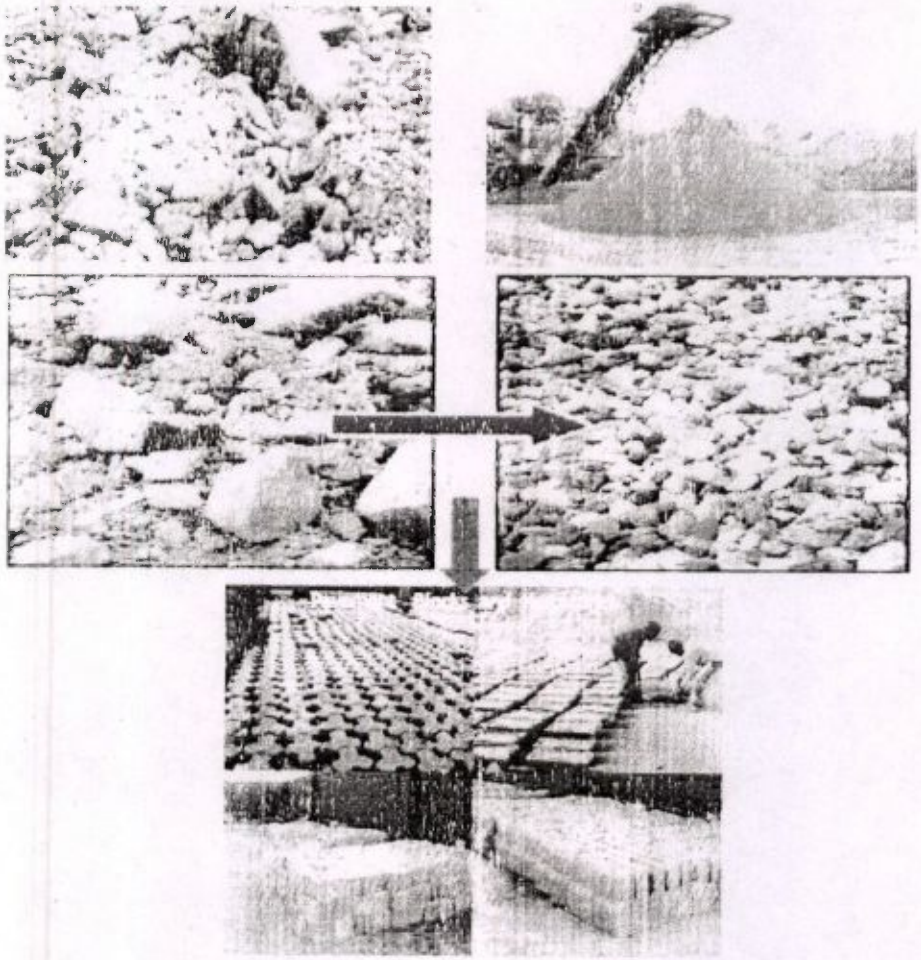

Figure 18: Eco Brick Process

7.5.10 Appropriate Technological Options

Under the Indian context following technologies are identified for processing of MSW:-

- Biomethanation for wet biodegradable wastes
- Conventional microbial windrow/mechanized/ Vermi-composting for wet biodegradable wastes
- Preparation of briquette/ pellets/ fluff as Refuse Derived Fuel (RDF) from dry high-calorific value combustible wastes
- Incineration / Gasification / Pyrolysis for dry high-calorific value combustible wastes
- Plastic wastes to fuel oil
- Plastic Granule Technology

The technologies listed above were identified on the basis of the range of populations and quantity and composition /quality (% biodegradable) of wastes generated. In addition, the cost

of setting up of processing plants along with the expected quantities of value added products and by-products were also considered.

For successful application of the combination of technologies suggested, wet waste, dry recyclable waste and other inert waste should not be allowed to be mixed through proper primary collection system of MSW as suggested in the report.

Following are combination of suitable processing technologies

i) For cities with population of 2 million and above, which generates more than 1100 TPD of MSW a standalone waste to energy plant based on thermal route is suited. These cities should also set up a combination of bio-Methanation, composting (VC/CC) plants besides setting up W to E plants to optimally utilize biodegradable wastes. Conversion of waste plastic to fuel oil and plastic granular technology which is an emerging technology is also suggested as an option

ii) Cities with population between 1-2 million, which generate more than 550 TPD of MSW are suited to setting up a waste to energy plant based on thermal route only with the support of adjoining cities supplying RDF to make the W to E plant viable These cities should also set up a combination of bio-methanation, composting (VC/CC) plants besides setting up of W to E plants to optimally utilize biodegradable wastes. Conversion of waste plastic to fuel oil which is an emerging technology is also suggested as an option.

iii) In respect of 415 Class I Cities which have a population range of 1 lakh to 1 million generating 30 to 550 TPD of MSW, the technological options are a combination of bio methanation, composting (VC/CC) plants to optimally utilize biodegradable wastes. However, these cities may set up a common / regional W to E plant after ensuring adequate availability of RDF on a regular basis from participating cities. Conversion of waste plastic to fuel oil which is an emerging technology is also suggested as an option. Hill stations are also included in this set of cities and local bodies will have to ensure that recommendations made for hill cities in respect of technological options be used for ensuring proper disposal of MSW.

iv) Towns below 100,000 populations which generate less than 30 TPD waste and have 45 to 55% of biodegradable fraction of MSW. A combination of bio-methanation, composting (VC/CC) and RDF preparation is considered as the most suitable technological option for management of MSW. These cities should segregate dry waste, prepare RDF and can supply RDF prepared as fuel to W to E plants established in cities above 1 million populations.

Looking at the population of Siliguri which was around 5,13,264 in 2011 and is around 5,61,819 as on 2015 (projected population) generating a total waste of 300 tons per day with a composition of more than 60% of bio degradable waste.

The technology adopted to treat compostable waste is windrow and for treating C&D wastes, eco brick technology has been proposed. As the percentage of plastic waste has come out to

be less than 10% in the analysed samples so no separate treatment process is proposed for the treatment of plastic waste.

The rejects from the composting process mainly includes soils, sands, stones & inert materials and directly disposed in the sanitary landfill within the project boundary. These rejects do not result in methane emissions as these do not contain any biodegradable material.

After analysis of the waste characterization and feasibility analysis, following option has been proposed for Treatment and Disposal of Solid Waste at Siliguri City.

1. Windrow Composting
2. Refuse Derived Fuel (RDF)
3. Eco Brick Technology
4. Scientific Landfill Site

The project activity utilizes aerobic composting and production of Eco Bricks through C&D waste has been used to process the municipal solid waste.

8. Planning and Design of Treatment Plant

8.1 Integrated Waste Treatment Facility

Designing any waste management facilities the following points to be taken into consideration

- Waste quantities generated,
- Design period,
- Waste characteristics of the proposed city.

8.1.1 Selected Options

The technology adopted to treat compostable waste is windrow and for treating C&D wastes, eco brick technology has been proposed. As the percentage of plastic waste has come out to be less than 10% in the analysed samples so no separate treatment process is proposed for the treatment of plastic waste.

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8.2 Design of Pre-sorting & RDF Plant

The waste reaching the integrated waste management facility is mixed waste, hence, needs to be segregated before its treatment to produce energy/compost. At present, mixed waste will be reaching treatment facility but subsequently after implementing our proposed collection system of wet waste and dry waste from households/commercials the load to the segregation unit will be reduced.

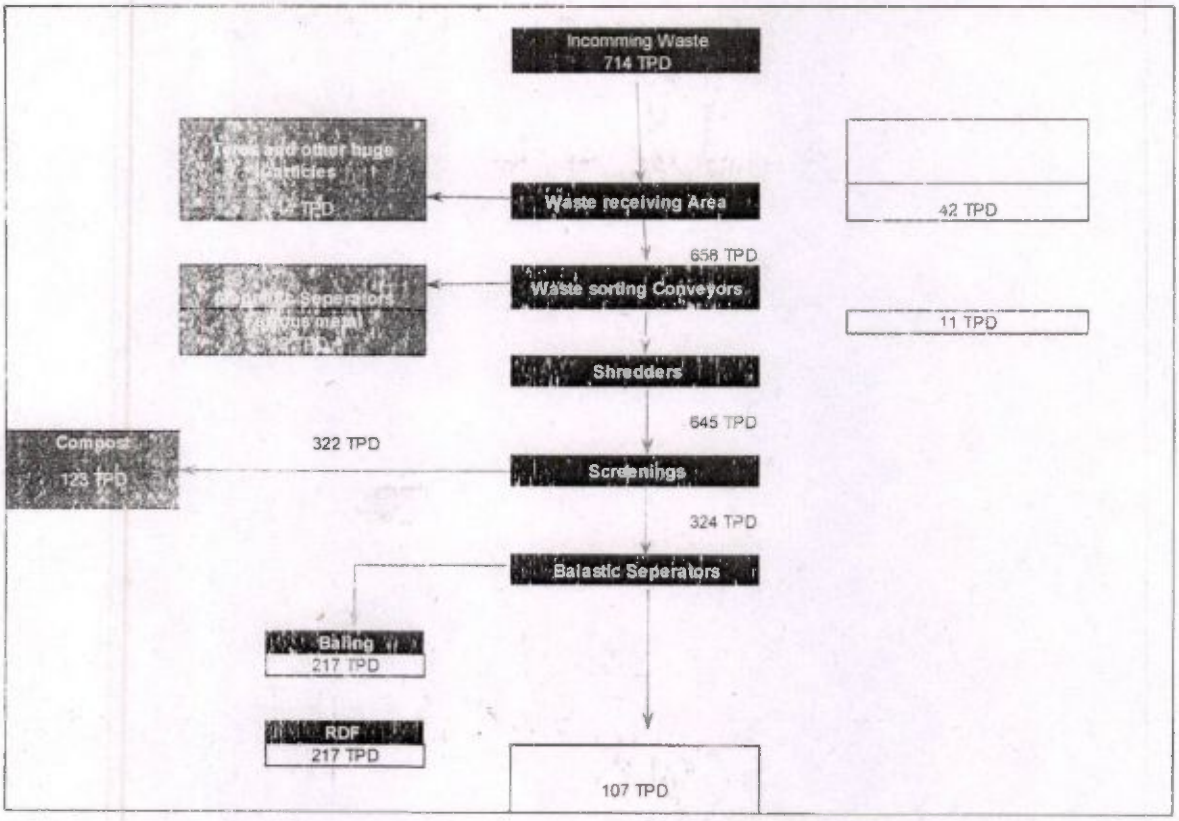


Figure 19: Material balance

Table 56: Material balance

Component	Tonnage (TPD)	Percentage (%)
Compost	78.7	11%
RDF	214.5	30%
Rejects	143.0	20%
Moisture Loss	214.5	31%
Recyclables – PET, Glass, Cardboards etc	35.8	5%
Metals	7.2	1%
Huge articles – tires , boulders etc..,	21.5	3%
Total	715	**100%**

Waste Receiving Platform:-

The waste receiving at the treatment plant will be unloaded into the Roofed RCC waste platform after weighing and inspection of the waste. The bulky material like huge boulders, tyres, coconut trunks and other heavy materials are sorted out manually. After this the waste is fed

using cactus Crab to the feed hopper of pre-processing section. The inclined conveyor belt below hopper takes the waste to manual sorting stations.

Mannual Sorting Platforms:-

Manual Screening is done to separate big objects which cannot be handled by the downstream equipments and machinery. A team of people, in the Manual Pick-up Zone, would insoect and pick out undesirable items from the belt (items of large-sized and/or harmful objects such as machinery parts, lead acid batteries, dead animals, big stones, tyres etc.). The items picked up are dropped onto gravity chutes for disposal appropriately. Large sized combustible objects like textiles, PET bottles, tree cuttings, wooden logs/boxes, etc shall also be picked out manually and put in separate bins provided for the purpose. Such Combustibles objects shall be cut into smaller pieces by a Cutter / Chipper separately to convert it to RDF.

Figure 20: Manual sorting station

- Proposed 2 line of sorting stations
- Ascending conveyors
- Light weight steel construction which will provide space underneath for up to 3 collecting containers for different fractions of valuables.
- The platform will have two staircases with handrails at the upstream end of the platform and two security ladders at the other end of the platform.
- Sorting platform will have sorting workplace, discharge chutes and provision of collecting containers.
- Sorting Conveyor

Magnetic Separators:-

Fractions after manual sorting belt shall be carried by a Belt Conveyor subjected to Magnetic separation and Homogenized (size reduction) through a Shredder to reduce the particle size down to less than 100 mm (the Magnetic Separator separates ferrous materials mixed with MSW) two numbers.

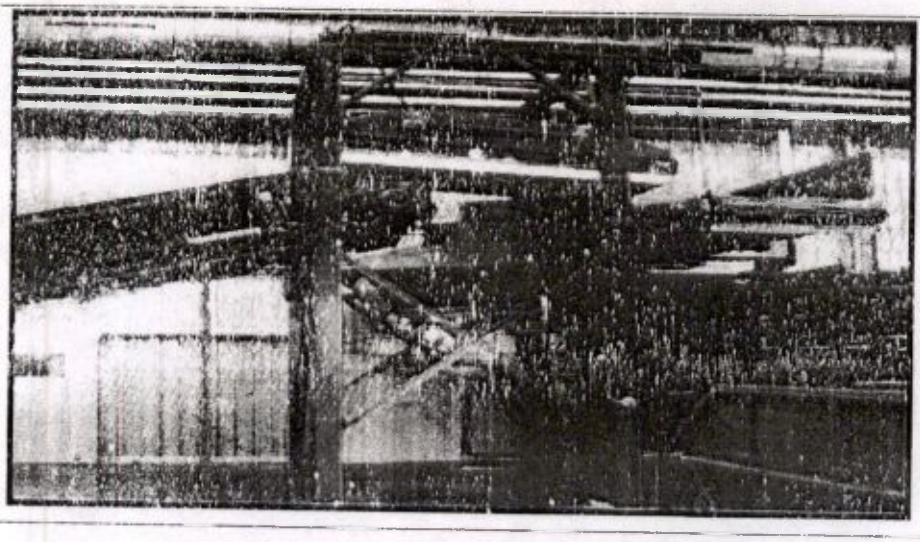


Figure 21 Magnetic Seperator

Shredders Used For Homogenization:-

Shredders are used to reduce the size of the waste down to 100mm. Size reduction helps in easy bio degradation and screening of waste. Also reduces the volume and load on to the presorting screens.

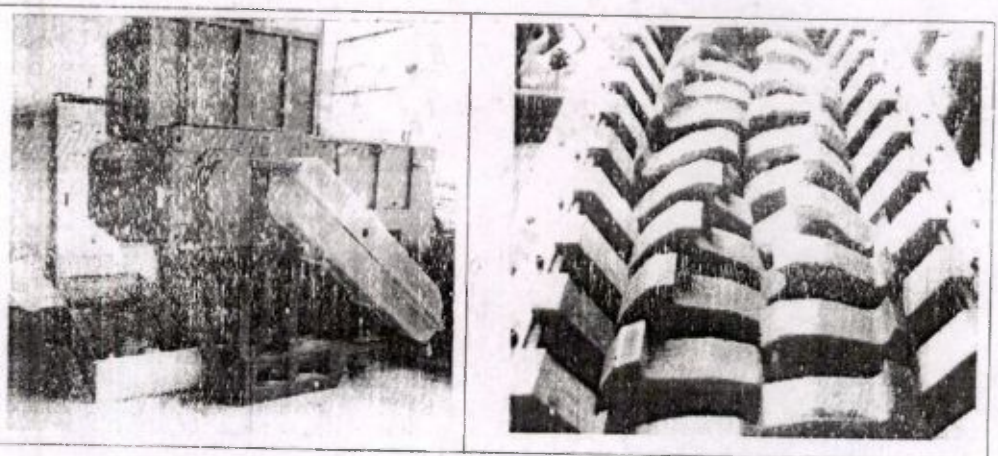


Figure 22: MSW Shreder

Pre Sorting Trommel:-

Waste after size reduction is fed into trammel with 50mm perforations. The undersize material (-50mm) are mostly organic material and over size are inorganic and combustible materials. The undersize is then transferred to compost plant for aerobic composting. The over size is further sent to aeration & screening to convert into RDF.

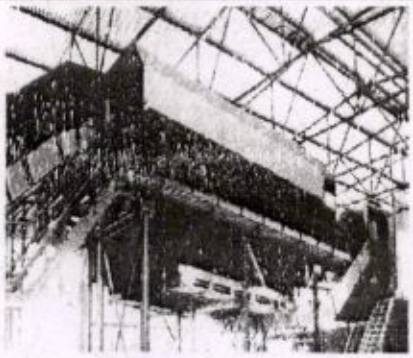


Figure 23: 50 mm tormmel

- Trommels shall be provided on each line of the process 50 TPH capacity.
- Diameter of the Tromrnel will be 1.5m dia x 10m length
- The Trommel will nave 50mm perforated welded mesh openings
- Power required will be 35 Hp with 960rpm.

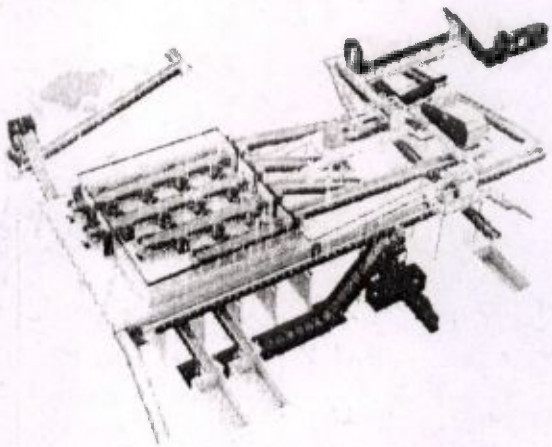


Figure 24: Sorting Stations and Screening

Air Dryers/Hot Air Generators:-

The oversize material (+50mm) coming out of trommels shall be passed through Air dryers where wet MSW is dried by injecting hot air into the system. The moisture content shall be brought down to 15%. The hot air is generated in a fixed grate specially designed Hot Air Generator (HAG). Alternately the hot air will be tapped from the power plant flue gas.

Ballistic Separator

The Ballistic Separator is equipment designed to separate solid waste at the inlet, depending on characteristics of size, density and shape. The equipment consists of an access ramp formed of

longitudinal drilled sheets, which have a ballistic type movement as a result of their two crankshafts located transversally on the top and bottom parts of the ramp. The inclination of the machine and the oscillatory movement of the paddles allows for the separation of the inlet flow in 3 different fractions

- 3D: Rolling elements, heavy elements, stones, etc.
- Fine elements: Sand, remains of food, etc.
- 2D: Planar, lightweight elements, paper, chipped plastic etc.

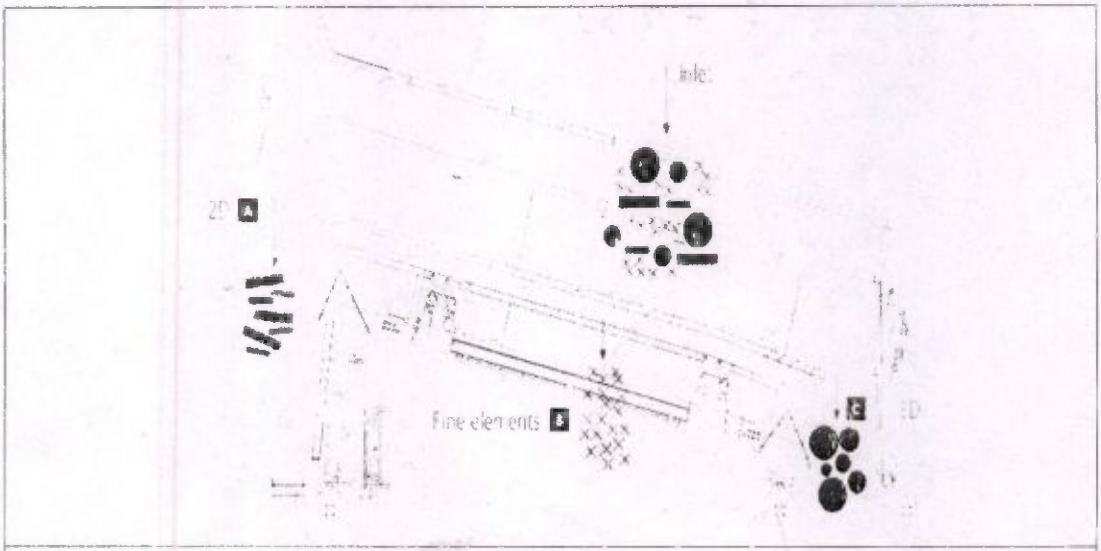


Figure 25: Process flow of Ballistic Separator

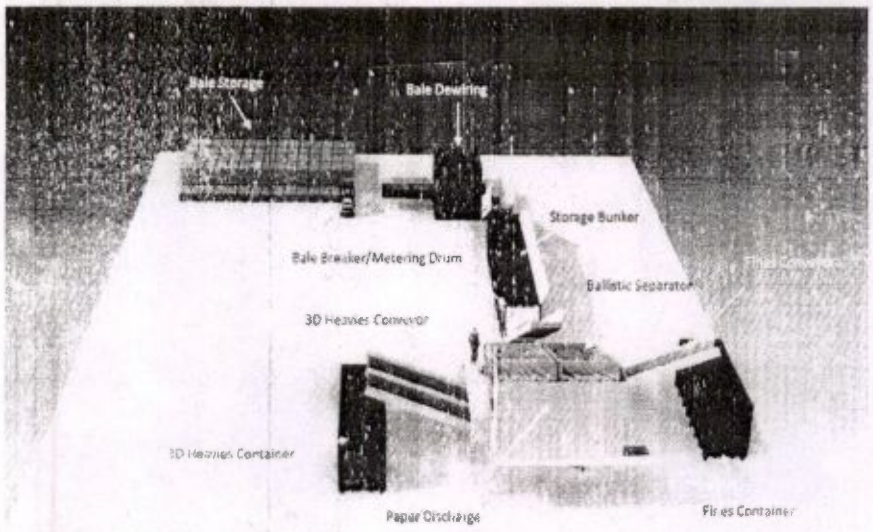


Figure 26: Typical view of Ballistic Separator

The output materials of the ballistic separator shall process as shown below

- 3D fraction which consists of heavy materials shall go to landfill
- Fines which consists of organic content shall go to composting plant
- 2D fraction which consists of lighter particles like paper, plastic etc. shall go to bailing for RDF storage

RDF Bailing & Storage:-

The 2D fractions from ballistic separators generally called Refuse Derived Fuel (RDF) Fluff. It will have a calorific value in the range of 2000 - 2500 kcal/kg with 15-20% moisture and 15-20% ash which can be incinerated in a boiler of the Power Plant. RDF produced shall be transported to the Power Plant through a Belt Conveyor for incineration or shall be providing a go down for storage of RDF material for at least 15 days.

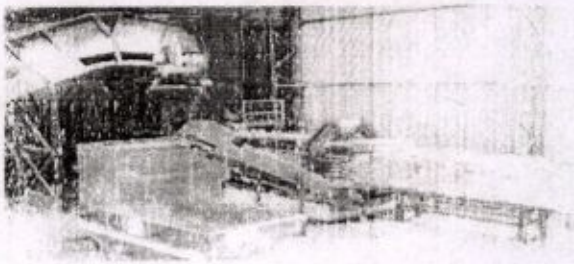


Figure 27: RDF Bailing

RDF PROPERTIES:-

MSW collected from different sources has different calorific values. However, after drying and separation of non-combustible fraction, the RDF produced shall have an average calorific value of 2000- 2500 kcal / kg with particle size of the size of about 100 mm acceptable for combustion in the Boiler of a Power Plant. The physical properties of RDF fluff produced shall have the following properties

Physical Properties of RDF Bale

- Shape :- Irregular
- Size :- 100mm x 100mm
- Bulk Density :- 100kg/m3 -200 Kg/m3

Proximate analysis

- Moisture : 10 % - 20 %
- Ash content : 10 % - 20 %
- Volatile matter : 40 % - 60 %
- Fixed carbon : 10 % - 20 %

Ultimate analysis

- Moisture : 10 % - 20 %
- Mineral matter : 15 % - 25 %
- Carbon : 35 % - 40 %
- Hydrogen : 5 % - 8 %
- Nitrogen : 1 % - 1.5 %
- Sulphur : 0.2 % - 0.5 %
- Oxygen : 25 % - 30 %

Combustion Properties

Gross Calorific Value of RDF (Avg.) : 3,000 kcal / kg

- Ash Fusion Temperature
  - Initial Deformation temperature : 860 o C
  - Softening temperature : 950 o C
  - Hemispherical temperature : 1040 o C
  - Fluid temperature : 1100 o C

Chloride Content : 0.04 %

Elemental Ash Analysis (% of Oxides)

- Silica : 53.10 %
- Alumina : 11.18 %
- Iron Oxide : 4.87 %
- Titanium dioxide : 0.89 %
- Calcium Oxide : 13.15 %
- Magnesium oxide : 2.90 %
- Sodium oxide : 5.79 %
- Potassium oxide : 1.56 %
- Sulphur trioxide : 2.55 %
- Phosphorous pentoxide : 1.43 %

Construction Specifications And Functions Of All The Presorting & Rdf Units

The Presorting unit consists of waste receiving platform , presorting shed and RDF unit consists of RDF process shed and RDF storage go down

Parameter	General Requirements
Waste receiving platform	Open to Sky Concrete platform with proper slope shall be provided to prevent leaching into the ground and to provide hard surface to facilitate machine movement. Retention period is 3 days

Parameter	General Requirements
	1.2 to 1.5m high external brick wall shall be provided to avoid wastes being blown away by the wind and prevent spillage outside. The drain will be provided outside the wall. There will be an opening provideo in the bottom of the wall to drain the leachate into the drain. The opening is of 30cm x 20cm size covered by wire mesh structure so that only liquid can pass through. **Function of the waste receiving platform** is used to unload the incoming waste. This is the starting point of the treatment facility. On this platform any bulk articles like tyres, boulders shall be man picked and removed. Slope shall be maintained to collect lechate and transport. The detention period is 3 days.
Presorting shed	Roofing is required to protect from rain & Sun Concrete platform with proper slope shall be provided to prevent leaching into the ground. The Facility will be equipped with with hopper, feeding conveyor, manual sorting stations, magnetic separator, shredders, trommels of 50 mm, reject conveyors and transfer conveyors. The under sized organic material will be conveyed by transfer conveyor to composting area and oversized shall be transferred to RDF processing unit.
RDF Process Shed	Roofing is required to protect from rain & Sun Concrete platform with proper slope shall be provided for workability. The facility will be equipped with conveyors, Hot air generators/Air dryers , ballistic separators to separate incoming waste into 3 fractions and bailing units.
RDF Godown	Roofing is required to protect from rain & Sun Concrete platform with proper slope shall be provided for workability. Storage capacity is for 7 days to store RDF

Waste Receiving Platform:-

Description	Quantity	
MSW Incoming waste in to the plant in TPD	715	TPD
Duration	3	days
Total quantity of waste for 3 days	2145	TPD
Density of MSW in ton/cum	0.45	
Volume of Waste in cum	4767	Cum
height of stack waste on platform in m	2	m
Area required to stack waste on platform in sqm/day	2383	sqm/cum
Add extra for working space movement	25%	
Total Area required	2979	sqm/cum
Dimensions of platform	**65 X 46**	

Presorting shed:- Size of the shed proposed for presorting section is - **50m x 15m**

RDF Process shed:- Size of the shed proposed for presorting section is - **50m x 25m**

The above dimensions are arrived based on equipment length, no of lines and quantity handled.

Storage godown:- Size of the shed proposed for storing RDF - **100m x 25m.**

Table 57: List of Processing Machineries & Equipments (Mechanical)

S. No	Equipment	Nos	Capacity	Purpose
	Pre Sorting & RDF specification for each line			***Proposed 2 lines with 8 hrs working***
1	Feed hopper	4		For homogeneous waste transfer onto conveyors.
2	Z conveyors	4	10 TPH	For conveying Raw waste to manual sorting stations
3	Manual Sorting Belt	4 lines	10 TPH	For handpicking recyclables
4	Magnetic Separators	2		For separation of Ferrous metals fixed on conveyors.
5	Shredders	2	50 TPH	Reducing the size of the waste for easy screening.
6	Rotary Cage Drum-trommel sieve of 50mm	2	50 TPH	For segregating large size Components for sorting
7	Chain belt Conveyor	2	20TPH	For conveying undersize to compost plant
8	Z conveyor	2	20 TPH	For conveying oversize to RDF plant
9	Air dryers	2		For drying waste to entering into ballistic seperator
10	Ballistic Separator	2	30 TPH	For separation of lighter and heavier materials
11	Baler	2	25 TPH	To bale the combustible material for easier transportation

Mobile Equipment for presorting and RDF plant operations

Table 58: Mobile Equipment

S.no	Name of the Equipment	Nos.
1	Grab Loaders	4
2	Front End Loader	4

S.no	Name of the Equipment	Nos.
3	Fork lifts	4
4	Tippers	2

8.3 DESIGN OF COMPOST PLANT

The undersize materials of trommel screen shall is the input material for compost plant and also fines from ballistic separator is also added into the compost plant.

Composting is a process of microbial degradation where organic matter is broken down by a succession of organisms in a warm, moist aerobic environment (controlled conditions).

Composting is a form of recycling. The composting process of organic waste helps in decreasing the amount of solid waste that must be sent to a landfill thereby reducing disposal costs. Composting also yields a valuable product that can be used by farmers, landscapers, horticulturists, government agencies and property owners as a soil amendment or mulch. The compost product improves the condition of soil, reduces erosion and helps suppress plant diseases.

Composting is an age old practice and the word compost is as old as agriculture itself. The solid wastes of plant and animal origin are utilized for conservation of carbon and mineralization.

The Compost Production Process

Composting is a process involving bio-chemical conversion of organic matter into humus (Lignoproteins) by mesophilic and thermophilic micro organisms. A composting process seeks to harness the natural forces of decomposition to secure the conversion of organic waste into organic manure. Composting can be done in two ways:

- Aerobic Composting.
- Anaerobic Composting.

Aerobic composting is more advantageous than anaerobic composting because of

- Rapid decomposition, normally completed within 6 to 8 weeks resulting in reduction of area required.
- Process is exothermic and the heat generated helps in destruction of harmful pathogens, eggs of disease carrying vectors and nullification of weed seeds.
- Production of foul smelling gases like methane, hydrogen sulphide is minimized.
- Nutrients are fairly preserved.

In order to accelerate and control the aerobic composting a specially formulated biological inoculum will be used to treat the organic waste, which is the key element in our technology. The inoculum will be subject to continuous improvement in composition

The processes involved in composting are as follows:

- Organic waste is delivered in a windrow.
- Biological Inoculums is sprayed on the waste in required quantities
- Water is sprayed on the waste or by addition of biological inoculums
- Each windrow is turned on 6th and 11th days outside to the center to provide aeration. This also destroys insect's larvae.
- Turning is carried out by using front end loaders etc.
- On 16th day winorow is broken down
- It is then passed through a rotary screen of about 35mm&16mm square mesh to remove oversize contrary material
- The oversized material +35mm & +16mm is sent to air classifier with lighter particles to RDF and heavier particles to landfill for disposal
- The under size (-35mm & -16mm) material is send to curing shed for maturation for 2 to 3 weeks.
- The material after curing is send to 4mm perforations fine screen. The +4mm fractions are send to
- Screened compost is to be stored for 30 days to ensure stabilization

The schematics of composting process are as follows:

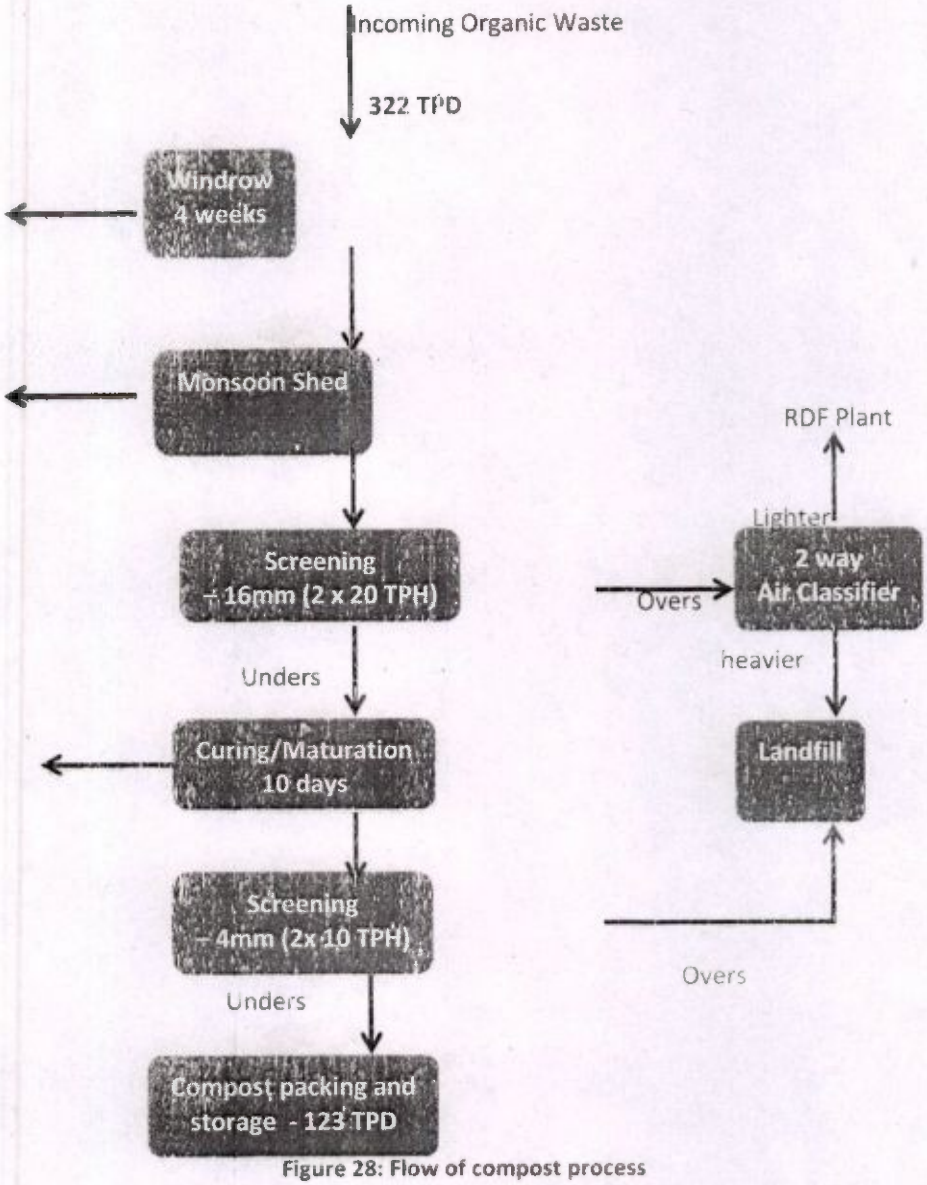


Figure 28: Flow of compost process

The organic material present in MSW can be converted into a stable mass by aerobic decomposition. Aerobic microorganisms oxidize organic compounds to carbon dioxide and oxides of nitrogen and carbon from organic compounds used as a source of energy, while nitrogen is recycled. Due to temperature reactions, temperature of mass rises.

The final product so produced will be black in colour, fine powdery in nature, has an earthy aroma and is completely free from pathogenic organisms and weed seeds. This product is the one, which has undergone sanitization and stabilization. This ensures pH and C/N ratio at the required levels.

Important factors responsible for a scientific decomposition over a specific period of time are as follows:

Carbon Nitrogen Ratio

The decomposition of organic matter is effected by the presence of carbon and nitrogen. Decomposition of organic matter is brought about by living organisms, which utilize the carbon as a source of energy and the nitrogen for building cell structures. More carbon than nitrogen is needed but if carbon is too high, decomposition decreases. In the soil, another factor enter into the series of nitrogen cycles, occurring when carbon is in great excess, it is the presence of nitrogen in the soil in a form available to bacteria. In case too great a ratio, it will result in living microbial cell's making use of the available soil nitrogen in the proper proportion. This condition is known as "Robbing' the soil of nitrogen and has the effect of delaying the availability of nitrogen as a fertilizer for growing plants. A C/N ratio of 20 has been widely accepted as the upper limit at which there is no danger of robbing the soil of nitrogen.

The optimum C/N ratio for composting therefore cannot be optimum one for the soil, since, the living organisms utilize about 30 parts of carbon for each part of nitrogen an initial C/N (Available quantities) ratio of 30:01 would seem most favorable for rapid composting.

Moisture Content

Aerobic decomposition can proceed at any available moisture content from 30% to 100%, if aeration can be provided.

In practical aerobic composting, high moisture content must be avoided because water displaces air from interstices between the particles and thereby give rise to anaerobic conditions. On the hand too low moisture content deprives the organisms of the water needed for their metabolism.

The maximum moisture content for satisfactory aerobic composting will vary with the material used. Investigation indicates that the moisture content of the municipal refuse fall in the range of 40 to 60% which is most satisfactory range for aerobic composting. Additives of various types are used with materials such as night soil, sewage sludge, garbage slop, which contain excessive amounts of moisture. When the moisture content is too low (below 40%) it may be corrected by adding water to it.

Temperature

Proper temperature is a very important factor, particularly in the aerobic composting process. High temperature is essential for the destruction of pathogenic organisms and undesirable weed seed. The optimum temperature range is between 50°C to 70° C, around 40° C usually being the most satisfactory. The temperature increase in the mass leads to sanitization where harmful pathogens, weed seeds are killed. This is also an important one in the composting process.

Aeration

Aeration is necessary for thermo-phillic aerobic composting in order to obtain the rapid decomposition, fast decomposition that is characteristic of the process and also is useful in reducing high initial moisture content in composting materials. Several different aeration techniques have been utilized with varying degrees of success. Turning the material is the most common method of aeration when composting is done in stacks. Hand turning of the compost in piles or pits is most commonly used for small villages and farms. Mechanical turning is most economical in large municipal installations. The most important consideration in turning compost apart from aeration is to ensure that the material on the outside of the pile is turned into the centre, when it will be subjected to high temperature. In hand turning with forks, this can be readily accomplished-e.g., piles or windrows on top of the ground are simply reconstructed with the materials from the outer layers placed on the inside of the new piles. In case of composting in pits, or trenches, the material can be moved from one pit to another for aeration or if a little space is left at the end of the pit at the initial filling, the material can be turned within the pit. The loss of volume of the material during the stabilization period will facilitate turning within the pit. Mechanical equipment for turning windrows in large composting operation has been developed extensively as a result of the increased interest in composting as a method of refuse disposal.

The important criterion for the high degree of aeration is for the avoidance of anaerobic conditions, maintenance of high temperature and the control of flies.

pH Value

Decomposition will be faster at a neutral pH range because most microorganisms grow faster under these conditions. Under aerobic conditions, there will be a drop in pH-value initially which later begins to rise resulting in a slightly alkaline in the final stage.

Alkaline characteristics in the decomposing stage conditioned with high temperature leads to loss of nitrogen through volatilization of ammonia. This occurs mostly when composting materials have a low C/N ratio. Organic matter with pH-value of 5.5 to 8 is suitable for decomposition.

Use of Inoculum

Special inoculum containing several pure strains of developed, laboratory-cultured micro-organisms, which are essential in the decomposition of organic matter, can be used for accelerated decomposition and quality improvement.

Microorganism like:

- Bacillus sp.
- Trichoderma sp.
- Aspergillus sp.
- Phanerochaete sp.

Use of inoculum like consortium of degrading micro organisms / cow dung solution has been recommended mainly to reduce period of decomposition to around 40 to 45 days and also to prevent foul smell and leachate generation.

Construction Specifications and Functions of all the Compost Plant Facilities

The Composting Plant apart from Tipping floor & presorting shall be consisting of the following facilities and components:

1. Windrow Platform
2. Monoosn shed
3. Preparatory Section
4. Curing Shed
5. Refinement Section
6. Godown

Parameter	General Requirements
Windrow Platform	Open to Sky Concrete platform with proper slope shall be provided to prevent leaching into the ground and to provide hard surface to facilitate machine movement. Retention period is 28 days 1.2 to 1.5m high external brick wall shall be provided to avoid wastes being blown away by the wind and prevent spillage outside. The drain will be provided outside the wall. There will be an opening provided in the bottom of the wall to drain the leachate into the drain. The opening is of 30cm x 20cm size covered by wire mesh structure so that only liquid can pass through. **Function of the windrow platform** is to treat organic waste from the presorting unit to the windrow platform and the waste will be piled up in a trapezoidal shape with a height of 1.5. There will be seven rows for each days waste and these rows of waste will be shifted for every week into the new position. Innoculum will be spread onto the fresh waste to speed up the degradation of the organic matter. The detention period is 28 days.
Monsoon Shed	Roofing is required to protect from rain. Height clearance of 5.5m is required for dumping, spreading, mechanical aeration, and proper ventilation Concrete platform with proper slope shall be provided to prevent leaching into the ground and to provide hard surface to

Parameter	General Requirements
	facilitate machine movement. Retention period is 7 days 1.2 to 1.5m high external brick wall shall be provided to avoid wastes being blown away by the wind and prevent spillage outside. The drain will be provided outside the wall. There will be an opening provided in the bottom of the wall to drain the leachate into the drain. The opening is of 30cm x 20cm size covered by wire mesh structure so that only liquid can pass through. **Function of the Monsoon shed** is protect the decomposed waste from rain before going to primary screening. The semi decomposed waste can be stored in the monsoon shed for 15 days. The waste will be piled up in a trapezoidal shape with a height of 1.5.
Preparatory Section	Roofing is required to protect from rain & Sun Concrete platform with proper slope shall be provided to prevent leaching into the ground. The Facility will be equipped with hopper, feeding conveyor, trommels of 35/16 mm, reject conveyors and transfer conveyors. The under sized digested material will be conveyed by transfer conveyor to curing area and rejects shall be conveyed by tipper to the landfill.
Curing Shed	Roofing is required to protect from rain & Sun. Concrete platform with proper slope shall be provided to prevent leaching into the ground and to provide hard surface to facilitate machine movement. Digested material will be stacked in the curing area for 10 days for further digestion and maturation of the digested material
Refinement Section	Roofing is required to protect from rain & Sun Concrete platform with proper slope shall be provided for workability. Vibro screen (4mm) rejects material above 4mm and density separator segregates metals (ferrous and non-ferrous), pebbles, sand and all undigested but same sized contaminants by weight.
Godown	Roofing is required to protect from rain & Sun Concrete platform with proper slope shall be provided for workability. Storage capacity is for 7 days.

Design of Compost Plant

The following are the design concepts adopted to arrive at the sizes of various components of compost plant.

	Waste Quantity & Composition	20 Years	30 Years	
1	Initial waste generation	336.0	336.0	t/day
2	Waste generation	576.0	714.4	t/day
3	Biodegradable Waste	45%	45%	
4	Recyclable Waste	40%	40%	
5	Inert	15%	15%	
	Design of Compost Plant			
	Capacity & Land Requirement			
1	Design Period	20	30	Years
2	Ultimate waste for compost	259.2	321.5	t/day
3	initial compost period	28	28	days
4	total waste for composting	7,258	9,002	tons
5	Length at Top	30	30	m
6	Width at Top	20	20	m
7	Wlength at Bottom	20	20	m
8	Width at bottom	10	10	m
9	Depth	1.5	1.5	m
10	Area of each windrow	400	400	cum
11	Volume of each Windrow	600	600	
12	Assumed waste density in compost	0.5	0.5	t/cum
13	Waste handled in each windrow	300	300	cum
14	number of widrwos required (Design life)	25.00	31.00	no.s
15	Net area for each windrow	600.00	600.00	sq. m
16	Gross area reqd. for each windrow	780.0	780.0	sq. m
17	total area required for compost	19,500	24,180	sq. m
18	total area for composting	19,500	24,180	sq. m
19	Area required for other faciilities (tipping floor, processing and storage & facilities)	25350.0	31434.0	sq. m
	Mancent Sites			
2	Ultimate waste for compost	155.5	192.9	t/day
3	initial compost period	7	7	days
4	total waste for composting	1,089	1,350	tons
5	Length at Top	30	30	m
6	Width at Top	20	20	m
7	Wlength at Bottom	20	20	m
8	Width at bottom	10	10	m
9	Depth	1.5	1.5	m
10	Area of each windrow	400	400	cum
11	Volume of each Windrow	600	600	
12	Assumed waste density in compost	0.5	0.5	t/cum
13	Waste handled in each windrow	300	300	cum
14	number of widrwos required (Design life)	4.00	5.00	no.s
15	Net area for each windrow	600.00	600.00	sq. m
16	Gross area reqd. for each windrow	780.0	780.0	sq. m
17	total area required for compost	3,120	3,900	sq. m

18	total area for composting	3,120	3,900	sq. m
	Curing Shed			
1	Ultimate waste for compost	124.4	154.3	t/day
2	initial compost period	10	10	days
3	total waste for composting	1,244	1,543	tons
4	Depth	1.5	1.5	
5	Assumed waste density in compost	0.7	0.7	t/cum
6	Volume of waste	870.91	1080.24	cum
7	Net area ffor curing	580.61	720.16	sqm
8	Gross area reqd. for curing considering 10% for circulation	638.7	792.2	m2
	Area required for complete composting plant	29108.7	36126.2	sq. m
		29108.7	36126.2	sq. m
		2.91	3.61	ha

Refinement Section:- Size of the shed - 30m x 15m

Storage go down:- Size of the shed proposed for storing 100TPD for 7 days is - **35m x 25m**

List of Processing Machineries & Equipments (Mechanical)

The organic waste received is routed to composting plant and decomposing the waste for a period of 30 days and screening after 15 days to separate minute particles of glass, plastic, metals has been provided. The reject area and the course manure area are set apart. The rejects from the 1st and 2nd screen are directed towards land fill & RDF site and the reject of 3rd and 4th screen are secured for use as pit fill manure and the cover material /absorbent.

Air classifier is used at outlet of primary screens rejects to separate lighter & heaver fractions. Heavier fractions are send to landfill and lighter fractions to RDF unit for bailing.

Equipments are used to turn waste at regular intervals and used to shift the waste for feeding to the machinery. Rejects are pushed and the finished material is also moved to bagging area. The front end pay loaders are essential for above activities.

Table 59: Equipments required for compost plant

S. No	Equipment	Nos.	Capacity	Purpose
	Windrow management			
1	Backhoe excavator with FE bucket	4		For windrow formation
2	Track type Excavator	2		For windrow formation and turning
3	Slurry Pump	2		Spraying the leachate and innoculum slurry on the windrows
	PRIMARY SECTION (Coarse Segregation)			***Proposed 2 lines with 8 hrs working***
1	Front End Loader	2		to collect and feed fermented waste to the feeder belt
2	Chain Belt Feeder Conveyor	2	20 TPH	to collect and feed fermented waste to the main feeder belt

S. No	Equipment	Nos.	Capacity	Purpose
3	Chain Belt Feeder Conveyor- Z type	2	20 TPH	to carry the fed fermented waste into the next screen
4	Trommel Screen- 35mm	2	20 TPH	to screen out oversized (>35mm) fermented waste
5	Chain Belt Process Conveyor- 35	2		to carry <35mm screened material to the next screen
6	Chain Belt L type Reject Conveyor-35	2		to carry >35mm screened material
7	Trommel Screen- 16mm	2	20 TPH	to screen out oversized (>16 <30mm) rejects
8	Chain Belt process conveyor-16	2	20 TPH	to carry <16 mm fermented material to distribution system
9	Chain Belt Reject Conveyor-16	2	20 TPH	to carry >16mm screened rejects ADS
10	Drag Chain type conveyor	2		to distribute semi screened material in the curing sheds
11	Hydraulic Power Pack	2		to generate hydraulic power for all the above equipments
	SECONDARY SECTION (Refinement)			***Proposed 2 lines with 8 hrs working***
1	Drag Chain conveyor	2	10 TPH	to distribute the screened (<16mm) material to next screens
2	Bucket Elevator	2	10 TPH	to lift the digested and screened material vertically to feed into next equipment
3	Trommel- 4mm/vibro sieve	2	10 TPH	to screen <16mm material thro 4mm screen
4	Chain belt conveyor- Z type	2		To carry <4mm screened material
5	Chain Belt conveyor- L type	2		to carry screened oversized (<16>4mm) material
6	Grinder	2		to grind digested Organic material coming out of the Reject conveyor
7	Chain belt conveyor- Z type	2		to transfer the ground Organic material
8	Gravity separator with Aspirator	2		to remove heavy impurities mainly sand and glass pieces
	REJECTS SHIFTING			

8.3.1 Performance standards for compost

Processing of Municipal Solid Waste would be undertaken to ensure that the compost produced after such Processing is reckoned as being Fit for Sale

The sampling procedure for compost testing is as set out below. The compost proposed to be sold shall be placed in at least ten heaps of almost equivalent size. One random sample from each of these heaps shall be taken. Such random samples shall then be thoroughly mixed and a single random sample taken and tested. In case the composition of this single random sample satisfies the criteria set out in the **table given below** shall be certified as being "Fit for Sale". Apart from the regular procedure we ensure the samples thus collected are also analyzed in the authorized test houses periodically.

Table 60: Composting Standards

S. No	Description	Standards
i	Moisture, percent by weight	15.0-25.0
ii	Colour	Dark Brown to Black
iii	Odour	Absence of foul odour
iv	Particle Size	Max. 90% material should pass through 4.0 mm IS Sieve
v	Bilk Density (g/Cu.cm)	0.7 – 0.9
vi	Total Organic Carbon, percent by weight, Minimum	16.0
vii	Total Nitrogen (as N) percent by weight minimum	0.5
viii	Total Phosphates (as P2O5) percent by weight minimum	0.5
ix	Total Potash (K2O) percent by weight minimum	1.0
x	C.N. Ratio	20:1 or less
xi	PH	6.5 – 7.5
xii	Conductivity (as dsm-1) not more than	4.0
xiii	Pathogens	Nil
xiv	Heavy metal content (as mg/Kg) percent by weight, maximum	
	Arsenic (as As2O3)	10.00
	Cadmium (as Cd)	5.00
	Chromium (as Cr)	50.00
	Copper (as Cu)	300.00
	Mercury (as Hg)	0.15
	Nickel (as Ni)	50.00
	Lead (as Pb)	100.00
	Zinc (as Zn)	1000.00

8.4 Eco Bricks

So far in India, there is very little effort to manage and utilize C&D waste. There is potential to recycle and reuse C&D waste. The crushed concrete can be used for making pre-cast products like Eco Bricks, Kerbstones, Pavement blocks, square tiles etc. or can be sold as such in the construction industry. As per studies conducted by the Central Road Research Institute (CRRI), there is enormous possibility of using processed C&D waste aggregates for road works and embankment construction.

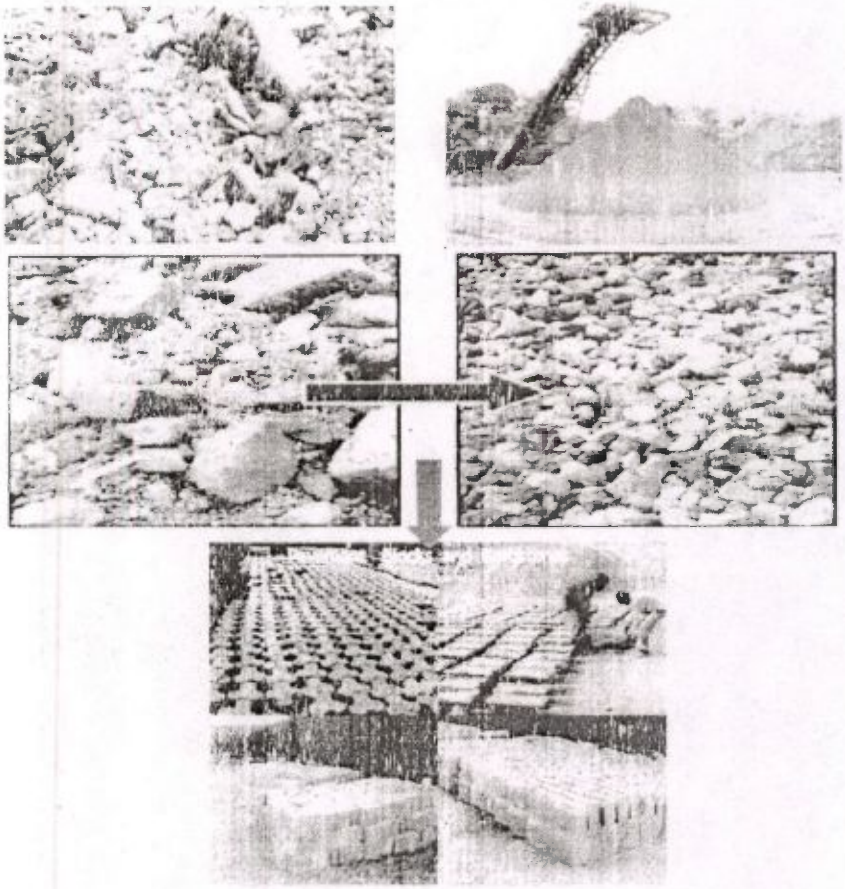


Figure 29: Eco Brick Process

Table 61: Calculation of number of Eco bricks from C and D waste

S. No.	Particulars	Quantity	Unit
1	Incoming Waste	336	MT/day
2	Rate of Incoming Waste	10%	
3	Total amount of C and D waste	33.6	MT/day
4	Minimum requirement of waste to start the plant	2	MT/day
5	Boiler ash to be added and if not available river sand to be added.		
6	Requirement of Waste and Other Material		
a	Aggregate of C & D - 70 %	1400	kg
b	Sand or Boiler Ash - 20%	400	kg
c	Cement - 0.075%	150	kg
d	Water - 9.925%		
7	Total Brick Production per day	748	no.
8	Per brick Cost	4.5	INR
9	Total brick cost	3366	INR
10	Revenue by selling bricks per day	5984	INR

9. LANDFILL SITE SELECTION & PLANNING

The MSW Rules 2000 mandate that each Municipal Corporation shall set up an engineered landfill for disposal of waste. Land filling shall be restricted to non-biodegradable, inert wastes and other wastes those are not suitable either for recycling or for biological processing. Land filling shall also be carried out for residues of waste processing facilities as well as pre-processing rejects from waste processing facilities. Land filling of mixed waste shall be avoided unless the same is found unsuitable for waste processing. Under unavoidable circumstances or till installation of alternate facilities, land filling shall be done following proper norms.

MSW Left unmanaged and uncontrolled, openly dumped on the land:

1) Generate liquid and gaseous emissions (leachate and landfill gas) that can pollute the environment, and
2) Represent a breeding ground for disease-bearing animals and microorganisms. Other risks to the public health and safety and to the environment are also posed by the uncontrolled land disposal of solid wastes.

Sanitary land filling, which is the controlled disposal of waste on the land, is well suited to Developing countries as a means of managing the disposal of wastes because of the flexibility and relative simplicity of the technology. Sanitary land filling controls the exposure of the environment and humans to the detrimental effects of solid wastes placed on the land. Through sanitary land filling, disposal is accomplished in a way such that contact between wastes and the environment is significantly reduced, and wastes are concentrated in a well-defined area. The result is good control of landfill gas and leachate, and limited access of vectors (e.g., rodents, flies, etc.) to the wastes. The practice of sanitary landfilling, however, should be adopted in accordance with other modern waste management strategies that emphasize waste reduction, recycling, and sustainable development.

9.1 Basic principles

All definitions of "sanitary landfill" call for the isolation of the landfilled wastes from the environment until the wastes are rendered innocuous through the biological, chemical, and physical processes of nature. Major differences between the various definitions are in the degree of isolation and means of accomplishing it, as well as in the requirements for monitoring and closing the fill and in maintaining the fill after its active life.

In order to be designated a sanitary landfill; a disposal site must meet the following three general but basic conditions:

i) Compaction of the wastes,
ii) Daily covering of the wastes (with soil or other material) to remove them from the influence of the outside environment, and
iii) Control and prevention of negative impacts on the public health and on the environment (e.g., odours, contaminated water supplies, etc.). However, meeting all specific aspects may be technologically and economically impractical in many developing countries. Therefore,

the short-term goal should be to meet the more important aspects to the extent possible under the existing set of technical and financial circumstances.

The basic design and operating aspects of a sanitary landfill in terms of routes of impact outside the fill and of meeting the three basic conditions are illustrated in Figure

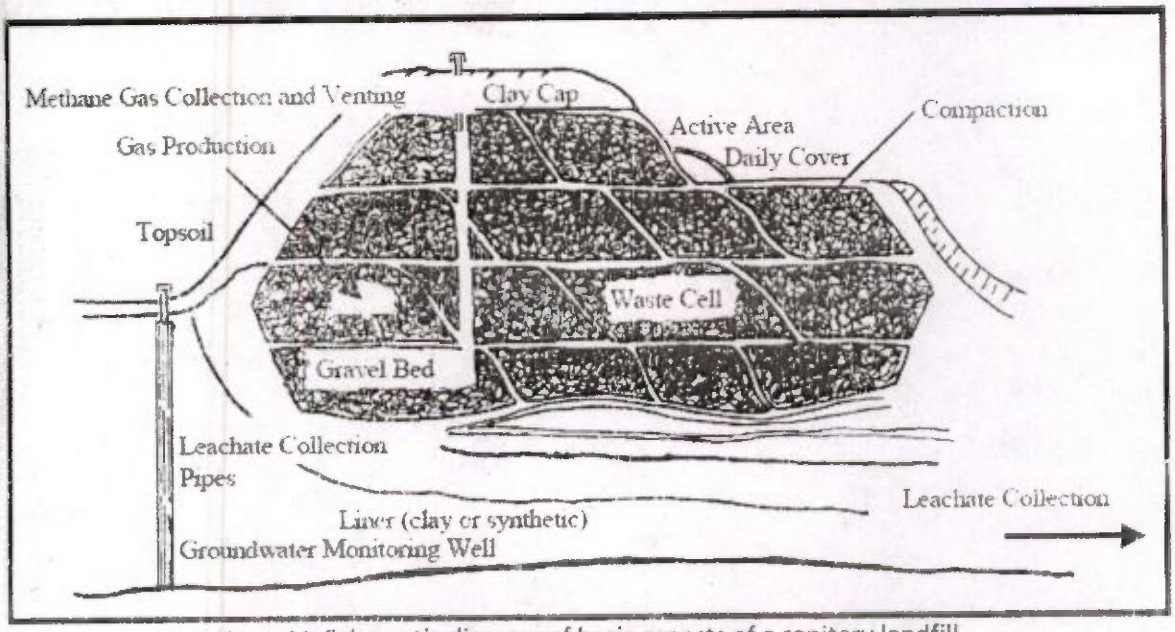


Figure 30: Schematic diagram of basic aspects of a sanitary landfill

9.1.1 Planning for a Landfill:

Planning involves the collection of information on type, amount, generation rate, and characteristics of the wastes to be accepted for landfilling. it should be noted that the underlying assumption is that reduction and recycling are the preferred courses of action, and that landfilling is indicated only when reduction and recycling are unfeasible, and is intended for the residue left after recycling.

9.1.2 Land filling Process

Physical, chemical, and biological processes are used for Land filling. Of the three types, the biological processes probably are the most significant. However, the biological processes are strongly influenced by the physical and chemical processes.

9.1.2.1 Physical

In general, significant physical reactions in the fill are in one of three very broad forms:

Compression (Compaction), Compaction is an ongoing phenomenon that begins with compression and size reduction of Particles by the compacting machinery and continues after the wastes are in place.

Dissolution: - The amount of water that enters a fill has an important bearing on physical reactions. Water acts as a medium for the dissolution of soluble substances and for the transport of unreacted materials.

Adsorption: - Adsorption In a typical fill, the broad variety of components and particle sizes of the wastes provides conditions that lead to an extensive amount of adsorption, which is the adhesion of molecules to a surface.

9.1.2.2 Chemical

Oxidation: - Oxidation is one of the two major forms of chemical reaction in a fill. Obviously, the extent of the oxidation reactions is rather limited, in as much as the reactions depend upon the presence of oxygen trapped in the fill when the fill was made.

Ferrous metals are the components likely to be most affected. The second major form of chemical reaction includes the reactions that are due to the presence of organic acids and carbon dioxide (CO_2) synthesized in the biological processes and dissolved in water (H_2O). The dissolution of CO_2 in water deteriorates the quality of the water, especially in the presence of calcium and magnesium.

9.1.2.3 Biological

The importance of biological reactions in a fill is due to the following two results of the reactions:

i) The organic fraction is rendered biologically stable and, as such, no longer constitutes a potential source of nuisances.

ii) The conversion of a sizeable portion of the carbonaceous and Proteinaceous materials into gas substantially reduces the mass and volume of the organic fraction. At this point, it should be remembered that a fraction of the nutrient elements in the waste is transformed into microbial protoplasm. Eventually, this protoplasm will be subject to decomposition and, hence, it makes up a reservoir for breakdown in the future.

Biological decomposition may take place either aerobically or anaerobically. Both modes come into play sequentially in a typical fill, in that the aerobic mode precedes the anaerobic mode.

a) Aerobic decomposition

The greater part of decomposition that occurs directly after the wastes are buried is aerobic. It continues to be aerobic until all of the oxygen (O_2) in the interstitial air has been removed. The duration of the aerobic phase is quite brief and depends upon the degree of compaction of the wastes, as well as the moisture content since the moisture displaces air from the interstices. Microbes active during this phase include obligate as well as some facultative aerobes. Because the ultimate end products of biological aerobic decomposition are "ash", CO_2, and H_2O, adverse environmental impact during the aerobic

phase is minimal. Although intermediate breakdown products may be released, their amounts and contribution to pollution usually are small.

b) Anaerobic decomposition

Because the oxygen supply in a landfill soon is depleted, most of the biodegradable organic matter eventually is subjected to anaerobic breakdown. This anaerobic decomposition is biologically much the same as that in the anaerobic digestion of sewage sludge. Microbial organisms responsible for anaerobic decomposition include both facultative and obligate anaerobes.

9.1.3 Environmental factors

The principal factors that influence biological decomposition in a conventional fill are moisture, temperature, and the microbial nutrient content and degree of resistance of the waste to microbial attack. Moisture is a limiting factor in a fill at moisture content levels of 55% to 60% or lower, because microbial activity is increasingly inhibited as the moisture drops below the 55% level. For practical purposes, it ceases at 12%. Therefore, decomposition can be expected to proceed very slowly in fills located in arid regions.

The activity of most microbes' increases with rise in temperature until a level of about 40°C is reached. For some types of microbes, the upper temperature is on the order of 55° to 65°C.

9.1.4 Density

Progressive settlement of the entire mass of the fill occurs as a consequence of decomposition and weight of overburden. Because of the effect of settlement, increase in density becomes a continuing phenomenon. The in-place density of a properly operated, relatively deep fill can be of the order of 900 kg/m3; whereas that of a poorly compacted fill would be only about 300 kg/m3.

9.1.5 Settlement

Settlement is manifested by a decrease in volume of the affected mass and subsequent reduction in elevation. For several reasons, the drop in elevation is not uniform throughout the fill. The lack of uniformity may be a serious constraint on the use of the completed fill. Undoubtedly, the greater the organic fraction and the deeper the fill, the greater will be the extent of settling.

Because of the variations in the above factors and wide differences between operational procedures encountered in sanitary landfill practice, it is not surprising that a similarly wide Variation exists between reported rates and the extent of settlement. Of the total settling, usually about 90% takes place during the first year. In arid regions, settlement may be only 3% after three years, while that in subtropical regions may be as much as 20% after the first year.

9.2 Types of Solid Wastes

Generally, sanitary landfills are considered land disposal facilities that receive solid wastes from residential, commercial, and industrial sources. The quantities and characteristics (e.g., composition, etc.) of the solid waste define the general procedures to be employed in the landfill operation.

9.2.1 Acceptable wastes

Most solid wastes generated by residential, commercial, industrial, and agricultural sources may be disposed in a sanitary landfill of modern design without necessarily directly or indirectly endangering the well-being of the public and the quality of the environment.

9.2.2 Unacceptable wastes

Wastes that should require specific approval of the responsible government agency for acceptance at the disposal site should include those that are legally defined as "hazardous waste" or wastes that contain materials that are defined as "hazardous materials" -- medical wastes, bulk liquids and semi-liquids, sludges containing free moisture, highly flammable or volatile substances, raw animal manures, septic tank pumpings and raw sludge, and industrial process wastes.

9.3 Landfill Technology

9.3.1 Introduction

Landfill technology applies to a variety of aspects of the construction and operation of the landfill facility.

9.3.2 Cell design and construction

The two basic types of landfill methods are the trench and the area. The trench method is best suited for sites that have a flat or gently rolling land surface, a low groundwater table, and a soil layer thicker than 2 m.

The area method is applicable with most topographies and probably would be the better of the two choices for sites that receive large quantities of solid waste. A design using a combination of the two methods may be the most appropriate approach at some sites.

Trench

The trench method involves the excavation of a trench. Once the excavation is completed, the waste is placed into the trench, spread, and compacted. The waste is deposited on the slope of the trench. The excavated soil serves as cover material. Soil not used for the daily cover is stockpiled for later use in a subsequent area that might be constructed on top of the completed trench fill.

The stability of the sidewall is a critical factor in the design of a trench landfill. Sidewall stability is a function of the characteristic strength of the soil, depth of the trench, distance between

trenches, and slope of the sidewall. Maximum depth and steepness of sidewall slope are compatible with clays, glacial till, or other fine-grained, well-graded, consolidated soils. Weaker soils require gentler sidewall slopes. Other factors that may affect soil stability and permissible steepness of sidewall slope are climatic conditions and the length of time the trench is to remain open.

Area

As opposed to the trench method, the area method does not involve excavation of trenches. Instead, a layer of waste is spread and compacted on the surface of the ground (on the inclined slope). Cover material is then spread and compacted over the layer of waste. The area method should be used on flat and gently sloping land. This method can be adapted to quarries, strip mines, ravines, valleys, canyons or other land depressions, and excavations made for the landfill.

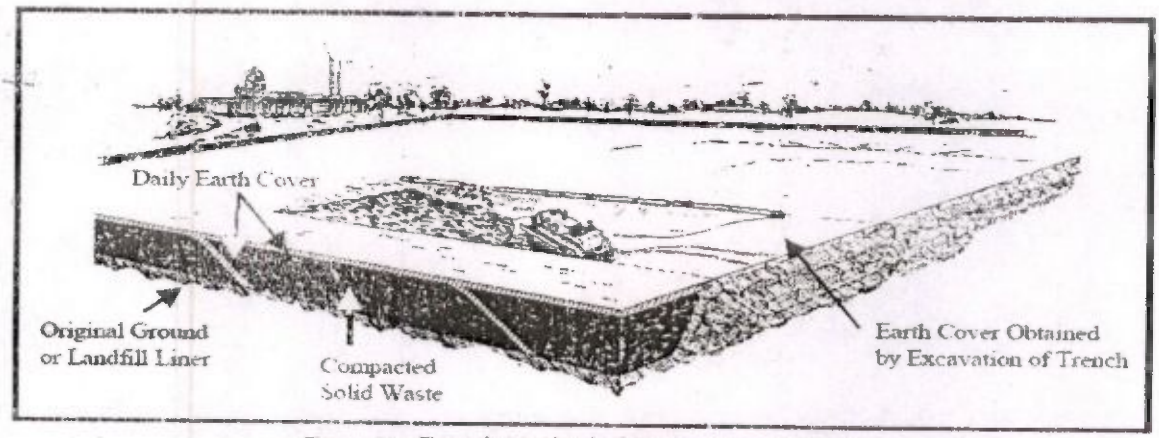


Figure 31:: Trench Method of Sanitary Land filling

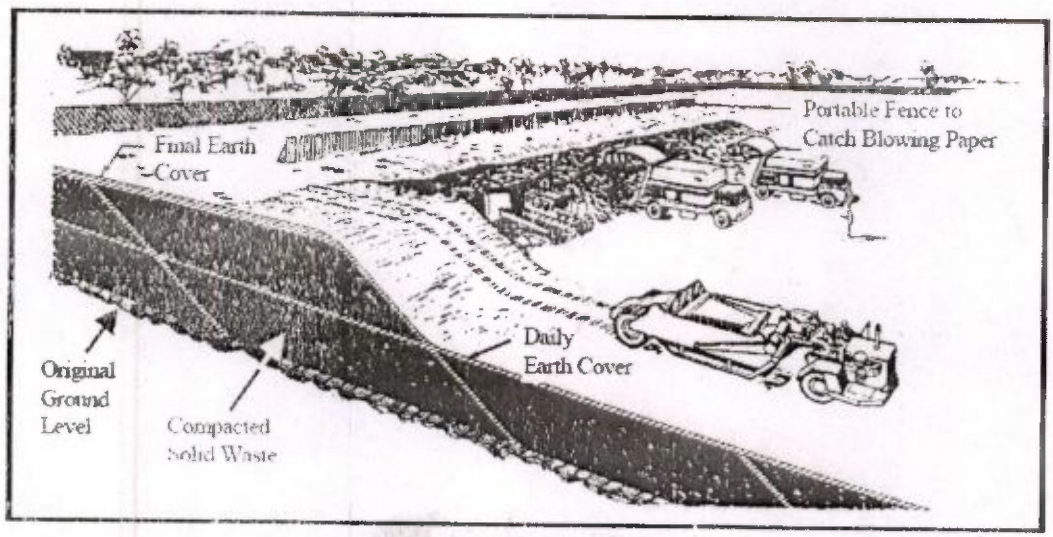


Figure 32:: Area Landfill

All true sanitary landfills consist of elements known as "cells". A cell is built by spreading and compacting the solid waste into layers within a confined area. At the end of each working day, or during the working day as well, the compacted refuse is covered completely (including the working face) with a thin, continuous layer of soil. The soil cover also is compacted. The compacted waste and its daily soil cover make up a cell. A series of adjoining cells at the same elevation constitute a "lift". A completed fill may consist of one or several lifts.

The cells are designed based on the quantity of wastes requiring disposal. The basic elements of a cell are: height, length, width of working face, slope of sidewalls, and thickness of daily cover. The height of a cell is a function of the quantity of waste, thickness of daily cover, stability of slopes, and degree of compaction. Typical heights vary between 2 and 4 m.

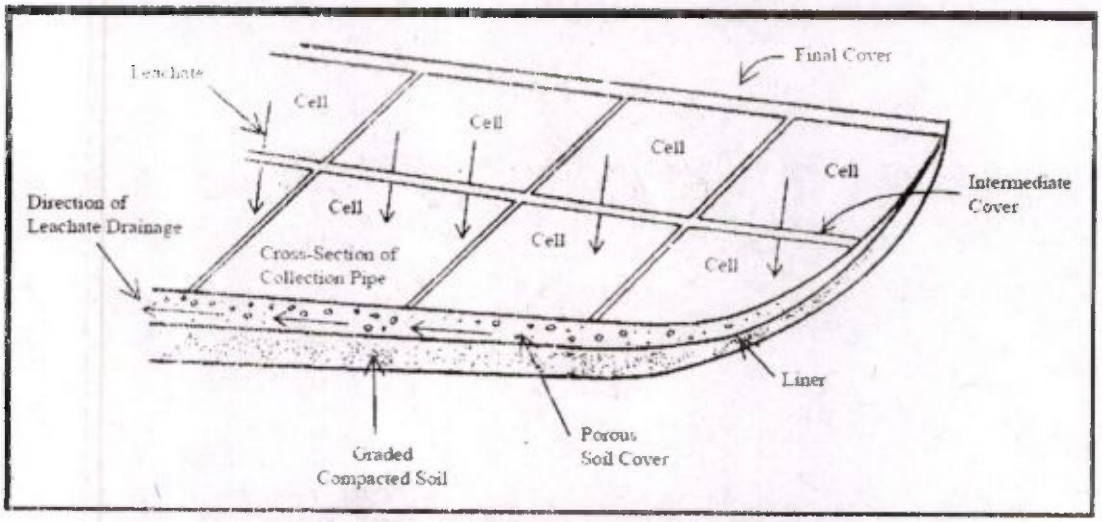


Figure 33:: Cellular Structure of a Landfill

The minimum width of the cell or minimum width of the working face depends upon the type of equipment used. It is generally recommended that the minimum width of the cell be about 2 to 2.5 times the width of the blade used for building the cell.

The slope of the cell is the inclined plane upon which the wastes are distributed. The maximum recommended slope is 1 to 3 (vertical to horizontal). Slopes less than 1: 6 results in an undesirably large area of the working face.

Ramp

The ramp, also known as the progressive slope method, consists of spreading and compacting the solid waste on a slope. The ramp method is similar to the area method. However, in a departure from the area method, cover material is obtained from the soil surface immediately in front of the working face -- thus, leaving a slight depression to begin receiving deliveries of

waste the following day. Because it does not involve the importation of cover, the ramp method promotes greater efficiency of site usage when a single lift is constructed.

Combination of Fill Methods

The area method and the trench method might be used in the same site if the particular site has varying thicknesses of topsoil and receives a large amount of wastes. The trench method would be used in situations where the topsoil layer is thickest. Soil not used for cover on the trench fill would be stockpiled for the area fill.

Slope Stability

The stability of slopes of wastes and of waste/bottom liner interfaces in the landfill are important in managing the fill cost effectively and in protecting the safety of landfill workers and other people that reside on or near the fill. The shear strength of solid waste is an important mechanical property used in the analysis and design of waste slopes. The amount of moisture in the waste can affect the shear strength and slope stability of the waste.

Bottom liner

A bottom liner (or, simply, liner) is an engineered system to contain and control the pollution of the land and water environments surrounding the land disposal operation. The design of a bottom liner, in the case of economically developing countries, will vary depending on a number of factors, including: the potential of the landfill polluting the land and water environments, the local hydrogeology and meteorology, and the availability of suitable materials and monetary resources.

Daily, intermediate, and final covers

The three types of landfill cover systems are described below.

Daily Cover:-

Daily cover controls vectors, litter, odours, fire, and moisture. Any soil material that is workable and has stability (clays, gravels, etc.) may be used. Typically, a thickness of 10 to 12 cm is recommended.

Intermediate Cover:-

Intermediate covers control gas migration and provide a road base. Soils used for intermediate cover must have strength and the required degree of impermeability. Typically, a thickness of 15 to 20 cm of compacted soil is recommended.

Final Cover

The final cover is the layer that is placed on the completed surface of the fill. The functions of the final cover are several. It controls infiltration of water (and, hence, indirectly controls leachate production), controls landfill gas migration, serves as a growth medium for vegetation,

provides a support for post-closure activities, and is a barrier between the external environment and the waste.

An important consideration in the design of a final cover is the degree of resistance that the cover offers to percolation and infiltration of moisture and to the upward migration of gases generated in the buried waste. This resistance may or may not be desirable. Thus, some cover designs call for the free percolation of rainwater through the cover; whereas, others call for resistance to such percolation.

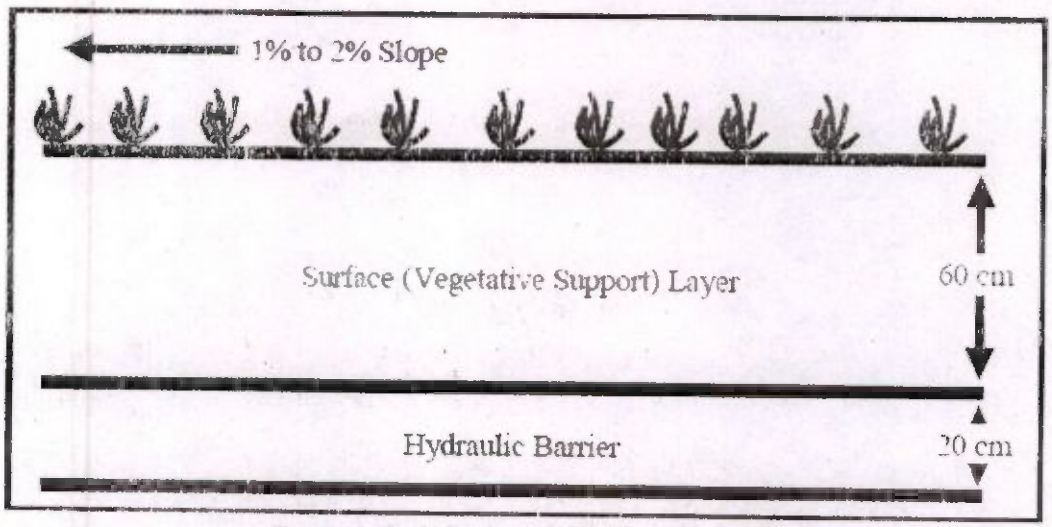


Figure 34: Basic Design of Final Cover System

The simplest design of a final cover system for a sanitary landfill consists of two layers:

i) Surface layer, and
ii) Hydraulic barrier

The hydraulic barrier essentially is the first layer of the cover specifically designed to prevent the passage of liquids into the waste. If a cover is to be designed and implemented in a developing country, it is advisable to use a thickness of about 60 cm for the surface layer and a thickness of 30 cm for the underlying hydraulic barrier. This design would be acceptable in areas with high evaporation and low rainfall (i.e., a climate with high temperatures, low humidity, and low precipitation)

In order to maintain the flow of water into the solid wastes to a minimum, the cover must be designed such that the major portion of precipitation becomes runoff. This objective can be accomplished by building a cover with a slope between 1% and 5%. This inclination promotes flow off the cover and at the same time limits erosion to an acceptable level. Erosion also is reduced by establishing vegetation. Vegetation also has an additional benefit because it

promotes evapo transpiration. Thus, slope and vegetation play important roles in the performance of the cover.

Customized methods of construction and use after completion

The design and construction of a sanitary landfill may be customized so as to accommodate both waste disposal and use of the facility after the completion of the active phase of the fill. Some examples of feasible uses are topographical contouring, reclamation of aquatic environment, strip mine reclamation, urban redevelopment, and gas recovery. The use of a landfill after its active life entails special considerations.

Two particular types of customized landfill construction and uses are described below:

Topographical contouring

Topographical contouring is the construction of a fill in the form of a hill. This approach allows more efficient use of the land by increasing the capacity of the landfill in a given area. The completed fill consists of a series of circular lifts tapered to approach the contour of a hill. In this case, the area method would be used for building the lifts. The maximum slope of the hill is determined by the angle of repose of the soil cover, the climbing capacity of the equipment, and the angle of slip and tip (roll over) of the equipment when operating at normal loading.

Design

As with all sanitary landfills, the design of a secure landfill largely depends upon the hydrogeological characteristics of the site. Thus, if the distance to the water table is substantial and the soils are impermeable, compaction of the soils at the site combined with the placement of a single liner, either of natural or of synthetic material, would be sufficient. In such a case, soil or bentonite could serve as a natural liner material and high-density polyethylene or chlorinated polyethylene could serve as a synthetic liner material. Prevention of mixing is effected by separating different areas of the facility from one another by forming sub cells using earthen dikes. Arrangements should be made for collecting and withdrawing leachate as it accumulates in the basin. This is done through a network of piping installed in the fill. Groundwater quality should be monitored by means of monitoring wells placed along the perimeter of the fill. Monitoring of groundwater should take place before the beginning of the deposition of wastes and be continued thereafter until chances of pollution become non-existent.

Closure of the fill

The closure operation is designed such that total and complete containment of the facility is assured, and that the completed fill does not pose a threat to the public safety and the environment. This objective is attained by adhering to the following procedure:

- Upon completion of the landfill, cover the upper surface of the completed fill with impermeable soils.
- Cover this layer with a synthetic liner (if available) to effectively seal this layer and underlying wastes from rainfall.

- Cover the synthetic liner with topsoil and seed the topsoil to produce vegetation to complete the closure operation. Leachate and gas collection pipes should protrude through the final cover. Finally, excavation of the completed fill should not be attempted since most buried hazardous wastes continue to be dangerous long after their burial. Excavation of completed, secured landfills can be a dangerous undertaking.

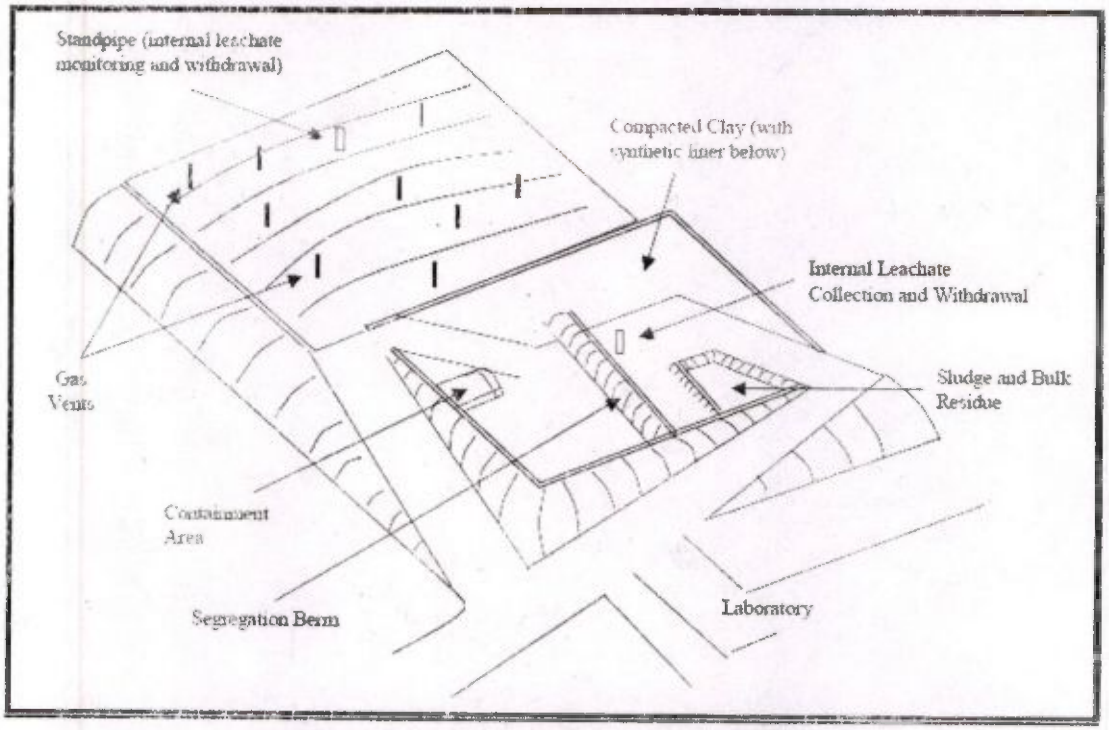


Figure 35: Typical Layout of Sanitary Landfill

It is obligatory on the part of municipal authorities to treat the organic fraction of waste before disposal. The corporation is further required to dispose of the inert waste collected from the city and rejects from the treatment plant at an engineered landfill in a scientific manner.

9.4 Site Characteristics & its implications on Landfill Design Facility

It is being noted that the whole area has been considered for developing the processing and disposal site.

9.5 Landfill Design Facilities

The landfill design is based on geological and hydro-geological conditions, projected waste generations volumes along with procedures to reduce potential impacts to the existing natural and social environment of the site.

The basic steps essential for the landfill designs are:

1. Landfill sizing

2. Site layout
3. Landfill layout
4. Leachate management
5. Landfill gas management

9.5.1 Landfill Sizing

The Volume of waste to be dumped in the landfill is worked out for the active period of landfill taking into account

i) The current waste generation per annum and
ii) The expected increase in population over the next 30 years.

9.5.2 Landfill Phasing

The excavation of the base of the landfill should be phased in accordance with a predetermined phasing plan. In order to minimize damage to the landfill base layers and ensure their continued integrity over the lifetime of the landfill and also to minimize Potential for infiltration of rain water, the excavation of the base is done in "phases". The Extent of each phase is designed such that the proposed waste fill volume (based on extent of base and waste fill contours) should be large enough for a period of at least two-three years. The base of the entire landfill would be excavated within the first few phases and subsequent waste placement would only be over already placed waste, until final waste fill contours are reached.

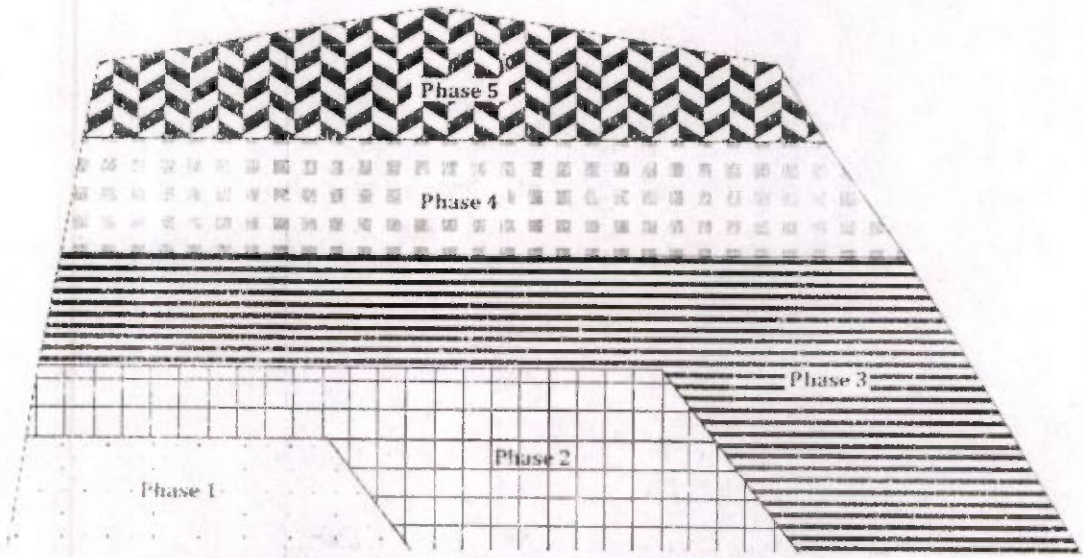


Figure 36: **Indicative Longitudinal Section Profile of Landfill Phasing**

It should be noted that the phases of the landfill which include the edge of the landfill have certain specific construction needs

i) Integrating the base clay liner with the clay barrier layer in the top cover.

ii) Preparation of a granular blanket layer, which is an extension to the drainage layer of the Leachate Collection System (LCS) system along the side slopes of the base. This granular blanket layer is required to prevent the entry of any rainfall runoff into the waste layers from the periphery of the landfill.

iii) Tucking in the geotextile and HDPE liner into the trench located along the periphery of the landfill, till the top cover is built, in order to maintain stability and integrity of the liner. Once the top cover is placed, the HDPE liner will remain in the trench, but the geotextile will be turned in and taken below the gravel layer of the gas venting layer.

Landfill Equipments

For controlled landfill operations the following equipment is required at a Sanitary Landfill.

Table 62: Equipments required at landfill Site

Sr. No.	Equipments	Number required	Functions
1	Landfill Compactor	1	For Spreading and Compaction of Waste
2	Dozer	1	For Spreading of waste, Covering of waste, maintenance of roads
3	Backhoe and front end loaders	1	Excavation and maintenance of ditches, Loading of cover Material
4	Truck with Tipper	2	Soil Transportation

Table 63: Land Fill Site Area required for dumping MSW up to 2047

Sr. No.	Design of Landfil			
1	Design Period	5	30	Years
2	Fraction of total waste to be landfilled	15%	15%	
3	Design life (2016-2036)	5	30	years
4	Total waste to be landfilled in design life	99,645	862,680	t
5	Assumed waste density in landfill	0.85	0.85	t/cum
6	total waste volume	117,229	1,014,918	cum
7	volume of daily cover (10 % of above)	11,723	101,492	cum
8	volume of liner& cover system	14,654	126,865	cum
9	volume available due to settlment	11,723	101,492	
10	total volume	131,883	1,141,782	cum
11	assume height of landfill	15	15	m
12	area of landfill required	8,792	76,119	sq. m
13	additional area required (trapizoidal shape) - 25%	10,990	95,149	sq. m
14	area of landfill required	1.10	9.51	ha
15	Total area required for landfill with 15 % for buffer	1.26	10.94	ha

Generally, landfills are designed for more than 30 years. Hence the area requirement would be around 30 hectare. But with limitation of land availability, 5 year design period may be considered.

Supporting infrastructure

A layout has been developed showing all the below supporting infrastructure at proposed Landfill site. All the drawings of each infrastructure has been developed and annexed separately for reference.

- Gate
- Guard Room
- Weighbridge and scale room
- Admin building , lab & rest rooms (G+1)
- Electrical panel room & DG
- Workers Dining
- Vehicle workshop
- Storage shed
- Vehicle wheel wash
- Wash rooms
- Process plant area
- Presorting & RDF Unit
- Compost process unit
- Waste capping area
- Power plant area
- Leachate treatment plant
- Roads & drains
- Boundary wall
- Green belt

9.6 Leachate Collection and Removal System

The principal sources of leachate include:

- Moisture content of waste entering the landfill
- Infiltration from direct precipitation on the waste surface
- Sealed areas of landfill which are only partially covered with waste
- Surface water flow onto the active face of the landfill

An effective leachate collection and removal system is a pre-requisite for landfill sites. For existing sites, the installation of an improved collection and removal system should be considered in the light of data obtained by way of the environmental monitoring.

The primary criterion for design of the leachate collection system is that all leachate be collected and removed from the landfill at a rate sufficient to prevent a hydraulic head greater than 12 in from occurring at any point over the lining system. The system is designed to remove the accumulation of storm water resulting from a 25-year, 24-hour storm, within 72 hours.

Other design criteria include the following:

- Bottom of the leak detection layer and the leachate collection layer is sloped at a minimum 2%.

- Granular drainage layer is 1 ft. thick with hydraulic conductivity >1 x 10-2cm/s.
- The system must be designed to minimize clogging.
- The system is located above seasonally high water table.
- System must be designed to handle the runoff from a 25-year, 24-hour storm.

The leachate collection system (LCS) consists of three main components; a drainage layer, a series of collector pipes, and a non-woven Geo-textile separator layer.

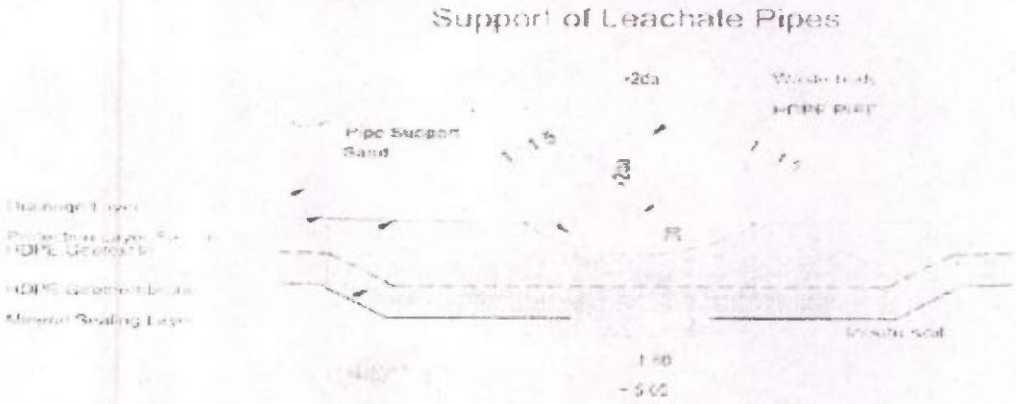


Figure 37: Support of a Leachate Pipe

The leachate collection system and its components will be laid over the HDPE geo-membrane. The LCS layer consists of a 300 mm thick gravel drainage layer of 12-25 mm sized rounded gravel and perforated HDPE pipes embedded in this gravel layer. The HDPE pipes will collect the leachate and are connected to a leachate evaporation pond. The gravel layer will be laid according to the slopes mentioned in the base soil liner layer.

The header pipes have a slope of 1% to one side. The header pipes are then connected to the Leachate collection chambers from where the leachate would be pumped onto the incoming waste. The Leachate collection pipes must be wrapped in Non-woven Geotextile so as to reduce the clogging of the pipes. The LC pipes are embedded in the leachate collection layer above the liner.

Figure 38: **Sealed Leachate Pond with Two Basins**

Leachate Pond:

The leachate pond is a basin to retain and pre-treat leachate within a period of several days. The pond allows sedimentation and biological stabilization. Organic pollutants in the leachate are removed by micro-organisms and by sedimentation processes. The leachate pond should have two basins to achieve an optimal leachate management. Division of the leachate pond into two individual ponds will make it possible to clean the ponds and their associated pipes. One basin might be cleaned or repaired while the other stays operational.

9.7 Leachate Treatment:

The type of treatment facilities to be used depends upon the leachate characteristics. Typically, treatment may be required to reduce the concentration of the following prior to discharge: degradable and non-degradable organic materials, specific hazardous constituents, ammonia and nitrate ions, sulphides, odorous compounds, and suspended solids. Based on the chemical characteristics of the leachate, treatment processes may include biological processes (such as activated sludge, aeration, nitrification/ denitrification), chemical processes (such as oxidation, neutralisation) and physical processes (such as air stripping, activated adsorption, ultra-filtration etc.), based on leachate characteristics.

9.7.1 Assessment of Quantity of Leachate Generated

Water that has percolated through the placed solid waste is known as leachate. During its progress through the waste the water entrains suspended solids, extracts soluble constituents of the waste and soluble products of the waste degradation process. The composition of leachate depends upon the stage of waste degradation and the types of waste within the landfill. The main components of leachate will comprise:

- Major elements and ions including Calcium, Magnesium, Iron, Potassium, Sodium, Ammonia, Carbonates, Sulphates, Chlorides, etc.
- Trace metals including Manganese, Chromium, Nickel, Lead, Cadmium, etc.
- Organic Compounds including Phenols, Poly Aromatic Hydrocarbons, etc.

Siliguri receives a rainfall of around 3344 mm per year. This indicates the leachate generation will be mainly during the monsoon period and rest of the months the leachate generation will be quantitatively to be less. But the suggested system will maintain leachate in the cell and during biogas recovery and vacuum creation of leachate will get circulated to some extent.

9.7.2 Calculation of leachate quantity:

Description		Calculation	Unit
Max recorded precipitation monthly	=	890	mm/month
Say	=	0.9	m/month
Total area of the landfill	=	8,792	sqm
Volume of the leachate for	=	5,539.09	Cum/month
Hence, leachate treatment system shall be designed for a capacity	=	184.64	Cum/day
Capacity of leachate collection tank, considering two day storage	=	200 x 2	Cum
	=	400	Cum

9.7.3 Design of Leachate Collection System

The primary function of Leachate Collection System is to collect and convey leachate out of the landfill unit and to control the depth of the leachate above the liner. The leachate collection system should be designed to meet the hydraulic performance standard of maintaining less than 30cm depth of leachate or head above liner, as suggested by USEPA Manual. Flow of leachate through imperfections in the liner system increases with an increase in leachate head above the liner. Maintaining a low leachate level above the liner helps to improve the performance of the composite liners.

The main components of leachate collection system are drainage layer and conveyance system. Leachate conveyance system is a network of pipes by which the leachate is collected through perforated HDPE pipes and collected in a sump. The drainage shall be provided as per the standards recommended by MSW Rules, 2000. The other design parameter which governs the leachate collection is the spacing between the pipes.

9.7.4 Size of Leachate Sump/ Primary Settling Tank

A leachate sump is provided for settlement of suspended solids in the landfill liquid waste. Since the landfill receives post composted waste, it is expected to have a BOD, of 4500 – 5000, which will essentially require anaerobic treatment, to initially reduce the BOD levels. However, cleaning of such tank has been found very difficult in case of leachate.

A tank of Depth 2.5 m is proposed in which a facultative condition will prevail, helping fast reduction of BOD in leachate. Also noted that a major portion of leachate also contain suspended solid. A detention time will help settle the solid part which also helps reduce the BOD

of leachate. A leachate Sump which of size 9 m x 17 m x 2.5 m, in phase I and 9 m x 17 m x 2.5 m has been ascertained the supporting calculations is provided below

9.7.5 Size of Oxidation Pond/ Evaporation tank.

An Oxidation pond based on evaporation concept has been provided for lechate treatment. The unit has been decided looking into the climatic condition of the region, with aired climatic conditions. The climate of the region has been found with fairly low humidity, which indicates high evapo-transpiration rates.

Assuming at least 50% leachate to be recycled back to the landfill from the sump, with the help of Leachate Recycling System;

Sr. No.	Description	Unit
a	Adopted Volume of Leachate for treatment	100 cum/day
	Depth of tank	2m
b	Free board	0.5 m
c	Size of Tank	400 sqm

The pond shall be provided with a bottom slope of 4 % to be provided sloping towards a sludge collection chamber. The Leachate collection ponds shall be of RCC structure with a firm sub-grade made from crushed aggregates/ brick bats/ selected soil. The sludge collection chamber of the leachate collection pond will be a RCC chamber of dimensions 3 x 3 x 3 mtrs. Placed on the nearer side of sludge collection bed from which sludge can be cleaned by physical aid and disposed in landfill site.

9.7.6 Spacing of Pipes

As suggested by USEPA Manual, the pipe spacing may be determined by the Mound Model.
In the Mound Model, the maximum height of fluid between two parallel drainage pipes is equal to

$$h_{max} = \frac{L \times c}{2}\left[\frac{\tan\alpha}{c} + \sqrt{1 - \frac{\tan\alpha}{c}\sqrt{\tan^2\alpha + c}}\right]$$

Where, C = Q/k

hmax = Maximum Hydraulic Depth (30 cm)

L = Distance between the Pipes

k = Permeability of Drainage Layer (0.01)

α = Slope (2%)

To calculate the inflow rate basically Darcie's equation would be used;

Q = K*I*A

Q = inflow rate

K = Permeability of Drainage Layer (0.01)

I = Gradient (2% or 0.02)

A = Area

Estimating inflow rate for unit area;

Q = (0.01) X (0.02) X (1 X1) = 0.002

Again applying this to Mound Model;

C = 0.002 / 0.01 = 0.02

Thus applying other inputs also the equation solves for L = 5.12 m (adopt 5 m)

Table 64: Standards for disposal of Leachate

Sr. No.	Parameter	Standards (Mode of Disposal)		
		Surface Water	Public Sewers	Land disposal
1	Suspended solids, mg/L, max	100	600	200
2	Dissolved solids (inorganic) mg/L, max.	2100	2100	2100
3	pH value	5.5 to 9.0	5. 5 to 9.0	5.5 to 9.0
4	Ammonical nitrogen (as N), mg/L, max.	50	50	-
5	Total Kjeldahl nitrogen (as N). mg/L, max.	100	-	-
6	Biochemical oxygen demand (3 days at 27° C) max. (mg/L)	30	350	100
7	Chemical oxygen demand, mg/L, max.	250	-	-
8	Arsenic (as As). mg/L, max	0.2	0.2	0.2
9	Mercury (as Hg), mg/L, max	0.01	0.01	-
10	Lead (as Pb), mg/L, max	0.1	1	-
11	Cadmium (as Cd), mg/L, max	2	1	-
12	Total Chromium (as Cr), mg/L, max.	2	2	-
13	Copper (as Cu), mg/L, max.	3	3	-
14	Zinc (as Zn), mg/L, max.	5	15	-
15	Nickel (as Ni), mg/L, max	3	3	-
16	Cyanide (as CN), mg/L, max.	0.2	2	0.2
17	Chloride (as Cl), mg/L, max.	1000	1000	600
18	Fluoride (as F), mg/L, max	2	1.5	-
19	Phenolic compounds (as C_6H_5OH) mg/L	1	5	-

9.8 Landfill Gas Management

A large part of mixed waste (50-70%) consists of biodegradable parts which will produce methane gas. With a view to reduce environmental impacts as well as GHG emissions it is mandatory to install a degassing system for the Sanitary Landfill.

The gas management strategies should follow one of the following options:

- Controlled passive venting
- Controlled active collection and treatment/reuse

Controlled passive venting

For all sanitary landfills controlled passive degassing systems in the form of gas windows covered by suitable passive gas vents is recommended. The gas windows are to be installed in the frame of the final covering. The gas windows are openings in the cover system which may be filled with compost to avoid the generation of bad odours. The size should be not less than 1 m x 1 m and the distance between two gas windows should be about 20 m.

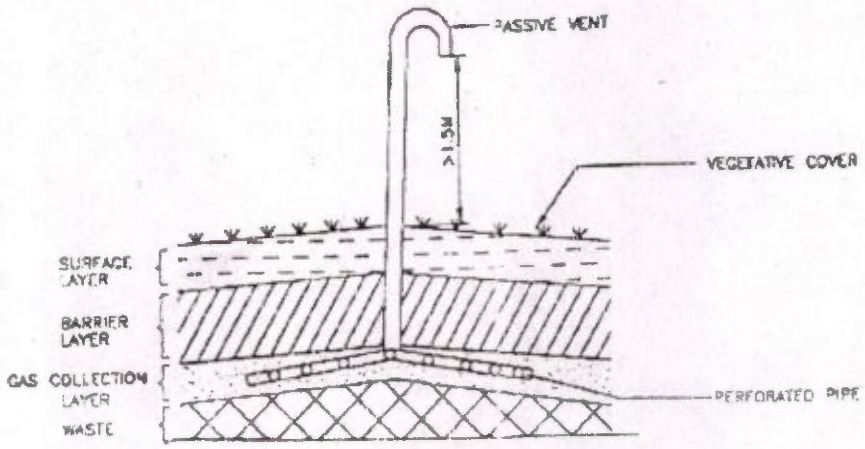


Figure 39: Placement of passing vents

Controlled active collection and treatment/reuse

In order to reduce GHG emissions, especially methane with its very high warming potential, future landfills should always install active gas collection systems. The active degassing system should contain the following elements as illustrated in below figure

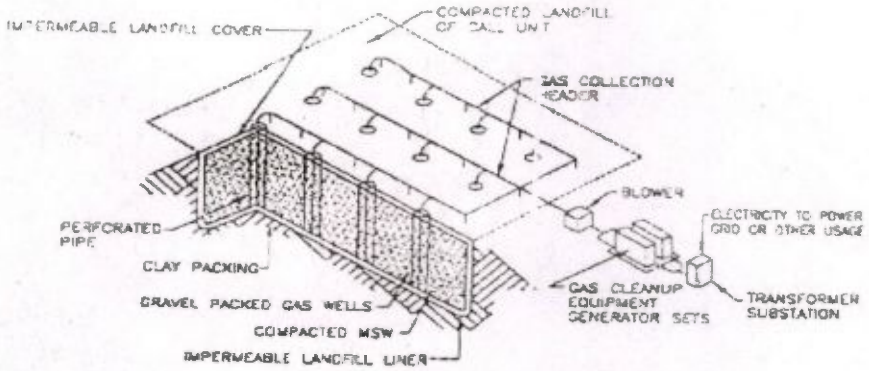


Figure 40: Gas recovery through wells-active

9.8.1 Landfill Gas Collection and Management System

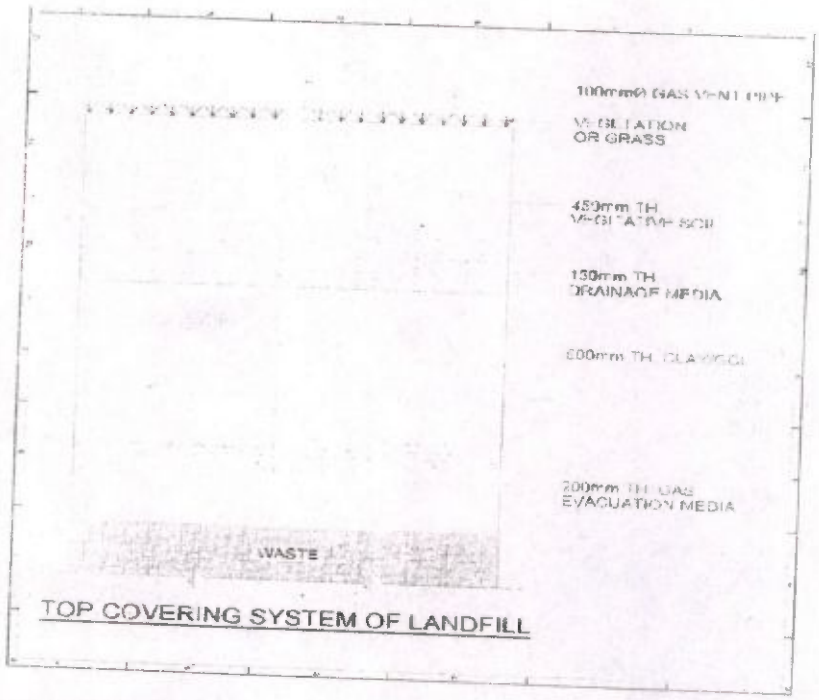
As only process comprising mainly plastics are sent to landfill the waste going to landfill can be categorised as inert and gas generation would be very minimal or negligible. The quantity of gas generated from the landfill can be estimated with the help of method suggested in CPHEEO Manual (Volume of Gas Generated, V = C X W X [P/100] m^3/year; C = Coefficient of Generation (6 m^3/ton/year); W = Weight of Waste; P = Percentage of Organic Component).

V = C X W X [P/100] m^3/year		
C = Coefficient of Generation	=	6 m^3/ton/year
W = Weight of Waste	=	24528 Tons/year
P = Percentage of Organic Component	=	05
Volume of Gas generated	=	7358 m3/year

9.8.2 Design of Landfill Cover and Sequence of its Laying

A final landfill cover is usually composed of several layers, each with a specific function. The surface cover system must enhance surface drainage, minimise infiltration, support vegetation and control the release of landfill gases. The landfill cover to be adopted will depend on the gas management system. The landfill cover proposed is in line with the recommendations of by the MoEF and CPHEEO and consists of the following components:

- Top cover layer of 450mm thick comprising of 300mm thick top soil and 150mm of good vegetation supporting soil
- Drainage layer with 300mm thick
- Clay Liner with 600 mm of thickness
- 450mm thick gas collection.



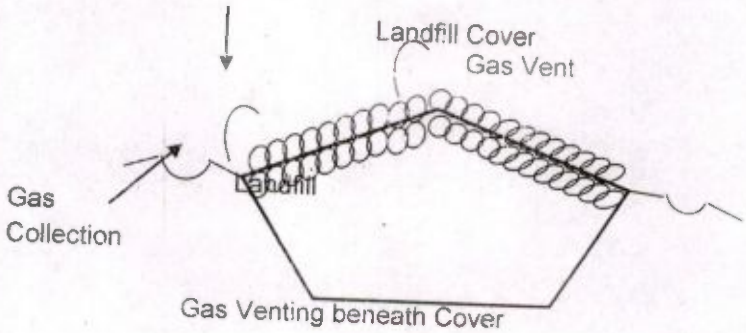
TOP COVERING SYSTEM OF LANDFILL

9.8.3 Landfill Gas Evacuation System

The gas management strategies should fallow one of the fallowing three plans.

- Controlled passive venting
- Uncontrolled release
- Controlled collection and treatment

For all MSW landfills, controlled passive venting is recommended. Only for small (less than 100 tons per day) shallow (less than 5m deep) and remotely located landfills, should uncontrolled release be allowed. Landfill gas monitoring will be adopted at all sites and remedial measures (such as flaring) undertaken if gas concentrations are above acceptable limits. Controlled collection and treatment/use will be adopted only after the feasibility of such a system is established and proven by an agency having experience in this area.



9.9 Employee Assignments and Responsibilities

The composition and number of the landfill staff have to be designed according to the size and the requirements of the Sanitary Landfill.

9.9.1 Provisional Staffing Table:

Department	Functions
Management	Landfill manager
Administration	Controller , Weighbridge Operator; Night Watchman
Operation	Foreman; Machine drivers (Wheel loader, dozer) ; Spotter; Unskilled Workers

9.9.2 Staff Responsibilities and Qualifications

The Table indicates the major assignments and responsibilities of the various employees who work at the landfill. However, the table does not necessarily include all duties that may be required to safely and successfully operate the Sanitary Landfill. The list should be mandatory for private as well as municipal operators.

Staff Qualification:-

Functions	Responsibilities	Education/ Experience
Landfill manager	Responsible for the waste Filling Compliance with operation manual and filling plans Responsible for daily (short-term) personal planning Responsible for supervision of the controller (weighbridge operator) Responsible for customers' contacts Adherence of safety rules	Civil engineering technician Training in safety matters Training in environmental issues Knowledge of environmental legislation.
Weighbridge operator (Controller)	Controls and recorded the incoming waste Operates the weighbridge Directs the vehicles to the disposal area Visual monitoring of delivered waste other than municipal waste	Administration competencies, Training in environmental issues Knowledge of environmental legislation
Night Watchman	Responsible for site security especially during night time	Training in safety matters
Foreman	Responsible for the waste filling procedure Responsible for the daily personal and equipment planning Responsible for the control of the compaction of the landfill Responsible for the cell construction Responsible for the road construction and control of the condition of the roads	Trained foreman with long time experience in construction works; Training in safety matters
Spotter	Responsible for the traffic regulation on the filling area and for organization of waste disposal	Special training in filling procedure Training in distinction of different waste and of acceptable and

Functions	Responsibilities	Education/ Experience
	Checking of unloading waste	unacceptable waste Basic training in safety

9.10 Land availability with SMC

Landfill Site 1 – Near Don Bosco School

- At present dumping ground is located at Dabgram-1, between Don Bosco School and Eastern Bye pass at the north of the city.
- The Site has been in use since 1949, when this locality was not inhabited but now the locality is populated.
- Area of the existing site is 28 acre but due to petroleum gas passing through the site the effective area under SMC is around 25 acres.
- The site consists of around 6-8 m of existing solid waste dumped in an unscientific way.
- Considering an average depth of 7 m over the entire site area and considering 30% of the waste which can be reclaimed from the existing waste dumped on the site. So, net area which can be reclaimed will be around 3 – 4 acres.
- Considering, the above calculations FIPL is of the opinion that the waste processing site cannot be proposed at the existing dumping ground due to shortage of space.
- The site can be used for the next 2-3 years till the time the proposed Landfill site and processing plant is set up at new location.
- A transfer station has been proposed at the existing dumping ground for Borough No. 5 and 1.

Proposed Landfill Site 2 – Putimari

- SMC has purchased land for landfill site at Putimari in Binnaguri Mouja.
- The Area of the site is 21.7 Acres.
- Site is approximately at a distance of 12 km by road from SMC office.
- It has been observed that Sahu River is flowing nearby the proposed Landfill Site.
- As per MSW Rules 2000, Landfill Site should be 100 m away from a navigable river or stream but a minimum of 30 m should be maintained in all cases.
- In case, it is to be used as landfill, then a space of 100 m from river high flood level should be left out.

- Area – The available land area of around 20 acres is on lower side as this will only be sufficient for 7-8 years of processing and disposal of solid waste. SMC needs to identify additional land for future.

As Municipal Corporation do not have any other land available and cost of land as well as It is proposed to construct retaining wall at landfill site on the edge towards the river. It is also proposed to fill the site with construction and demolition waste above HFL. A liner shall be placed above the construction and demolition waste. The site shall then be used for landfill. This shall protect surface as well as ground water from probable pollution.

10. FINAL CLOSURE AND ENVIRONMENTAL MONITORING PLAN

10.1 Closure of Landfill Site and Post Closure Plan

Determination of the end-use of a landfill site is an essential part of the plan for landfill closure and post-closure maintenance. Closure and Post closure care involves the routine inspection of the completed landfill site, maintenance of infrastructure and environmental monitoring. The authority shall inspect all facilities during the closure and post closure period at least once a year. The authority/concessionaire that operates the sanitary landfill shall be responsible for post closure activities and monitoring. A closure and post-closure plan for landfill should involve the following components:

10.1.1 Cover System

The final cover should be inspected 2 to 4 times a year

a) To check that vegetation growth is occurring satisfactorily and that plants are not showing stunted growth
b) To detect if any erosion gullies have been formed thereby exposing the barrier layers,
c) To earmark depressions that may have developed with time and (d) to identify pounding of water on the landfill cover.

At least one inspection shall be carried out during or immediately after the peak of the monsoon season.

10.1.2 Surface Water Drainage System

The surface water drainage system also should be inspected 2 to 4 times a year

i) To identify cracks in drains due to settlements;
ii) To delineate clogged drains requiring immediate clean up;
iii) To study the level of deposited soil in the storm water basin and initiate excavation measures. Broken pipes and extensively cracked drains may require replacement after filling soil beneath them to establish slopes for gravity flow. In extreme cases where long-term settlement shall be excessive, it shall become necessary to make sumps and operate storm water pumps for removal of accumulated water in the drainage system.

10.1.3 Leachate Management Systems

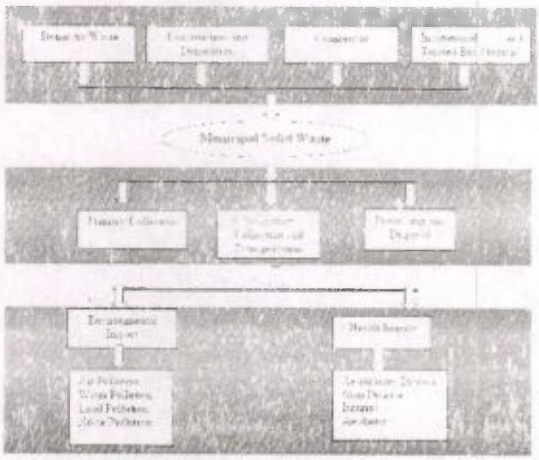
A weekly operating record of leachate management systems shall be kept in the post-closure period. Periodic inspection of the leachate collection systems (2 to 4 times a year) is to be undertaken to identify broken pipes, leakage of gas (if any) and damaged or clogged wells/sumps. Repair work will require skilled manpower and shall be carried out by the agencies operating the gas treatment and leachate treatment facilities. It may be necessary to install new gas extraction wells and leachate collection wells if the damaged / clogged facilities are inaccessible and irreparable.

Leachate utilization for humidity maintenance in composting windrows one of the most effective and useful method for disposal of leachate is to utilize it for maintenance of humidity during composting process in windrows.

10.2 Environmental Management Plan

Municipal Solid Waste Management System involves various activities like storage, collection, transportation, disposal etc. These activities even if properly controlled and with proper precautionary measures adopted, may have adverse impact on land, water and air environment, human and environmental health, aesthetics and quality of life. The Environmental and Health Impact Assessment will help in assessing the potential adverse effects of these activities and in formulation of precautions which could prevent these effects from taking place.

The most obvious environmental damage caused by municipal solid wastes is aesthetic, the ugliness of street litter and degradation of the urban environment and beauty of the city. More serious, however, and often unrecognized, is the transfer of pollution to water and ground water. Air pollution can be caused from the inefficient burning of wastes, either in open air, or in plants that lack effective treatment facilities from the gaseous effluents.



In SWM the workers are affected by existing waste management practices. The practices are fully associated with Health, Environment and Social Impacts of Workers.

Primary Collection process includes:

DTDC: In Siliguri DTDC is through cycle Rickshaws. Workers don't use PPE (Gloves and Mask) at the time of collection and transportation. Workers who are permanently engaged in this have high health impacts like respiratory disease, skin disease, injuries etc.

Street Sweeping: Street Sweeping workers are permanently associated with sweeping practices mostly affected by respiratory disease.

Drain Cleaning: Similarly Health Impacts and land pollution is also occurred when the workers don't use PPE and the residues are openly left for drying at the side of the drains.

Open Dumping: Open dumping of waste has high potential of environmental pollution and health impact. Major impact of open dumping is on ground water quality. During rainy season the leachate percolates to ground which may further contaminate the ground water table.

10.2.1 Environment and Health Risk Management at Landfill Site

The Environmental Management Plan (EMP) describes the processes that ULB should follow to maximize its compliance to environmental norms and minimize harmful impacts to the environment. It is a resource management and environmental planning, similar to development planning. This plan will also help the ULB to map its progress in achieving continual improvements towards sustaining the environment. In order to manage environmental issues, appropriate institutional arrangements along with suitable organizational structure need to be in place, with clear definition of a range of required activities, powers and responsibilities. The assessment of environmental impacts and mitigation measures have been identified for effective operation of environmental management activities in the pre-construction, construction, commissioning and O&M activities.

A comprehensive EMP consisting of proposed pollution control systems and additional mitigation measures for abatement of the undesirable impacts elucidated earlier has been drawn up, which are discussed in the following sections. A post study monitoring programme to be undertaken after commissioning of the Project, which would assist in detecting the development of any unwanted environmental situations has also been designed and already presented in the previous sections. In this context, the Project Proponent will deploy qualified and competent staff for the Project. The Environmental Management Plan consists of various interventions towards control of pollution during the Pre-construction, construction and the operation stages.

<u>Objectives of Environment Management Plan</u>

- Identifying potential environmental impacts and site specific mitigation measures;
- Identifying opportunities for enhancing pollution control measures;
- Implementation of resource conservation measures (water, energy, soil) etc.
- Reduce potential impacts on the environment;
- Sustainable development;
- Formulating monitoring programs.

Environment impacts during construction phase will be mainly due to civil works such as site clearing, foundation, construction, material and machinery transportation etc. The construction phase impact will be temporary in nature and localized phenomena except the permanent change in land-use pattern at the Project site. However, the control of pollution during construction phase is of considerable importance. Control measures recommended to mitigate the probable and limited adverse impacts are presented in the section below.

Due care will be taken to avoid water pollution during rainy season due to washout of waste material from dumpsite by appropriate constructing drains. At construction site, petroleum powered equipments and temporary storage of petroleum products may lead to fire hazard, if safety norms are not strictly followed. Hence, due care therefore, will be taken to avoid all sources of ignition near such places.

Air Quality Management

There will be potential impact on air quality due to onsite construction activities. The likely emissions from construction activities would include the following:

- Fugitive dust emissions from digging, filling, material handling, transportation and use of construction machinery etc;
- Increase in traffic volume resulting in additional vehicular emissions from vehicles bringing construction material and labour onsite;
- Emissions from operation of diesel generators for construction purpose in case of power supply failure.

Most of the gaseous emissions would be in the form of carbon dioxide (CO2), although smaller quantities of other gasses, such as oxides of nitrogen (NOx) and sulphur dioxide (SO2) would also be generated.

Adequate mitigation measures will be planned to minimize adverse impacts as follows:

- In order to minimize smoke generation, all vehicles will be maintained properly. Only Pollution under Control Vehicles (PUC) certified vehicles of contractor will be deployed at site for ensuring that diesel powered vehicles are properly maintained to minimize the exhaust emission as well as noise generation.
- Extensive tree plantation will be carried out along the plant boundary to control spread of fugitive emission. Two plants are to be planted against the de plantation of tree.
- During dry weather, dust is to be controlled by water sprinkling.
- ULB to ensure that no open burning activity is carried out at site.
- The construction debris is to be disposed off carefully.

Noise Management

Noise produced during construction phase may have a temporary impact on the existing ambient noise levels. Noise from construction equipments and traffic movements is expected to be about 85 dB (A).

The potential noise emissions will be mainly from:

- Diesel Generators: 85 dB(A)
- Heavy Duty Construction equipment: 75 to 95 dB (A)
- Batching Plant Boundary: 75 dB (A)
- Vehicular Noise: 85 dB (A)

Noise emissions will be controlled by the following measures

- Noise generating machines and equipments to be maintained as per standards.
- Oiling and greasing in the machines to be done regularly.
- Noise prone activity to be restricted to the extent possible.
- Diesel Generator sets to be provided with inbuilt silencer surrounded by acoustic enclosures.

- Onsite workers will strictly use noise protection devices like earmuffs. The construction machinery will be regularly maintained to minimize the noise levels generated.

Leachate Management

The landfill design includes measures to collect leachate and prevent pollution of surface-and ground water. Leachate will be treated by simple sedimentation and evaporation, and sludge that collects in the bottom of ponds will be allowed to dry out before being returned to the landfill. Given the amount of rain that falls in this region, and the pollution of land and water that can occur if a landfill is subjected to flooding, the detailed design should ensure that:

i) Surface water drains at the site are adequate to retain and dispose of the heaviest rains;
ii) O&M procedures require drains to be kept in working order at all times and checked regularly and cleared of any sediment or other debris.

Green Belt Development

With a view to attenuate air pollution, to absorb noise and take care of uptake of water pollutants, it is recommended to develop a greenbelt of 20% of total area, all around the boundary and at several locations within the Project Site. Plantation will also be done on road side connecting to the plant site.

Purpose of Green Belt Development

- Protect and develop natural and semi natural environment to ensure sustainable development.
- Improve air and water quality within the impact zone.
- Work as noise shield around periphery of project.
- Restore ecological balance.
- Improvement of local climate
- Ensure that urban dwellers have access to country side with consequent educational and recreational opportunities.
- Protect the unique character of rural communities.

11. PROJECT COST

11.1 Abstract of Cost Estimate

The total cost of the project for **base year** would be INR 45 Crores. Land cost and manpower cost has not been considered in the cost estimates.

Table 65: Cost Summary

S. No.	Particulars	Cost in Lakh Rs.
1	Primary Collection	429.2
2	Street Sweeping	143.5
3	Drain Cleaning	109.2
4	Secondary Storage	57.3
5	Collection and Transportation	100.2
6	Processing Plant	1038.5
7	Disposal Site	2620
	Sub Total	4497.90
	Contingencies 3 % 0.03% Considered.	1.35
	Total	**4499.2**

11.2 Detailed Cost Estimates

The detailed cost of various components of Solid Waste management plan is given in the trailing tables:

a. Capital Cost of Primary Waste Collection is given in the table below:

Table 66: Capital Cost of Primary Collection

S. No.	Vehicle/Equipment	Existing number with SMC	Required Number as per Calculation	Number to be procured	Rate in Rs.	Amount in Lakh Rs.
1	Number of Auto Rickshaw required for DTDC		74	74	439,450	325.2
2	Number of Manual Tri-cycles required for DTDC	280	582	302	32,645	98.6
3	Dust Pans	280	1454	1174	2,405	28.2
4	Gloves (Pairs)		8717	8717	61	5.3
5	Boots		1454	1454	617	9.0
6	Uniform		1454	1454	1000	14.5
7	Helmet		1454	1454	78	1.1
8	Safety Mask		75537	75537	7.21	5.4
Total						**429.2**

b. Capital Cost of Street Sweeping is given in the table below:

Table 67: Capital Cost of Street Sweeping

S. No.	Vehicle/Equipment	Existing number with SMC	Required Number as per Calculation	Number to be procured	Rate in Rs.	Amount in Lakh Rs.
1	Hand Cart for Street Sweeping	235	392	157	1,256	2.0
2	Sweeping Machine	1	3	2	5,367,562	107.4
4	Gloves (Pairs)		783	783	61	0.5
5	Boots		1566	1566	617	9.7
6	Uniform		1566	1566	1000	15.7
7	Helmet		1566	1566	78	1.2
8	Safety Mask		81392	81392	7.21	5.9
9	Shovel	235	392	157	2,884	4.5
10	Broom	5640	18783	13143	131	17.2
Total						**163.97**

164.1

c. Capital Cost of Drain Cleaning equipments is given in the table below:

Table 68: Capital Cost of Drain Cleaning

S. No.	Vehicle/Equipment	Existing number with SMC	Required Number as per Calculation	Number to be procured	Rate in Rs.	Amount in Lakh Rs.
1	Suction Cum Jetting M/c	2	5	3	3,138,925	94.2
2	Dust Pans		845	845	2,405	20.3
3	Gloves (Pairs)		422	422	61	0.3
4	Boots		845	845	617	5.2
5	Uniform		845	845	1000	8.5
6	Helmet		845	845	78	0.7
7	Safety Mask		43919	43919	7.21	3.2
8	Shovel		211	211	2,884	6.1
Total						**138.3**

138.5

d. Capital Cost of Waste Collection Bins is given in the table below:

Table 69: Capital Cost of Secondary Collection Bins

S. No.	Vehicle/Equipment	Existing number with SMC	Required Number as per Calculation	Number to be procured	Rate in Rs.	Amount in Lakh Rs.
1	1.1 CUM Bins - Community/ Compactor Bins (Roadside)	80	120	40	22000	8.8

S. No.	Vehicle/Equipment	Existing number with SMC	Required Number as per Calculation	Number to be procured	Rate in Rs.	Amount in Lakh Rs.
2	3.5 CUM Bins - Community/ Compactor Bins (Roadside)	10	30	20	38000	7.6
3	4.5 CUM Bins - Community/ Compactor Bins (Roadside)	30	30	0	42000	0.0
4	4 5 CUM dumper container	150	150	0	53000	
5	Two Wheel 240 L HDPE Bins		137	137	18000	24.6
6	20 L two Bins set		401	401	4000	16.0
7	Covered Vans - Existing Number 225 - Considered 40% of the existing covered vans to be in working condition	90	90	0		
Total						57.1
Covered Vans to be Phased out in next 5 years and 1.1, 3.5 and 4.5 CUM bins to be procured						

57.0

e. Capital Cost of Waste Collection Vehicles is given in the table below:

Table 70: Capital Cost of Secondary Waste Collection Vehicles

S.No.	Vehicle	Existing number with SMC	Required Number as per Calculation	Number to be procured	Rate in Rs.	Amount in Lakh Rs.
1	Compactor - 7 CUM	2	3	1	2600000	26.0
2	Compactor - 14 CUM	1	3	2	3500000	70.0
3	Dumper Placer - 4.5 CUM (4 old and 10 new one) - Tata Xenon and DI - LCV	14	14	0		
4	Tractor with Covered Refuse trailer	23	10	0		
5	Tipper 16 T	10	2	0		
6	Tipper 9 T	5	2	0		
7	Pay loader/Backhoe (3 old and 5 new ones) 1 Pay loader considered for two tippers	8	2	0		
8	For Uniform and protective wear					4.2
Total						100.2

Tractors and LCV Dumper Placer's to be Phased out in and MCV/HCV Dumper Placer, 7 CUM and 14 CUM compactors to be procured

f. Capital Cost of Compost Plant – Phase I – 200 TPD:

Table 71: Compost and RDF Plant - Capital Cost of Plant and Machinery - 2015 for 200 TPD

S.No.	Item	Criterion/Assumption	Existing Number with SMC	Number Required	Cost per Unit in Rs.	Cost in Lakh INR
	Compost Plant Equipment					
1	Plant : a. Pre Sorting Unit b. Compost Unit c. Eco Bricks Unit d. DG and Transfer Room e. Windrow Bed f. Semi-Finished Unit g. Finished Unit h. CCTV Monitoring i. RDF unit			1	100000000	1000
2	Loader Backhoe		1	1		
3	Tipper 16 CUM		2	2		
4	Tractor with tipper		1	1		
5	Windrow Turner			1	2000000	20
6	Water tanker 3000 l capacity			1	350000	3.5
7	Computerized Weighbridge			1	1500000	15
Total						**1038.5**

g. Capital Cost of Landfill Site and Vehicles

Table 72: Capital Cost of Landfill Site development

S. No.	Capital Cost of Landfill Site Item	Existing Number with SMC	Number Required	Cost per Unit in Rs.	Cost in Lakh INR
1	Landfill Site Infrastructure		1	LS	2500
2	Loader cum Excavator		1	2500000	25
3	Bulldozer		1	6000000	60
4	Compactor		1	3500000	35
Total					**2620**

11.3 Operation and Maintenance Cost:

Operation and maintenance cost per annum for various activities are considered as given below:

i) Primary Collection, Drain Cleaning and Street Sweeping 40% of capital cost
ii) Transport Equipment 30% of capital cost
iii) Processing plant 10% of capital cost
iv) SLF site 10% of capital cost

Table 73: O & M Cost

S. No.	Particulars	Cost in Lakh Rs.
1	Primary Collection	425
2	Street Sweeping	
3	Drain Cleaning	
4	Secondary Storage	
5	Collection and Transportation	135
6	Processing Plant	104
7	Disposal Site	262
	Total	**926**

11.4 Financial Structuring

The proposed financial structuring is done in line with the Swachh Bharat Mission (Urban) guidelines for the mission period, i.e. from 2017 to 2021. Post 2021, it has been assumed that funds if necessary, is to be released by the centre in the form of grants. According to the proposed plan, ULB will recover the capital cost and O&M cost from user charges, byproducts from compost plant, and Eco-brick. The total amount required to commission the whole system is Rs. 449,920,000.

Capital grants for the proposed project in the ratio of 75:20:5 to be funded by the Government of India (GoI), the Government of West Bengal and SMC's share in the form of long term loan from State Finance Department (10 years repayment period and annual interest of 9%).

S. No.	Funding Agency	Amount	% Share
1	Central Government	337,440,000	75
2	State Government	89,984,000	20
3	Local Government	22,496,000	5

Table: Installments to be paid by ULB

Sr. No.	Components	Amount
1.	Total Loan able Amount	22,496,000
2.	Annual interest (9% per annum)	12,557,287
3.	Total Amount to be paid (10 year period)	35,053,287
4.	Installment to be paid by ULB	3,505,329

11.5 Revenue Options

The revenue sources proposed under MSW management are:

1. Sale of Windrow compost
2. Sale of Plastic Granules
3. Sale of Eco Bricks
4. Levy of User Charges

The revenue that can be generated from various treatment processes are as follows:

11.5.1 Revenue from Sale of Windrow compost

S. No.	Particulars	Qty.	Units
1	Total Amount of Waste Generated per Year	123,309,045	kg
2	Total Amount of Bio Degradable Waste Generated per Year (60%)	73,985,427	kg
3	Total Amount of Bio Degradable Waste remains after composting (15%)	11,097,814.05	kg
4	Price per kg (Rs)	3	INR
5	Total Revenue Generated Per Year	33,293,442.15	INR

11.5.2 Revenue from Sale of RDF

S No	Particulars	Qty.	Units
1	Total Amount of Waste Generated per Year	123,309,045	kg
3	Total Amount of RDF(30%)	36,992,713.5	kg
4	Price per kg (Rs)	4.5	INR
5	Total Revenue Generated Per Year	166,467,210.75	INR

11.5.3 Revenue from Sale of Eco Bricks

S. No.	Particulars	Quantity	Unit
1	Incoming Waste	313	MT/day
2	Rate of Incoming Waste	10%	
3	Total amount of C and D waste	31.3	MT/day
4	Minimum requirement of waste to start the plant	2	MT/day
5	Boiler ash to be added and if not available river sand to be added.		
6	Requirement of Waste and Other Material		
a	Aggregate of C & D - 70 %	1400	kg
b	Sand or Boiler Ash - 20%	400	kg
c	Cement - 0.075%	150	kg
d	Water - 9.925%		
7	Total Brick Production per day	748	no.
8	Per brick Cost	4.5	INR
9	Total brick cost	3366	INR
10	Revenue by selling bricks per day	5984	INR
11	Revenue by selling bricks per year	21,85,257	INR

11.5.4 Revenue from User Charges

Sr. No.	Particulars	Nos.	Charge per Month	Total per per year
1	No. of Families	115957	25	34787100
2	Institutional	172	300	619200
3	Commercial	204	300	734400
4	Industrial	38	1000	456000
5	others	2800	25	840000
6	Hotels/Bhawans	65	1000	780000
7	Nursing Homes	35	2000	840000

Sr. No.	Particulars	Nos.	Charge per Month	Total per per year
8	Pathology Labs	50	300	180000
9	Hospitals	4	5000	240000
	Indoor Stadium, K.J. Stadium, K.C. Bhawan	3	1000	36000
	Total Collection			39,512,700

The following table shows the capital expenditure separately for the Mission Period and for the rest of the project period. Year wise capital expenditure and installments to be paid has also been calculated to understand the actual expenditure to be borne by the ULB. Annual income from sale of recyclables, compost products and user charges has been calculated in order to identify the total annual profit.

year	Capital Expenditure	O&M	Installment to be paid	Total Revenues	Net Income
2017	449920000	92,600,000	3,505,329	156,702,351	(389,322,977)
2018		97,230,000	3,505,329	186,344,507	85,609,178
2019		102,091,500	3,505,329	216,994,534	111,397,705
2020		107,196,075	3,505,329	248,652,709	137,951,305
2021		112,555,879	3,505,329	281,317,806	165,256,598
2022		118,183,673	3,505,329	286,357,238	164,668,236
2023		124,092,856	3,505,329	291,274,205	163,676,020
2024		130,297,499	3,505,329	296,190,621	162,387,793
2025		136,812,374	3,505,329	301,108,776	160,791,073
2026		143,652,993	3,505,329	306,027,934	158,869,613
2027		150,835,642		310,947,351	160,111,708
2028		158,377,425		315,744,386	157,366,961
2029		166,296,296		320,543,244	154,246,948
2030		174,611,111		325,342,433	150,731,322
2031		183,341,666		330,142,729	146,801,063
2032		192,508,749		334,942,633	142,433,883
2033		202,134,187		339,620,267	137,486,081
2034		212,240,896		344,299,834	132,058,938
2035		222,852,941		348,980,600	126,127,659
2036		233,995,588		353,661,834	119,666,246
2037		245,695,367		358,345,802	112,650,434
2038		257,980,136		362,905,366	104,925,230
2039		270,879,143		367,467,734	96,588,592
2040		284,423,100		372,029,916	87,606,816
2041		298,644,255		376,594,203	77,949,948
2042		313,576,468		381,159,860	67,583,392
2043		329,255,291		385,601,988	56,346,697
2044		345,718,055		390,046,303	44,328,247
2045		363,003,958		394,492,080	31,488,121

year	Capital Expenditure	O&M	Installment to be paid	Total Revenues	Net Income
2046		381,154,156		398,939,348	17,785,192
2047		400,211,864		403,387,366	3,175,502

Looking at the profit level, the ULB may repay the loan prior to the prescribed period of 10 years as mentioned above, but the profitable amount at the same time also should be used for IEC activities, Capacity Building and upgrading of the compost and Plastic Granule plants in line with improved technologies down the time scale.

11.6 Sources of Funds

Siliguri Municipal Corporation, through various schemes may get financial support for introducing appropriate solid waste management systems and for setting up processing and disposal facilities. These include the following:-

- Swachh Bharat Mission for the Mission Period.
- 13th and 14th Finance Commission Grants from Ministry of Finance.
- Viability Gap Funding from Ministry of Finance.
- Support for Purchase of Compost from Ministry of Agriculture.
- PPP as a source of funding.

12. INSTITUTIONAL ASPECTS AND CAPACITY BUILDING

Improvement of SWM requires promotion of an institutional framework that is transparent and has very well-defined roles and responsibilities for the different actors. Authorities and service providers should be accountable to the public in accordance with principles for good governance. Moreover, the professionalization of the SWM sector and its workers is essential to improve the provision of such an important service that affects the health, environment, and quality of life of urban populations.

Municipal Corporation is therefore responsible for collection, sweeping, storage, transfer, treatment, and final disposal of waste. However, the provision of this service is not efficient, and the providers are not accountable to the residents and business establishments they serve. Another typical problem is that SWM services come under municipal departments without the expertise to handle them, such as public health departments.

12.1 Decentralization of Administration

To perform SWM services effectively, a decentralized administrative set up has been proposed. A three tire monitoring set up has been proposed for efficient implementation of this project. At ward level, Zonal level and at city level.

Settlement Level Administration- At settlement level, the committee will be responsible for ensuring door to door to collection system and road sweeping activities.
The settlement Level Committee will include group of residents, ward councilor, CBOs and NGO Representatives, Private Land owners.

Ward Level Administration: The ward level administration will be fully responsible for ensuring storage of waste at source, primary collection of waste, street Sweeping, draining cleaning etc. The beat (team) leader of each service i.e. primary collection of waste, street sweeping, waste collection from public places and sanitary supervisor for each 12,500 population will be responsible for monitoring.

At ward level, a ward committee may be proposed for overall performance monitoring purpose along with public awareness activities. The other function of this committee would also be to take up the grievances of the local residents of the ward and try to resolve them at the earliest.
The ward level committee will include the local ward councilor, one supervisor and the beat leader for primary collection, Street Sweeping, draining cleaning. It would also include members from Local NGO, CBOs and RWAs if any.

Zonal Level Administration: Zonal Level Administration will effectively supervise and support the ward level Administration and solve the zonal level issues such as proper transportation system and identification of adequate collection points. Sub sanitary Inspector one for each

25,000 population and sanitary Inspector for each 1, 00,000 populations will be responsible for it. The administrative body will arrange weekly/monthly review meetings and present weekly/monthly Reports to city level administration. Training to SWM workers regarding the impact on environment and public health on improper waste management activities is to be conducted bi-annually.

The zonal level committee will include the responsible Supervisor, Sub Sanitary Inspector and Sanitary Inspector.

Six boroughs have been proposed for serving sanitation services to Siliguri city including all aspect of solid waste management i.e. door to door collection, street sweeping, drain cleaning etc. The population and its density have been considered to decide the zones. For each Zone one SI has been given the responsibility to monitor the activities.

The proposed zones are shown in exhibit below.

Borough	Sanitary Supervisors	Sanitary Sub Inspectors	Sanitary Inspectors	Borough Officer	Chief Sanitary Inspectors/ Assistant Engineer	Assistant Executive Engineer
1	8	4	2	1	1	1
2	10	5	3	1		
3	10	5	3	1		
4	10	5	3	1		
5	9	5	3	1		
Total	**47**	**24**	**14**	**5**	**1**	**1**

City Level Administration: The City Level Administration will effectively supervise and support the Zonal level Administration and provide help such as procurement of new vehicles, maintenance of existing vehicles, setting up and maintenance of processing plant and landfill site. It will also arrange monthly review meeting to evaluate the existing progress of activities. The body will also prepare performance evaluation indicators and monthly progress report which is to be sent to the State. Arrange qua terly workshop for capacity building and general awareness. The body will also frame bylaws; finalize fees to be levied as user charge after doing proper consultation at the state level and also evaluate financial aspects related to SWM systems.

The City Level Committee will include Sanitary Inspectors, Chief Sanitary Officer, Assistant Public Health Engineer, Public Health Engineer/Environmental Engineer, Municipal Chairman and Municipal Commissioner.

District Level Review and Monitoring Committee (DLRMC) should be constituted with a view to fulfill the objective of ensuring satisfactory monitoring of projects under the chairmanship of Member of Parliament or District Collector.

12.2 Delegation of Powers

Authority and responsibility will go hand to hand. For fixing accountability there would be adequate delegation of fiscal and disciplinary power to the officers and the supervisory staff responsible for managing solid waste and carrying out all day to day functions smoothly.

12.3 Organizational Set up to address Sanitation Issues

SWM department will be under Commissioner, Municipal Corporation. The Public health/Environmental Engineer will be reporting to the commissioner. The organizational set may be divided into 4 sectors:

i) Primary Collection
ii) Secondary Collection and Transportation
iii) Treatment/Processing facility
iv) Disposal Facility

For monitoring and supporting the above sectors and its efficient implementation committees along with their members and their roles and functions has been proposed.

Human Resource Development

Government agencies involved in MSWM issues handbooks to the industry and waste separation and recycling/reuse guidebooks to the community in general. Waste management officers to be sent in meetings and conferences to learn about new technologies and to attend workshops or conferences. Professional bodies and trade and manufacturers' associations also conduct seminars, workshops, and demonstration projects for the benefit of their members.

Training for Supervisors and Senior Officers

All officers and supervisors must be exposed to training to learn about the changing technologies in the SWM sector and best practices adopted by different cities within the State, Country, and abroad. The workshops and training programs may be defined including the following points:

i) Develop Cost-efficient models of MSWM systems and appropriate technology for local application.
ii) Formulation of Research programs for waste minimization, including the development of low-pollution products, closed-loop recycling processes, and other low-pollution manufacturing processes
iii) Joining with industries and institutions for higher learning.

Refresher Courses for Supervisory Staff: Refresher courses should be conducted for officers and supervisors at least after every five years.

Promotional Opportunities: Adequate promotional opportunities should be available in the decentralized SWM hierarchy to encourage supervisory staff members to remain in the department.

12.4 Inter Departmental Co ordination

Inter-departmental Coordination is required in between Siliguri-Jalpaiguri Development Authority, State Pollution control board, National Environmental Engineering research institute and National Green Tribunal for effective solid waste management in the city.

12.5 Involvement of Private Sectors

Solid waste management, processing and disposal are an area where the private sector has still not shown much interest. The private sector has, therefore, to be given some incentives by way of long term contract, assured supply of garbage at the plant site, lease of land at nominal rates for entering this field.

NGO as well as Private sector participation may be encouraged in such a way that it does not affect the interests of the existing labour, it does not violate the provisions of the above law, does not exploit the private labour and yet reduces the burden of the urban Municipal Authorities. This will substantially help in improving the quality of service of the urban local bodies, effect economy in expenditure and also give scope to the private sector to enter the waste management market.

12.6 Community Participation

Community is in the centre of all the activities, yet it is ignored by the decision makers and made to merely wait and watch and ultimately what people get in hand is what they do not want or what is not in their priority. This creates a void between the administrators and those administered and an atmosphere of apathy is created which distances people from government initiatives. Public awareness, effective community participation, transparent and clean administration, introduction of citizen charters and accountability at all levels can only bridge this gap. Solid Waste Management (SWM) is one such activity, where public participation is key to success. The local body can never be successful in Solid Waste Management without active community participation, whatever may be the investments made from the municipal or Government funds. The local body should therefore, seriously consider involving community in all programmes through a consultative process and variety of other communication approaches.

12.6.1 Strategy of Community Participation

The following strategy may be adopted by Siliguri Municipal Corporation for community participation.

i) **Identification of group of people to be addressed**

The SMC may identify Residential Area, Commercial, Markets and Office areas. The Residential area may be classified as High Income group, Middle Income group and Low Income group. The level of awareness and sensitivity of each group is different so SWM awareness needs to be tackled differently for each group.

ii) Identification of the Areas in Solid Waste Management Where Community Participation is Essential

Solid Waste Management involves several stages of activities where people's participation is critically required in some of them and local body has to do the rest of the work.

People's participation is essential in the following areas.

- Reduce, Reuse & Recycling (R R R) of waste.
- Not to throw the waste/litter on the streets drains, open spaces, water bodies, etc.
- Storage of organic/bio-degradable and recyclable waste separately at source.
- Primary collection of waste
- Community storage/collection of waste in flats, multi-storied buildings, societies, commercial complexes, etc.
- Managing excreta of pet dogs and cats appropriately.
- Waste processing/disposal at a community level (optional)
- Pay adequately for the services provided.

iii) Reach the Community

The local body should decide the methodology to be adopted for reaching the community and seeking their cooperation and effective participation in SWM services. This is a very difficult area of activity and unless this is done meticulously, desired results may not be achieved.

The essential steps in this direction is to select representative samples of the community and go through a consultative process to ascertain the perceptions of the people about the SWM services being given to them, their expectations and extent to which they are willing to support and participate in the process. Their choice of technological options available also needs to be ascertained.

The consultative process could be taken up as under

- Identification of Problems
- Finding out Optional Solutions
- Consult Community on Options Available
- Workout the Strategy of Implementation
-

12.7 Public Awareness and Training

NGOs may be involved in creating public awareness and encouraging public participation in SWM planning and practice.

The Municipal Authorities may also encourage NGOs to enter this field and organize rag pickers in doorstep collection and sorting of waste and provide them an opportunity to improve their working conditions and income. The Municipal Corporation can give incentives to NGOs in their effort of organizing rag pickers in primary collection of recyclable and/or organic waste, and provide financial and logistic support to the extent possible.

12.8 Institutional Strengthening

SWM services are highly labour intensive on account of increased wage structure of the Government and municipal employees. This service is becoming more and more expensive. Besides, the efficiency of the labour force employed in the urban local bodies is far from satisfactory. High wage structure and inefficiency of the work force are resulting into steep rise in the cost of service at Siliguri and yet the people at large are not satisfied with the level of service being provided by the urban local body. Efforts to increase the efficiency by H.R.D. and institutional strengthening are needed to improve the performance to some extent. It is, therefore, necessary that the Municipal Authorities seriously considers NGO/private sector participation in generating public awareness in solid waste management.

Private sector participation or public private partnerships may be considered by Municipal Authorities keeping in mind the provisions of the Contract Labour (Regulation and Abolition) Act 1970 of the Government of India which does not permit contracting out the services already being provided by the urban local body. Therefore, while considering any measure of privatization it is necessary to keep in mind the provisions of the above law and consider private sector participation in those areas where Municipal Authorities is not currently providing a service. This will check growth in the establishment costs, bring in economy in expenditure and introduce an element of healthy competition between the private sector and the public sector in solid waste management services. There should be a right mix of private sector and public sector participation to ensure that there is no exploitation of labour as well as of the management.

NGO/private sector participation can, therefore, be considered in newly developed areas, under-served areas and particularly in areas where local bodies have not been providing service. For example:

NGO/private participation should be encouraged in the areas of door to door collection of domestic waste, door to door collection of commercial waste, door to door collection of hospital waste, hotel waste and construction waste and in the area of awareness and creating public participation. Supplying vehicles on rent, supplying vehicles on lease, repairs and maintenance of vehicles at private garages are also some areas where the private sector can be involved.

12.9 Redressal of Public Grievances

Siliguri city should have effective system to redress public grievances. Public can register their complain using various methods as detailed out below.

i) **Commissioner Helpline:** In this help line people can register their complaint by mobile application, toll free number and using website. In this system they can also check status of their complaints.

ii) **Public hearing:** Public Hearing is processes by which people who may be affected by a particular action or decision have the opportunity to ask questions, make submissions or register

objections to a panel of experts. The panel may comprise of elected representatives, government officials, non-government organizations, experts from the field, media, etc.

12.10 Action Plan for Capacity Building

Each staff member engaged in the solid waste management programs should receive adequate training in the areas of solid waste management, sanitary landfill operations, waste disposal techniques, hazardous solid waste management, groundwater standards, leachate treatment processes, recycling, resource recovery and environmental law. In addition to the initial training, the following may be taken to ensure that employees remain updated in the field of solid waste management:

i) Solid waste staff should attend at least one formal training program every 3 years.

ii) At least one trade journal and one professional journal in the field of solid waste management as well as textbooks and reference materials should be available to the staff with its orientation class to everyone.

iii) Each solid waste staff member shall participate at least once annually in joint inspections with the member's supervisor and State solid waste program representative. MoEF/CBUD to provide additional formal staff training to ULB health departments to enhance technical knowledge and ensure universal application of the rules and regulations.

iv) Staff members from the ULB should be invited to participate at staff meetings held by MoEF/CBUD on a regular basis in regional and central offices.

v) State level health departments should provide with copies of the Solid Waste Management's Policy and Procedures to the Ulbs.

13. INFORMATION, EDUCATION, COMMUNICATION AND MONITORING PROCESS

Information, Education and Communication (IEC) can be defined as an approach which attempts to change or reinforce a set of behaviours in the "target audience" regarding a specific problem in a predefined period of time. IEC strategies involve planning, implementation, monitoring and evaluation. When carefully carried out, the communication strategies help to foster positive waste management practices individually and institutionally and can contribute to sustainable changes in the environment.

IEC is an umbrella term which aims at achieving measurable behavioural changes within specific target audiences by sharing information and ideas. It involves, appropriate channels, messages and methods based on their needs & perceptions. It includes generation and dissemination of general and technical information, facts & issues. It is based on people's concerns, perceived needs & prevalent practices. IEC aims to enable target audiences to make rational & informed decisions so as to reach mutual understanding.

***Capacity building** often refers to assistance which is provided to entities, which have a need to develop a certain skill or competence, or for general upgrading of performance ability.*

The major objectives of the IEC and Capacity Building are as follows:

- Bringing of attitudinal and behavioural changes among the residence w.r.t. the segregation of waste and sanitation improvement.
- Public awareness through IEC programmes and educating the masses on various aspects of solid waste management and achieve the target of receiving segregated waste from each household.
- Creating Public Participation in Planning and Management of MSW Activities.
- Capacity Building of the personnel involved in implementing MSW i.e. Institutional Capacity of Sanitary and Health Department of Municipal Corporation for improved MSW Management.
- Integration and involvement of private sweepers and rag pickers in improving MSW management.

13.1 Public Participation & Awareness through IEC Plan

The success of any solid waste management scheme can be measured through the extent of cooperation and participation of people, effectiveness of the proposed system and operational efficiency. Communication is an integral part of planning for sustainable development. The development of human society is largely because of its ability to communicate information and ideas with each other and to use such information and ideas for progress.

The programmes being implemented by the Government Departments aim at sustainable holistic development in all development projects. The success of these programmes is critically dependent on the participation of the people, particularly target groups, in the implementation

process. The approach should be to emphasize on communication with target groups, local community for the implementing programme of SWM at strategic locations in town.

13.2 Target group Points for Mass Awareness

Sr. No.	Target Group	Action Plan
1.	Households	1) Not to throw any solid waste in the neighborhood, on the streets, open spaces, and vacant lands, into the drains or water bodies. 2) Keep food waste/biodegradable waste in a noncorrosive container with a cover (lid) 3) Keep, dry/recyclable waste in a bin/bag or a sack. 4) Keep domestic hazardous waste if and when generated separately for disposal at specially notified locations.
2.	Multistoried buildings, commercial complexes, private societies, etc.	1 to 4 as above; 5) Provide separate community bin/bins large enough to hold food/biodegradable waste and recyclable waste generated in the building/society. 6) Direct the member of the association/society to deposit their waste in community bin on day to day basis before the hour of clearance.
3.	Slums	1 to 4 as above; 5) Use community bins provided by SMC for deposition of food and biodegradable waste.
4.	Shops, offices, institutions, etc.	1 to 4 as above; 5) If situated in a commercial complex, deposit the waste so stored as per 2 and 3 above in community bins provided by the association.
5.	Hotels & Restaurants	1 to 4 as above. However, the container used should be strong and with lid.
6.	Vegetables & Fruit Market	1) Provide large containers, which match with transportation system of the local body. 2) Shop keepers not to dispose of the waste in front of their shops or open spaces. 3) Deposit the waste as and when generated into the large container placed in the market.
7.	Meat & Fish Markets	1) Not to throw any waste in front of their shops or open spaces around. 2) Keep non-corrosive container/containers with lid handle and deposit the waste in the said containers as and when generated. 3) Transfer the contents of this container into a large container provided by the association of the market or local body on day to day basis before the hour of clearance.
8.	Street Food Vendors	1) Not to throw any waste on the street, pavement or open spaces. 2) Keep bin or bag for the storage of waste that generates during street vending activity.

Sr. No.	Target Group	Action Plan
		3) Preferably have an arrangement to affix the bin or bag with the hand-cart used for vending.
9.	Marriage Halls, Community Halls, etc.	1) Not to throw any solid waste in their neighborhood, on the streets, open spaces, and vacant lands, into the drains or water bodies. 2) Provide a large container with lid which may match with the transportation system of the local body and deposit all the waste generated in the premises in such containers.
10.	Hospitals, Nursing Homes etc.	1) Not to throw any solid waste in their neighborhood, on the streets, open spaces, and vacant land, into the drains or water bodies. 2) Not to dispose off the biomedical waste in the municipal dust bins or other waste collection or storage site meant for municipal solid waste. 3) Store the waste as per the directions contained in the Government of India, Ministry of Environment Biomedical Waste (Management & Handling) Rules 1998 and modified in 2003.
11.	Construction & Demolition Waste	1) Not to deposit construction waste or debris on the streets, footpaths, pavements, open spaces, water bodies, etc. 2) Store the waste within the premises or with permission of the authorities just outside the premises without obstructing the traffic
12.	Garden Waste	1) Compost the waste within the garden, if possible. 2) Trim the garden waste once in a week on the days notified by the local body. 3) Store the waste into large bags or bins for handing over to the municipal authorities or contractors appointed for the purpose on the day of collection notified.

13.3 Approach of IEC Plan

The basic approach of Information, Education and Communication Plan is to make the public aware about the need of reduction and segregation of waste from the households along with the collection system of waste to take public cooperation for making the environment pollution free and to develop proper hygienic conditions.

Attitudinal and behavioral changes of the residents of Siliguri are important for the success of the segregated waste collection and its sustainability. For this purpose, communication with the residents is required through various techniques and modes. The proposed public participation & awareness programme may be carried out using localized and area specific popular tools that may be identified during project implementation period.

However, some of the effective tools to forge public participation shall include the following:

- Focused Group Discussions (FGDs)

- Inter personal communications
- Creating local committees comprising of local influential people, RWA /Society members and important stakeholders.
- Printed materials and Audio-visual aids
- Other locally popular media

13.4 Communication

Communication Planning is an integral part of planning for sustained development. The development of human society has largely been due to its ability to communicate information and ideas with each other and to use such information and ideas for progress. First attempt would be to launch a public campaign to raise awareness about cleanliness. Door to Door Campaign for door to door information spreading, involvement of health workers (Sanitary staff) would be easy and speedy along with the volunteers. It will also create a platform for better communication among public and sanitary staff. The volunteers and health workers will help in spreading the project information with the help of support material which will be helpful for providing effective information along with time saving.

13.4.1 Focus Group Discussion & Public Meetings

Through Focus group Discussions and public meetings people could be directly informed, educated and convinced for their role and responsibilities for the segregation at source and for their involvement in solid waste management. This is an effective tool; usually time taking as discussions last for 1 or 2 hours.

13.4.2 Media Support

Mass media is a great tool to spread information among the community in a very fast and effective medium. For the IEC purpose, print media as well as electronic media could have a great role for informing people about the project and how their support can do the changes for making their town clean and hygienic.

13.4.3 Folk Programme

Folk Programmes like street plays are the entertaining media for the community on one hand and educating people in a very effective manner on the other hand. These programmes are very successful in low income groups and slums. These activities not only generate awareness but educate people about the issues and their solutions.

13.5 Social Mobilization

For social mobilization, attitudinal and behavioral changes of the residents', involvement of major stakeholders are essential. For this purpose institutions and other organizations involved in social activities would be contacted as they are great awareness centers for social mobilization and public awareness. The organizations / institutions / stakeholders', which can play an active role in social mobilization, are listed below:

- Educational Institutions (Schools, Colleges, etc.)

- NGOs/ CBOs/ RWAs
- Sr. Officials/ Administration Officers / Sr. Citizens

13.6 Identification and Action

The basic approach of Information, Education and Communication Plan is to make the public aware of the need of reduction and segregation of waste from the households along with the collection system of waste to take public cooperation to make hygienic structure of the area. Selection of target groups plays a key role in creating effective awareness in residential. For solid waste management, it becomes more important as the source of MSW starts from houses due to which target starts from household female head, youths and children who requires some form of role model or different methods to influence their behavior. It is a very important aspect which could be at waste generators level and may reduce, reuse and recycle their waste. The other part of target groups may be waste collector and waste managers. These types of target groups are directly involved with the solid waste management. Along with this, there are other groups which can be helpful for the better management of MSW segregated waste, collection, operation, handling and proper disposal.

13.7 Training Programmes

The basic approach of Training & Capacity Building is to bring effectiveness to the existing Solid Waste Management System in Siliguri town and to increase operational efficiency of the sanitary staff of Municipal Corporation Siliguri. Municipal Corporation has appointed many officials & sanitary staff for waste management in the town. To know their knowledge, to judge their efficiency, a baseline data would be collected through questionnaire survey, structured interviews of the ULB staff. On the basis of the findings of the study, training programmes and training schedule would be prepared for different levels of the ULB staff. Training programme to be planned and workshops to be organized for imparting training to the official

13.7.1 Objective of Training Programmes

The Training Programme is to be planned with the following aim:

- To sensitize the involved group with working knowledge of the benefits of waste reduction, segregation and management.
- To impart clear instructions about the respective roles from generator to waste managers.

For achieving these objectives, a core group of trainers, needs to be organized for continuous in-house training of the manpower to be deployed and other sanitation staff of SMC. For the success of this programme it is essential that training and orientation programme is to be planned for all the people involved at different levels of solid waste management system like Administrative and Officials, Technical and non-technical staff etc. Along with these, private sanitary staff and rag-pickers should also be motivated for their active role in waste collection process.

Table 74: Information Education & Communication

S No.	Activities	Implementation Period	Unit Cost (Rs)	Total cost (Rs)
A	Program Communication			
1	Door to Door campaign: One to one interaction (Health worker, NGO field staff and volunteers)	Twice a year (Volunteers 6@Rs.100/- per day for 20 days per schedule)	L.S	24,000
2	Public Address (Focus group discussion, stakeholders meeting workshop and seminars)	Two meetings at different locations in all 47 wards	1,500	141,000
3	School Programs (Essay, painting, poster, debates, quiz competitions/ Introduce projects, games and role play & Rallies through students)	2 activities in a month for initial 10 months.	5,000	120,000
4	Print Media (Newspapers, Magazine, Flyers etc.)	For initial 10 months		
a	Newspaper Articles	1 Media support meeting for proper coverage in Newspapers in every two months	5,000	25,000
b	Support Materials: (Pamphlets, Handouts, Posters, Banners, Wall Paintings etc.)		L.S.	25,000
5	Street Plays : (Nukkad Nataks)	Street Plays in each middle and lower strata of societies about 20	5000	100,000
		Sub-Total (A)		445,000
B	Training			
1	Training need assessment study through structured interviews	Of Stakeholders, ULB's Staff and Sanitary Workers	L.S	100,000
2	Conducting Training of Sanitary Workers	25 Trainings	10000	250,000
		Sub-Total (B)		350,000
		Total (A+B)		**785,000**

Total Cost of IEC and Capacity Building is estimated at Rupees Seven Lakhs, Eighty Five Thousand Rupees only.

13.8 Exposure Visits

For capacity building of the department, senior officials should be frequently exposed to developments taking place in various parts of the State and country by sending them out on city

visits and to attend seminars, workshops and training courses. They should also be involved in all decision-making processes.

13.9 Encouragement to NGOs

NGOs may be involved in creating public awareness and encouraging public participation in SWM planning and practice.

The Municipal Authorities may also encourage NGOs to enter this field and organize rag pickers in doorstep collection of waste and provide them an opportunity to improve their working conditions and income. The Municipal Corporation can give incentives to NGOs in their effort of organizing rag pickers in primary collection of recyclable and/or organic waste, and provide financial and logistic support to the extent possible.

13.10 NGO/Private Sector Participation

SWM services are highly labour intensive on account of increased wage structure of the Government. This service is becoming more and more expensive. Besides, the efficiency of the labour force employed in the urban local bodies is far from satisfactory. High wage structure and inefficiency of the work force results into steep rise in the cost of service and yet the people at large are not satisfied with the level of service being provided by the urban local body. Efforts to increase the efficiency by H.R.D. and institutional strengthening will, to some extent improve the performance but they may not be enough. It is, therefore, necessary that the Municipal Authorities seriously considers NGO/Private sector participation in solid waste management.

13.11 Rehabilitation and Resettlement plan for Rag Pickers

As we all know that the livelihood of rag pickers is based on daily collection of recyclables from waste spread across the city it is also well known fact that this is the only source of earning for these rag pickers but the procedure adopted by them is unhygienic and harmful as they don't use any kind of personal protection equipment while collecting waste which further leads to a negative impact on their health. Since the plan proposed earlier is an inclusive plan which includes people from all sections of the society, so we have included the rag pickers also in this. The following measures suggested below shows how we should include them in the proposed plan which may further improve their livelihood pattern.

i) The Rag pickers should be involved in the process of daily waste collection system by providing them proper training.

ii) The Rag pickers should be employed and properly trained as per their potential or educational qualification if any.

iii) The Rag pickers should be employed in Waste processing facility for segregation of recyclables.

iv) These Rag pickers should be included in the construction process in Landfill site.

v) The Rag pickers should be employed in daily cleaning of toilets.

vi) The Rag pickers should be employed at Community Toilets for proper monitoring on behalf of Municipal Corporation to administer daily activities at Community Toilets and collection of user charges.

vii) The female rag pickers should be employed for road sweeping purpose.

13.12 Incentives to the Private Sector

Solid waste management, processing and disposal are an area where the private sector has still not shown much interest. The private sector has, therefore, to be given some incentives by way of long term contract, assured supply of garbage at the plant site, lease of land at nominal rates for entering this field.

NGO as well as Private sector participation may be encouraged in such a way that it does not affect the interests of the existing labour; it does not violate the provisions of the above law, does not exploit the private labour and yet reduces the burden of the urban Municipal Authority. This will substantially help in improving the quality of service of the urban local body, effect economy in expenditure and also give scope to the private sector to enter the waste management market.

13.13 Mobile Sanitation Courts

With a view to ensure adherence to the instructions given by the civic body to the citizens and making them aware of their civic responsibility of not littering the street and throwing the solid waste anywhere on the streets or open spaces, it is recommended that provision should be made in the relevant by-laws, rules etc to recover Additional Cleaning Charges from the citizens who dispose of waste on the street or in open public places necessitating the cleaning of the road again by the Municipal Authorities. The power to levy such charges should be delegated to the supervisors of the level of Sanitary Inspectors and above. The amount of additional cleaning charges to be levied should be specified for different categories of offenders and should be kept higher for repeat offences.

13.14 General Rules for Handling Complaints

The general rules/ etiquettes for handling complaints include:

- Listen to the complaint and get all details
- Repeat the message to confirm your understanding
- Tell the customer what will be done and when
- Handle complaints quickly
- Follow-up to be sure the complaint is redressed
- Confirm the complaint has received a satisfactory response and thank the customer
- Inform public of services, your responsibilities and theirs

13.14.1 General Information to be Collected and Updated from Time to Time

i) Area of the city;

ii) Population of the city;

iii) Decadal growth of population;
iv) Number of wards, their area and population;
v) Ward-wise information in regard to:

Population density in different wards;

- No, of Households, shops and Establishments
- Vegetable/fruit/meat/fish markets
- Number of Hotels & Restaurants
- Number of Hospitals and Nursing Homes
- Number of Industries
- Number of slum pockets /their population
- Road length width wise
- Percentage of area covered with under-Ground sewage system
- Percentage of area having surface Drains
- Percentage of area having no drainage Facility
- Total number of public toilets and Toilet seats.
- Number of public urinals
- Number of Nuisance spots

13.15 Waste Generation

The waste generation data to be collected and maintained in the database should comprise of:

- Average quantity of waste generated per capita/kg/day
- Average quantity of waste produced each day in metric tons (MT)
- Total quantity of waste produced annually (MT)
- Breakup of the quantity of waste generated per day in kg or MT
- Household, shops and establishment waste
- Vegetable and food market waste
- Meat, fish and slaughter house waste
- Construction and demolition waste
- Non-infectious hospital waste
- Non-hazardous industrial waste

13.15.1 Waste Collection

The collection of data has two components primary collection and secondary collection. The data to be collected and maintained in the database for each of the two components is as detailed below:

i) **Primary Collection**

Primary collection is the first and prime activity of solid waste management. For planning and designing effective, sustainable, cost effective and efficient primary collection system, the following information is required for each ward of the city:

- Area
- Present and future growth of population

- Population density
- Source of waste generation
- Sanitation workers in local body
- Contract workers
- Voluntary agency workers
- Tools and implements used in primary collection system
- Welfare measures for the workers
- Personnel protective equipments provided to the workforce
- Mode and frequency of collection from various sources
- No. of Safai karamcharis required to report for duty
- No. of Safai karamcharis actually reported
- No. of safai karamcharis absent
- No. of houses actually attended by each safai karamcharis
- Amount of waste collected
- Houses left unattended
- No. of street bins emptied and amount of waste transferred to the waste storage depots
- No. of persons required to supervise
- No. of cases where performance found satisfactory
- No. of cases where performance was not up to mark
- Action taken and proposed to be taken
- Complaints received and attended

ii) **Secondary Collection**

The second and vital activity in solid waste management services is the transfer of waste to intermediate storage point's i.e. waste storage depots. To design an intermediate waste storage point and to ensure a synchronized transportation system the following information is to be established for each ward of the city:

- Location
- Area
- Capacity
- Type of transfer system
- Mode of unloading
- Mode of loading
- Number of secondary collection locations per ward
- Amount of waste received from various sources in each ward

13.15.2 Waste Transportation

To enable designing a cost effective and efficient transportation system synchronized with primary and secondary collection system, the following information is to be established for each ward of the city:

- Number of collection points
- Distance between collection points
- Quantity at collection points
- Number of vehicles available with the local body for waste transportation
- Type of vehicles and their carrying capacity.
- Number of trips made by vehicles/shift/day
- Fuel consumption of vehicles
- Distance traversed by vehicles
- Details of manpower working in each shift
- Quantity of waste transported in each shift
- Total quantity of waste transported/day
- Percentage of waste transported/day
- Breakdown reported during the day and action taken
- Number of bins cleared during the day
- Number and location of bins left unclear
- Arrangement made for clearing backlog

13.15.3 Waste Processing and Disposal

To have an effective and planned operation of disposal and to design for developing an engineered and scientific disposal system, following information is to be established and maintained in the database:

- Percentage of waste treated
- Amount of rejects from plant
- Details of processed waste
- End use of processed waste
- Quantity of waste disposed to landfill after processing
- Amount of waste received for processing
- Characteristics of waste (physical & chemical)
- Amount of waste received for disposal in landfill
- Amount of waste received from processing unit
- Amount of waste disposed off in landfill
- Volume of leachate generated
- Leachate management system

13.15.4 Financial aspects

Operating cost

- Cost of collection per ton/day
- Cost of transportation per ton/day
- Cost of disposal per ton/day
- Allocation of revenue and Capital budget for SWM vis-à-vis the City Corporation's budget.

13.15.5 Daily Reports to be sent

- Collection of waste
- Number of sweepers required to report for duty
- Number of sweepers actually reporting for duty
- Number of sweepers absent
- Areas left unattended
- Arrangements made or proposed to be made for clearing the backlog

Inspection by Supervisors for street sweeping & Primary collection

- Number of persons he is required to supervise
- Number of persons supervised during the day
- Number of cases where performance found satisfactory
- Number of cases where performance was not up to the mark
- Action taken or proposed to be taken
- Complaints received and attended

Inspection of cost recovery services

- Such as Hotels, Hospitals, commercial streets and offices
- Number of cost recovery sites under his charge
- Number of sites inspected
- Deficiencies noticed
- Complaints received and attended
- Action taken or proposed to be taken

Inspection of bulk community waste storage sites

- Number of sites in the area under his charge
- Number sites inspected
- Number of sites found well maintained
- Number of sites found ill maintained or needing repair or replacement
- Action taken
- Number of unauthorized waste disposal sites or sites identified during field visits
- Action taken

Inspection of silt removal sites & building waste disposal sites

- Number of silt removal sites inspected
- Number of sites found satisfactory
- Number of sites where silt was found lying outside the man hole or surface drain
- Number of construction sites/construction waste disposal sites visited
- No of sites where construction waste was found disposed of unauthorized
- Action taken

Transportation of waste

- Number and type of vehicles and equipment required to report for duty
- Number and type of vehicles and equipment which actually reported for duty
- Breakdowns reported during the day and action taken
- Number of trips made to the disposal site by each vehicle
- Number of bins cleared during the day
- Number and locations of bins left uncleared and
- Arrangements made or proposed to be made for clearing the backlog

Quantities of waste transported

- Number of vehicles deployed during the day
- Number of trips made
- Quantity of waste transported
- Number of vehicles which did not make adequate trips
- Number of vehicles which carried less garbage
- Action taken or proposed to be taken against defaulters

Inspection of processing sites

- Whether the plant was functional during the week
- Whether it received the garbage as prescribed regularly
- Whether the site is properly maintained and waste stacked properly
- Quantity of Bio organic fertilizer/desired material produced
- Quantity of produce sold during the week
- Quantity of end product in stock
- Any irregularity noticed
- Action taken

Inspection of waste disposal site

- Name of the site inspected
- Whether all the staff was present on duty during the week
- Whether the required machinery was available on site on all the days
- Whether the approach road and internal roads are properly made
- Whether the weigh bridge is functional and properly used
- Quantity of waste received at the site on the days during the week
- Whether the entire waste was spread, compacted and covered on the same day
- Whether communication facilities such as telephone, wireless etc. remained functional during the week
- Whether shelter and drinking water facility is adequate
- Deficiencies noticed
- Remedial action taken or proposed to be taken

Record of trip made by transport vehicle at the processing and disposal sites

- Sr. Number
- Date
- Vehicle Number
- Name of the Driver
- Arrival time of the vehicle
- Trips made including this trip
- Waste Source and Route Number
- Weight of Waste in M. tones
- Deficiencies noticed
- Action taken

Workshop performance

- Number and percentage of vehicles on road
- Number and type of vehicles under repairs at Corporation's or private workshop
- Nature of breakdown
- Duration of breakdown: under one week, 1-2 weeks, 2-4 weeks and over one month
- Reasons for delay in repairs
- Expected date of vehicle to be back on road
- Number and type of vehicles and equipment required to be given to the SWM Dept. by the workshop or through contractor
- No and type of vehicles and equipment actually given
- Shortfall if any
- Reasons
- Alternate arrangements made

Each vehicle should maintain a logbook showing information of its movement and performance as under:

- Inspection of workshop stores
- Whether the list of fast moving items is maintained
- Whether the list of critical items is maintained
- Whether minimum level of stock is maintained
- Items found to be out of stock
- Items found to be over stocked
- Deficiencies/ irregularities noticed
- Action taken

Computerization of inventory daily with in and out information, balance in stock would be very useful to keep track of availability and replacement of spares.

Recovery of additional cleaning charges

- Name of the ward

- Areas visited
- Addl. cleaning charges recovered:

Number Amount

- From households
- From shops
- From offices
- From other establishment
- From road side vendors, eating joints

Total Cost Recoveries/Penalties

- Ward-wise cost recoveries made every month for a variety of services rendered
- Ward-wise penalties or levy of administrative charges from offenders every month

Legal Matters

- Number of cases filed in the courts each month for violation of sanitation laws.
- For the effective monitoring of SWM services, the information collected in various
- Performa's should be carefully analyzed and corrective measures taken promptly.
- There should be route maps and duty charts with each of the supervisory staff, who should check whether work on site is going as per schedule and whether vehicles and manpower are giving their optimum output. Mobiles and other communication networks are essential for effective communication and monitoring of Services.

13.15.6 Monthly Report

Public Participation

- Total number of sweepers allotted for door to door waste collection work in each ward.
- Number of sweepers getting good response from citizens in the matter of doorstep collection
- Number of sweepers not getting response from the public
- Percentage of public participation
- Improvement in this area over the last month

13.15.7 Performance Monitoring Indicators

There are a number of specific performance measures that can be used to assess the individual functional elements or operating sub-systems of any Municipal Solid Waste Management systems. There are also measures that help gauge the overall performance of the same system.

It is important to note that general performance measures have to be compiled at regular intervals and then compared over time to enable Solid Waste Management managers to monitor and establish positive and negative trends in waste management system. For e.g., if at any time it is found that there is variation in revenue collection i.e. it is going down over past

few months, it is important for the concerned person of Siliguri ULB to look into the matter and find way of overcoming this.

13.16 Project Benefits Assessment

13.16.1 Social Cost-Benefit Assessment

The proposed plan for Municipal Solid Waste Management in Siliguri town is based on 4R principal (Reduce, Reuse, Recycle and Recover). The plan is developed in lines with the requirements of MSW Rules 2000/Draft MSW rules 2013 and ensures well-being of the society at large. The MSW management plan proposes up-gradation of the existing infrastructure and development of new infrastructure as per the current status of MSW management facilities in Siliguri town. In the proposed plan, infrastructure provision has been done to ensure that collection, transportation, treatment and disposal of MSW in Siliguri is done properly. The proposed approach will have positive and negative environmental, social and economic benefits to MSW workers and the overall society.

The benefits and adverse impacts from the proposed MSW management plan are summarized below:

Sr. No.	Benefit Description	Comments	Quantitative impacts (wherever possible) and Underlying Assumptions
Benefits to Siliguri Municipal Corporation/other MSW workers			
1	Improved working conditions	- Provision of wheel barrows with covered containers and brakes. - No manual handling of waste proposed.	- Workers will be given infrastructure for waste collection and handling as per design. - Workers will be given appropriate competence training.
2	Improved workers morale	- Ability to perform activities as desired. - Improved efficiency	- Infrastructure structure is maintained.
3	Improved health and safety	- Reduction to waste exposure as waste to be covered at all stages of handling. - Segregation of waste at source- biomedical and industrial hazardous waste not mixed with the MSW. - No manual handling of waste	- Workers given appropriate training on waste handling. - Infrastructure facilities maintained as per the proposed design.
4	Employment opportunities	- New Infrastructure facilities (Compost Plant and Sanitary Landfill) Proposed	- Infrastructure facilities to be run as per the proposed design.
5	Reforms driven economic sustainability	- Grants are being provided on the condition that Siliguri Municipal Corporation	- Reforms implemented.

Sr. No.	Benefit Description	Comments	Quantitative impacts (wherever possible) and Underlying Assumptions
		would undertake suitable reforms in Management, Accounting and other areas so as to maintain sustainability of the project in the long run.	
Benefits to the Society			
6	Easy access to MSW Infra Facilities	- Every locality will have one secondary collection point. - Door to door collection facilities in all the localities.	- Secondary collection points also to be made available. - Door to door waste collection from all households.
7	Clean and Hygienic conditions resulting reduction in number of infections and other diseases such as bronchitis, hepatitis, diarrhea, parasitic infections	- 100% door to door collection of waste proposed. - MSW handling in covered containers. - Daily cleaning of secondary waste storage depots. - Waste transportation in covered vehicles.	- Provided MSW management is done as per the design.
8	Environmental Improvement	- No dumping of waste on ground. - Covered waste handling, so no foul odour at collection points. - No open burning of waste - Recycling of waste. - Composting of biodegradable waste - Development of engineered landfill site.	- Provided MSW Management is done as per the design.
9	Improved quality of life.	- Improved surroundings - Clean Environment - Access to Infrastructure	-
10	Improved awareness and civic sense in people	- Training and awareness of people for MSW Management.	- Dissemination of information, education and communication as per the design.

The negative and positive impacts summarized above indicate that positive impacts can be maintained and enhanced and negative impacts can be minimized with a properly planned approach. To achieve the broader objective of well-being of the society, the above aspects need to be inculcated in the project implementation plan and its long-term operation and maintenance. The actual benefits to the society can only be realized after a period of successful implementation of the proposed plan.

14.MANAGEMENT ASPECTS: MONITORING MSWM SERVICE PROVISION

14.1 Monitoring MSWM Service Provision:-

Institutionalizing appropriate quality assurance systems is essential to ensure a continuous and efficient municipal solid waste management system. The performance of all components of solid waste management systems, from collection to processing and disposal, should be maintained on a daily basis.

14.2 Management Information System

MIS is a computerized system which stores and retrieves from a database of information; this data can be analyzed for identifying problem areas and improving service delivery efficiency.

A comprehensive monitoring and evaluation system should be adopted for assessing progress towards meeting the targets in the MSWM Plan and for monitoring successful implementation of the plan. The monitoring system adopted should:

1) Collect data regularly, and
2) Analyze collected information, take/propose corrective measures, and support the planning & implementation process.

Collection and analysis of data related to solid waste management is required to assess the existing situation and propose adequate measures to improve service delivery. A Management Information System (MIS) can retrieve relevant information which can then be used by decision makers.

MIS assists in monitoring the efficiency of SWM systems. It increases transparency and accountability of officials in the solid waste management system. It helps in establishing a strong and reliable information data base necessary to facilitate planning, mid-course corrections and decision making. Geographic Information Systems (GIS) and visual capture of information using cameras are now being integrated with the MIS to provide spatial and visual validation for provision of services.

Communication technologies such as Radio Frequency Identification (RFID), Global Positioning System (GPS) and General Packet Radio System (GPRS) are now integrated with Geographic Information Systems (GIS) for monitoring the solid waste management system. These can be suitably adopted by cities to improve the efficiency of service.

Computer application of mentioned tools need some prior data/information to provide correct information to decision makers.

Integrated Technologies

Management Information System (MIS)

It is a typical computer based system used to manage information about the operation, which is important for decision making. A MIS (Management Information System) can manage large amount of spatial and attribute data such as type of waste, vehicles etc. It provides concise, correct and timely information to decision makers.

Radio Frequency Identification (RFID)

RFID tags are designed to enable data capture by electronic readers, which then transmit this information via a wireless network to the MIS. These tags are pre-loaded with information related to the physical location to which they are attached. Auto-ID technologies have been used to reduce the amount of time and labor needed to input data manually and to improve data accuracy. Predominantly, RFID tags are used to identify secondary collection bins and help monitor their pick-up and evacuation at the treatment/processing/disposal site.

Global Position System (GPS)

GPS is a satellite-based navigation system which records geographical/physical locations on the earth. The satellites periodically emit radio signals to GPS receivers, based on the identification and reflection of these signals, GPS are used to calculate distance and to compute two-dimensional or three-dimensional position. GPS is used for tracking the position of trucks and bin locations.

General Packet Radio System (GPRS) Technology

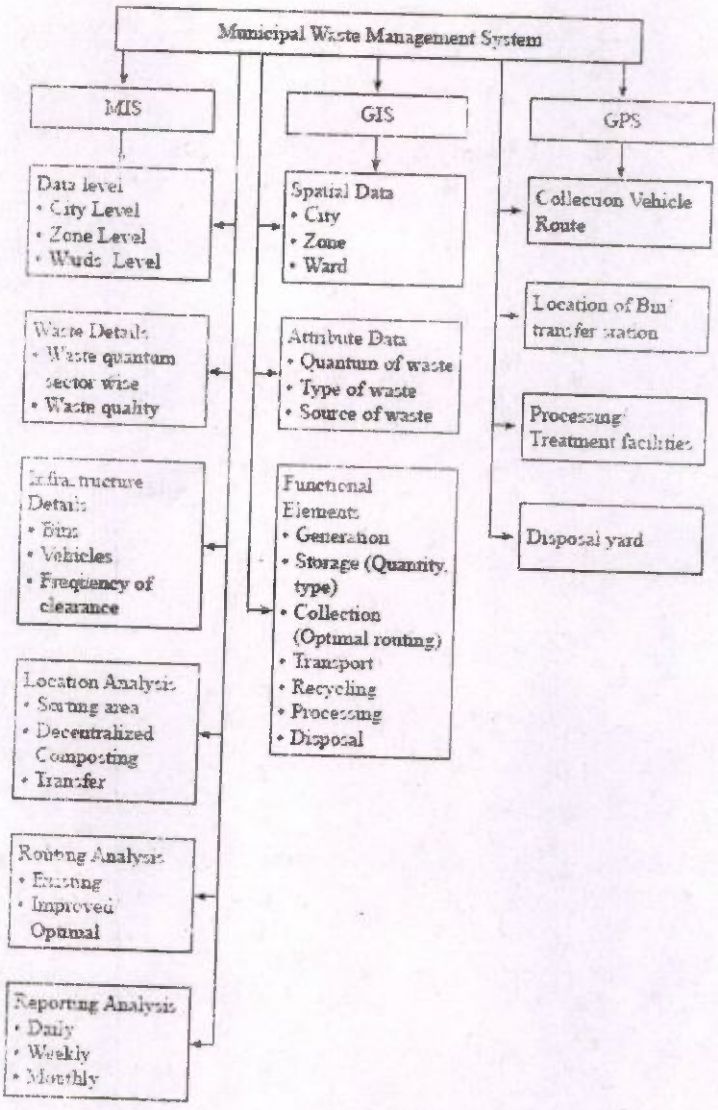
GPRS is a wireless data network system which achieves real-time sending and receiving of data. The GPRS technology helps transfer data from remote devices to centralized data integration and management systems.

Geographic Information System (GIS)

GIS integrates software and hardware for collecting, managing and analyzing spatial and attribute data in a computer-based system. It helps to analyze spatial and related attribute data to identify patterns, trends and relationships. GIS systems help in planning waste transportation routes and locations for waste collection bins. Linked with RFID and GPRS systems, GIS provides real time, data on vehicle, collection of waste, bin pick up and transportation to treatment/disposal systems.

Use of integrated technologies such as MIS, GPS and GIS has resulted in the development of integrated and comprehensive solutions for SWM. Beneficial uses of these systems include:

- Data aggregation and process monitoring is managed electronically, avoiding day to day human intervention, thereby increasing reliability and transparency of information.
- Movement of vehicles may be monitored on real time basis by using a surveillance system based on GPS/GIS communication technologies, thereby reducing noncompliance and enhancing efficiency.
- Status of evacuation of bins on a daily basis can be monitored, facilitating increase in service efficiency.



Integrated Technologies (MIS, GIS, GPS, RFID) for Monitoring Solid Waste Management

Real time monitoring of status of bin clearance, estimation of amount of waste in and around bins, surveillance of movement of vehicles, optimization of routes and reallocation of bins according to the estimated waste, are possible through integration of several technologies, hence providing transparency in civic administration.

Below Figure indicates integration of various technologies for solid wastes monitoring and management.

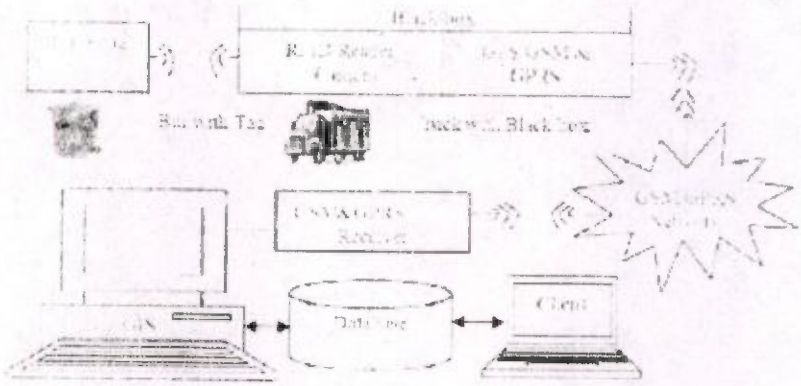


Figure 41: Solid Waste Monitoring and Management System

Each container is equipped with an RFID label having a unique identification code. Low frequency passive tags are proposed because they offer long term low cost solutions and are operational in extreme conditions resistant to environmental hazards. Geo-coding of containers is done manually through field visits and by noting the locations using a GPS receiver. When the container gets loaded onto the truck, the reader reads the serial number of the tag on the container. At the same time, the GPS receiver on the truck calculates its location using satellite data. The serial number of the tag, location, date and time are transmitted real time via the GSM network to the communication gateway of the control server. The same is repeated when the truck reaches its destination. After data processing, information is transferred to the GIS terminal. Real time information can be shared with clients via a web based solution.

14.3 Monitoring Achievement of SLBS

Assessment of Service Level Benchmarks is based on an analysis of information collected to monitor MSWM system on a regular basis, as discussed in the previous section. State Governments use SLBs to monitor long term progress of SWM service provision in ULBs. Release of funds from the State Finance Commission is partially contingent on achievement of pre-defined goals of SLBs. Indicators stipulated by the Ministry of Urban Development (MoUD), GoI, for benchmarking solid waste management service provision are:

1. Household level coverage of SWM services through door-to-door collection of waste
2. Collection efficiency
3. Extent of segregation of waste
4. Extent of recovery of waste collected
5. Extent of scientific disposal of waste at landfill sites
6. Efficiency in redressal of customer complaints
7. Extent of cost recovery for the ULB in SWM services
8. Efficiency in collection of SWM charges

14.4 Operation & Maintenance Plan For MSWM Services

Irrespective of whether the provision of services is by private contractor or ULB, operation & maintenance plan has to be adhered to. The Operation & Maintenance (O&M) plan should be drafted by the authority responsible for procurement and management of equipment/facilities: either the ULB or the private operator. O&M plans developed by private operators should be ratified by the solid waste management department. The O&M Plan should include preventive maintenance schedules and responsibilities and also guidance for break-down maintenance. It should be the responsibility of the supervisor and operator to regularly maintain and update the O&M Plan. It should also indicate procedures for recording, reporting, analysis and further action.

- Operation & Maintenance for MSWM ensures timely availability of required spares (including high wear & tear components, critical components with long lead times for procurement), thereby reducing down-times.
- Preventive O&M provides financial planners with necessary budget information
- Preventive maintenance of equipment and fleet required for different activities (such as primary collection, secondary collection and transportation, transfer station, processing site and landfill) ensures their continuous utility at full capacity through their design life.

Key Components of an Operation & Management Plan:

1) O & M plan should address critical components subject to high wear & tear, avoiding potential cost implications of break-down maintenance
2) The O&M Plan shall be prepared at the time of procurement by the authority and schedule of preventive maintenance should be determined and strictly observed.
3) O&M records shall be maintained for all equipment. An analysis of this information will indicate critical issues of frequent breakdowns and components undergoing regular wear and tear. Supervisors could use this information to identify incorrect operating practices leading to frequent break downs. This analysis may also lead to the identification of equipment which is ill-suited to perform the requisite tasks.
4) The O&M Plan should include contact information of concerned staff responsible for maintenance of specific equipment
5) Management personnel should periodically review this information to refine maintenance plans for individual vehicles and to identify improvements to the overall maintenance program.
6) The effectiveness of the O&M plan is evident from observed plant/machinery down times, as well as from vehicle fleet available in working condition.

Good operating principles for waste processing, treatment and disposal facilities

Adequate and appropriate human resource available for operating the SWM facility with due consideration to minimum qualifications of key employees, supervisor and operators.

1) Hands-on training of staff
2) Regular inspection of facility by superior staff and ensuring timely corrective measures
3) Mechanism for reporting unacceptable/ prohibited activities in sites
4) Mechanism for reporting accidents and mishaps, with recorded investigative processes, follow-up action; including analysis of mishaps periodically to identify danger areas/weaknesses in the process system/equipment

5) Scheduled Environment Monitoring as per MSW (M&H) Rules 2000 and other applicable norms

Preventive Maintenance

Preventive maintenance is an essential part of the operation of collection equipment and transportation vehicles to ensure maximum life of the equipment and fleet life is at its maximum capacity most of the time. However, there is a need to make a clear distinction between preventive maintenance – which is carried out at a defined and disciplined schedule – and crisis (or break down) maintenance which is only carried out when a fault develops.

Good preventive maintenance starts with the selection and specification of appropriate vehicles and equipment. Vehicles should be well suited to pre-defined requirements, localized conditions and should be procured after ascertaining ease of availability of spare parts. Cost of spares should be considered while making purchase decisions. Local availability of spare parts is often associated with reliability. Preventive maintenance schedule must be notified well in advance to all concerned and should be strictly enforced.

Benefits of Preventive maintenance

An important aspect of a planned preventive maintenance programme is that it helps to take corrective measures well in advance, anticipate faults and prevent a major break down which could endanger the safety of the personnel and entail huge cost implications.

A preventive maintenance programme gives advance notice of any requirement for spare parts, ensuring that equipment/vehicles are not out of service while the parts are being obtained in due course of time.

Accountability & Responsibility for Preventive Maintenance

Preventive maintenance imposes responsibility and accountability at various levels, such as drivers, store in-charges, mechanics and the workshop manager, for breakdowns and delays in repairs after a breakdown. Delays in procuring spares may also be due to lack of funds for purchasing essential parts, for which the financial controller/officer may be accountable.

Example of a Preventive Maintenance Schedule for Vehicles

i) Daily checks by drivers
ii) Weekly servicing checks by a junior mechanic will highlight issues which a driver may not be able to identify and/or indicate if the daily checks are not effective
iii) Monthly service check by a senior mechanic shall reveal any inadequacies in the weekly checks
iv) The six monthly checks identify issues which have not been identified/addressed by the monthly checks

The success of a preventive maintenance programme is indicated by fleet and equipment availability on any day. The success can also be indicated by calculating the number of vehicles (perhaps of a particular type) that are ready for service on any particular day, divided by the total number of vehicles in the current fleet. The numbers could indicate the condition of the vehicles and whether the maintenance programme is improving or weakening. Availability levels can be used to show the number of standby vehicles that are needed (for each type of vehicle) and which types of vehicle are more reliable.

14.5 Record Keeping

ULBs should maintain reports for all monitored elements. The Head of the SWM department should review all reports along with the M & E team and issue relevant guidance. Monitoring and reporting proves to be beneficial only when the generated data is effectively analyzed for improving performance.

Appropriate training and strengthening of capacities of existing staff is required to ensure accurate collection and reporting of monitored data. Capacity building is required for all levels of staff; external support from experts may be sought to streamline and integrate M&E of all functions.

14.6 Complaint Redressal System

A complaint redressal system creates a platform for citizens to voice their concerns and grievances regarding provision of solid waste management services and also helps in promoting efficiency and transparency at the ULB level. The ULB, through an analysis of the complaints/grievances it receives, is able to identify lacunae and bridge major gaps in service delivery. The time taken for resolution of grievances and the action taken are also monitored and recorded through this system. Typically ULBs have a common complaint redressal system for all municipal services.

A complaint redressal system is effectively supported through the introduction of a citizen charter. Citizen's Charter is a written, voluntary declaration with a basic objective to empower the citizens to get public service delivery by the municipality in a given time frame.

The Citizen's Charter includes:

1) Information on municipal services and expected outcomes
2) Defines municipal service delivery standards
3) Indicates response time for rendering services or redressing grievances
4) Information dissemination process on the complaint redressal process
5) Contact details of officers responsible for provision of the various municipal services

The Citizen's Charter should be prepared by the ULB and officially adopted by the Municipal Council/ Committee and widely publicized. Urban Development/Local Government departments in the State Government may prepare a model/draft citizen's charter to be adopted by all ULBs in the state to be used while preparing city specific citizens charters for their own city and must be vetted by the citizens.

14.7 Elements of a Complaint Redressal System

Typical elements of a complaint redressal system include:

1. A centralized computerized complaint management system which is networked to all the zonal/ward level complaint centers.
2. A grievance redressal officer from the solid waste management department / cell at senior level should be responsible for recording and monitoring the nature of complaints being received and also for taking necessary actions.
3. Multiple channels or a combination of different channels may be adopted for receiving complaints from citizens like phone calls to a centralized customer service number, 'SMS'

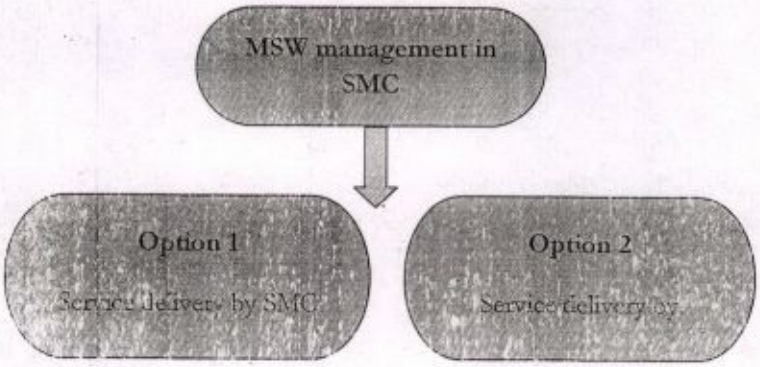
messages to notified mobile numbers, walk-in complaint registration, online complaint registration through the internet. Complaint registration through the postal service may be considered, if relevant, based on the demography and size of the ULB.

4. Complaint registration & recording system should:
   - Assign a unique ID to each generated complaint
   - Record contact details of the complainant
   - Record details of the physical location (zone/ward/area) relevant to the complaint
   - Assign the complaint to the concerned official in the solid waste management department / cell
   - Record the stipulated time within which the complaint shall be redressed
   - Provide an acknowledgement receipt to the complainant with all the above details, in case the complaint is registered manually/ online. Telephone based complainants should be provided a complaint reference number with an SMS of registration.
5. Field officers, after resolving the complaint, should take resolution certificate from the complainant and subsequently inform the complaint cell. The complaint shall thereafter be treated as resolved.
6. Complaint resolution & feedback: The designated official for complaint resolution in the SWM department / cell shall be made aware of received complaints on a day to day basis. Feedback could be taken through telephone, online, SMS.
7. Complaints which are not resolved in stipulated time shall be deemed "pending" and appropriate reasons may be recorded against the complaint and the designated officer should be informed. Also, the complainant should be informed of the reasons for the delay immediately.

Reporting & Complaint Analysis: A daily status report of complaint redressal should be prepared by the responsible officer and submitted to the officer in-charge for further directives. The complaint management system should generate periodic area wise reports on number of complaints received, nature of complaints, time taken for resolution etc. The report should highlight the critical issues namely frequently received similar complaints, frequently delayed responses, repetition of complaints, if any and time for resolution of complaints etc. The weekly analysis of all complaints received should be report

14.8 Options for Project Implementation

The Project Facilities could be developed by implementing authority either by deployment of its own resources or under an appropriate PPP framework. The two primary development options comprise:



A. Option 1: Service delivery by SMC

Under this option, the two distinct activities, with respect to collection & transportation of MSW and treatment & disposal of MSW, would need to be undertaken by implementing authority in the following manner.

I. Collection and transportation of MSW

- Procure tools / equipment and vehicles such as auto tippers, pushcarts, dumper bins, dumper placers and etc. for collection and transportation of MSW
- Hire manpower for carrying out the activities envisaged.

II. Treatment and disposal of MSW

- Select a contractor to undertake development of the compost facility and develop the landfill facility.
- Hire skilled manpower for carrying out the operations and maintenance of the developed facilities.

B. Option 2: Service delivery through Private Operator(s) with implementing authority playing the role of a facilitator

Increasingly, MSW management activities are being privatized in different cities, with the ULBs assuming the role of a facilitator. PSP is increasingly being viewed as a solution for providing efficient MSW management services, by many ULBs. There exist different options for implementation of the Project under PPP frameworks.

In this option, implementation of MSW management would be undertaken by a private operator(s). The private operator(s) would need to carry out their roles and responsibilities as per the contractual agreement signed with implementing authority. The involvement of private operator(s) in various stages in the MSW management chain is detailed below.

I. Collection and Transportation

Implementing authority would identify private operator for carrying out this activity. Primary collection of MSW from the households would be carried out by the private operator. The private operator would be responsible for identification of collection crew, procurement of tools/ equipment/ vehicles and operation & maintenance of the same. The dumper bins, transportation vehicles and other equipment would be procured by the private operator who would also be responsible for O&M of the same. The private operator would be required to collect the user charges from the households for provision of door to door collection services.

II. Treatment and landfill facility

The private operator would be responsible for development of an integrated treatment and disposal facility. The operator would be responsible for mobilization of finances for development of these facilities (capital expenditure) and also O&M of these facilities in accordance with design, construction and O&M specifications provided by implementing authority.

A comparative analysis of the risks associated in an event of implementation of the two options discussed above is set out in the table below:

Table 72: Comparative analysis of the risks

Options	Parameters	Impact
Service delivery by implementing authority	Manpower	Recruitment & management of operational staff by ULB
	Skill set	Implementing authority would need to appoint technical consultants for developing a strategy for integrated MSW management and for design and construction of MSW treatment & disposal facilities. Implementing authority would also be required to hire skilled manpower to operate and maintain the treatment and disposal facilities
	Service Delivery	Since payments to operational staff are not performance based and often their motivation levels are low, this could affect the level of service delivery.
	Finances	Implementing authority would need to mobilize finances for procurement of tools / equipment and vehicles and for development of C&T and T&D facilities.
	Project Risks	The projects related risks such as design risk, cost overrun risk, time risks etc. and adherence to applicable laws would be retained by implementing authority.

Options	Parameters	Impact
Service delivery under PPP frameworks	Manpower	Implementing authority would need only supervisory staff as the private operator would be responsible for deployment of staff for providing MSW management services.
	Skill set	The onus of providing skilled manpower would be with private operator
	Service Delivery	As the payment to the operator would be made subsequent to demonstration by him of adherence to performance standards specified by implementing authority, the service delivery levels would be high.
	Finances	The private operator would need to mobilize finances for procurement of tools / equipment and vehicles and for development of T&D facilities.
	Project Risks	The projects related risks such as design risk, cost overrun risk, time risks etc. and adherence to applicable laws would be retained by private operator.

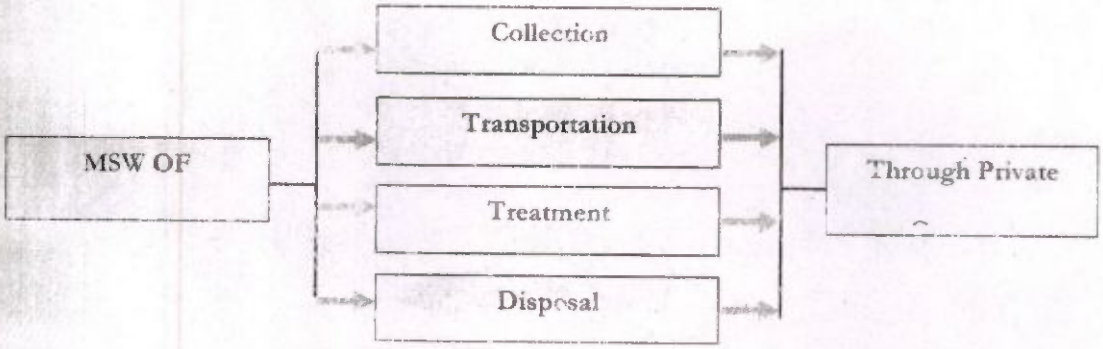
Under Option 1, implementing authority would not only retain all the Project related risks and be required to raise finances for undertaking the Project, but would also need to monitor and manage the operational staff. In contrast, if implementing authority implements the Project under Option 2, it would need to appoint private sector operator and recruit only sector specialists for overseeing their activities. In view of the local situation, and from the point of view of effective implementation of MSW management in the town, Option 2 is more suitable for SMC.

14.9 Project Implementation under an appropriate PPP Framework

The components of the Project could be implemented in the following ways.

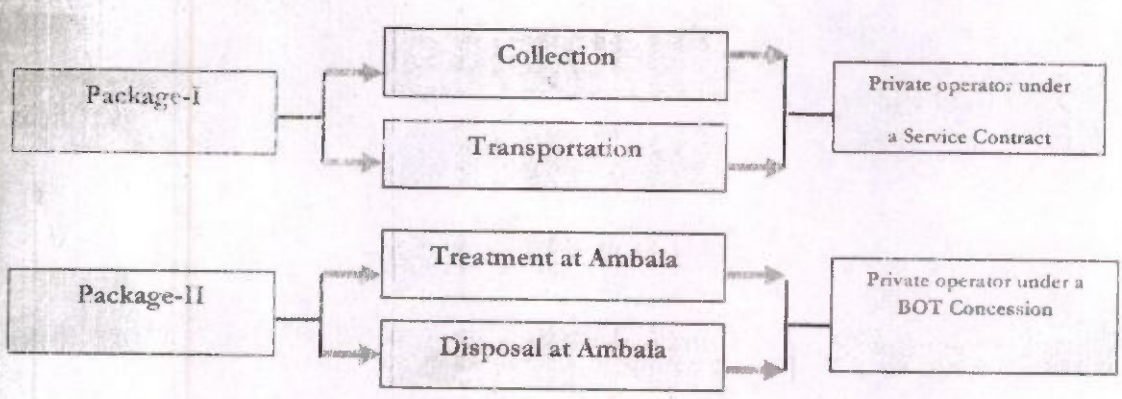
Option 1: Implementation by a single private operator

Under this option the entire chain of MSW management activities including collection and transportation of MSW and treatment and disposal of MSW facility would be undertaken through the private operator. The private operator under this option would be selected through a transparent competitive bidding process. Implementing authority in turn would need to pay a service fee for the services rendered. The advantage of having a single private operator would be that since the entire system is implemented by a single private operator, the operations would be easy to undertake and monitor but the disadvantage could be failure of the private operator in performing its obligations would lead to collapse of the entire SWM system in Cluster.



Option 2: Implementation by different operators

Under this option two packages could be formed; Package I - Collection and Transportation and Package II- Treatment and Disposal of MSW at Siliguri. Each of the two packages could be undertaken independently by different operators. The private operators could be selected through a transparent competitive bidding process. C&T of MSW could be implemented by private operator under a service contract.



In Option 2 SMC would need to appoint two private sector operators for C&T and Treatment/Disposal of waste. In view of the local situation and from the point of view of effective implementation of MSW management in the town, Option 1 is more suitable for SMC.

14.10 Indicative Implementation Framework

The Project could be developed under a BOT Concession framework and the salient features of the same are set out below.

- The mobilisation of finances would be the responsibility of the private operator. The entire finance required for the Project would have to be raised by the private operator within a pre-specified time frame. Therefore, implementing authority would not be responsible for raising the funds for meeting the initial capital expenditure.

- Implementing authority would lay down the performance standards for the C&T activities and the technical specifications for the construction of integrated T&D facility and subsequent O&M of the same, which would have to be adhered to by the private operator. In the event that the private operator fails to meet the performance standards and technical specifications laid down by implementing authority, implementing authority would have the option of substituting the private operator.
- The risk of time-bound completion of the Project would be passed on to the private operator.
- Since the revenue streams from the Project would commence only after completion of the Project, it would be in the interest of the private to complete the Project as early as possible. implementing authority may also stipulate a penalty to be paid by the private operator in case of delay in implementation of the Project.

The risk of over-runs in construction cost and operational expenses would be passed on to the private operator. Since the private operator is responsible for the implementation of the Project, any increase in cost of the Project would also be borne by him.

Anexure-1

DPR appraisal format

Sl. No	Particulars	Details
1	Name of the City	Siliguri
2	No. of Wards	47
3	Population (2011)	5,13,264
4	Present Population (Projected)	5,59,625
5	Area	41.9 sq. km
6	No. of households (2011)	1,15,957
7	No. of commercial establishments	19,867
8	Road length (A, B & C) in (Kms)	977
9	Total Qty. of waste generated	313 TPD
	a. Total quantity of wet waste	215 TPD
	b. Total quantity of dry waste / recyclable waste	62 TPD
	c. Total qty. of chicken & mutton waste	10 TPD
10	Other Waste	26
	a. Total qty. of C&D waste	10 TPD
	b. Total qty. of street sweeping waste /silt	16 TPD

Financial Aspects

S. No.	Particulars	Cost in Lakh Rs.
1	Primary Collection	429.2
2	Street Sweeping	143.5
3	Drain Cleaning	109.2
4	Secondary Storage	57.3
5	Collection and Transportation	100.2
6	Processing Plant	1038.5
7	Disposal Site	2620

	Sub Total	4497.90
	Contingencies 3 %	1.35
	Total	4499.2

Design period = 30 years

Revenue (Proposed)

Revenue from Sale of Windrow compost

S. No.	Particulars	Qty.	Units
1	Total Amount of Waste Generated per Year	123,309,045	kg
2	Total Amount of Bio Degradable Waste Generated per Year (60%)	73,985,427	kg
3	Total Amount of Bio Degradable Waste remains after composting (15%)	11,097,814.05	kg
4	Price per kg (Rs)	3	INR
5	Total Revenue Generated Per Year	33,293,442.15	INR

Revenue from Sale of RDF

S No	Particulars	Qty.	Units
1	Total Amount of Waste Generated per Year	123,309,045	kg
3	Total Amount of RDF(30%)	36,992,713.5	kg
4	Price per kg (Rs)	4.5	INR
5	Total Revenue Generated Per Year	166,467,210.75	INR

Revenue from Sale of Eco Bricks

S. No.	Particulars	Quantity	Unit
1	Incoming Waste	313	MT/day
2	Rate of Incoming Waste	10%	
3	Total amount of C and D waste	31.3	MT/day
4	Minimum requirement of waste to start the plant	2	MT/day
5	Boiler ash to be added and if not available river sand to be added.		
6	Requirement of Waste and Other Material		
a	Aggregate of C & D - 70 %	1400	kg

Annexure-2

Ministry of Urban Development (CPHEEO)

Appraisal Format for Consideration of Projects for Solid Waste Management

1	**Proposal**	Integrated solid waste management plan, Siliguri
2	**Name of State/UT**	West bengal
3	**Name of City**	Siliguri
4	**Objectives**	The broad objectives of the Detailed Project Report (DPR) would be to determine a technically and economically viable solid waste management project for a phased implementation
5	**Whether CDP is prepared**	Yes
6	**Background**	A detailed description of the existing Solid Waste management system in Siliguri is presented in this chapter to provide an understanding of the system prevalent in the city. Maintaining overall cleanliness in the city and taking up all the necessary measures to achieve the same is the primary responsibility of the solid waste management department. Their functions include collection, segregation, transfer and disposal of waste, and road-cleaning activities.
7	**Present Status**	Collection efficiency- 68%
8	**Service level benchmark (as per annexure) before and after the project**	
9	**Need of Project**	The Municipality not able to cover all the area due to lack of infrastructure like, Vehicle, equipment and workforce. The collection efficiency is not up to 100% due to lack of vehicles and manpower.

b	Sand or Boiler Ash - 20%	400	kg
c	Cement - 0.075%	150	kg
d	Water - 9.925%		
7	Total Brick Production per day	748	no.
8	Per brick Cost	4.5	INR
9	Total brick cost	3366	INR
10	Revenue by selling bricks per day	5984	INR
11	Revenue by selling bricks per year	21,85,257	INR

Revenue from User Charges

Sr. No.	Particulars	Nos.	Charge per Month	Total per per year
1	No. of Families	115957	25	34787100
2	Institutional	172	300	619200
3	Commercial	204	300	734400
4	Industrial	38	1000	456000
5	others	2800	25	840000
6	Hotels/Bhawans	65	1000	780000
7	Nursing Homes	35	2000	840000
8	Pathology Labs	50	300	180000
9	Hospitals	4	5000	240000
	Indoor Stadium, K.I. Stadium, K.C. Bhawan	3	1000	36000
	Total Collection			39,512,700

Funding pattern

S. No.	Funding Agency	Amount	% Share
1	Central Government	337,440,000	75
2	State Government	89,984,000	20
3	Local Government	22,496,000	5

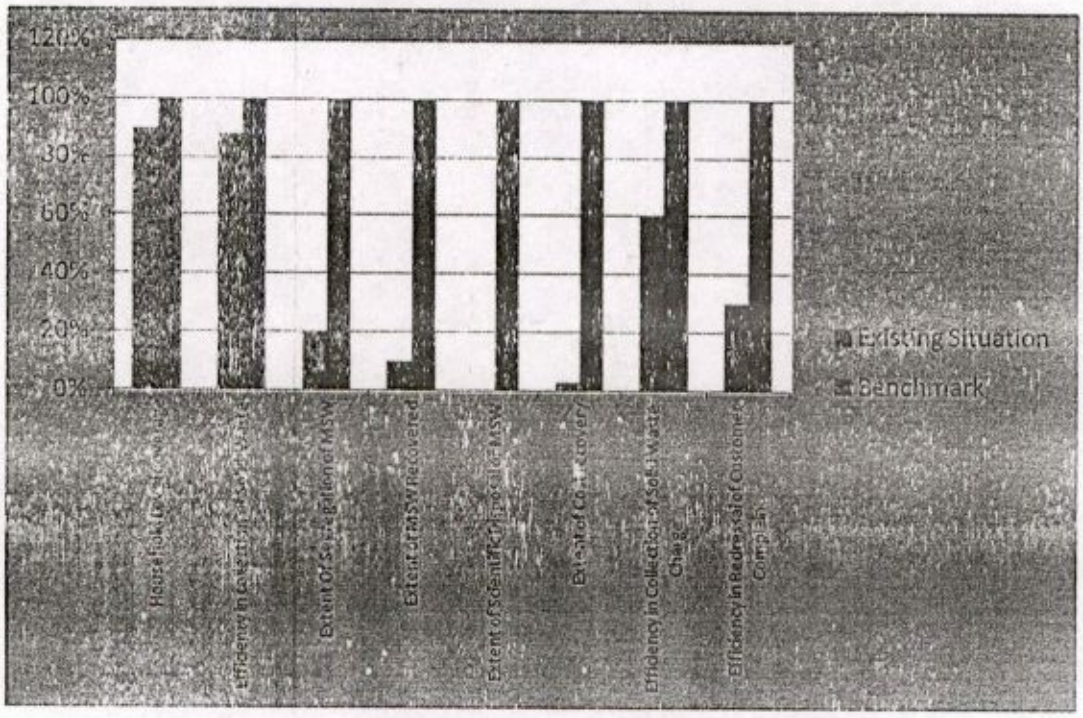
18	Implementing Agency	SMC
19	Annual O&M expenditure (Rs. Lakh)	
	-Existing : 2015-16	
	- Proposed (year 2016-17)	926 Lakh
20	Agency Responsible for O&M	Siliguri MC
21	Charges for solid waste management	
	-Existing : 2015-16	
	- Proposed (2016-17)	3951 Lakh
22	Revenue generation (Rs. Lakh)	
	-Existing : SWM cess 2014-15 (2015-16 till October)	
	- Proposed (year 2016-17)	
23	CPHEEO's Technical comments :	
24	SLSC Approval Detail	
	a. Approval date :	
	b. Approval letter No. :	
	c. SLSC approvals note available :	
	d. State and ULB Share & budget (in INR Lakh)	
25	List anticipated hindrances in project implementation and measures for solutions	
26	Whether the project is recommended for Sanction or not (Y/N)	
27	If not, please mention reasons and area for improving DPR	
28	Estimated cost for consideration & approval (INR crore)	

		The SMC is looking forward to strengthen collection, transportation and processing of waste through this project.
10	**Population**	
	- **As per 2011 census**	5,13,264
	- **Base year**	5,59,625
	- **Design year (2022)**	6,38,606
	- **End year (2042)**	8,49,184
11	**Solid Waste Generation**	
	- **Base year**	313 TPD
	- **Design year (2022)**	391 TPD
	- **End year (2042)**	644 TPD
12	**Project Components**	
	i. No. of packages & details	Single package
	ii. BOQs ready Yes/No	
	iii. Analysis rate ready	
13	**Land required under project& status of land availability**	Available with SMC
14	**Estimated cost (Proposed in Crore Rupees)**	**44.99 C**
15	**Timeline for Implementation**	15 months
16	**Funding pattern**	20% by GOI, 70% by GOH and rest to be invested by SMC
17	**Whether the project (or part of the project) has been taken up for funding earlier through any other scheme? If yes, please provide detail of components of the project taken up. Amount sanctioned and expenditure.**	No

Service Level Benchmark Indicators –Solid Waste Management

S. No.	Indicators	Existing Situation	Standards according to SWM Rules, 2000, CPHEEO Manual and Service Level Benchmarks	Observations from Consultant's Team
1	Municipal Solid waste collection efficiency (Waste collected – 250 TPD; Generated – 300 TPD)	80 %	According to service level benchmarks, it should be 100%	Unavailability of secondary dustbins at appropriate locations. Awareness among citizens for throwing waste in Proper place is required. Quantification of Solid waste in absence of weigh bridge is not possible.
2	Door to door waste collection (102,395 from Total 1,15,957)	88%	According to service level benchmarks, it should be 100%	MSW is not collected from Ward Nos. 1; 28; 40 and 47 -total 13,562 Households.
3	Segregation at source	Nil	According to service level benchmarks, it should be 100%	Waste segregation at primary collection is practiced but that is wasted as there is no segregation of waste at secondary collection point.
4	Waste collection frequency	Daily	Bio degradable waste is to be collected for disposal on a daily basis. Recyclable waste may be collected when the bin becomes full.	Daily collection is in practice throughout the town.
5	Collection Type	Covered vans/Uncovered tractors/ truck	Wastes from secondary dustbins are to be collected through covered tractors or auto tippers.	Covered tractors or auto tippers are not used to transport wastes to the open dumping site. However, SMC has got some new machinery and compactors for

S. No.	Indicators	Existing Situation	Standards according to SWM Rules, 2000, CPHEEO Manual and Service Level Benchmarks	Observations from Consultant's Team
				collection and transportation of solid waste.
6	Disposal	Open dumping.	100% of Segregated inert waste should be disposed in the identified sanitary land fill.	Wastes Collected are dumped to the dumping ground without any treatment.
7	Cost Recovery in SWM Services (Rs. 0.3 Crores collected against expenditure of Rs. 17 Crore)	3%	According to service level benchmarks, it should be 100%	Ward wise Household and shops SWM Charge collection by Ward Committee. SMC only get revenue from Hotels, Hospitals etc.



Service Level Benchmarks vis-a-vis existing situation

Checklist

Sl. No	Particulars	Yes/No
1	Council resolution attached or not?	
2	NOC / Authorization given by SPCB for landfill site along with permission from other statutory bodies such as airport authority (if applicable), Mines & Geology, Environment Impact Assessment (EIA) (for new landfill sites), NOC from Village Panchayath (if Applicable) attached or not?	
3	Financial model for capital cost (Central share /State Share /ULB share etc) shown or not?	yes
4	Filled MoUD Proforma attached or not?	yes
5	Normative Standards / Service Level Benchmark considered or not?	yes
6	Layout plan / designs & drawings attached or not?	yes
7	Waste characterization & quantification done or not?	yes