DRAFT REPORT

Andhra Pradesh Urban Finance & Infrastructure Development Corporation

Detailed Project Report

on

Municipal Solid Waste Management

for

Visakhapatnam

Prepared & Submitted by:

Feedback Infra Private Limited

in JV with

Eco Save Systems Pvt. Ltd

August 2016

Contents

List of Abbreviations

APUFIDC	Andhra Pradesh Urban Finance & Infrastructure Development Corporation
CPHEEO	Central Public Health & Environmental Engineering Organisation
DPR	Detailed Project Report
DTDC	Door to door collection
GoAP	Government of Andhra Pradesh
GVMC	Greater Visakhapatnam Municipal Corporation
JNNURM	Jawaharlal Nehru National Urban Renewal Mission
MSW	Municipal Solid Waste
RDF	Refuse Derived Fuel
ULB	Urban Local body
W2E	Waste to Energy
MTPD	Metric Tonnes per Day

1 EXECUTIVE SUMMARY

Visakhapatnam (nicknamed Vizag) is the largest city, both in terms of area and population in the Indian state of Andhra Pradesh. It is the administrative head-quarters of Visakhapatnam district and also the Financial Capital of Andhra Pradesh. For this the Administration of Visakhapatnam has taken right steps to implement proper solid waste management programme towards full compliance of MSW Rules 2000 (MOEF, GOI) in Visakhapatnam.

Andhra Pradesh Urban Finance & Infrastructure Development Corporation has taken initiatives for implementation of solid waste management programme in **Visakhapatnam District** and up gradation & systematization of Visakhapatnam District's urban waste by establishment of centralized waste processing & disposal facility.

M/S Feedback Infra (Pvt) Ltd in Joint Venture with Eco Save Systems (Pvt) Ltd. have been selected and appointed as consultant for preparation of DPR on SWM for the Visakhapatnam District

The total area is 681.96 Sq.km and the population of Visakhapatnam district as per census 2011 is 18, 83,000 this means a Density of 3533persons/Sq.km. GVMC has been divided into six zones totally consisting of 72 wards.

GVMC (officially Greater Visakhapatnam Municipal Corporation is conducting scientific processing and disposal of solid waste in the entire district. GVMC is carrying out Collection & Transportation functions through contractual arrangements.

The need for proper MSW collection & transportation as well as processing & disposal has been realized by all the residents, shop keepers, service providers and the hospitality industry.

As per the field survey, total quantity of solid waste of the district is 920 MT/day, out of which about 70% is generated by Domestic Household, Commercial Establishments, and Hotels & Restaurants and Institutional waste.

The average per capita waste generation of solid waste in Visakhapatnam was observed to be 0.45-0.47 kg/per capita/day. It is noticed that the waste generation from High-income groups was found to be 0.40 – 0.45 kg/day and from the low-income groups between 0.35-0.40 kg/day. The commercial and the street sweepings also contribute for increase of the per capita waste generation for the city of Visakhapatnam.

Projected quantities of MSW in Visakhapatnam are given in the table below

Table 1.1 Projected quantities of MSW in Visakhapatnam

S. No	Year	Population	Waste Gener-ation Rate (Kg/C/day)	Waste generated (MT)
1	Year 2020	2236649	0.49	400,025
2	Year 2030	2978974	0.53	576,283
3	Year 2040	3967670.5	0.58	839,956

For planning of processing & disposal facility, the MSW has been considered as 709,034 MT/day.

Collection System of waste

Door to door collection services includes collection of waste from households and commercial establishments, markets and other waste generating sources.

In order to improve the system, all the roads and lanes having habitation or commercial activities may be covered on a day to day basis

Secondary collection system is to store the waste. Waste is temporarily stored in the secondary collection points prior to its transportation to transfer station and disposal site.

Transfer station located at town road for secondary transportation of waste

Processing Technologies and Land Area requirement:

Processing of all the collected and delivered waste shall be carried out through Aerobic composting. Approximately 80% of the waste can be utilized fruitfully, leaving behind 20% residues that will be disposed off in sanitary land fill.

The technologies which are being used in Indian conditions are:

- Aaerobic Windrow Composting
- Refuse Derived fuel(RDF) used to generate Power (WTE)
- Scientific landfilling

Disposal of inert material into a scientifically designed landfill i.e proposed at Tangudipalli village which is 40kms from city. Total land area required for the ultimate projected year 2043 years is estimated at 54 hectare.

Project Cost

The Total project cost required for Visakhapatnam Integrated waste treatment plant is given below:

Table1.2 Total project cost required for Visakhapatnam Integrated waste treatment plant

S. No.	Item Description	Amount in Rs Lakhs
1	MSW collection & Transportation	3807.00
2	MSW Treatment & Disposal (Compost & RDF)	8333.00
3	Power Plant	3200.00
4	Contingences	767.00
	Total Project Cost	**16107.00**

The above includes vehicles required ie Autos at 70 Nos, Push carts at 1600 nos, Waste Bins at 1609 nos and Rear End Loaders at 12 nos

Project Structuring

Tipping Fee Model is the viable one. If GVMC can structure an assured compost buy-back either for its own urban forestry or through other Government owned institutions or agricultural cooperatives in the adjoining areas, this can help the GVMC bring down the tipping fee levels. Initiatives like this can potentially improve project viability.

2 INTRODUCTION TO THE PROJECT

Municipal solid waste management is an important as it impacts health, environment and aesthetic society if it is not managed properly. Hence to improve quality and standard of living in the state, the Government of Andhra Pradesh (GoAP) has proposed to strengthen the Municipal Solid Waste Management system covering collection, segregation, recycling, transportation, processing and disposal with option for composting, waste to energy, disposal in all 110 urban local bodies (ULBs) in Andhra Pradesh, which is in line with national objective of SWATCH BHARATH MISSION, a prestigious project of Govt of India.

The Swachh Bharat Mission (SBM) emanates from the vision of the Government articulated in the address of The President of India in his address to the Joint Session of Parliament on 9th June 2014:

"We must not tolerate the indignity of homes without toilets and public spaces littered with garbage. For ensuring hygiene, waste management and sanitation across the nation, a "Swachh Bharat Mission" will be launched. This will be our tribute to Mahatma Gandhi on his 150th birth anniversary to be celebrated in the year 2019"

SBM is being implemented by the Ministry of Urban Development (M/o UD) and by the Ministry of Drinking Water and Sanitation (M/o DWS) for urban and rural areas respectively.

Mission Objectives

1. Elimination of open defecation
2. Eradication of Manual Scavenging
3. **Modern and Scientific Municipal Solid Waste Management**
4. To effect behavioral change regarding healthy sanitation practices
5. Generate awareness about sanitation and its linkage with public health
6. Capacity Augmentation for ULB's
7. To create an enabling environment for private sector participation in Capex (capital expenditure) and Opex (operation and maintenance)

Mission components

1. Household toilets, including conversion of insanitary latrines into pour-flush latrines
2. Community toilets
3. Public toilets
4. **Solid waste management**
5. IEC & Public Awareness
6. Capacity building and Administrative & Office Expenses (A&OE)

The Guidelines for Swachh Bharat Mission (SBM) are enclosed as Annexure.

Swachha Andhra Corporation (SAC):

Swachha Andhra Corporation was incorporated from 1st May 2015 with a goal to achieve the "Swachh Bharat Mission" campaign launched on 2nd October 2014 by Hon'ble Prime Minister of India. Swachha Andhra Corporation has the mandate to fulfil the Mahatma Gandhi's dream of "Swachh Bharat" by eliminating open defecation, eradication of manual scavenging, Solid and Liquid Waste Management, Information, Education and Communication and Capacity Building activities to maintain the cleanliness and hygiene in urban and rural areas of Andhra Pradesh. Swachha Andhra Corporation is taking up the activities of construction of Individual Household Toilets, Community Toilets and Public Toilets. For scientific processing and disposal of municipal Solid waste, waste to energy projects and waste to compost projects are taken up under public private partnership. To tackle the Construction and Demolition waste, C&D waste processing plants are under development through public private partnership mode. Steps are also taken to reclaim valuable municipal old dump sites through process of bio-mining. With political will, backed by a dynamic team and massive support from citizens, the Government of Andhra Pradesh is all set to achieve universal access to Sanitation and thereby make the Urban and Rural areas Smart, Clean, Safe and Healthy.

The GoAP intends to institutionalize a holistic Integrated, sustainable environment and eco-friendly Municipal Solid waste Management System in the urban local bodies (ULBs) of the state. In view of this, Government has appointed APUFIDC a government entity and nodal agency for the development of projects in Urban Infrastructure. APUFIDC will be responsible for preparation of detailed project reports for 110 ULB's in the state of Andhra Pradesh. As part of the process, all the 110 ULB's have been divided in to 5 zones and APUFIDC invited Request for Proposal (RFP) from empanelled consultants to prepare Detailed Project Report for Municipal solid waste management, in compliance with MSW rules 2000 under the aegis of the Environment (Protection) Act 1986 and the guidelines issued there under from time to time.

After the bidding process, the work of five zones has been awarded to 5 different empanelled consultants. The consortium of Feedback Infra Pvt Ltd & Ecosave Systems (P) Ltd have been awarded with work of preparation of DPR of Zone-1 consisting of 14 ULB's in three districts viz. Visakhapatnam, Vizianagaram and Srikakulam.

2.1 Urbanization in Andhra Pradesh

Urbanization is now becoming a global phenomenon, but its ramifications are more pronounced in developing countries. High rate of population growth, declining opportunities in rural areas and shift from stagnant and low paying agri-

culture sector to more paying urban occupations, largely contribute to urbanization.

The annual rate of growth of urban population in India is 3.35% (Census of India, 2011). The proportion of population living in urban areas has increased from 17.35% in 1951 to 31.2% in 2011(Census, 2011).The total population of India, as per 2011 census, is 1210.1 million, of which 833.0 million is rural comprising about 68.8 % and 337.1 million is urban constituting to 31.16 %. In Andhra Pradesh, the urban population of 28.3 million inhabits 353 towns of different size classes. According to the provisional population 2011, Andhra Pradesh has 7 percent of India‟s total population. The urban population of Andhra Pradesh is 33.41 percent of total population of 84.6 million, and it ranks 5th in the all India level in 2011. Studies indicate that urban growth that is being experienced in Andhra Pradesh could be attributed largely to rural migration to existing towns and cities.

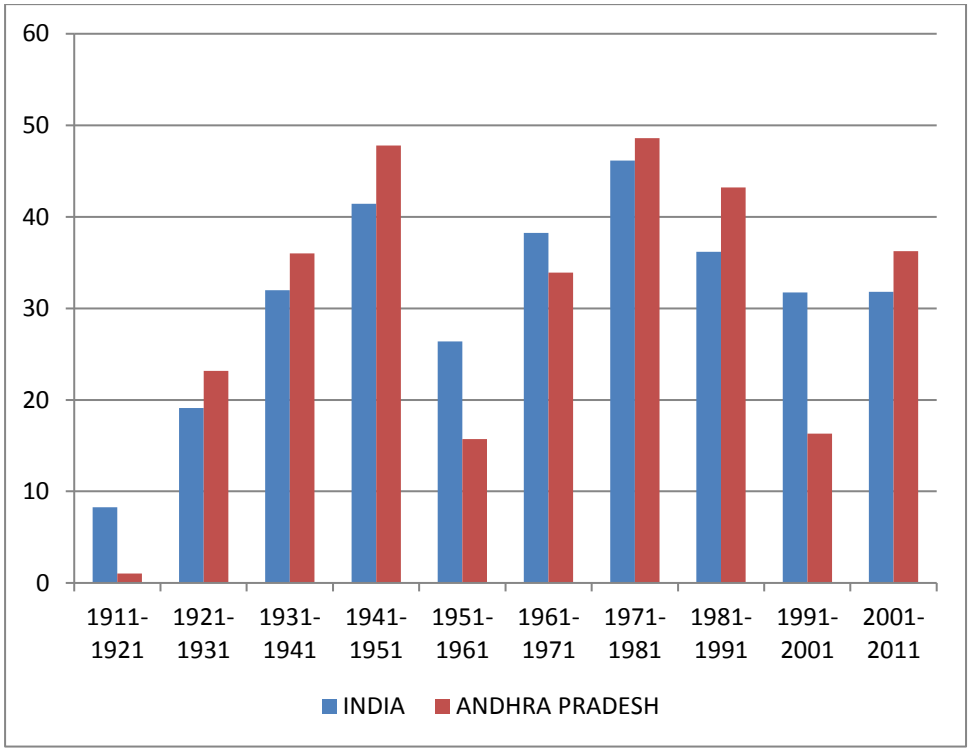


Figure 2-1: Decadal Growth Rate of Urban Population of India and Andhra Pradesh Generation[i]

Urbanization in conjunction with change in lifestyle contributes to higher waste generation, and unscientific waste handling causes health hazards and urban environment degradation. Figure shows past and projected Per capita waste generation in India. Solid Waste Management, in current situation, is already a mammoth task in India and is going to be more complicated with the increase in urbanization, changing lifestyles and increase in consumerism. Financial con-

straints, institutional weaknesses, improper choice of technology and public apathy towards Municipal Solid Waste (MSW) have made this situation worse.

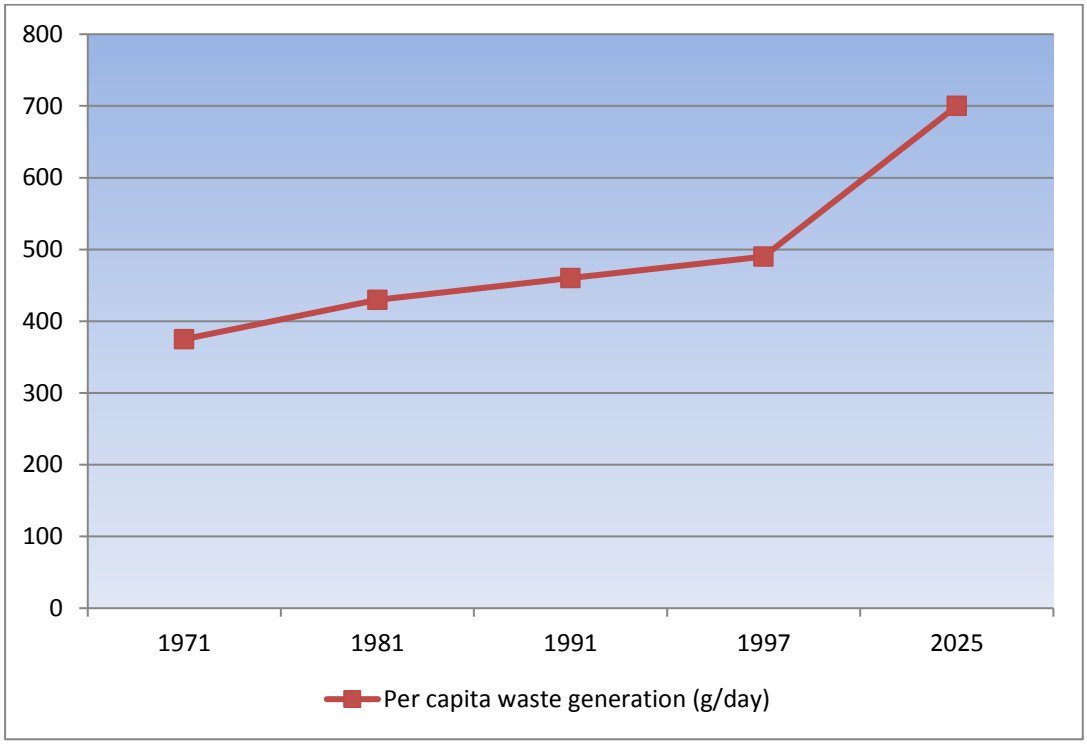


Figure 2-2: Past and Projected Trend of Per capita Waste Generation[ii]

2.2 Problem Associated With Solid Waste Management

With the 74th Constitutional Amendment specifying powers of ULBs and responsibilities of Local Self Govt. and PIL filed in Supreme Court of India in 1996 alleging GOI, State Governments, Union Territories & ULBs failing to discharge obligatory duties regarding MSW management. In March 1999, Expert Committee set up by Supreme Court, submitted detailed recommendations for all Class I cities and various stakeholders for implementation. Municipal solid waste Management and Handling rules -2000 also specifies solid waste management as a obligatory function of urban local bodies , but in actual practice the solid waste management is given the last priority and the duties are either not performed or poorly performed consequently the city has to face numerable problems related to environment and sanitation .

The major deficiencies associated with the system are described in the following sections

Rapidly Increasing Areas to be Served and Quantity of Waste:

The solid waste quantities generated in urban centres are increasing due to rise in the population and increase in the per capita waste generation rate. The increasing solid waste quantities and the areas to be served strain the existing SWM system.

Inadequate Resources:

While allocating resources including finance, SWM is assigned with a low priority resulting in inadequate provision of funds. The inadequacy of human resource is mainly due to the absence of suitably trained staff.

Inappropriate Technology:

The equipment and machinery presently used in the system are usually that which have been developed for general purpose or that which have been adopted from other industry. This results in underutilization of existing resources and lowering of the efficiency.

Disproportionately High Cost of Manpower:

Mostly out of the total expenditure, around 90% is accounted for manpower of which major portion is utilized for collection. Since citizens tend to throw the waste on the adjoining road and outside the bin, the work of the collection staff is increased. Hence, the cost of collection increases considerably.

Societal and Management Apathy:

The operational efficiency of SWM depends on the active participation of both the municipal agency and the citizens. Since the social status of SWM is low, there is a strong apathy towards it, which can be seen from the uncollected waste in many areas and the deterioration of aesthetic and environmental quality at the uncontrolled disposal sites.

Low Efficiency of the System:

The SWM system is unplanned and is operated in an unscientific way. Neither the work norms are specified nor the work of collection staff appropriately supervised. The vehicles are poorly maintained and no schedule is observed for preventive maintenance. Due to shortage of financial resources, the vehicles are often used beyond their economical life resulting in inefficient operation. Further, there is no co-ordination of activities between different components of the system. The cumulative effect of all these factors is an inefficient SWM system.

2.3 Status of Solid Waste Management

Considering average 450 gm/capita/day of solid waste and increase of 5% per year on account of increase in the population and change in lifestyle of the people, it is it is assumed that urban India will generate 2,76,342 TPD by 2021, 4,50,132 TPD by 2031 and 11,95,000 TPD by 2050. As per CPCB, only 68% of the MSW generated in the country is collected of which, 28% is treated by the municipal authorities. Only 19% of the total waste generated is currently treated.

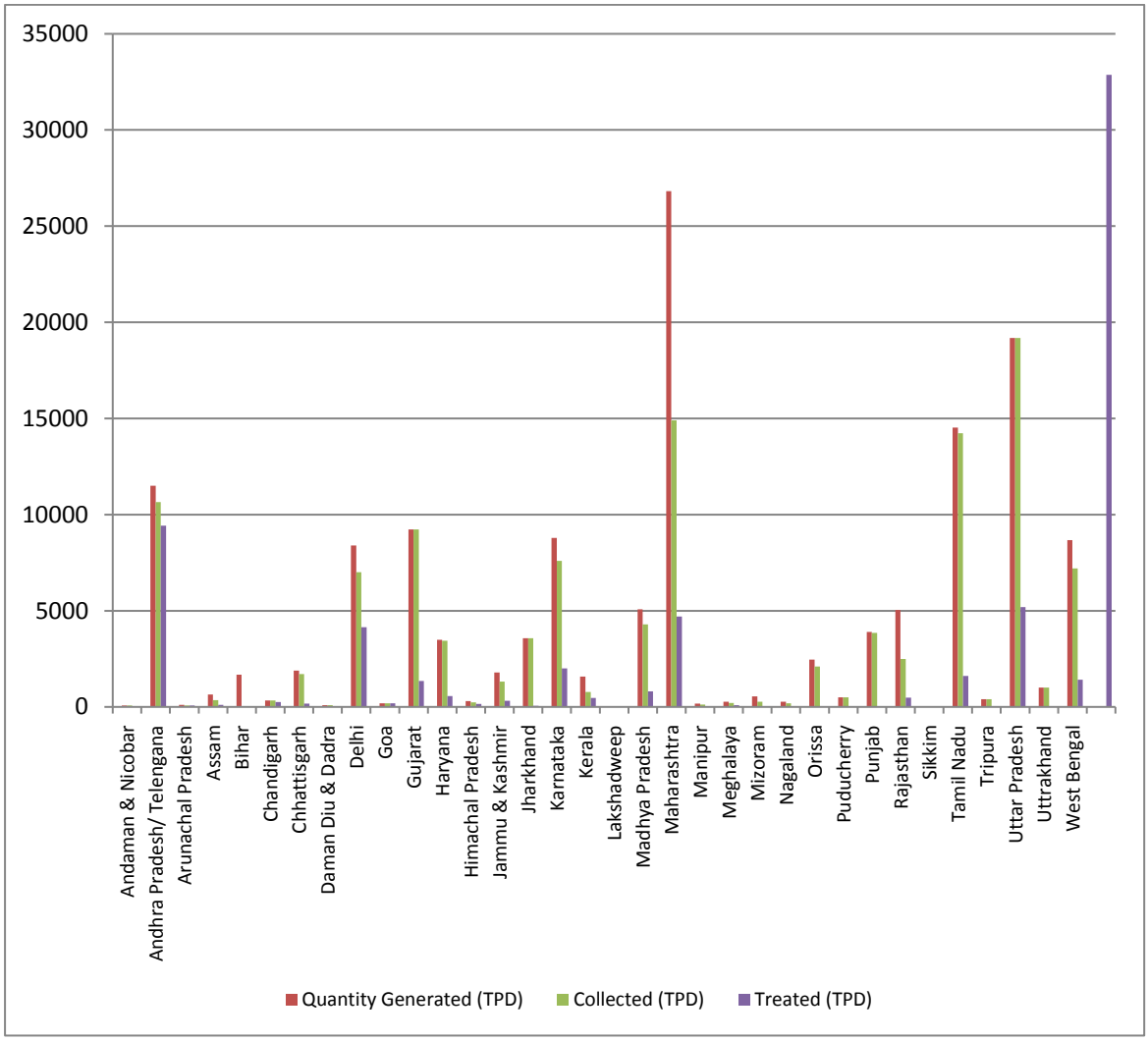


Figure 2-3: MSW management in India as on Feb 2015[iii]

In Andhra Pradesh, 110 Municipalities and 15 corporations are generating 11500 TPD of MSW. In the above figure it appears that AP is treating almost all the waste it is generating. But as per APPCB only 1595 TPD is being processed (Source, APPCB Website). This indicates a huge gap in the generation and treatment of solid waste which is matter of great concern. With rapid urbanization and improving in standard of living of the people, the waste generation is increasing day by day. Dumped waste and unscientific disposal of solid waste will ultimately lead to health hazard and pollution to environment.

2.4 Present Project Details

The project area awarded to M/s. Feedback is ZONE 1, which covers ULB's of Visakhapatnam, Vizianagaram and Srikakulam districts. The proposed area "Greater Visakhapatnam Municipal Corporation" falls under the district of Visakhapatnam.

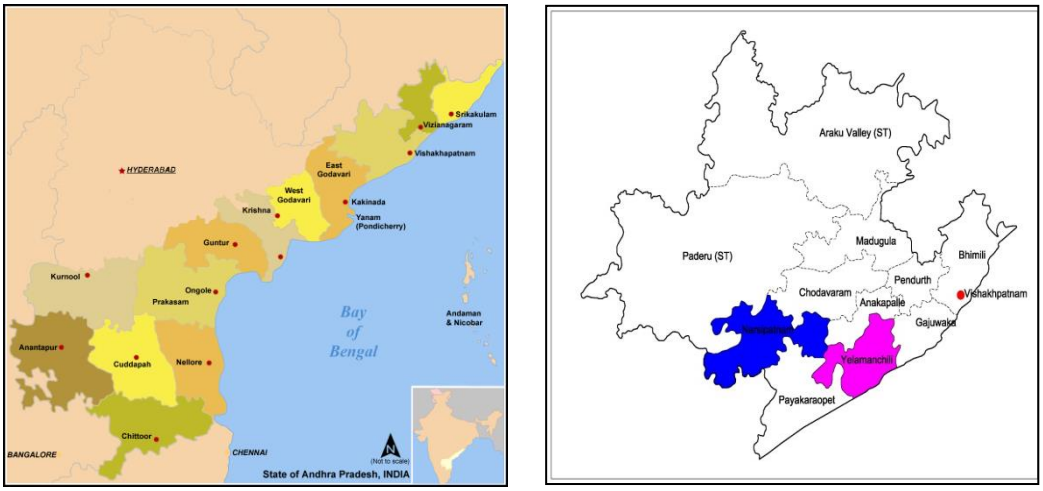


Figure 2-4: Project Area

A team of technical experts from Feedback Infra Pvt. Ltd met the officials of the GVMC and discussed regarding the existing solid waste management system in GVMC. The photographs with the officials and field visits carried in Visakhapatnam are enclosed in PHOTO PLATE - 1.

2.5 Objectives

The objective of the project is to prepare a holistic, integrated, sustainable, environment friendly and executable municipal solid waste management system which is in line with objective of the prestigious mission of Govt of India - SWACH BHARATH ABHIYAN and to meet the following requirements to implement the Solid Waste Management in the ULB's of A.P.

- Analyze the quantity and types of Municipal solid waste generated per capita per day, in the ULB's for different sources and types of waste generated
- Appraise the current mechanism for Primary and Secondary collection of solid waste, including details of physical infrastructure such as Waste bins, Collection points, Road length covered, number of Sanitary workers employed and type of vehicles used, etc
- Study the adequacy of existing infrastructure facilities for collection, transportation and disposal of solid waste and list and quantify the deficiency based on the various available normative standards
- Appraise the daily collection at various stages, number of Shifts & trips made by Vehicles, Carrying capacity, distance travelled to transfer stations, treatment and disposal site,
- Optimization of transport routes and location of transfer stations for cost effective transportation of waste.
- Existing tie up and arrangements of the Council, with Private operators, for collection, transportation, treatment and disposal of solid waste.
- Assess the present mode of disposal of solid waste such as burning, compost-

ing, landfills and any other methods, with particular emphasis on compliance within regulatory framework. Provisions in the existing system, if any, for segregation of solid waste and recycling. Details of existing dumping yards/compost yard such as area, facilities available, adequacy etc. If facilities for any waste processing / treatment exist, details such as plant size, capacity, maintenance expenses, etc.

- Evaluate the existing solid waste management expenditure incurred by the council with a view to determine efficiency of operations, in terms of cost per ton of waste, cost per capita and other operating parameters as relevant
- Feasibility & Evaluation of the proposed landfill sites
- Suggestions for Institutional strengthening, staff requirement and training
- Amendments in laws if any

Based on the studies carried out and deficiencies noted prepare Detailed Project proposal for improving the solid waste management practices in the Town, which may meet the requirements of law and yet be cost effective and implementable in the urban local bodies under study. The Detailed Project Report (DPR) shall suggest improvements to fulfil the requirements laid down in MSW Rules 2000, notified by the MOEF, Govt of India.

2.6 Scope of Work

To meet the proposed objective, a broad scope of work has been out lined in RFP as follows:

- Realistic assessment of quantity characterization of quantity, characterization and classification of MSW, the current scenario in each ULBs.
- Planning- Detailed planning for resource requirements and implementation strategy.
- Proposed DPR shall be in-line with SWM rules, 2000 of GOI and the toolkit of the Govt. Of India for SWM projects.
- Scope of Work should adhere to:
  - ✓ Keeping wet and dry waste stream separated at the household/ source level itself.
  - ✓ Doorstep collection, Segregation of wet waste.
  - ✓ Composting of biodegradable waste.
  - ✓ Recycling of dry waste by category.
- Strategies for 100% source segregation and door to door collection of household and commercial waste, street sweeping, silt removal, vegetable and fruit market waste, slaughter house waste, etc and suitable incentive structure to promote source segregation and recycling.
- Identification of ideal site for setting up compost production and generation of green energy through bio-mechanization in the proposed ULB/Cluster of ULBs as per feasibility.

- Transportation of resources from secondary collection point to the proposed processing plant with the detailed process.
- Analysis of the need for transfer station and its basic design features.
- Tie-ups for inorganic waste and suggestions for suitable technologies for processing.
- Options and strategies for processing of organic waste.
- Opportunities for involvement of various group of the society in MSWM activities.
- Techno-economic and environment analysis of various options for MSWM processes and institutionalization.
- Road map towards achieving zero landfill facility
- Innovative incentive structure to the operating personnel for motivation and for ensuring sustainability of MSWM
- Exploring innovative processes and their enforcement for making the habitation litter free, bins free and dump free so as to prevent health hazards.
- Creating and sustaining the supply chain for recycled waste (products and employments).
- Availability of land for proposed landfills.
- Implementation strategy including resource requirement.
- Information, Education and Communication (IEC) campaign models and enforcement plans.
- Streamlining and optimization of transportation system.
- Options for using the inert material like construction and demolition waste.
- Opportunities for reclamation and bio-mining of old dump site.
- Impact of the proposed MSWM system on community health and environment
- Proposed Measures for involvement of stakeholders in MSWM
- Measures for leadership development and change management
- The study should also consider the existing project being implemented on cluster basis in consultation with the concern Municipal Commissioners and C&DMA. The consultant shall study the land availability for landfill in each ULB within the proposed cluster and the distance to the centre of the clusters, and quantity rejects to be taken to the land fill. In each region clustering is to be done wherever practicable.
- The DPR submitted should be practical and thoroughly implementable with zero land filing and with operation & maintenance strategies of MSWM.
- The DPR should propose a practical action plan for each ULB with cost implications and financial requirements for each suggested methodology and consolidating for each cluster and overall cost of implementation for the entire zone / state.
- The DPR should also suggest implementation strategies for the MSWM plans

for. (i) Individual ULB's which not part of the clusters. (ii) For the clusters of ULBs. (iii) For improvement in the clusters in which MSWM project is under implementation.

- The consultant should provide independent DPR's for each proposed cluster and for ULB's.
- Based on the feasibility study, the numbers of clusters that can be formed in the region are to be proposed. The DPR for the ULB which the common processing unit is proposed for the cluster should contain the complete details of the technology and cost estimation of the processing unit.

3 PROFILE OF ULB's - VISAKHAPATNAM CITY

3.1 Introduction

Visakhapatnam, popularly known as Vizag, is a fast developing port city in India. Visakhapatnam is the second largest urban agglomeration in Andhra Pradesh state. On account of rapid industrialization, there has been significant migration into the city. The city was originally a small fishing village but due to its natural harbor, it developed into a major port. It has experienced rapid industrialization with the growth of major industries, including steel, petroleum refining and fertilizer. With the formation of "Greater Visakhapatnam" in 2005 the city's development is set for a quantum leap. The city of Visakhapatnam has implemented a number of reforms including e-governance and citizen-friendly initiatives. Visakhapatnam has been the first city in the country to implement e-governance and still leads in offering a variety of services to its residents online. The location map of the study area is shown in **Figure 3-1.**

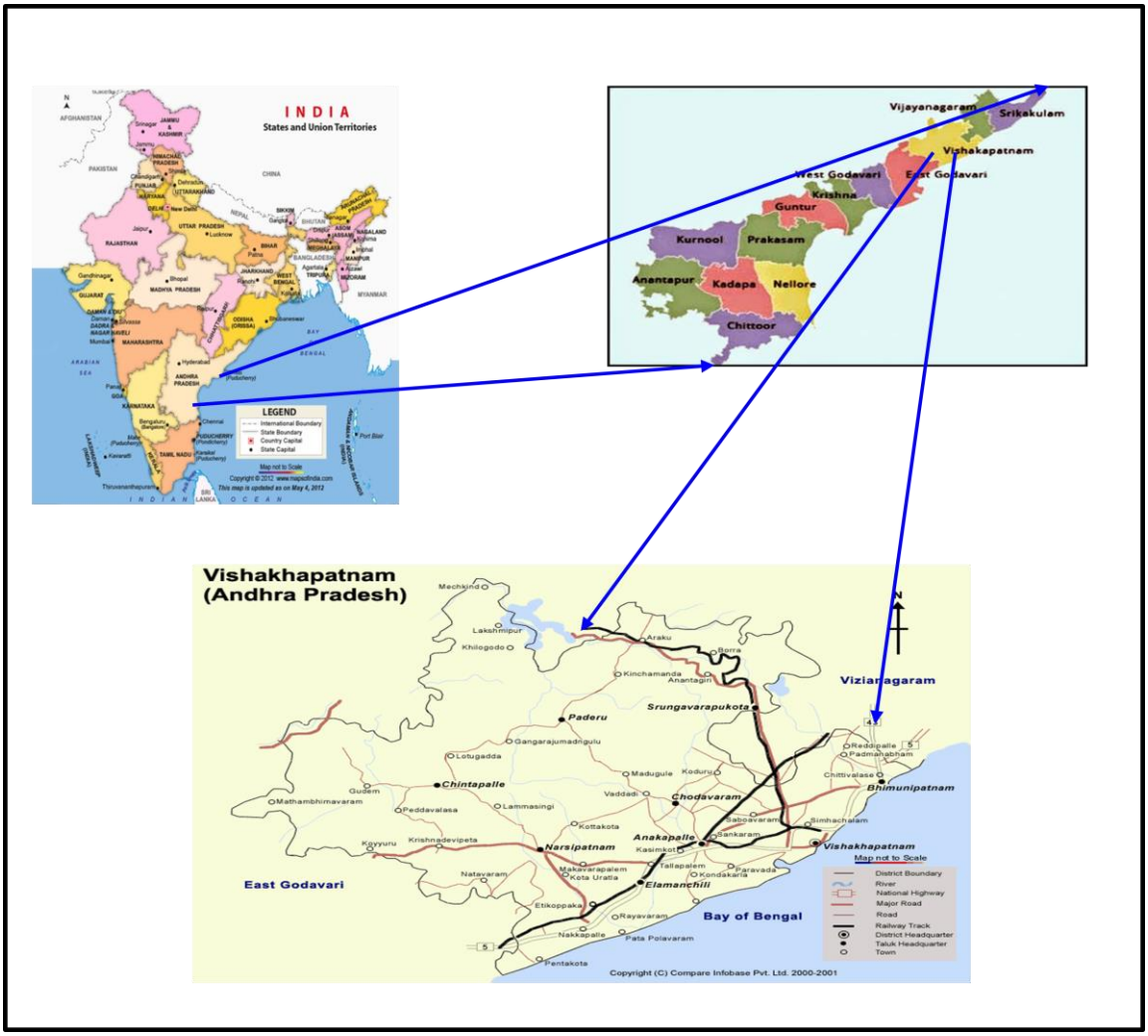


Figure 3-1: Location map of Visakapatnam, Narsipatnam and Yelamanchili

3.2 Historical Background of Visakhapatnam

Visakhapatnam's history stretches back to the 6th century BCE. Historically, it was considered part of the Kalinga region, and later ruled by the Vengi kingdom, the Pallava and Eastern Ganga dynasties. Archaeological records suggest that the present city was built around the 11th and 12th centuries CE with control over the city fluctuating between the Chola Dynasty and the Gajapati Kingdom until its conquest by the Vijayanagara Empire in the 15th century. Conquered by the Mughals in the 16th century, European powers eventually set up trading interests in the city, and by the end of the 18th century it had come under French rule. Control passed to the British in 1804 and it remained under British colonial rule until India's independence in 1947. After independence, Visakhapatnam developed into one of the country's chief ports and became the headquarters of the Eastern Naval Command of the Indian Navy. The city is often known as The Jewel of the East Coast, The City of Destiny and the Goa of the East Coast. Visakhapatnam's beaches (such as Ramakrishna Mission Beach and Rushikonda), parks (such as Kailasagiri and VUDA Park), museums (such as the Kursura Submarine Museum and Visakha Museum), and proximity to areas of natural beauty (such as the Kambalakonda Wildlife Sanctuary, Araku Valley, and Borra Caves) have helped the city become a significant tourist destination.

The Corporation is working closely with other planning and service delivery institutions in the city for improving the quality of life. GVMC has entered into partnerships with the resident welfare associations and the slum communities in undertaking solid waste management and management of neighbourhood parks. The impact assessment identified difficulties for the city in operation and maintenance of this additional infrastructure created in poor settlements.

3.3 Salient features of Visakhapatnam

Climate	Climatic Features Southwest Monsoon Temperature: Max: 34 ^{0}C, Min :17.5^{0}C Temperature over the plains: Max 44 ^{0}C Min 12.8 ^{0}C, Hilly region- 20 ^{0}C and Average annual Rainfall: 95 cms
Population	The population of about 18, 83, 185 people is spread in an area of 681.96 sq.km.
Geographical Features	Latitude- 170 30’ 15” to 18 011’ 15” North

	Longitude - 820 57’ 37” to 830 28’ 12’’East
Distance from major Cities	Mumbai - 1361 km Delhi - 1880 km Bhubaneshwar- 425 km
Total Length of City Roads	2825 km
Transportation	Airport -8.7 km (North) from the city
	Railway stations – 12.7km (East) from the City
Substation	132 KV power substation is located at Anandpuram which is 8km away from present dumpsite i.e kapuluppada
Temples	Simhachalam temple : 32 km (North) from the city
Park	Kailasagiri park :30 km (NE)
Language	Official Language: Telugu, Other languages: Hindi and English
Normal rainfall	1202 mm
Town plan	Town plan map collected from the GVMC is enclosed **Figure 3-2**
Regional Significance	Visakhapatnam was originally a small fishing village. Mainly due to its natural harbour, it has developed into a major port city. It has experienced rapid industrialization with the onset of major industries viz., Oil Refinery, a private sector fertilizer factory, Hindustan Zinc Smelter and Visakhapatnam Steel Plant. The construction of the outer harbour and Steel Plant have considerably changed the character of the city. On account of rapid industrialization and urbanization there has been tremendous amount of migration into the city. Today the services and information technology contribute significantly to the economy.

Administrative & political Setup	For administrative convenience GVMC is divided into 6 zones. Apart from these zones the neighbouring Anakapalle and Bhimunipatnam (Bheemilli) municipalities were merged under GVMC in 2013. Apart from the two municipalities, the 10 villages merged with the GVMC are K.Nagarapalem, Kapuluppada, Chepaluppada, Nidigattu, JV Agraharam, Thadi, Salapuvanipale, Rajupalem, Valluru and Koppaka. This ULB has rag pickers issue.

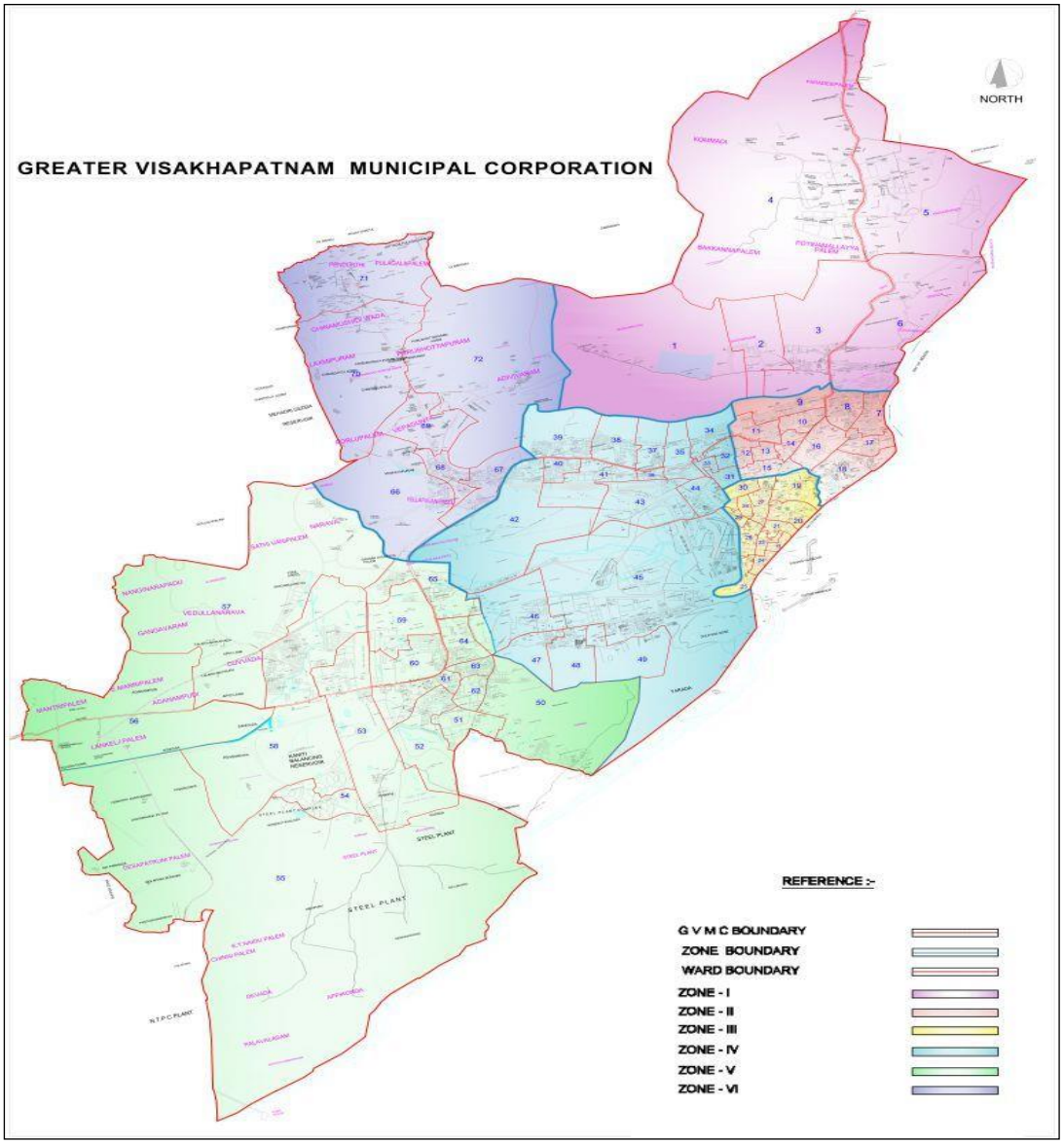


Figure 3-2: Town map of Greater Visakhapatnam Municipal Corporation

3.4 Land use pattern

The land utilization pattern for Visakapatnam City is given in table below:

Land Use	area in sq.km	Percentage (%)
Residential	108.47	20.35
Industrial	26.09	4.89
Roads & Railways	93.6	17.56
Agricultural / Vegetation	58.42	10.96
Hills & Forests	138.94	26.07
Water bodies	12.3	2.31
Ports	56.44	10.59
Vacant Land	38.74	7.27
Total	**681.96**	**100.00**

Table 3.1: land utilization pattern for Visakhapatnam City[iv]

3.5 Demographic Features of Visakhapatnam

Present Scenario

Visakhapatnam is currently ranked as the second largest urban agglomeration in Andhra Pradesh. For administrative convenience GVMC is divided into 6 zones. Apart from these zones the neighboring Anakapalle and Bhimunipatnam (Bheemilli) municipalities were merged under GVMC in 2013. Apart from the two municipalities, the 10 villages merged with the GVMC are K.Nagarapalem, Kapuluppada, Chepaluppada, Nidigattu, JV Agraharam, Thadi, Salapuvanipale, Rajupalem, Valluru and Koppaka.

The population of Vizag urban agglomeration increased from 1.05 million in 1991 to 1.32 million in 2001. The growth of population was more than 80% during 1971-81 and 37.11% during 1991-2001. Due to formation of GVMC and merger of surrounding villages, several well established urban components of the city are located within the GVMC. The details of population of the Municipal Corporation Visakhapatnam and now functioning as the Greater Visakhapatnam Municipal Corporation are given in **Table 3.2**

Municipality	Area (sq.km)	Population in lakhs			Density (Persons/Sq.km) (2011)
		Year 1991	Year 2001	Year 2011	

GVMC	681.96	9.87	13.45	18.83	3533

Table 3.2: Population Generation trends

The population forecasting has been carried out by using the four methods mentioned below.

Arithmetic Progression Method

This method is generally applicable to large and old cities. In this method the average increase of population per decade is calculated from the past records and added to the present population to find out population in the next decade.

Geometric Progression Method

In this method, percentage increase is assumed to be the rate of growth and the average of the percentage increase is used to find out future increment in population.

Incremental Increase Method

In this method the increment in arithmetical increase is determined from the past decades and the average of that increment is added to the average increase.

Decadal Growth Method

In this method it is assumed that rate of percentage increase decreases and the average decrease in the rate of growth is calculated. Then the percentage increase is modified by deducting the decrease in rate of growth.

For the present report, the geometric progression method has been considered for arriving at population projections for the year 2016 as well for the year ending i.e 2042 year. The projected tables were presented below.

S.No	Year	Arithmetic Progression Method	Geometric Progression Method	Incremental Increase Method	Decadal Growth Method
1	2012	1761434	1778373	1758038	1771291
2	2013	1794740	1830078	1787330	1815531
3	2014	1828046	1883287	1816005	1860877
4	2015	1861352	1938043	1844062	1907355
5	2016	1894658	1994391	1871501	1954994
6	2017	1927964	2052377	1898323	2003823
7	2018	1961270	2112050	1924528	2053872
8	2019	1994576	2173457	1950115	2105170

S.No	Year	Arithmetic Progression Method	Geometric Progression Method	Incremental Increase Method	Decadal Growth Method
9	2020	2027882	2236649	1975085	2157750
10	2021	2061188	2301679	1999437	2211643
11	2022	2094494	2368600	2023171	2266883
12	2023	2127800	2437466	2046288	2323501
13	2024	2161106	2508334	2068788	2381534
14	2025	2194412	2581263	2090670	2441017
15	2026	2227718	2656313	2111934	2501985
16	2027	2261024	2733544	2132581	2564476
17	2028	2294330	2813021	2152611	2628527
18	2029	2327636	2894809	2172023	2694179
19	2030	2360942	2978974	2190817	2761470
20	2031	2394248	3065587	2208994	2830442
21	2032	2427554	3154718	2226554	2901137
22	2033	2460860	3246440	2243495	2973597
23	2034	2494166	3340829	2259820	3047867
24	2035	2527472	3437963	2275527	3123992
25	2036	2560778	3537920	2290616	3202019
26	2037	2594084	3640784	2305088	3281994
27	2038	2627390	3746639	2318942	3363967
28	2039	2660696	3855571	2332179	3447987
29	2040	2694002	3967671	2344798	3534106
30	2041	2727308	4083029	2356800	3622375
31	2042	2760614	4201742	2368184	3712850

Table3.3: Summary of population projections for Visakhapatnam city based on arithmetic progression, geometric progression, incremental increase & decadal growth methods.

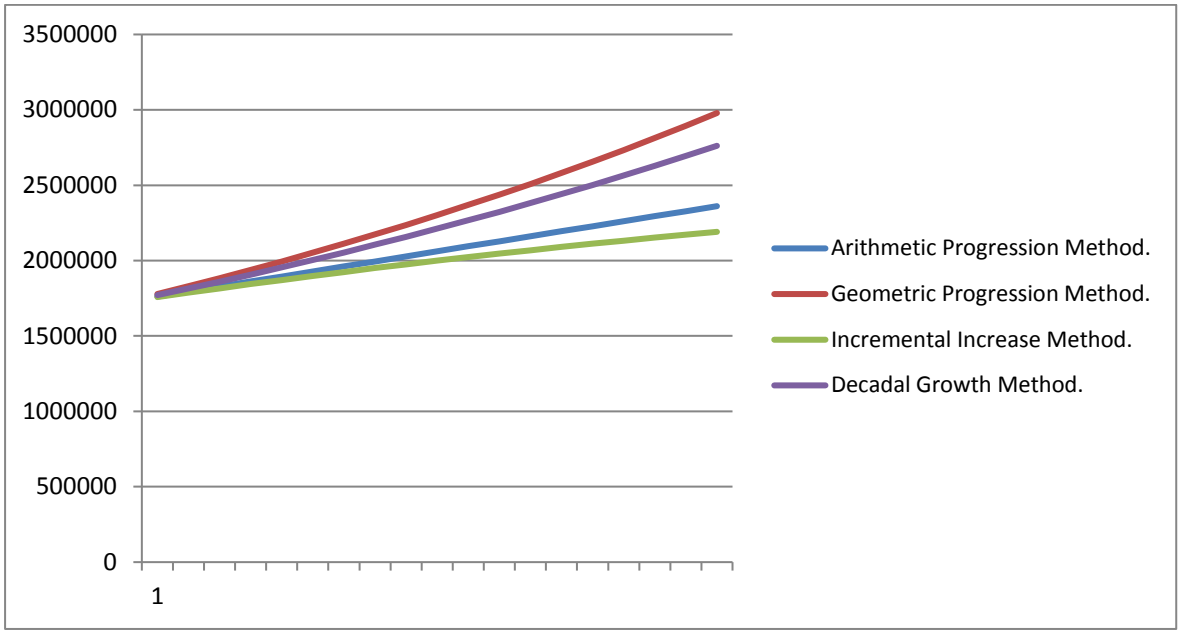


Figure 3-3: Population Projections for Visakhapatnam City

GEOMETRICAL PROGRESSION METHOD OF POPULATION PROJECTIONS FOR Vizag City.				
PREVIOUS POPULATIONS :				
S. No	**Year**	**Population**	**Rate of Growth (r) per Decade.**	**Remarks.**
1	1981	728947		
2	1991	987634	0.355	
3	2001	1345938	0.363	
4	2011	1728128	0.284	
Geometric Mean, r_g = (0.355*0.363*0.284)^(1/3)			0.332	

Ex – 2012 population = 1728128*((1+0.332)^(1/10)) = 1778373

3.6 Socio –Economic Details

The economic impetus in Visakhapatnam over the past three decades has provided numerous employment opportunities, which is evident from the population growth rates for the past three decades. The demographic trends of growth essentially follow the geographical expansions, which were the result of various developmental initiatives in the infrastructure and on the industrial front. During

the first quarter of the century, a very slow increase is recorded as there was no major event except the opening of the East Coast Railway line. During the second quarter of the century, a steady rise is recorded till Independence was observed, with the establishment of major institutions. A significant growth of the city after partition, which lasted during the third quarter of the century, is due to the development of port activities and industrialization. The new industrial policy declared by the Government of Andhra Pradesh in 2005 gives boost to new investors who are willing to invest in Andhra Pradesh. Visakhapatnam is the district of plentiful opportunities.

The City having an investment of Rs. 20,000 Crores is the industrial capital of the State. The City is recognized as the fifth-fastest growing "Industrial Metropolis" in the Asian subcontinent and the fastest growing industrial city on the East coast of India strategically located midway between Calcutta and Chennai. The geographical advantage with a natural harbor and bountiful infrastructural facilities helped the city acquire industrial importance and well known place in the international market. The ideal industrial climate has led to the development of core industries. Rich deposits of iron and aluminum ores in close proximity and good rail and road connectivity and Export oriented Zones and EXIM parks present interesting possibilities for setting up major industries. The basic requirements which are necessary for establishing an industry are power supply, raw materials, transportation facilities etc are available in Visakhapatnam and very large plants have come to be established in Visakhapatnam and environs. – Hindustan Ship Yard, Bharat Heavy Plates and Vessels factory and such others. The employment potential is 2,00,000 workers. With its long coastal line, fishing and travel & tourism is a major economic activity. There is also a handful opportunity for development of brackish water, prawn culture & pisci culture since this is an export oriented and a lot of investment can be poured into it.

The state government as well the city administration have made concerted efforts to make Visakhapatnam the second economic development hub in the areas of Information Technology Enabled Services, Pharma and Biotechnology, development of Consumer goods and Ancillary industries/Tourism after Hyderabad. Significant efforts in this direction include some of the recent projects supported by the Corporation which include Upgradation of the local Airport, setting up of VSEZ, Simhadri Power Plant, Special Economic Zone, Pharma City at Parawada, Gangavaram Port, Gems and Jewellery Park and Apparel Export Park amongst other Projects. There is a possibility of a few more manufacturing unit being located in the close proximity to the City. The transport infrastructure has permitted industrial investment and growth in the region. In addition to the international and national linkages, the Corporation has undertaken several initiatives to upgrade the municipal roads and public utilities and amenities to international standards.

GVMC has been divided into six zones totally consisting of 72 wards, zone – I consists of wards 1 to 6, zone – II consists of wards 7 to 18, zone – III consists of wards 19 to 30, zone – IV consists of wards 31 to 49, zone – V consists of wards 50 to 65 and zone – VI consists of wards 66 to 72. The basic infrastructure and facilities are provided across all the zones, each zone has its own socio-economic characteristics. **Table 3.4** presents zone wise descriptions of socio-economic features of the City.

Zone	Description
Zone-I	This zone consists of wards 1 to 6 having middle income and low income group people and the slum population in this zone accounts to 1, 40,793. National Highway (NH-5) passes by this zone. Jodugullapalem fishing village falls under this zone with a population of above 2500. Hanumanthawaka area in this zone is known for its small animal slaughter house and another piggery slaughter house. This zone is scarcely populated and is mainly a hilly region. The famous Rushikonda, which is one of the favourite tourist spot in Visakhapatnam, also falls under this zone. Places like Madhurawada, Hanumanthawaka are considered as commercial areas for this zone.
Zone-II	This zone consists of wards 7 to 18. This is one of the major commercial zones in GVMC. One of the famous University in Andhra Pradesh ie. The Andhra University falls under this zone. The famous recreational centers like VUDA park and R.K. Beach also fall under this zone. This zone mainly consists of High income group people in areas like Kirlampudi layout, Beach road and MVP Colony. Peddajalaripeta is a major fishing village with population above 24,000 falls under this zone. This zone also has good medical facilities for eg. Visakha eye hospital, mental care hospital and R.C.D hospital fall under this zone. This zone is also famous for cinema talkies.
Zone-III	This zone consists of wards 19 to 30. This is also one of the major commercial zone in the city of Visakhapatnam and this zone lies in the heart of city. Kurupam and Allipuram markets are the known markets in the Vizag city. Bukkaveedhi, Kotaveedhi and Kotha Jalaripeta are the fishing villages with a population of above 8000 fall under this Zone. This zone majorly has mixed income group population. Important areas in city like Daspalla hills, Daba gardens, Rockdale layout, Suryabagh, Kobbarithota, Beach road and Krishna nagar etc.., fall under this zone.

Zone-IV	This zone consists of wards 31 to 49. This zone has mixed income group population with majority of middle and low income group. Highest number of slums in Greater Visakhapatnam exists in this zone with a population of 149212. This zone majorly has State & Central Govt. Quarters like Port quarters, Zink quarters (P), CSF quarters and Loco diesel quarters etc.
Zone-V	This zone consists of wards 50 to 65 having middle and low income group population and the slum population in this zone accounts to 121458. This is basically an industrial zone. Industrial areas like Gajuwaka and Steel plant falls under this zone. This zone also has major commercial establishments. Main markets like Gajuwaka Banana market and Kanithi road market exists in this zone.
Zone-VI	This zone consists of wards 66 to 72. This zone has majorly middle and low income group population. This zone is a scarcely populated zone.

Table 3.4: Zone Characteristics, Visakhapatnam City (Source Year 2015)

Zone	Slum Population	No. of slums	Notified slums	Non notified slums
I	1,40,793 128	128	44	84
II	50,014	52	37	15
III	84,150	66	66	11
IV	1,49,212	142	130	12
V	1,21,458	125	101	24
VI	95,305	87	14	73
Total	**6,40,932**	**600**	**381**	**219**

Table 3.5: Details of Slums in Visakhapatnam city (Source Year 2015)

3.7 Fishing

Fishing is one of the major activities in the GVMC area. The export value of the fishing products in India is in Crores of rupees, 70% of which is from Andhra Pradesh and major portion of this is from Visakhapatnam. It is estimated that around 6 lakh people of the state depend on fishing activity of which one fourth are in Visakhapatnam. It is also observed that 50% of the total fisherman population (45,000) is residing in more than 11 villages of Visakhapatnam Urban Mandal which shows that most of the fisherman are concentrated in and around Vi-

sakhapatnam fishing harbor as it provides livelihood and have potential for better job prospects for them. The population in these villages varies from just 20 persons in Cheepulapalem in Kapuluppada Mandal to 24,000 persons in Peda Jalaripeta village of Visakhapatnam Urban Mandal. It also happened that due to the closing of Bheemunipatnam port in 1933 after commissioning of Visakhapatnam port in the same year, most of the fishing activities have been shifted from Bheemunipatnam to Visakhapatnam. All fisherman villages are connected with approach roads. Excepting a couple of hamlets, majority of these habitations are provided with drinking water supply and common traditional infrastructure such as temple and burial ground. Most of the villages in Visakhapatnam, Yendada and Kapuluppada mandals are deprived of education and health facilities and public toilets.

4 CURRENT WASTE ASSESSMENT AND EXISTING SOLID WASTE MANAGEMENT SYSTEM

4.1 Introduction

The solid waste is heterogeneous and commingled. The trends seen are the proportion of putrescible organic matter is greater in low income countries than those of high income. The proportion of paper and plastic waste is more with increasing national income, which shows that waste density is a function of national income. Moisture content is also higher in low income countries. The composition of waste in a given urban centre varies significantly with socio-economic status (household income).

The factors influencing the waste quantities are income, population, social behaviour, climate, industrial production, consumer behaviour and high standard of living. Forecasting waste quantities in the future is as difficult as it is in predicting changes of waste composition. The factors promoting change in waste composition are equally relevant to changes in waste generation. Most of the requirement in Visakhapatnam is met from the exported goods from main land. As such no activities of production are taken place in Visakhapatnam. Therefore most of the packing material was found on the streets of the town.

4.2 Sources of Solid Waste

Sources of Municipal Solid Waste (MSW) may be broadly classified as follows:

- Domestic Origin: Kitchen waste (left over/rejected food materials), human waste, paper, plastic, rags, metal, rubber, glass, cardboard, expired medicine, containers of medicine/disinfectants, etc.
- Street/Kerb side Waste: Street/ sweepings comprising dust, grit, dry leaves, papers, plastic, rubber, glass, cardboard, metal-pieces, etc. junk containers, carcass of animals and so on.
- Market Origin: Paper, plastics, cardboard, packaging materials, etc.
- Industrial Solid waste: Scrap metals, alloys, ores, glass, paper, plastic, chemicals and other industry specific items.
- Hospitals/Medical solid waste: Hospital wastes include used bandages, infected linen, Plaster of Paris, injection vials, medicine bottles and containers, disinfectants, diseased organs etc. apart from common solid waste items (Paper, plastic and food materials etc.)
- Commercial Institutional Origin: Paper, plastic, cardboard, packaging material etc. from shops and offices, leftover food from hotels/restaurants and miscellaneous items.
- Agricultural and Animal Waste; These also find their way into the urban

area through the agricultural marketing complexes, dairy & poultry farms, Zoological & botanical gardens, etc.

4.3 Storage of waste

Storage of waste at the source is the first important step of solid waste management. Every household, shops establishments, market yards etc., generate solid waste on day-to-day basis. The waste should normally be stored at the source of waste generation till collected for disposal. Generally it is observed that no bins for storage of waste at source are kept. Though few households use bins, shops and establishments, institutions etc. normally do not have waste storage bins. As a result most of the waste from the domestic places, institutions and even from hospitals comes on to the street. The situation in Visakhapatnam is no different and more over with open drainage system, it is observed that the surface drains are clogged with wastes especially plastic bags etc. The situation in slum areas is further worse, the drains being completely filled with waste.

Seasonal variations in the waste quantity arise from factors with respect to both climate, cultural, and religious events. During monsoon, the waste becomes wet and heavy and total tonnage increases. Climate affects the generation of vegetative waste and at the end of the autumn season leaves may comprise a significant proportion of the street sweepings. The wastes from marriage halls are generally more during the marriage season. About 15-20% of spoilage is anticipated in summer season especially with vegetables like tomato, cauliflower etc., so these factors does have bearing on the waste generation.

Source segregation of recyclables and biodegradables (organic waste) will not only provide an efficient way for resource recovery, but will also substantially reduce the pressure and pollution at Landfill sites. It is understood that implementation of such practices takes time and requires significant cooperation from the public. However, initiation should be made and efforts should be diverted to progressively increase the segregation practices. Community Participation indicates various actions that could be taken by GVMC to increase the public participation for the management of MSW. The sections below deal with issues that need to be considered for source segregation and various options available to GVMC to implement the system.

Individual houses

Mixed waste is stored in various containers like plastic bins, cartons, plastic carry bags etc by households. Source segregation is not in practice in Visakhapatnam. Domestic waste will be collected by push carts followed by streets bins. In most of the wards door to door collection is in practice, some types of receptacles presently used for storage by Visakhapatnam households are:

- Buckets

- Plastic Bins
- Polythene bags/containers.

Slums

The solid waste generated is stored in on the street/roadside or thrown in the surface drains or in the backyard of the house.

Street/Road sweepings

Street sweepings comprise of natural wastes, road traffic wastes, behavioral waste and silt from open drainages.

Natural waste	-fallen leaves, decaying vegetation, dust blown from unpaved areas etc.
Road traffic waste	-rubber, mud oils etc, excreta of animals
Behavioral waste	-litter thrown by pedestrians

Open Surface Drainage waste	-Silt, plastic bags etc.

The sweepers are allotted certain stretches of the roads. Two sweepers are allocated one side of the road; hence six (6) to Eight (8) sweepers are involved for each stretch of the road. One sweeper is involved in sweeping the pavement & kerb side and piling it at intervals. In some places only two sweepers were involved for both the sides of the road.

Sometimes two or more piles are aggregated into a single big pile of sweeping. The other sweeper is involved in collecting the waste heaps and transferring it into the handcart. The waste from the handcarts is dumped in a designated collection point. The Municipal vehicle picks it from the collection point. After completion of a stretch of road, the sweepers reverse their roles and the process is repeated.

Shops/Office/Institutions

Sanitary workers while sweeping the roads in the morning collect the waste bags with wet waste placed outside the shops in their handcarts containing detachable containers and some of the recyclable waste is being collected by waste collectors. The waste from these sources is dry recyclable waste. The wastes are stored in plastic bins; plastic covers or swept directly to the streets.

Hotels & Restaurants

The Hotels & Restaurants are not having the facilities to store their waste on site in large steel/plastic containers and dispose them accordingly. Proper segregation of dry and wet waste is not being met by the generator. The same is the case with small time restaurants, street side food vendors who throw off their leftover food on the roads.

Market yards: Fruit & Vegetable Markets

The vegetable and fruit waste from Purna Market and other small markets need to store their waste in the bins. In addition to these there are small daily, bi-weekly and weekly markets in different residential areas of the town apart from

the door to door fruit & vegetable vendors. These markets produce wastes, which are ideal for production of compost. In view of this, it is desirable that all vegetable market waste be stored separately.

Marriage/Function halls

These are places where large quantity of waste is generated but only during functions / marriages or other social gatherings are held. Hence these establishments are advised to install their own large size containers for storage of waste at source.

Hospitals/Nursing Homes/Pathological Laboratories

Two types of waste are generated from these establishments, one is municipal refuse and other is bio-medical waste. These two types of waste are stored separately in hospital premises. The municipal vehicles carry the waste to the dump site.

Construction waste

This waste should be stored within the site with a proper screen around it to prevent scattering of the waste. The owner may request for providing appropriate skips/containers for storing their waste on payment basis.

4.4 Existing collection and transportation system by GVMC

a) Primary Collection System: Door to Door Collection

Transportation of waste from secondary collection points at regular intervals is one of the essential jobs in MSW Management. Presently segregation and Door-to-Door garbage collection is being carried out in 72 election divisions out of 72 and Bheemli. Waste is collected from the Households and recyclables sold a way by the workers and the Organic waste is collected into the plastic baskets in the trolley. In-Organic Waste particularly thin plastic carry bags which are not purchased are separately collected into Gunny Bags.


Waste collection by push Carts:

Push Carts (Total 800 Nos) and Rickshaws (720 Nos) covering 200 to 250 houses for both collection and segregation. Presently 40% Households are being covered in 45 Sanitary Divisions.

In the afternoon the street sweeping and drain cleaning activity is being attended by the workers and garbage is stored in the street dumper bins.

b) Secondary Waste Collection

The collection and transportation of waste is practiced on all the days of the year including the public holidays by GVMC. In GVMC, waste stored in open spaces is either loaded manually or with the help of loaders (in case of huge accumulations) in trucks. The vehicles involved in the solid waste transportation in Visakhapatnam include dumper placers, tractors, mini vans, tippers (big & small). Dumper placers will carry the bin and unload the waste at the transfer station and will perform on an average of 4-5 trips per day. Mini tippers transport the waste from the open secondary collection points to transfer stations. Dumper placers deployed with a capacity of 4.5 cum for carrying the waste from Secondary collection point to the Kapuluppada .

Hotels and Food waste

The leftover food from all the star hotels and other hotels is being collected by pig farms daily in huge quantity may be approximately 20 MT per day.

Waste from Commercial Establishments

Mainly Dry Organic Waste like paper, Rubbish, Package Material, etc.., are collected into the dumper bins by servants. The Commercial Waste and Waste from houses uncovered under Segregation collected into dumper bins (575 No.s) is approximately 300 MT.

c) Transportation

75 Dumper placers, 132 TATA Acres, 64 Small Tippers Transport the Garbage from storage point to transfer station and windrows compost. 10 Big Tippers (Taras) Transport waste from transfer station to Kapuluppada.

d) Man Power

1313 permanent workers, 3919 Out Sourcing workers, 30 Permanent Drivers, and 200 Out Sourcing Drivers are working.

Scientific processing of Waste

GVMC by following Solid Waste management handling rules 2000 selected one of the least expensive and less capital intensive, but approved method of windrows composting. The windrows composting is De-Centralized in five locations covering the entire city as follows:

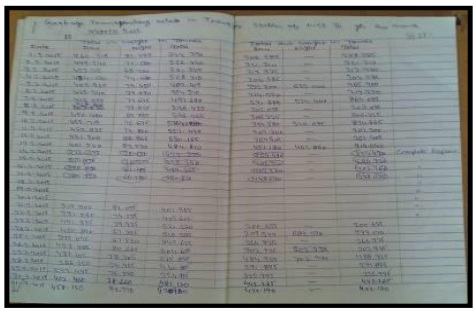
S.No	Location	Coverage
1	KRM Colony	II – Zone
2	Vepagunat	IV & VI- Zones
3	Gajuwaka	V- zone
4	Bheemali	Bheemali Zone

4.5 Transfer station

Being area of Visakhapatnam city is large and the disposal site is far from the city, transfer station is established to transfer the waste from dumper placers & trucks. The transfer station is located at town road. The collection vehicles including dumper placers, tippers and tractors will pick up the waste from the secondary open collection points & dumper bins and transfer of waste directly in the transfer stations.






A ramp facility is also provided to facilitate unloading of vehicles or dumper placer containers, directly into large container trucks at transfer station. Waste is weighed at Weigh Bridge at the entrance gate, a record is being maintained for in time, out time, weight of the solid waste disposing in to the transfer station and vehicle number. The big Tarus vehicle (20 ton capacity) transport the waste to disposal site located at Kapuluppada which is 25 kms away from the city.

4.6 Treatment and Disposal of waste

The collected waste from Households will be deposited into the concrete/mild steel bins located in respective wards by sweeper. The sanitary workers of municipal corporation lifts waste from the bins, at a frequency of once in a day. The waste from the road side bins and street sweepings is collected regularly and transported to the disposal yard.

The waste generated from all the wards will be disposed at the dump site located near Kapuluppada. Currently, GVMC disposes the entire waste generated at Kapuluppada disposal site. This site is operating for the last 7 years with about 80 acres. Three JCBs and one bulldozer are employed by GVMC for solid waste disposal management, including the operation of the waste disposal site.

The existing waste disposal site where crude open dumping is practiced with no leachate collection and treatment system and does not meet the current requirements of the MSW 2000 Rules. Open burning of waste, indiscriminate disposal, presence of stray animals & rag pickers at the disposal site and leachate

migration into the subsurface are common occurrences.

The total quantity of waste generation and the quantity reaching the dump yard may not be same. The total waste dumped at Kapuluppada dump site is about 600-650 TPD, where as the total waste generation is about 920 TPD.

Biomedical Waste Management Facility:

M/s. Maridi Eco Industries Pvt. Ltd is operating a biomedical waste treatment plant in 5 acres within the Kapuluppada disposal site.

Compost Plant

There is a small compost plant in the Visakhapatnam city which is located in ward no. 10 behind Eenadu office. It was established on pilot basis in the year 2001 with coordination of NGO Ex-nora. Total area of the compost plant is 1.5 acres and is receiving a total solid waste of 5 to 6 Tons per day. There are 27 members working for this compost plant to segregate the recyclables and biodegradable, and compost plant maintenance. There are 3 dumper bins provided in this compost plant to carry the inert material and disposes it in the Kapuluppada disposal site. Composting is done in the aerobic process which is in presence of oxygen.

Institutional Aspects

The Chief Medical Health Officer has the responsibility for overall SWM management assisted by a team of Assistant Medical Health Officers, Sanitary Super-

visors, Sanitary Inspectors, Engineers, Ward Officers, Sanitary Officials and Workers. At the central level there is an Executive Engineer assisted by Deputy Engineers, drivers and helpers.

Sanitary staff for GVMC

S. No.	Deployment of Sanitary Staff	City Level Analysis
1	Chief Medical Officer of Health	1
2	Assistant Medical Officer of Health	6
3	Sanitary Supervisors	6
4	Sanitary Inspectors	51
5	Health Assistants	21
6	Sanitary masteries	55
7	Sanitary Workers	3772

Source: Greater Vishakhapatnam Municipal Corporation

Engineering Staff required

S. No.	Deployment of Sanitary Staff	City Level Analysis
1	Chief Engineer	1
2	Superintending Engineer	3
3	Executive Engineer	16
4	Deputy Executive Engineer	22
5	Assistant Executive Engineer	73
6	Work Inspectors	80

Source: Greater Vishakapatnam Municipal Corporation

For the easy of management, entire Visakhapatnam City is divided into 6 sanitary zones. The zone wise distribution of sanitary workers is done in accordance with the population density of the division and length of roads.

Key Concerns in the Existing System

- Secondary storage points are in very poor condition

- Rag pickers who are taking out most of the recyclables which is having high calorific value.
- Drain silt and Municipal solid waste is getting mixed
- Transfer station maintenance is not good
- No scientific disposal, waste is being dumped at Kapulluppada without any treatment and No scientific landfill.

Deficiency Analysis/ Compliance of MSW Rules 2000

The below table shows the deficiency analysis in the MSW management system existing currently.

Component	MSW Rules 2000	Compliance	Photos
Generation	Prohibit littering on the streets, promote segregation of recyclable waste at source and ensure storage of waste at source in two bins; one for biodegradable waste and another for recyclable material.	The municipal corporation has already initiated educating the citizen to store the waste at source by offering the service of door to door collection of waste. Presently segregation and D2D garbage collection_is being carried out in 72 election divisions out of 72 and Bheemali. Waste is collected from the Households and recyclables sold a way by the workers and the Organic waste is collected into the plastic baskets in the trolley. But still waste is found on the road sides.	

Component	MSW Rules 2000	Compliance	Photos
Segregation at source	Set up treatment facilities for biodegradable waste using composting or waste to energy technologies meeting the standards laid down in schedule IV.	Corporation is encouraging the source segregation at door to door /primary collection. But still Segregation of waste at the source of generation absent. Recyclables including newspapers, plastics and metals are collected by rag pickers.	

Component	MSW Rules 2000	Compliance	Photos
Primary Collection	Organize Primary collection of biodegradable and non-biodegradable waste from the doorstep, (including slums and squatter areas,) at pre-informed timings on a day-to-day basis using containerised tricycle/handcarts/pick up vans.	Each Push Cart (Total 800 Nos) is handled by 2 to 3 workers covering 200 to 250 houses for both collection and segregation. Presently 40% Households are being covered in 45 Sanitary Divisions. In the remaining Households recyclables are segregated through Rickshaws (720 Nos) and In-Organic material Segregated at Windrows compost. Unhealthy and unhygienic waste disposal practices followed by disposal in to drains and open places.	
Secondary Collection	Abolish open waste storage depots and make provision of covered containers or closed body waste storage depots.	Poor maintenance of collection points. Separate collection points for various streams of waste absent. Mixing of drain silt at this level Manual lifting and open transfer of the waste from the collection points leading to spilling of waste . Personal protection equipments used by the workers clearing the waste absent.	 

Component	MSW Rules 2000	Compliance	Photos
Street Sweeping	Organize Street sweeping covering all the residential and commercial areas on all the days of the year irrespective of Sundays and public holidays.	In the afternoon the street sweeping and drain cleaning activity is being attended by the workers and garbage is stored in the street dumper bins.	
Transportation	Organize Transportation of waste in covered vehicles on a day to day basis avoiding multiple and manual handling of waste.	Corporation is putting efforts to dispose the waste by using 75 Dumper placers, 132 TATA Acres, 64 Small Tippers Transport the Garbage from storage point to transfer station and windrows compost. 10 Big Tippers Transport waste from transfer station to Kapuluppada. But Open tipping trucks are used which are highly unhygienic. Arrangement for lifting of waste from congested by lanes of markets and remote areas of the city absent.	
Community participation		Community participation is absent except very small initiative at one or two places	

Component	MSW Rules 2000	Compliance	Photos
Public Awareness		No significant educational programs, campaigns, NGO activities for public awareness on solid waste management, significance of recycling, reuse and segregation of MSW.	
Disposal	Minimise the waste going to the land fill and dispose of only rejects from the treatment plants and inert material at the engineered landfills.	Scientific waste processing practices as per MSW 2000 rules absent. No scientific disposal. Unmanaged landfill site	

5 WASTE QUANTIFICATION AND CHARACTERIZATION

5.1 Introduction

Quantification of municipal waste generated was carried out by Feedback Infra Pvt. Ltd from 10th April to 30th May, 2015 separately for different sources of generation such as residential, commercial, institutional, street sweeping and drain cleaning, markets, slaughter houses, function halls, cinema halls, etc. Waste composition, characteristics and quantities of solid waste is essential for:

- It provides the basic data on which the management system is planned, designed and operated.
- The changes/trend in composition and quantity of waste over a period of time are known which help in future planning.
- It provides the information for the selection of equipment and appropriate technology.
- It indicates the amount and type of material suitable for processing, recovery and recycling.
- The forecast trends assist designers and manufacturers in the production of vehicles and equipment suitable for the future needs.
- The waste generation rates have been worked out on the basis of field surveys, waste sampling and discussion with the different waste generators and the officials of the Visakhapatnam Municipal Corporation. The results of the study are set out in this section.

a) Sources of waste generation

A waste characterization study for Greater Visakhapatnam was carried on 22nd May to 30th May 2015, to analyze the physical and chemical characteristics of waste samples. The sources of waste generation from GVMC are as follows.

- Residential /Individual houses
- Slums
- Market yards
- Road /Street sweepings
- Hotels & Restaurants
- Shops/Office/Institutions
- Hospitals/Nursing Homes/Pathological Laboratories
- Marriage/Function halls
- Construction waste

b) Methodology for waste quantification and characterization

Information on the nature of wastes, its composition, physical and chemical characteristics and the quantities generated are basic requirements for devising solid waste management plans. For the purpose of solid waste management, it is important to look into the properties of the waste material apart from their origin. Accordingly, they may be classified as:

- Biodegradable: Organic materials, which can be degraded by biological agents, e.g., microbes are known as biodegradable. Examples are food material, fruit and vegetable waste, garden waste (plant waste) etc.
- Recyclables: Plastic, Paper, metal etc
- Combustibles: Relatively dry material having a high calorific value, such as paper, plastic, rags, cardboard, etc. are known as combustibles.
- Hazardous; Certain items which are hazardous for human or animal health and detrimental for the environmental either due to their chemical or pathogenic nature, are classified as hazardous waste e.g., hospital waste, certain industrial etc.
- Inert; Dust, cinder, grit and other debris are known as inerts.

During the collection of municipal solid waste samples the major collection sites are identified which are covering a larger size of population. Based on the type of area such as residential, commercial, industrial, market, slum etc. sampling points are distributed uniformly all over the study area. The sampling points are further classified based on economic status of population such as high, middle and low income group.

About 50 kg of Municipal Solid Waste (MSW) is collected from ten points outside and inside of the solid waste heap of city. The total quantity of waste so collected is thoroughly mixed and then reduced by method of quartering till a sample of such a size is obtained which can be handled personally. The sample so obtained is subjected to physical analysis.

The methodology adopted for collecting MSW samples at city is as per CPHEEO manual based on the type of area such as residential, commercial, industrial, market and slum etc.

The Physical Characteristics like moisture content, density, percentage of different components such as, paper, plastic, glass, metal, organic matter, sand, soil, bricks, stones etc were analysed.

The Chemical Characteristics like pH, percentage of Nitrogen, Potassium and phosphorus, total carbon and C/N ratio were analyzed and represented in the report. Calorific value of the municipal solid waste (in Kcal), Toxic characteristics

were also analyzed and given in the report.

The information on the quantity of wastes generated and its composition are the basic needs for the planning of a solid waste management system. Quantity and characteristics of solid waste generated varies with income, socio-economic conditions, social developments and cultural practices.

In high income countries the waste generated is more compared to that of low income countries whereas the density of waste is low from high income countries and high in low income countries indicating that more volumes of wastes are generated in high income as compared to low income.

Review of National Statistics – Waste Characteristics

The characteristics of solid wastes also have been very inconsistent with time. There have been tremendous changes with time, and these changes are expected to continue.

Population Range (in Million)	Number Of Cities Surveyed	Paper	Rubber, Leather, And Synthetics	Glass	Metals	Total Compostable Matter	Inert
0.1 to 0.5	12	2.91	0.78	0.56	0.33	44.57	43.59
0.5 to1.0	15	2.95	0.73	0.35	0.32	40.04	48.38
1.0 to2.0	9	4.71	0.71	0.46	0.49	38.95	44.73
2.0 to5.0	3	3.18	0.48	0.48	0.59	56.67	49.07
> 5	4	6.43	0.28	0.94	0.80	30.84	53.90

Table 5.1: Total Physical Characteristics of Municipal Solid Wastes in Indian Cities[v]

During the sampling, we have analyzed the characterization study of waste. The physical composition of waste is analyzed at site and the chemical composition and Toxic Characteristics were analyzed at laboratory.

5.2 Quantification of Waste

The information on the quantity of wastes generated and its composition are the basic needs for the planning of a solid waste management system. Quantity and characteristics of solid waste generated varies with income, socio-economic con-

ditions, social developments and cultural practices. The characteristics and quantity of waste generated based on the income pattern is presented in the **Table5.2**. It is noticed that in high-income countries the waste generated is more compared to that of low-income countries whereas the density of waste is low from high-income countries and high in low-income countries indicating that more volumes are generated in high-income countries as compared to low income.

	Low income countries	**Middle income countries**	**High income countries**
Waste generation –per capita	0.4-0.6 kg/capita/day	0.5-0.9 kg/capita/day	0.7-1.8 kg/capita/day
Composition (% by weight)			
Metal	0.2 – 2.5	1-5	3 - 13
Glass, ceramics	0.5 -3.5	1-10	4 -10
Food and organic waste	40-65	20-60	20-50
Garden waste	40-65	20-60	20-50
Paper	1-10	15-40	15-40
Textiles	1-5	2-6	2-10
Plastics/rubber	1-5	2-6	2-10
Misc. combustibles	1-8	-	-
Misc. incombustible	-	-	-
Inert	20-50	1-30	1-20
Density –kg/m^3	250-500	170-330	100-170
Moisture - % by wt.	40-80	40-60	20-30

Table5.2: Patterns of composition characteristics and quantities of Municipal Solid waste[vi]

Review of National Statistics – Waste Quantification

Historically it is observed that the quantity of waste generated has been increasing with improvement in life style. However, India still remains to be on a very low per capita generation of municipal solid waste. From the solid waste quanti-

ties generated in various Indian cities, it is seen that urban areas generate more waste than less urbanized.

MSW Survey

Waste quantification has been carried out for Visakhapatnam from the following sources:

- Residential /Individual houses
- Slums
- Market yards
- Road /Street sweepings
- Hotels & Restaurants
- Shops/Office/Institutions
- Hospitals/Nursing Homes/Pathological Laboratories
- Marriage/Function halls
- Construction waste

Residential and commercial area

The residential and commercial areas are major sources of generation of solid waste. Based on the average per capita generation of municipal solid waste, it can be estimated that the waste generation from the households is about 552 MT. The commercial areas like CMR central, RTC Bus stand, Purna Market, Nehru Bazaar, Beach Road, Madhurawada Junction generates high quantity of solid waste.

Slums

There are more than 600 slums in the Visakhapatnam city. Haphazard Distribution of slums within the City is observed with outer fringe areas of the City having major concentrations of slum population. In zone I, ward number 1, 2, 3 has relatively overcrowded dwellings; therefore, slum distribution is marginal in this area.

The quality of life in each of the slums is appalling with low level of municipal facilities. Unlike the town wards, in the slum areas door step waste collection is not possible, therefore, large size wheeled community dustbin is placed on the outer boundary of each slum. These dustbins can be directly taken to the waste processing and disposal site. The total waste generation contributes in Households waste.

Market Waste

Next to household waste, one of the major contributors of municipal solid waste quantity is the market waste. The four main vegetable & Fish / Meat markets are Purna Market and other small and medium markets. The total waste generated from these markets was observed to be 55-60 TPD. In addition to these there are daily, by-weekly and weekly markets found in residential areas of the city. These markets produce wastes, which are ideal for production of compost.

Street sweepings and Drain cleaning

Daily sweeping of public roads, streets, lanes, and by-lanes is a routine activity where there is habitation of commercial activity on one or both sides of the streets isolated pockets or roads. Street sweeping waste is mainly inert waste comprising of dust, sand and stones. This waste also contains litter, and animal waste. Currently, most of the waste generated in the City is collected as street sweeping, since wastes from majority of residential and commercial establishments are discarded on and along the roads.

It is therefore not possible to accurately assess the waste generation rate from street sweeping. However based on the discussion with the sweepers and sanitary staff it was estimated that this waste is in the range of 60-65 kg/km/day for 4 lane roads, 40 kg/km/day for double roads and 30 kg/km/day for single roads. For the total 2825 km of road length in Visakhapatnam it is estimated that 65 MT of street sweeping wastes are generated per day. The total waste generated through drain cleaning was observed to be 50-54 tons/day. Since the waste generation is a continuous process, waste collection, transportation and disposal is required to be done daily. There can therefore be no holiday in street sweeping primary collection, transportation, processing and disposal of waste.

Drain cleanings are the major components of waste in urban areas. A major portion of sanitary worker's time goes for the cleaning of streets and drains. Most of the waste generation from drains will be plastics, silt, coconut shells, and rubber. Drains can be cleaned and the waste will be thrown on the road side.

Uses of appropriate tools play an important role in improving the efficiency of the work force. The Equipment used for Manual Street sweepings in Visakhapatnam are Short brooms, Containers and Long handled brooms to the workforce.

Class	Type of street	Frequency of sweeping
A.	Shopping	Daily
B.	Market Areas	Daily
C.	Town centre and minor streets	Daily
D.	Sub-urban shopping streets	Daily
E.	Residential streets (lanes / by lanes)	Daily
F.	Roads and streets having no households / establishments on either side.	Daily
G.	Sub-urban main streets	Daily

Table 5.3: Street Sweepings

Hotels & restaurants

There are around 600 to 650 hotels, star hotels, Bar and restaurants in Visakapatnam City. The waste generation from these hotels and restaurants is observed to be 18-21 tons/day. All of them are storing their waste on site in plastic containers. Dry and wet waste may be stored separately. In case of restaurants, waste may be stored in smaller containers or plastic bags.

Marriage/ Function halls in Visakapatnam

These are places where large quantity of waste is generated but only occasionally during functions/marriages and other social gatherings. Waste generated from the function halls comprise of mainly organic waste such as food waste, flowers and leaves. Number of function halls in the city is about 160 and the waste quantification for this category was done based on the survey, seating capacity and average occupancy days in a year. The maximum quantity of waste generation from these halls was observed to be 0.08 – 0.09 Kg/ per capita/day. Hence the total quantity of waste generated from the function halls will be around 14 TPD. The peak waste generation is during certain auspicious months when there are maximum social gatherings taking place.

Commercial Establishments (Shops/office/institutions etc.)

The waste from the commercial establishments like shops and offices, wholesale and retail stores, Paint shops, Jewellery shops and general stores have been considered in this category. The number of commercial establishments is about

80,000. In order to assess the waste generated by these establishments, field visits and field assessment surveys were carried out in the major commercial areas of Visakhapatnam.

Discussions were also held, with the shop owners on the amount of waste generated by each of them and disposal practices. Hence, based on the survey the waste generation factor will be around 0.63 kg per unit. This quantity is observed to be very high. High quantity of packaging material leads to higher waste generation. About 40 to 42 MT of waste is generated from the commercial establishments.

Hospitals/Health centers

About 664 Clinics, 50 hospitals and 66 nursing homes are present in different areas of Visakapatnam city. Two types of waste are generated from these establishments, one is municipal refuse and other is bio-medical waste. These two types of waste may be stored separately. About 2-3 MT of waste is generated by the Hospitals. Municipal waste may stored in black ploythene bag or in black colored buckets. Biomedical waste may be stored separately. The municipal vehicles will collect the waste and dump at Kapuluppada Dump site.

Construction waste

Construction and demolition waste is generated whenever any construction/demolition activity takes place, such as, building roads, remodeling etc. It consists mostly of inert and non-biodegradable material such as concrete, plaster, metal, wood, plastics etc. A part of this waste comes to the municipal stream. This waste is being dumped alo ng with the solid waste haphazardly. A quantity of about 1-2 tons of construction and demolition waste reaches the dump site every day.

Waste generated from parks and gardens mainly comprise of organic waste such as leaves, grass and bush cuttings. This type of waste also contains leftover garbage by the visiting public in the parks and gardens.

The waste quantification for this category was done based on the discussions with the Forest officers, gardeners and sweepers involved in waste collection and were estimated as 500 kg/unit for large parks like VUDA, Tenneti, Kailasagiri, Thotlakonda park etc., and for small parks waste generation factor was estimated to 120 kg/unit per day.

The total parks under recreational and open space are around 40. At this rate the total solid waste generated from parks in the Visakhapatnam city works out to 5-6 TPD.

Waste generation from the Institutions

Visakhapatnam is one of the important educational centers in Andhra Pradesh. One of the famous Universities in India is Andhra University in Visakhapatnam. The City has approximately 180 Primary schools, 45 secondary schools and 15 colleges. Garbage generation from this category was done based on the size of the school or institution. The activities of these institutions generally do not contribute much to the solid waste of the city. Waste generation factor is also assumed based on the capacity of the school. A quantity of about 4-5 tons of construction and demolition waste reaches the dump site every day.

Temples

Most of the waste from temples will be food waste, plastic, paper, leaves, flowers. Waste

Quantification for this category can be done based on the bins provided in the temples. Approximately 5-7 dust bins will be cleared from the temples daily. Average waste generation per unit can be estimated as 12 kg/unit for medium and small temples and 108 kg/unit for big temples. At this rate quantity of waste generation from the temples are estimated to 5.0 MT.

Waste from Chicken, Beef, Mutton and Fish Stalls

Waste quantification of this category was done based on the field visit and field

assessment survey team, discussions with the vendors and the officials of the Municipal Corporation of Visakhapatnam. Waste generation factor can be estimated as 0.4 - 20 kg/unit. The total waste generation from the Chicken, Beef, Mutton and Fish Stalls are about 3-4 tons per day.

Slaughter House

There are two slaughter houses located in Hanumanthavagu, for sheep & goats and another is in Chengalrao peta for Beef only. It is estimated that 1,00,375 numbers of medium animals slaughtered per annum in the Hanumantha vagu Slaughter house and 3650 numbers of big animals slaughtered per annum in the Chengalraopeta slaughter house. Waste quantification was done based on the CPHEEO manual, waste generation from the slaughter houses is 2.4 ton per day. The total waste generated from the slaughter house is about 2.5 -3 tons per day.

Cinema Halls

Most of the waste generation from this category was paper, food, plastic, bottles. Waste

Quantification of this category was done by the general assessment and seating capacity. Waste generation factor is 6 kg/unit. There are 35 cinema theatres in the Visakhapatnam city and waste quantification was works out to be around 0.8 to 1.0 Tons per day.

Summary of Waste Generation

The average daily waste generation estimated in Visakhapatnam is around 920 tons. The average per capita waste generation of solid waste in Visakhapatnam was observed to be 0.45-0.47 kg/per capita/day. It is noticed that the waste generation from High-income groups was found to be 0.40 – 0.45 kg/day and from the low-income groups between 0.35-0.40 kg/day. The commercial and the street sweepings also contribute for increase of the per capita waste generation for the city of Visakhapatnam.

Table 5.4 gives the breakdown of waste generation from various sources and **Figure 5-1** shows percentage of sources of waste generated.

S. No	Type of Waste	Waste generated (Tons/day)	% of Waste Generation
1	Domestic Household waste	552	60
2	Commercial Establishments waste	82.8	9
3	Hotels & Restaurants	18.4	2
4	Institutional waste	18.4	2

5	Parks and Gardens	9.2	1
6	Street sweeping waste	92	10
7	Waste from Drains	54.00	5.87
8	Hospitals	3.04	0.33
9	Markets	58.42	6.35
10	Temples	4.97	0.54
11	Construction and demolition waste	2.02	0.22
12	Chicken, Mutton, Beef, Fish stalls	3.96	0.43
13	Slaughter houses	3.04	0.33
14	Cinema halls	1.20	0.13
15	Function halls	16.56	1.8
	Total	**920.00**	**100**

Table 5.4: Total Waste Generation

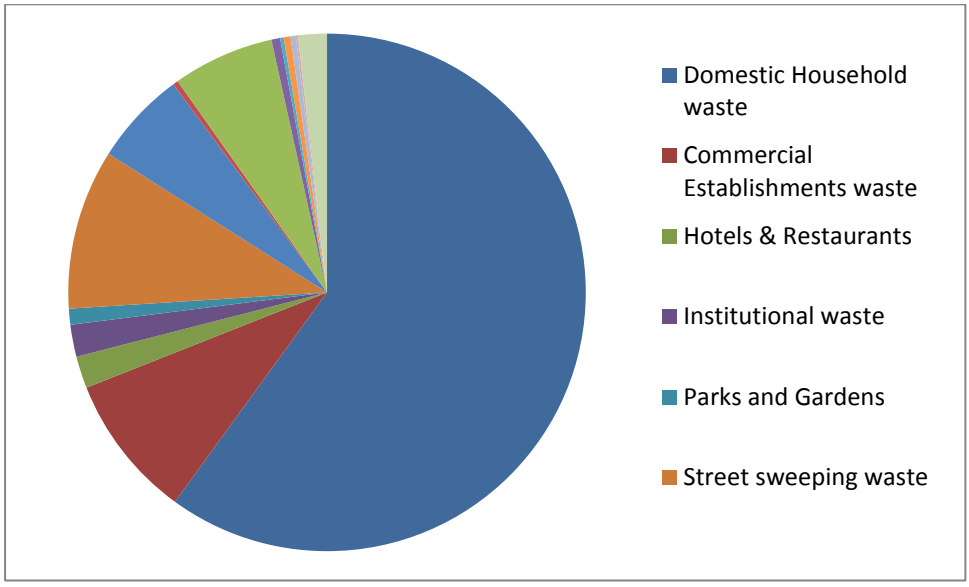


Figure 5-1: Percentage of sources of waste Generations

Primary Survey

Procedure:

The methodology used for calculating the per capita waste quantification for Residential, Commercial and street sweeping at Visakhapatnam city is given below.

Residential:

The per capita survey at residential area has been calculated at 6 random selected wards. The 10 houses in each ward have been identified based on 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 Visakhapatnam is given in **Table 5.5.**

	Ward No	Persons	Residential (Kgs)	Commercial (Kgs)	Street sweeping (Kgs)	Total waste (Kgs)	Waste generation rate (kg/C/day
Day 1	6	39000	10530	5265	1755	17550	0.45
	12	30000	9720	4860	1620	16200	0.54
	24	17969	4636	2318	773	7727	0.43
	31	21391	6931	3465	1155	11551	0.54
	40	25641	6154	3077	1026	10256	0.4
	45	9378	2757	1379	460	4595	0.49
Day 2	6	39000	10296	5148	1716	17160	0.44
	12	30000	7200	3600	1200	12000	0.4
	24	17969	4528	2264	755	7547	0.42
	31	21391	4492	2246	749	7487	0.35
	40	25641	8308	4154	1385	13846	0.54
	45	9378	2870	1435	478	4783	0.51
Day 3	6	39000	10998	5499	1833	18330	0.47
	12	30000	8100	4050	1350	13500	0.45
	24	17969	4959	2480	827	8266	0.46
	31	21391	5647	2824	941	9412	0.44

	Ward No	Persons	Residen-tial (Kgs)	Commer-cial (Kgs)	Street sweep-ing (Kgs)	Total waste (Kgs)	Waste gener-ation rate (kg/C/ day
	40	25641	10154	5077	1692	16923	0.66
	45	9378	2870	1435	478	4783	0.51
	Total		**121149**	**60575**	**20192**	**201916**	**0.47**

Table 5.5: Per Capita Survey Results

Commercial:

Randomly 6 wards were selected for per capita survey at commercial centers. The per capita survey at commercial places has considered at 6 random selected wards. The bins identified are depending on the type of centers like thick commercial complexes, thin commercial areas and streets containing market yards. The capacity of each bin or heap of MSW at all the 10 points and the number of fillings of each bin in a day has been calculated and the averaged value has been projected for the further calculations.

Street Sweeping:

The street sweeping data was collected on each day by weighing the heaps on a road length having 1 km stretch. The same procedure was adopted at various centers like commercial/residential etc. The data projected in the DPR is based on the road length survey.

Primary Survey results

The methodology adopted for collecting MSW samples at Visakhapatnam is as per CPHEEO manual based on the type of area such as residential, commercial, industrial, market and slum etc.

To assess the waste generation levels primary survey was also carried out in selected wards of Visakhapatnam City. Around six typical wards were selected and data related to number of persons in each ward, the waste generation in terms of residential, commercial and street sweeping waste details were collected on day to day basis. Waste Characterization was also carried during the survey.


The primary survey carried by Feedback is shown in Photographs. The wards of Visakhapatnam identified for survey purpose are 31, 18, 40, 54, 62 and 71. The survey was conducted on three consequent days and waste contributing levels of each of the ward was assessed in kgs.

The per capita waste generation is estimated based on the total municipal waste generation to the corresponding population for each ward and extrapolated to arrive at the suggested waste generation from the whole of the Visakhapatnam city.


From the above table it's seen that the average per capita generation for Visakhapatnam city is about 0.47 kg/capita/day. The survey continued for other identified wards of Visakhapatnam the respective wards identified are 3, 16, 33, 52, 68 and 71. The survey conducted for three consequent days and waste contributing levels from each ward was assessed in kgs.

	Ward No	Persons	Residen-tial (Kgs)	Commer-cial (Kgs)	Street sweep-ing (Kgs)	Total waste (Kgs)	Waste gener-ation rate (kg/C/ day
Day 1	3	35000	10290	5145	1715	17150	0.49
	16	21500	5547	2774	925	9245	0.43
	33	21700	8072	4036	1345	13454	0.62
	52	23400	7722	3861	1287	12870	0.55
	68	38250	10328	5164	1721	17213	0.45
	71	26075	6884	3442	1147	11473	0.44
Day 2	3	35000	9240	4620	1540	15400	0.44
	16	21500	5934	2967	989	9890	0.46
	33	21700	7031	3515	1172	11718	0.54
	52	23400	6037	3019	1006	10062	0.43
	68	38250	14459	7229	2410	24098	0.63
	71	26075	7979	3989	1330	13298	0.51
Day 3	3	35000	9240	4620	1540	15400	0.44
	16	21500	5676	2838	946	9460	0.44
	33	21700	5208	2604	868	8680	0.4
	52	23400	4914	2457	819	8190	0.35
	68	38250	8033	4016	1339	13388	0.35
	71	26075	6571	3285	1095	10952	0.42
	Total		**139164**	**69582**	**23194**	**231939**	**0.47**

Table 5.6: Per Capita Survey Results

Apart from the above, waste generation was also assessed based on the capacity of each vehicle and the number of trips made in a day to the dumpsite. The necessary details were collected and the waste quantity reaching the dumpsite is found to be about 600 -700 tons per day which translates to about 0.45 kg/capita/day to 0.47 kg/capita/day However it should be noted that the quantity of waste reaching the dumpsite is about 75-80% of the generation quantities

only. So the total waste generation estimated is 920 TPD. Based on the geometric population projections, the future trends of waste generation is also estimated and presented in the report. As per the calculations 957 TPD in 2016, 985 TPD in 2017 and 1035 in the year 2018 are generated respectively.

Waste Quantification

Waste Quantities depend on the population. The total waste generation from the municipality is estimated based on the population of the town and the per capita waste generation. The future waste generation from each of the towns is also been predicted. The Future Generation trends of waste have been carried out by population forecasting methods.

For the present report, the geometric progression method has been considered for arriving at population projections for the year 2012 as well for the year ending i.e 2042 year. The projected tables were presented below.

S. No.	Year	Arithmetic Progression Method	Geometric Progression Method	Incremental Increase Method	Decadal Growth Method
1	2012	1761434	1778373	1758038	1771291
2	2013	1794740	1830078	1787330	1815531
3	2014	1828046	1883287	1816005	1860877
4	2015	1861352	1938043	1844062	1907355
5	2016	1894658	1994391	1871501	1954994
6	2017	1927964	2052377	1898323	2003823
7	2018	1961270	2112050	1924528	2053872
8	2019	1994576	2173457	1950115	2105170
9	2020	2027882	2236649	1975085	2157750
10	2021	2061188	2301679	1999437	2211643
11	2022	2094494	2368600	2023171	2266883
12	2023	2127800	2437466	2046288	2323501
13	2024	2161106	2508334	2068788	2381534
14	2025	2194412	2581263	2090670	2441017
15	2026	2227718	2656313	2111934	2501985
16	2027	2261024	2733544	2132581	2564476

S. No.	Year	Arithmetic Progression Method	Geometric Progression Method	Incremental Increase Method	Decadal Growth Method
17	2028	2294330	2813021	2152611	2628527
18	2029	2327636	2894809	2172023	2694179
19	2030	2360942	2978974	2190817	2761470
20	2031	2394248	3065587	2208994	2830442
21	2032	2427554	3154718	2226554	2901137
22	2033	2460860	3246440	2243495	2973597
23	2034	2494166	3340829	2259820	3047867
24	2035	2527472	3437963	2275527	3123992
25	2036	2560778	3537920	2290616	3202019
26	2037	2594084	3640784	2305088	3281994
27	2038	2627390	3746639	2318942	3363967
28	2039	2660696	3855571	2332179	3447987
29	2040	2694002	3967671	2344798	3534106
30	2041	2727308	4083029	2356800	3622375
31	2042	2760614	4201742	2368184	3712850

Table 5.7: Population projection

5.3 Collection Efficiency of GVMC

The necessary details were collected and the waste quantity reaching the dumpsite is found to be about 600 -700 tons per day which translates to about 0.45 kg/capita/day to 0.47 kg/capita/day. However it should be noted that the quantity of waste reaching the dumpsite is about 75-80% of the generation quantities only.

5.4 Future Generation trends

Based on Geometric progression projections and the per capita survey results the waste quantification calculations were carried for the year 2030. The below table gives the quantification details.

Sl. No.	Year	Population by Geo-metric method	Waste Gen-eration Rate (Kg/c/day).	Total Waste for One day (in M.T.)	Waste gen-erated from HH per day. @ 30% (in M.T.)	Commercial Waste @ 60% (in M.T.)	Street Sweeping @ 10% (in M.T.)	Waste Gen-eration per Annum (in M.T.)
1	2012	1778373	0.45	800	480	240	80	292,098
2	2013	1830078	0.46	842	505	253	84	307,270
3	2014	1883287	0.47	885	531	266	89	323,078
4	2015	1938043	0.48	920	552	276	92	336,008
5	2016	1994391	0.48	957	574	287	96	349,417
6	2017	2052377	0.48	985	591	296	99	359,577
7	2018	2112050	0.49	1,035	621	310	103	377,740
8	2019	2173457	0.49	1,065	639	319	106	388,723
9	2020	2236649	0.49	1,096	658	329	110	400,025
10	2021	2301679	0.5	1,151	691	345	115	420,056
11	2022	2368600	0.5	1,184	711	355	118	432,269

12	2023	2437466	0.5	1,219	731	366	122	444,838
13	2024	2508334	0.5	1,254	753	376	125	457,771
14	2025	2581263	0.52	1,381	829	414	138	504,168
15	2026	2656313	0.52	1,381	829	414	138	504,168
16	2027	2733544	0.52	1,421	853	426	142	518,827
17	2028	2813021	0.52	1,463	878	439	146	533,911
18	2029	2894809	0.53	1,534	921	460	153	560,001
19	2030	2978974	0.53	1,579	947	474	158	576,283
20	2031	3065586.9	0.54	1,655	497	993	166	604227
21	2032	3154717.8	0.54	1,704	511	1022	170	621795
22	2033	3246440.1	0.55	1,786	536	1071	179	651723
23	2034	3340829.3	0.55	1,837	551	1102	184	670671
24	2035	3437962.8	0.56	1,925	578	1155	193	702720
25	2036	3537920.4	0.56	1,981	594	1189	198	723151

26	2037	3640784.2	0.57	2,075	623	1245	208	757465
27	2038	3746638.8	0.57	2,136	641	1281	214	779488
28	2039	3855571.1	0.57	2,198	659	1319	220	802152
29	2040	3967670.5	0.58	2,301	690	1381	230	839956
30	2041	4083029.2	0.58	2,368	710	1421	237	864377
31	2042	4201741.9	0.6	2,521	756	1513	252	920181

Table 5.8: Quantification Details

5.5 Waste characterization

Physical Composition of Waste:

About 50 kg of Municipal Solid Waste (MSW) is collected from ten points outside and inside the solid waste heap of the city. The total quantity of waste so collected is thoroughly mixed and then reduced by method of quartering till a sample of such a size is obtained which can be handled personally. The sample so obtained is subjected to physical analysis. The methodology adopted for collecting MSW samples is as per CPHEEO manual.

The physical composition of municipal solid waste is normally presented as Organic, Recyclables and Inert matter.



Waste samples were collected and analyzed for these three parameters and data is presented in the below table.

Item	Item wise Generation %
ORGANIC WASTE Comprising of Leaves , Fruits, Vegetables, Food Waste, Fine organic Matter, Hay and Straw etc	52.0
RECYCLABLES Comprising of Rubber and leather, Plastics, Rags, Paper, Wooden Matter Coconuts, Bones, Straw, fibers	23.0
INERT MATTER Comprising of ash, Crockery, Earthen ware (pots), Stones and Bricks, Metals, Glass, sand, silt from drains etc.	25.0
TOTAL	**100**

Table 5.9: Physical Composition of Waste (On site physical characterization study by Feedback Infra)

Chemical Characterization of waste

Chemical characteristics considered for municipal waste are mainly, moisture, nitrogen, phosphorous, potassium, C/N ratio etc. The characteristics of waste for Indian waste are presented below: MSW sample was collected from the dump yard of Visakhapatnam city and analyzed for various chemical characteristics. The results are shown in the below table.

It is noticed that the C/N Ratio of the collected sample found to be 25.5 which is normal with compared to CPHEEO norms. Calorific Value of the collected sample is about 1220 cal/gm which is on the higher side. Similarly the Moisture content of the sample was also on the lower side i.e 38.9 %. .

The total waste generation calculated for the ultimate year 2030 is 1579 TPD. Out of which 821 TPD is organic waste, 363 TPD recyclables and 395 TPD are Inerts/Rejects. The organic waste is proposed to be processed by setting up compost /Bio-mechanization plant.

The recycle recoverable material generated at Visakhapatnam for the year 2015 amounts to 211 TPD. These materials include rubber, leather, plastics, rags, paper, wooden matter, coconut shells, straw and fibres etc.

Chemical Characterization of waste			
S. No.	**Item**	**Unit**	**Result**
1	pH (5% solution)	-	8.01
2	EC(5% solution)	µsiemens/cm	1108
3	Total Waste Soluble	mg/gm	3.4
4	Moisture content	%	38.9
5	Total organic Carbon	%	18.4
6	C/N Ratio (Dry)	-	25.5
7	Calorific Value	Kcal/kg	1220
8	Total Phosphorus	%	0.76
9	Total Potassium as K	mg/gm	0.92
10	Total Nitrogen as N	%	0.72
11	Arsenic as As2O3	mg/kg	BDL
12	Cadmium as Cd	mg/kg	2.3
13	Chromium as Cr	mg/kg	16.4
14	Nickel as Ni	mg/kg	8.6
15	Lead as Pb	mg/kg	17.2
16	Zinc as Zn	mg/kg	36.8
17	Copper as Cu	mg/kg	91.6

Table 5.10: Chemical Composition of Waste (SV Enviro Labs, Visakhapatnam)

6 COLLECTION AND TRANSPORTATION PLAN

6.1 Introduction

This chapter provides Solid Waste Management Plan (SWMP) for primary and secondary waste collection system and transportation system for Visakhapatnam 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 2000. 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. The detailed methodology of segregation is discussed further.
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. ULB is responsible for collection of entire 100% waste generated in the city 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 (Chapter 8).
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.

6.2 Overview of the recommended C&T Plan:

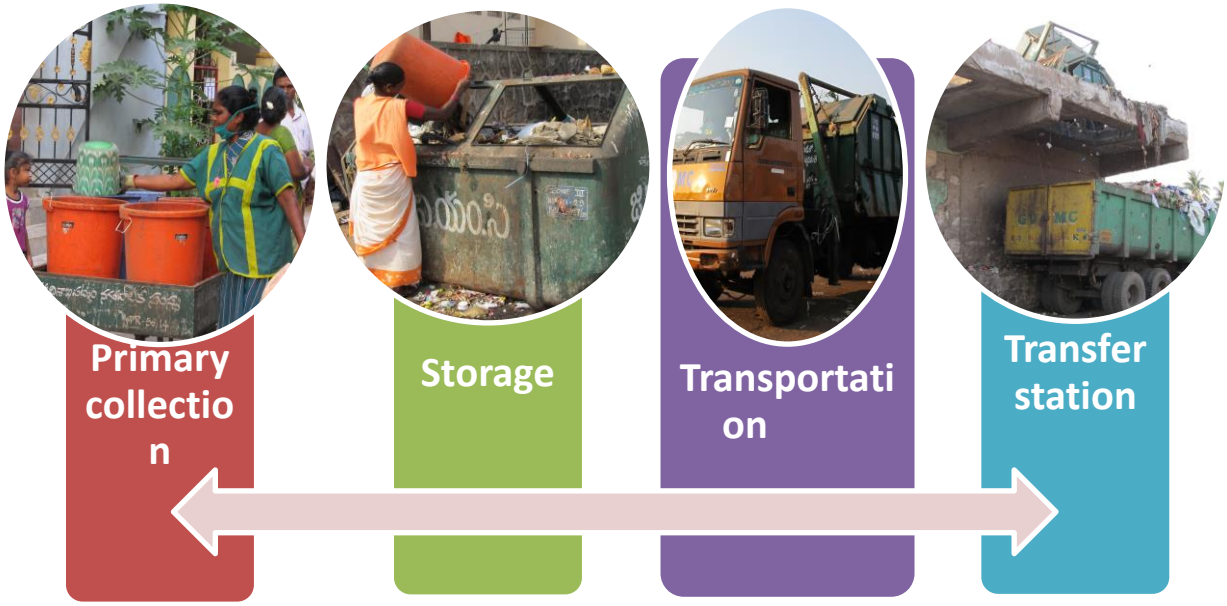
Collection and transportation, probably the most important component of the SWM operation requires active involvement of the citizen, NGOs and private entrepreneurs. Besides introduction of equipment and vehicles for minimum handling and exposure of waste, awareness creation is the key in developing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

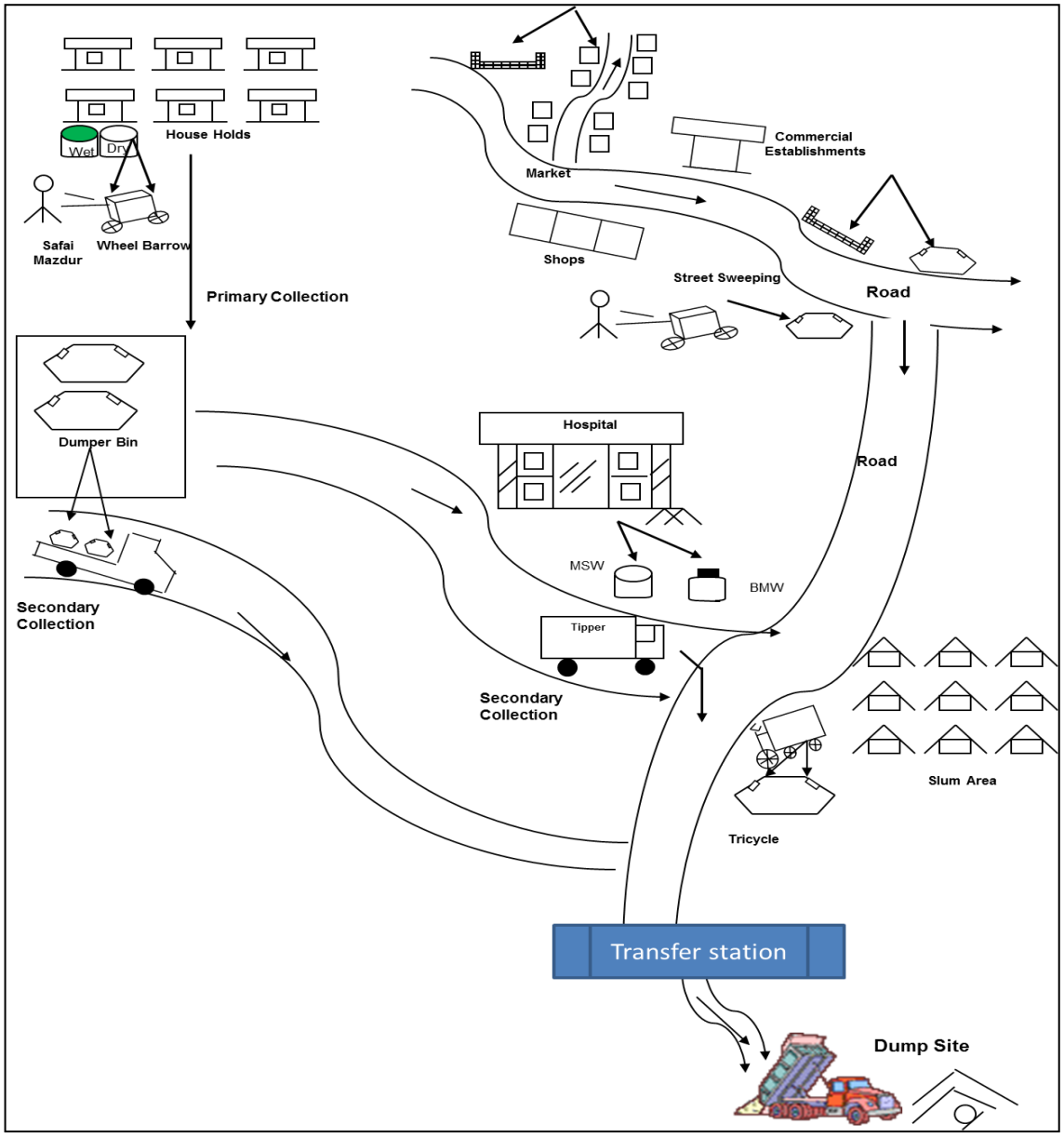
The suggestions are mainly for:

- 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.





6.3 Segregation and storage of waste at source

Source segregation of recyclables and biodegradables (organic waste) will not only provide an efficient way for resource recovery, but will also substantially reduce the pressure and pollution at Landfill sites. It is understood that implementation of such practices takes time and requires significant cooperation from the public. However, initiation should be made and efforts should be diverted to progressively increase the segregation practices. Community Participation indicates various actions that could be taken by GVMC to increase the public participation for the management of MSW. The sections below deal with issues that need to be considered for source segregation and various options available to GVMC to implement the system.

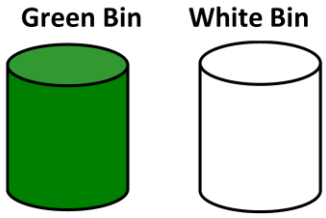
Segregation of waste at Source:

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

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

The efficiency of the proposed Waste Management Plan described below is driven by the separation of waste at the primary collection level. For this purpose, following approach needs to be adopted by the residents as well as the GVMC personnel.

- The waste will be stored by the generators in two separate bins, one for bio-degradable and one for recyclables.



- Waste collectors will collect waste on a day-to-day basis in two separate bins-green bins for bio-degradable and white bins for recyclables.

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

Storage of waste at Source

Citizens could be encouraged to have separate storage facilities for food/biodegradables and recyclables/non-bio-degradable so as to ensure that no waste goes to ground and a system of 'Single handling' is developed. Residents will be made aware to segregate waste at the source and store it in separate bins, prior collection and transported by the private operator.

A 3-bin system of storage of waste is suggested by MoEF in its guidelines of solid waste management. However, such a system of segregation in the initial stages of waste management is difficult for the community to practice. However, a single bin system could be encouraged which can be upgraded to a 2-bin system progressively. In the single bin system all the wastes are to be kept in a single bin.

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

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

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

Segregation of waste at source will be introduced along with door-to-door waste collection. Hotels, offices, shops and restaurants need to keep adequate number of bins to facilitate easy handling and transfer of waste to Municipal collection system. Plastic, HDPE or reinforced fibre-glass bins are recommended for this purpose.

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

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

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

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

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

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

Provision of suitable containers at source is the responsibility of individual generators. However GHMC initially shall provide bins to households to encourage the source segregation. The main role of GVMC will be mainly to create awareness amongst the people with the support of NGOs. As segregation and storage require a high degree of human awareness on the health and environment perils of throwing waste on ground, a continued and concentrated effort is required to create this awareness.

It is essential to keep the streets and public places clean at all times of day. This is possible only if waste producers cooperate and effectively participate in the waste management efforts of the Vizag City Municipal Corporation. If people keep on throwing wastes on the streets indiscriminately, the Visakhapatnam

City Municipal Corporation cannot keep the City clean in spite of its best efforts. People, therefore, have to form a habit of storing the waste at source in their personal bin/bins and discharge the same into the Municipal system only, at specified times.

In Ward No.18 the above practices are implemented perfectly. The same has to be implemented in all other wards of GVMC.

6.4 Primary Collection of waste:

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 GVMC 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. Domestic hazardous waste is produced occasionally and so such waste need not be collected from the doorstep. People could be advised or directed to put such waste in special bins kept in the City for disposal of such wastes as per the directions given by Municipal Corporation.

Area	Activity	System	Vehicles / Equipments	Frequency of service
Residential	DTDC	Common Collection bins	Tricycles/Auto tippers	Daily
Slums	DTDC	Common Collection bins	3.5/4.5 cum bins	Daily

Commercial Areas	DTDC	Common Collection bins / Transfer station	Tricycles / Auto tippers	Daily
All the above	Secondary collection	Transfer Stations	Regular/ Static com-pactors	Daily

Table 6.1: Door To Door Collection (DTDC) systems

Door step collection - Households

The door to door collection of waste shall be done on a day to day basis between 6.00 am to 10.00 am. The GVMC shall ensure that infrastructure is made available for undertaking this activity in compliance with MSW Rules 2000. At present door to door collection is with pushcarts/rickshaws and autos. We propose to continue the practice till life of pushcarts, gradually pushcarts may replace by Autotippers. At present segregation at source is not there 100% and collection of waste is also not in segregated manner. This will be achieved through awareness among citizens and also training of safai karamcharis. The detailed writeup on awareness (IEC) discussed in subsequent chapters.

Mode of collection	Area of collection	Primary Collection Vehicle	Secondary storage
Door to Door	Residential colonies high density in gentle terrain	Wheelbarrows with 6 nos 40 lit capacity bins -4 green color bins for Bio-degradable waste, 2 yellow color bins for recyclables	1. Bio-degradable in dumper container 2. Non biodegradable- Sell or dispose in for the same

Table 6.2: Primary collection from residential areas

Phase II:

At present GVMC is adopted the door step collection by Push carts and sufficient no.of pushcarts are available with the GVMC, Hence it is recommended to follow the similar kind of operations till the pushcarts life comes to an end i.e for the 2 years. Meanwhile auto tippers would be introduced wherever the short fall of push carts are there at present and will be replaced by 90% of the pushcarts in subsequent years i.e. 2-3 years and wherever the narrow lanes are there, shall provide pushcarts. Door to door collection operation by auto-tippers are efficient and economically feasible as it covers 1300-1500 houses in one trip with limited manpower moreover managing of huge manpower is becoming difficult day by day hence we recommend to switch on to auto tippers in the due course of 2-3 years. We recommend all the auto tippers can be used.

Door step collection – Commercial Establishments

A direct and separate collection system is recommended for Large and Medium Hotels and Restaurants, Hospitals (non-infectious component of hospital waste only), industries etc. Waste from these sources should be collected from the source and transported to the treatment/disposal site directly. The objective of the system is to eliminate this waste at the secondary storage area. This system should operate on a user fee basis. GVMC may organize the system by using the present fleet and manpower by engaging sanitation workers of their own for doorstep collection of hotel and restaurant waste. The hotels and restaurants may be directed to use two-bin system for the storage of food waste and other recyclable material. Both the wastes should be collected separately in the vehicle. Initially the source segregation may not be effective; the mixed waste shall be transported directly to the integrated facility.

Markets waste can be stored in 1100cum bins. For each major market, compactor bins are to be provided compulsory. It is estimated that 5 bins each should be provided at purna market, Banana market and Kaniti Road market at Gajuwaka. These bins can lift mini compactor and disposed off in the integrated facility and the number of trips can be done depends on the bins get filled up.

The existing tippers can be utilized for transportation of waste from bulk generators wherever required.

STREET SWEEPING

In order to improve the system, all the roads and lanes having habitation or commercial activities may be covered on a day to day basis. This may be done by employing one person per 350 m in city centre including commercial & important areas, one person per 500 m in medium density areas and 750 m in

WBM roads i. e low density areas. If most of the households, shops and establishments are covered through door to door collection, hardly any domestic waste is expected to be on the streets to be picked by the street sweepers. The total road length (including BT, WBM and Earthen) in Visakhapatnam is about 2825 kms. The roads are categorized in to those in city center and busy area, in medium density area, low density and fringe areas and the requirement of sweepers are worked out as per the MoEF norms as presented in Table.

The worker engaged in street sweeping shall be provided with long handle broom, metal trays, Gum boots, gloves, shovels and uniforms. The sweepers should work in pairs, carrying out the following:

- Sweeping two 'single beat' lengths
- Collecting the sweeping in container cart.
- Cleaning the drains which are included within the street sweeping activity.
- Carrying the drain cleanings
- Depositing the sweeping & drain cleanings in the nearby container
- Cleaning the container stations with in the beat length
- Kerbside collection from shops/establishments along the road/street

Daily sweeping is also required along the main roads, commercial centers, markets in high density areas. Street cleaning needs to be undertaken on all days including Sundays and public holidays with special focus on busy centres, markets, bus terminals, railway stations and tourist places. In order to improve the system carryout inventory of all the main roads, streets and by-lanes and identify the beats for street sweeping and drain cleaning. Based on the road length data available and the norms set out by MoEF and Government of India, it is estimated that GVMC could have around 1087 beats to be attended daily, 1711 beats on alternate days and 2119 beats once in a week.

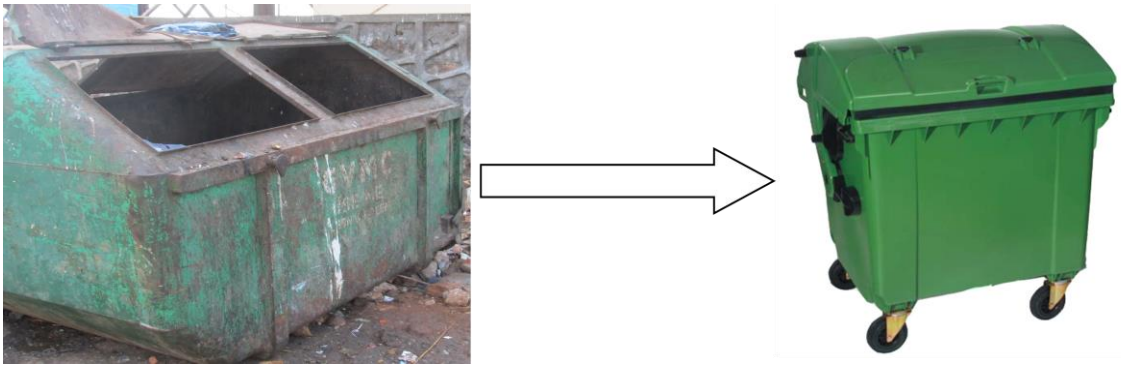
Location	Road Length, km	Beat Length, m	No. of Beats	Frequency	Crew required
City Centre, Commercil and Important Areas	380.40	350.00	1087	All Seven Days	Mechanical Road sweeping machine
Medium Density Areas & Housing Colonies	855.58	500.00	1711	Alternate day	978

Low Density Areas and Fringe Areas	1588.93	750.00	2119	Once in a week	454

Table 6.3: Distribution of road length & beat allocation for street sweeping

6.5 Secondary Storage

The main objective of the secondary collection system is to store the waste. Waste is temporarily stored in the secondary collection points prior its transportation to transfer station and disposal site. At present dumper placer container of 4.5 cu.m. Capacity is being used for secondary storage of waste and lifted daily by GVMC staff. The existing bins are not in good in shape and not in sufficient quantity, hence to improve existing storage system, it is proposed to add additional bins with capacity of 1100 lit. For storage of waste at markets and bulk generators, propose to use 1100lit bins.



It is suggested to continue the present bin locations and use waste sanitizing agents and insect repellents to prevent the menace of breading of flies and mosquitoes at the secondary storage points. For secondary storage facilities are to be developed are dumper containers of 4.5 m3 single dumper lifting vehicles are proposed.

Phase II:

Over the period of 2-3 year, waste collected in auto tippers shall be transferred to Rear End Loaders, then transport to the integrated waste management facility. GVMC shall identify 3 collection points to transfer the waste in to Rear End Loaders. For bulk waste generators like markets and shopping complexes may store waste in 1100 lit bins, which will be lifted by compactors to transport the waste.

6.6 Secondary collection and Transportation

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

- Daily transportation of waste loaded in the containers to the transfer station.

- Transportation of waste from transfer stations to integrated facility through 20 tonner tippers
- Direct transportation of Construction and Demolition waste to integrated facility

Existing dumper placer vehicles will be used to lift dumper bins and propose to introduce compactor vehicles to life 1100 lit bins as well waste from autos. Waste which is being collected in compactors can directly transport to dumpsite without using transfer station. At present there are 10 longhaul trucks available to transport waste received at transfer station, we propose to use same vehicles and replace periodically. We suggest using mini compactors of 8 cum with carrying capacity of 4MT for markets and hotels. Waste is collected in compactor will transport to transfer station and in zone 1 waste is directly transport to processing and disposal facility. Wherever auto tippers deployed for door to door collection from households will go directly to transfer station and unload waste in to long haul trucks for further transportation of waste in to processing site.

6.7 Transfer station

It is suggested to use existing transfer station located at town road for secondary transportation of waste except zone 1.

Existing transfer station capacity would be so designed that there will not be any noticeable queuing up at the Transfer Stations. The vehicles coming in and going

out are weighed by arranging weighing platforms. There is a provision to wash the vehicles and bins at these Transfer stations.

Underneath the unloading platform which is an RCC deck, office and repair shop and store are located. In addition to this, the following actions and provisions will help to reduce the odour emission and also improve esthetics

1. Spraying of microbial culture
2. Greenbelt provision
3. GI sheeting

The entire Transfer station area is paved with concrete blocks and is maintenance free. Separate arrangement is also envisaged to discharge the waste in an appropriate manner from the tricycles and auto tippers brought from the nearby areas to avoid duplication of the work.

The existing transfer station shall be used for transfer of waste from auto tippers to Rear End Loaders.

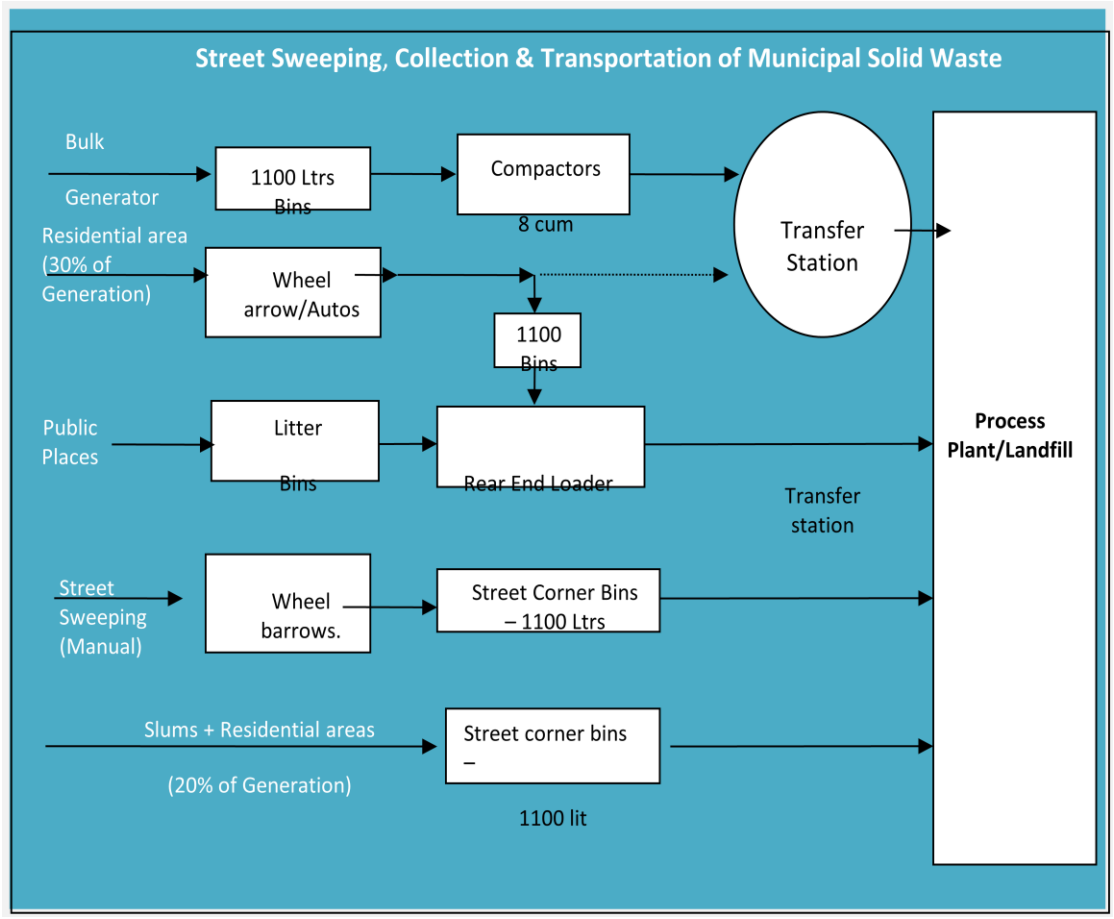
6.8 Infrastructure Requirement for the entire Visakhapatnam City

The following design basis has been considered for infrastructure calculations.

- Year of Waste Quantity for primary, secondary collection and storage vehicles calculations is 2016.
- Per capita waste generation is 0.48 Kg/capita/day & total waste is 957 MTPD.
- Assuming that only 60% from households, 30% from commercial, institutional, market yards, slaughter houses etc. and 10% from street sweeping based on past experiences.
- Considering that each pushcarts can cover 300 houses in a day.
- Capacity of each pushcarts is 0.17 tons.
- Autotipper covers 1300-1500 houses in a shift and capacity of autotipper is

1.2 tons.

- The waste generation from slums was considered as 20% the residential waste generation.



Infrastructure for Primary, Secondary Collection and Transportation Vehicles and Storage Bins:

Population 2016	1994391	Nos
House hold	**438363**	Nos
Per capita waste generation	0.48	Kg
Waste Quantification	**957**	TPD
*Residential	574	TPD
Commercial	287	TPD
Street sweeping	96	TPD
Residential		
Pushcarts @50% of households	219182	HH

Pushcarts required @ 300 for each pushcart	731	Nos
Standby@20%	146	Nos
Existing pushcarts	**1600**	**Nos**
Autos @50% of households	219182	HH
No.of autos required @1300 per each auto	169	Nos
Excess @20%	33	Nos
Existing Autos	**132**	**Nos**
Required Autos after considering existing	70	Nos

Table 6.4: Required infrastructure for collection of H/H waste & street sweeping waste required for the base year is 2016

At present there are about 100 no's of dumber bins but they are not in good shape hence 1100 litre bins are proposed to cater to 70% of the waste being generated i.e 669 TPD. Presently, it is proposed to use existing pushcarts to collect waste generated from 50% of households and the balance 50% will be covered by autos. This collected waste needs to be stored at secondary storage points. Hence it's proposed to introduce 1100 litre bins here.

Waste considered @ 70% the total waste	669 TPD
Capacity of each 1100 lit Bin	0.5 Tons
No.of Bins required (1100 litre)	669/0.5
Total no.of bins	1340 Nos
Standby @ 20%	1609 Nos

Table 6.5: Requisite Bin Details

Primary collection:

Pushcart – Collection of waste from Households			
	Routes	**Start time**	**End time**
Trip 1	HH 1	6:00 AM	
	HH 100		8:15
Trip 2	HH 101	8:40AM	
	HH 201		11:00
Trip 3	HH 202	11:30	

	HH 300		1:45 PM
Unloading and reporting	**1:45 pm – 3:00 pm**		
Autotipper – Collection of waste from Households			
	Routes	**Start time**	**End time**
Trip 1	HH 1	6:00 AM	
	HH 450		8:15
Trip 2	HH 451	8:40AM	
	HH 900		11:00
Trip 3	HH 901	11:30	
	HH 1300		1:45 PM
Unloading and reporting	**1:45 pm – 3:00 pm**		

It is proposed to introduce compactor vehicles (REL) to the system for the remaining waste which is not transporting by Taurus vehicles which is coming 417 tons. One REL can make 4 trips per day and life 12 tons in each trip. So the total no of REL required for the transportation of waste is 10 vehicles and 2 vehicles are as standby.

Vehicles	**Waste Quantity**	**Total per Capacity in tons**	**Trips**	**Bins/ Vehicles in Nos.**		**Total Requirement in Nos**
			(No's)	**(No's)**	**Stand by -10%**	
Secondary Transportation (To Transfer station)						
Rear End Loaders-18 cum	417	12	3-4	10	2	12
Secondary Transportation (To Dump site)						
Taras vehicle	720	20	3-4	9	1	10
Existing						10
Required						Nill

Table 6.6: Requisite Number of Vehicles

A REL can make a minimum of 3 trips in each shift clearing 30 bins. Where as a Taras Vehicle can make 3-4 trips per day and will clear a minimum of 15 TPD to 20 TPD waste. The details are provided here under.

Trip estimate: Secondary transportation vehicles:

Shift: 1

Distance – to Kapuluppada 30 km

Travel time to and fro – 1hr 30 min

Loading unloading – 30 min

Total trip time – 2 hrs

Shift time – 8 hrs

No.of trips per shift – 8/2 = 4 considered 3 trips including break and trafiic delay

Requirement of Waste Transport vehicles & Bins of different capacities.

The manpower requirement for driving the vehicles and lifting the garbage is based on shifts. The total work force required in the primary and secondary collections are formulated in the below table.

Vehicles	No. of Vehicles	Staff per vehicle	Shifts	Total staff
Pushcarts	731	1	1	731
Autotippers	169	2	1	338
Sweepers	1530	1	1	1530
Big compactors	10	2	1	20
Long haul trucks	10	2	1	20
Total field Staff				**2639**

Designation	No.of required staff
Project Manager	3
Supervisors	30
Mechanics	5
Electrical	5
Fitters	5
Total official /mechanical staff	**150**

Table 6.7: Requisite Number of Vehicles Required Staff for SWM

Required tools & equipments

Each worker will be provided with a broom and a dustpan for waste collection and adequate Personnel Protective Equipments (PPE).

- Number of brooms required - 2700
- Number of dustpans required - 2700
- Number of pair of gloves - 3000
- Number of pair of boots - 3000
- Number of uniform - 2639 (A uniform for a worker will include two sets of uniform for summers and two sets for winters).

The total infrastructure cost estimates required for the above have been given in the coming chapter.

Workshop Facility for Vehicle Maintenance

The Municipal Corporation must have adequate workshop facilities for the maintenance of their fleet of vehicles and containers, hand carts etc. Such facilities may be created by the Municipal Corporation departmentally or through a contractual arrangement. The workshop, public or private, should have adequate technical staff, spares and preventive maintenance schedules to ensure that at least 80% of the vehicles remain on the road each day and the down time of repair/maintenance is minimized to the extent possible. Spare assemblies should be kept available which could be given as replacements until necessary repairs are carried out. The following items were proposed at Work Shop. The organizational pattern at GVMC has shown in below figure. **Organizational pattern at Work Shop**

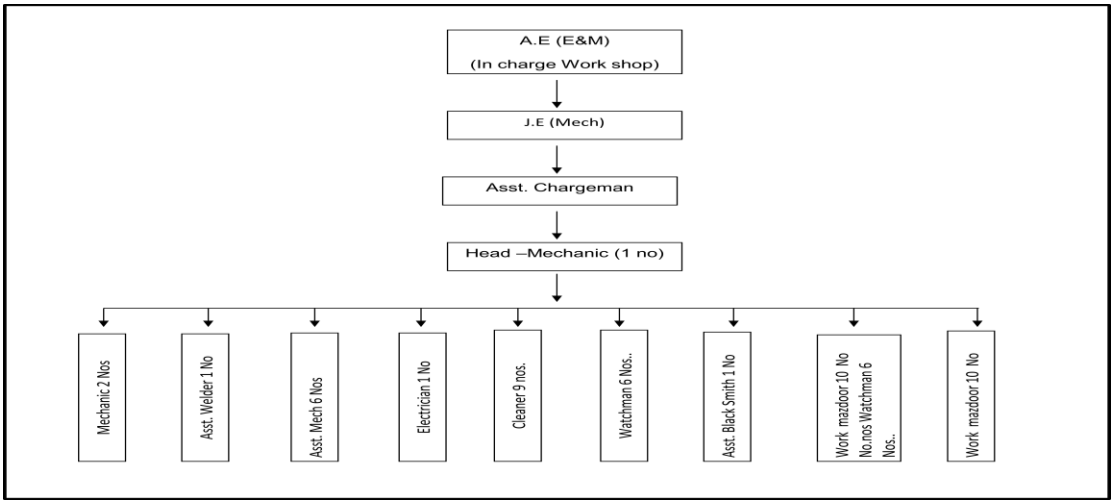


Figure 6-1: Organizational pattern at Work Shop

6.9 Design Recommendation for Collection & Transportation plan – Handling future waste:

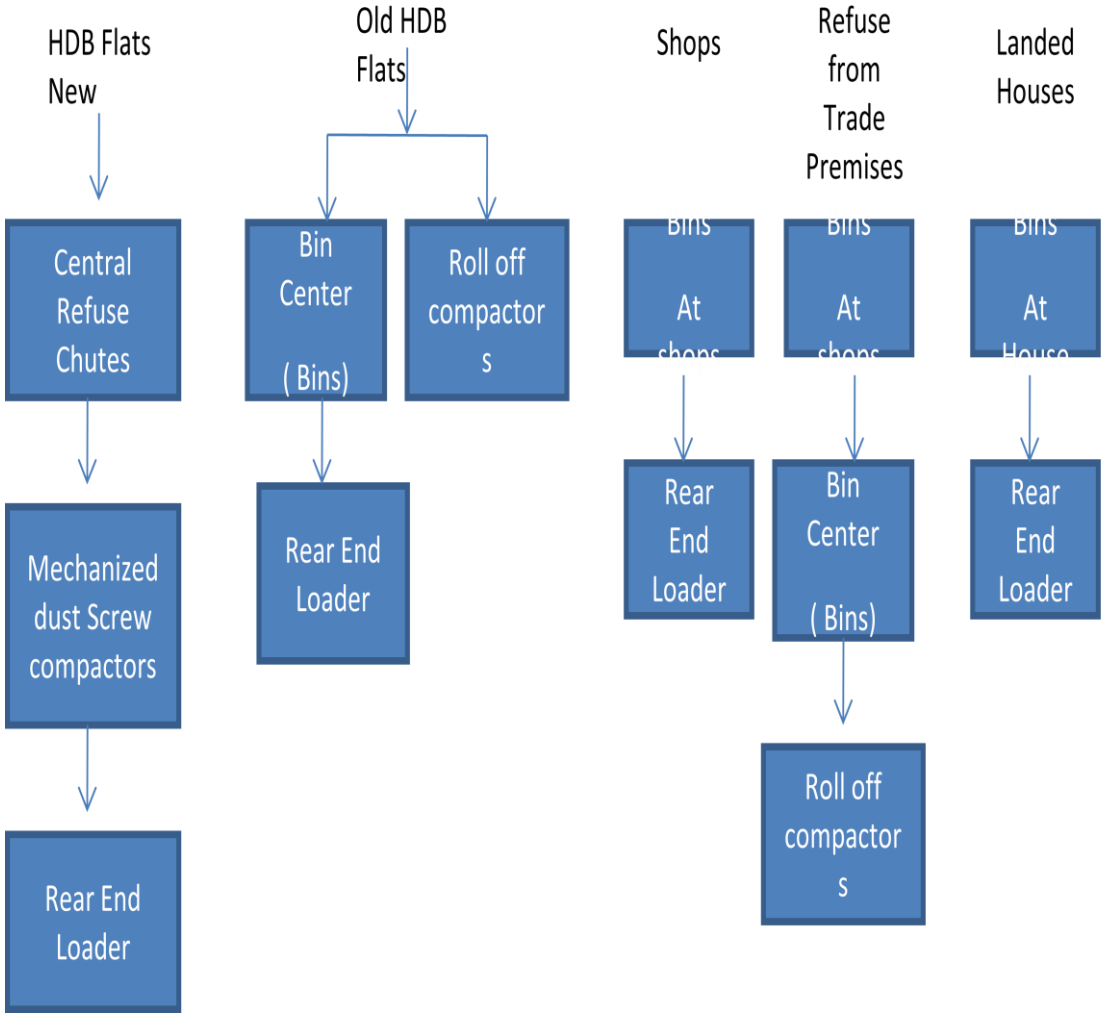
Storage at Source	Bin system of storage at source is in practice at present, but introducing waste segregation into the system with a target to achieve 100% complete source segregation in 1-2 years. Due to bifurcation of erstwhile Andhra Pradesh in to AP & Telangana, Vishakapatnam has got a huge potential of becoming a metropolitan city with the present rate of rapid urbanization. This can further lead to development of vertical growth culture / high rise apartments / gated communities etc. Keeping in view this development we propose waste chute system with dust screw compactors for storage of waste at in these communities. How it works: Waste which is collected through the chute is compacted in dust screw compactor system, which would be collected and transported by Rear End loaders**.**
Primary collection	At present door to door collection is carried out by using wheel barrows. Wheelbarrows have depreciation period of 3 years so wheel barrows may be replaced with auto tippers in high income group colonies and areas with wide roads. Auto tipper covers 1000 to 1200 houses per day. Waste collected in autos may carry the waste to transfer station directly so that the system can be bin free, partially. Waste from slums may be collected in wheel barrows & shifted to the autos at resource point's enroute to the transfer station.
Secondary storage	GVMC shall target for community bin free system in 5 years. Waste storage bins at markets and bulk generators may be continued and lifted by compactors.
Transportation	Refuse compactors may be introduced to handle increased waste generation wherever possible for safe handling of waste.
Transfer station	Existing transfer station shall be modernized and maintained.

	Identify suitable places for 2 more transfer stations in city to handle future waste generation.

Case Study:

MSW Collection and Transportation System in Singapore

Singapore is the place where collection and transportation system is very well established and source segregation is also 100% with active participation from the community. Waste generation in Singapore is mainly from housing apartments called HDB flats, Individual houses called as landed houses and trade centers (hawker centers, shops and markets. The collection and transportation system for these waste generators is very well designed and for recyclable waste separate collection and transportation system is established.



New HDB flats:

Waste from each flats is disposed to waste collection chute available in each floor for every flat and waste which is being thrown to the chute is collected in dust

screw compactor. Waste which is stored and compacted in dust screw is collected and transported by REL (Rear end loaders commonly called as Mobile refuse compactors)

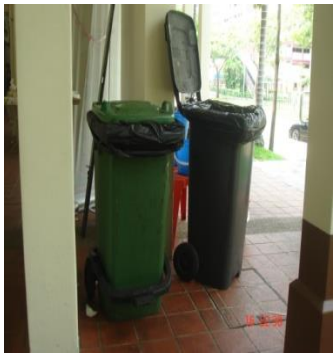


Old HDB Flats:

At old Flats, there are individual chutes with collection bins at the bottom which is collected by collection crew bring to common bin centers there waste is being disposed to roll off compactors for compacting the waste. The filled compactor is lifted by hooklift vehicles. For some flats, bins are lifted by REL's.

Trade Premises:

Waste is collected from trade premises are collected and bring to bin centers by collection crew.


Landed Houses:

Waste is stored at individual landed houses is being collected by Rear End Loaders

7 IDENTIFICATION OF MSW PROCESSING TECHNOLOGIES

7.1 Introduction

The most important objective of municipal waste management is a safe disposal of the waste, generated daily. This would involve the following activities:

- Separation of recyclable fractions and recycling the same
- Beneficial utilization of organic fraction of the waste
- Disposal of inerts into a scientifically designed landfill

The disposal of waste involves *processing* to separate or utilize the waste fractions organic and inorganic, of which the recyclables are sent for recycling whereas the organics which dominate the proportion go to aerobic composting, vermi-composting or waste to energy conversion. These different options require many inputs for decision making processes and would involve different capital investments. A careful consideration of waste quantity generated is also an important part of this decision making.

In the following sections the processing techniques and methodologies in use are explained, subsequently an optimum model of waste processing and disposal for the GVMC is arrived.

7.2 MSW Processing Techniques

There are several MSW processing technologies which are being followed in various parts of the world. Further, it is to mention that out of the various processing technologies, the technologies which are being used / considered for use in Indian conditions are: (i) Composting, (ii) Anaerobic digestion to recover bio-

gas and electricity, (iii) Refuse Derived Fuel and (iv) Pyrolysis, as below under different technical groups

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

Table 7.1: List of Identified MSW Processing Technologies

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 bio degradable 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.

Composting:

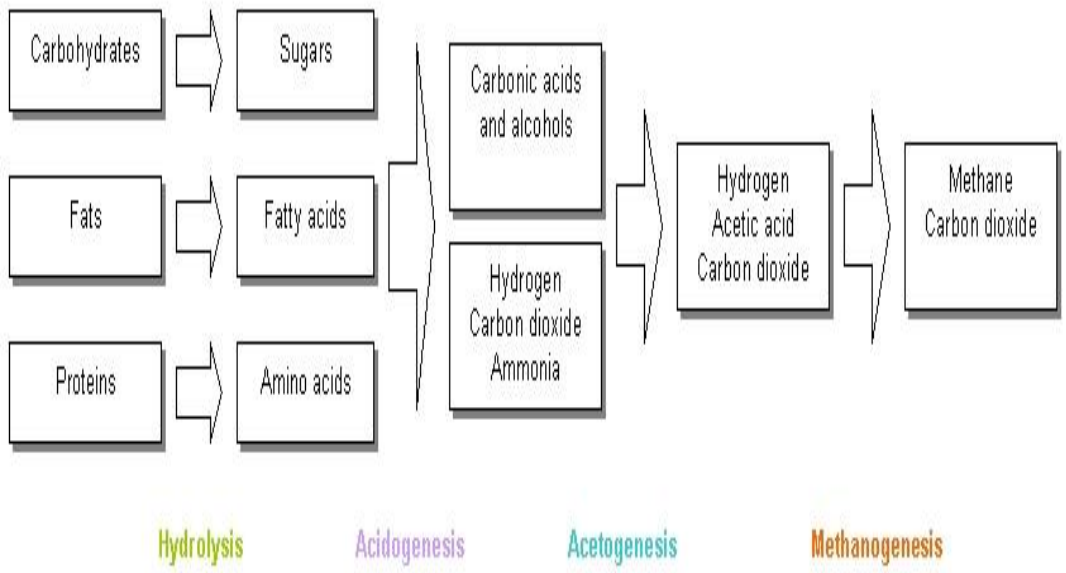
Composting is a natural micro-biological process where bacteria break down the organic fraction of the MSW under controlled condition to produce a pathogen-free material called “compost” that can be used for potting soil, Soil amendments (for example, to lighten and improve the soil structure of clay soils) and mulch. The microbes, fungi, and macro-organisms materials is placed into one or more piles (windows) and the natural microbial action will cause the pile to heat up to 65-80^{0}C, Killing most pathogens and weed seeds. A properly designed compost heap will reach 70^{0}C within 6 to 10 days, and slowly cool off back to ambient temperatures as the biological decomposition is completed. Systematic turning

of the material, which mixes the different components and aerates the mixture, generally accelerates the process of breaking down the organic fraction and a proper carbon/nitrogen balance maintained (carbon to nitrogen or C/N ratio of 20:1) in the feedstock insures complete and rapid composting. The composting process takes about 17 to 180 days.

There are two fundamental types of composting techniques i.e. open or windrow composting, this is done in outdoors with simple equipment and is a slower process. The other is closed system composting, where the composting is performed in an enclosure (e.g., a tank, a box, a container or a vessel).

Anaerobic Digestion:

In Anaerobic Digestion biodegradable material is converted by a series of bacterial groups into methane and CO_2. A first group break down large organic molecules into small units like sugar this step is referred to as hydrolysis, another group of bacteria converts the resulting smaller molecules into volatile fatty acids mainly acetate, but also hydrogen (H_2) and Co_2 This process is called acidification. The last group of Bacteria, the methane producers or methaogens, produce biogas (methane and Co_2) from the acetate and hydrogen and Co_2. This biogas can be used to fuel boilers or reciprocating engines with minimal pretreatment. In addition to biogas, anaerobic bioconversion generates a residue consisting of inorganic, non – degradable organics, non degraded bio degradable, and bacterial biomass. If the feedstock entering the process is sufficiently free of objectionable materials like colorful plastic, this residue can have market value as compost. Anaerobic Digestion process is also referred to as Bio-methanization process. A pictorial representation of this process is as below



Bio Reactor Landfill:

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

Thermal Processing Technologies

Thermal technologies are those technologies that operate at temperature greater than 200^0C and have higher reaction rates. They typically operate in a temperatures greater than 200^0 C to $5,500^0$ 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.

Incineration:

Mass-burn Systems are the predominant form of the MSW incineration. Mass-burn systems generally consists of either two or three incineration units ranging in capacity from 50 to 1,000 tons per day; thus facility capacity ranges from about 100 to 3,000 tons per day. It involves combustion of unprocessed or minimally processed refuse. The major component of a mass burn facility include

1. Reception of Refuse, handling and storage systems;
2. Combination and Steam generation System (a boiler);
3. Flue gas cleaning system;

4. Power generation equipment (steam turbine and generator);
5. Condenser cooling water system and
6. Residue hauling and Storage system

Pyrolysis:

In Pyrolysis, at high temperature of 700^0 C to 1200^0C, thermal degradation of organic carbon based materials is achieved through the use of an indirect, external source of heat, in the absence or oxygen free environment. This thermally decomposes and drives off the volatile portions of the organic materials, resulting in a Syngas composed primarily of Hydrogen (H_2), Carbon monoxide (CO), Carbon dioxide (CO_2) and Methane (CH_7). Some of the Volatile components form tar and oil which can be removed and reused as a fuel. Most Pyrolysis systems are closed systems and there are no waste gases or air emission sources (if the syngas is combusted to produce electricity, the power system will have air emissions control systems. The syngas can be utilized in boilers, gas turbines, or internal combustion engines to generate electricity or used as raw stock in chemical industries. The balance organic material that are non-volatile or liquid that is left as a char material, can be further processed or used for its adsorption properties (activated Carbon). Inorganic materials form a bottom ash that requires disposal, although some pyrolysis ash can be used for manufacturing brick materials.

Gasification:

In Gasification process, thermal conversion of organic carbon based materials is achieved in the presence of internally produced heat, typically at temperatures of 660^0 to 1800^0C, and in a limited supply of air/oxygen (less than stoichiometric, or less than is needed for complete combustion) to produce a syngas composed primarily of H_2 and CO. Inorganic materials are converted either to bottom ash (Low-temperature gasification) or to a solid vitreous slag (High temperature gasification that operates above the melting temperature of inorganic components). Some of the oxygen injected into the system is used in reactions that produce heat, so that pyrolysis (endothermic) gasification reactions can initiate after which the exothermic reactions control and cause the gasification process to be self-sustaining. Most gasification systems, like Pyrolysis are closed systems and do not generate waste gases or air emission sources during the gasification phase. After cooling and cleaning in emission control systems, the syngas can be utilized in boilers gas turbines or internal combustion engines to generate electricity or to make chemicals.

Plasma arc Gasification:

In Plasma Arc Gasification process using alternating current (AC) and /or direct current (DC) electricity is passed through graphite or carbon electrodes with

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

Liquid Plastic plant:

HBE, has developed a process to convert mixed plastic waste into the more useable liquid form, Liquid RDF, using a process called catalytic pyrolysis. In effect, the process proposes to provide an integrated plastic waste processing facility which offers an economical and environmentally responsible alternative to the usual approaches of landfill disposal, incineration and recycling.

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.

Refused Derived Fuel:

The RDF process typically includes through pre-separation of recyclables shredding, drying and densification to make a product that is easily handled. Glass and plastics are removed through manual picking and by commercially available separation devices. This is followed by shredding to reduce the size of the remaining feedstock to about eight inches or less for further processing and handling. Magnetic separator is used to remove ferrous metals. Eddy –current separators are used for aluminum and other non-ferrous metals. The resulting material contains mostly food wastes non-separated paper, some plastics (recyclable and non-recyclable) green wastes wood and other materials. Drying to less 12% moisture is typically accomplished through the use of forced air. Additional sieving and classification equipment may be utilized to increase the removal of contaminations. After drying, the material often undergoes densification processing such as palletizing to produce a pellet that can be handled with typical conveying

equipment and fed through bunkers and feeders. The RDF can be immediately combusted on site or transported to another facility for burning along or with other fuels. The densification is even more important when RDF is transported off-site to another facility in order to reduce volumes being transported. RDF is often used in waste to energy plant as the primary or supplemental feedstock or co-fired with coal or other fuels plants in kilns of cement plants, and with other fuels for industrial steam production.

Mechanical Separation:

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

Most of the rural towns it is seen that C&D debris (more than 90%) is reused and the rag pickers take away most of the recyclable material at the collection points only. Therefore the MSW reaching the dumping ground does not require the elaborate mechanical separation process. This MSW has high organic content fit to be directly used for various technologies after manual sorting only.

Size Reduction:

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

7.3 Screening Technology Criteria

The criteria for screening the potential technologies which meet the objectives and goals.

a) Technology Reliability Criteria

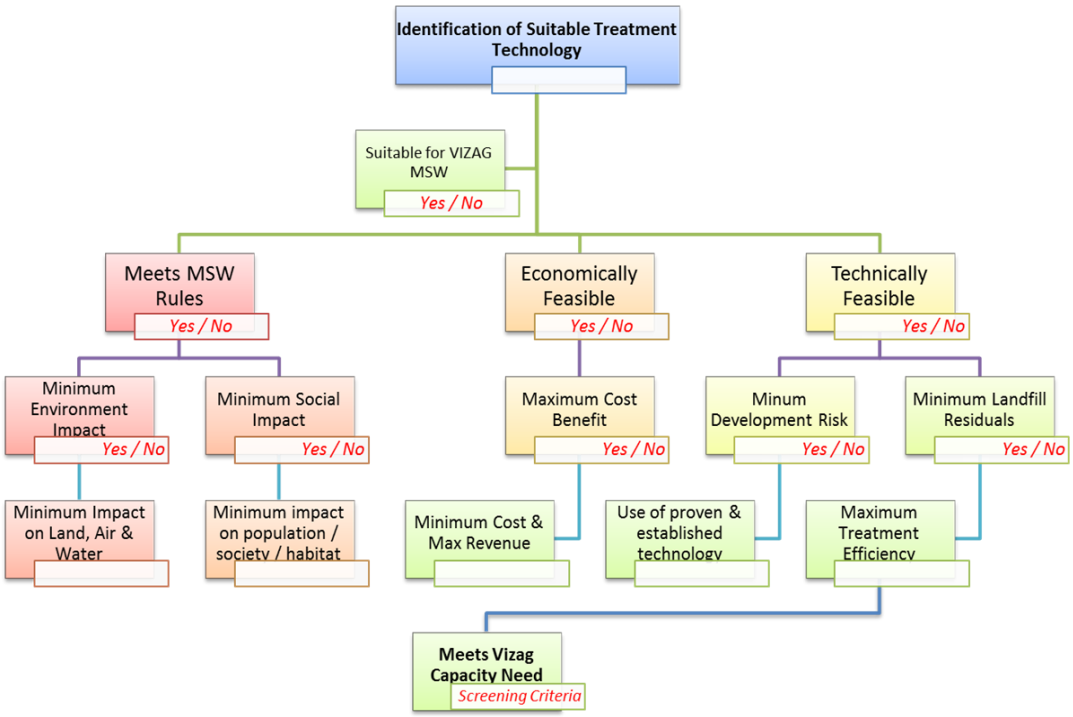
Technologies that are proven internationally for large scale application of MSW could be considered without reservations for Visakhapatnam District.

b) Environmental and Social Acceptability Criteria

Technologies that have minimum environmental and social impacts and conform to the regulatory requirements (MSW Rules, 2000)

c) Waste sustainability Criteria

Technologies those are suitable for MSW characteristics of Visakhapatnam District. A schematic representation of technology selecting criteria has given below.



7.4 Governing factors for choice of Technology

The decision to implement any particular technology needs to be based on its techno – economic viability, sustainability, as well as environmental implications keeping in view the local conditions and the available physical and financial resources. The key factors are

- The origin and the quality of the MSW
- Quantity of Waste generated
- Distances between the various municipalities falling in the particular zone/cluster
- Market for the finals products - Compost / anaerobic digestion Sludge / power
- Commercial fertilizer Prices Prevaling
- Land Price, Capital and labour cost
- Capabilities and experience of the technology provider.

It needs to be ensured that the proposed facility should fully comply with the environmental regulations laid down in the MSW Rules 2000 issued by MOEF, New Delhi and may be amended from time to time.

7.5 Selection of the most suitable technology for GVMC

The composition of urban waste has rapidly undergone a radical change in the fast few years in the country in tune with the growth of the economy resulting in the increasing use of packaging material comprising of paper and plastics.

At Present about 957 TPD of waste is being generated only from Visakhapatnam which consists of huge quantities of compostable and combustible materials.

The typical composition of MSW characteristics of Visakhapatnam are shown as below.

Item	Item wise Generation %
ORGANIC WASTE: Leaves , Fruits, Vegetables, Food Waste, Fine organic Matter, Hay and Straw etc	52.0
RECYCLABLES: Rubber and leather, Plastics, Rags, Paper, Wooden Matter, Coconuts, Bones, Straw, fibers	23.0
INERT MATTER: Ash, crockery, earthen ware (pots), Stones and Bricks, Metals, Glass, sand, silt from drains etc.	25.0
TOTAL	100

Table 7.2: Composition of MSW

The organic component of waste can be converted into useful product(s) and recyclables can be effectively recycled through a suitable technological option depending on the composition of the waste.

Considering the waste characteristics and quantity of waste being generated the following treatment technologies are proposed for Vishakhapatnam district

- **Aaerobic Windrow Composting**
- **Refuse Derived fuel(RDF) used to generate Power (WTE)**
- **Scientific land filling**

It is pertinent to mention that, recently State Government has also expressed its interest in setting up of a Waste to Energy plant (WTE) in Vishakapatnam. **The design concepts of these proposed treatment facilities are explained in the subsequent chapters.**

8 CLOSURE OF EXISTING DUMPSITE AND LAND RECLAMATION:

8.1 Introduction

GVMC is generating approximately 920 tons of municipal solid waste (MSW) per day, which is mainly disposed in the open dumpsite near Kapuluppada which spreads in an area of 73 acres. Currently, GVMC disposes the entire waste generated at Kapuluppada disposal site. This site is operating for the last 7 years. Three JCBs and one bulldozer are employed by GVMC for solid waste disposal management, including the operation of the waste disposal site. This site is still operating and receiving waste from all over GVMC area.

The present dump site falls under the category of uncontrolled solid waste disposal facility. Due to this scenario, anaerobic decomposition of organic content of the waste is leading to landfill gas generation, comprising mainly of methane. As, this site is not scientifically managed, there is no control over the escape of the landfill gas into the atmosphere.

Out of total area of 73 Acres, about 60% of the land is filled with waste. As per our proposal we shall close the existing waste for land reclamation to create space for construction of integrated treatment Facility.

8.2 Site Description:

The proposed site for integrated treatment Facility is located at Kapuluppada in Bhimlipatnam Mandal. The total area of the site is around 73 acres and the site falls under survey No. 314 of Kapuluppada Village. The land is situated on the down hills of three hillocks which form the boundary of the North, East and southeast side of the plot. The land is steeply sloping from North & East directions. The site is 24kms far from Airport and 0.5 kms from the NH5.

The site steeply sloping from the North to South & East to west direction with a contour variation from 60 m to 30 m (30 m height difference between lowest point to highest point). According to GVMC officials, garbage is being dumped in the site for the last 7 years. A power line with transformer feeding to the biomedical waste plant is situated at the edge of the plot. M/s. Maridi Eco Industries Pvt. Ltd is operating a biomedical waste treatment plant in 5 acres. A weighbridge is situated near the entrance to the biomedical plant, which is currently weighing the garbage lorries.

The land is located on the down hills of three hillocks which form the boundary of North, East and Southeast side of the disposal site. Map of the site location is provided in the Figure 11.1. The average height of ground level at the proposed site is about 30 m above mean sea level. The proposed integrated treatment Facility site is plain to undulating terrain due foot hill area. Area within the 5 km radius around the site is mixed type of hill and plain land.

The hydrology of proposed land fill site is located in secondary aquifers with intergranular porosity. Ground water level in the proposed site is in the range of 5-10m. The nearest piezometer location is Bheemunipatnam.

Red gravelly soil occupies most part of the region (45%), apart from coastal sandy soil, which stretches throughout the beach. The coastal sediments have low bearing capacity, high permeability and poor foundation characteristics. The soil type of proposed land fill site is coastal sandy soils. The soil profile of the land fill site is red clay soil up to one meter depth, red sandy clay with gravel up to three meter depth, soft disintegrated rock up to five meter depth, weathered rock up to nine meter depth

8.3 Planning of Closure of Existing Dumpsite for Land Reclamation

Concept planning and re-contour and stabilize slopes so that a final cover can be installed. Reclamation of land is a relatively new approach used to expand municipal solid waste (MSW) capacity and avoid the high cost of acquiring additional land. Once it gets filled, the landfill must be closed and no solid waste should be received at the site.

To utilize the available space optimally Feed back after a detailed survey is proposing the reclamation at Kapuluppada in a scientific manner at disposal yard. The existing features of dump site shown in below figure.

7.3.1. Quantity Assessment & Design Parameters

Kapuluppada dump site is located at 20 km from the city and is in operation since 2007.The quantity of existing waste in this dumpsite has been calculated by means of two methods.

By daily incoming waste data and by existing physical nature of the dump site,

i.e. height, area and waste quality.

S. No	Description	Dump Site
Method I for Estimation of Existing Quantity of the Waste		
1	Average quantity of waste disposed (MTD)	500
2	Period of disposal (Years)	7
3	Quantity of Waste accumulated (MT)	1277500
4	Quantity of waste accumulated after degradation (moisture and volatile loss -50%)	638750
Method II for Estimation of Existing Quantity of the Waste		
1	Area of waste dumped (Acres)	73 (but waste filled in 60% area)
2	Height of the waste (m)	4 mtr average height
3	Volume of the waste (m3)	709034
4	Density (MT/m3)	0.85
5	Quantity of waste (MT)	602680
	Adopted Quantity of Waste (MT)	602680 MT

As per our physical observation, we have adopted method II for closure of existing waste. Large quantity of waste is degraded and most of recyclable from the dump has been removed by rag pickers at site from many years.

Total area en marked for closure of existing waste is 14.8 Acres.

7.3.2 Design parameters for Waste dump capping:-

Bund Details :									
Ht. of Main Bund :		3.0	M						
Excavation BGL :		1.5	M	Av					

				g.					
Top Width of Bund :		3.0	M						
Berm Width :		4.0	M						
No. of Berms :		3.0	Nos						
SLF Slopes :									
Main Bund Outer Slope :		2	:	1					
Main Bund Inner Slope :		3	:	1					
Slope of Dump Above Bund Top :		3	:	1					
LF Final Slope :		20	:	1					
SLF Dimensions :									
			Area		**Perime-ter**			**EL**	
Total Landfill Area :			59991	sq m	1016	rm t	@ +	100.00	m
LF Garland Drains :					1012	rm t	@ +	100.00	m
Landfill Dimensions :	@ BBL	=	29136	sq m	828	rm t	@ +	97.00	m
Landfill Dimensions :	@ GL	=	41206	sq m	862	rm t	@ +	100.00	m
Landfill Dimensions :	@ BL	=	49279	sq m	932	rm t	@ +	103.00	m
Landfill Dimensions :	@ ABL	=	36171	sq	816	rm	@ +	108.0	m

				m		t		0	
4 m wide Berm - LF Dimensions :	@ ABL	=	32968	sq m	785	rm t	@ +	108.00	m
Landfill Dimensions :	@ ABL	=	22051	sq m	670	rm t	@ +	113.00	m
4 m wide Berm - LF Dimensions :	@ ABL	=	19432	sq m	639	rm t	@ +	113.00	m
Landfill Dimensions :	@ ABL	=	10707	sq m	524	rm t	@ +	118.00	m
4 m wide Berm - LF Dimensions :	@ ABL	=	8679	sq m	486	rm t	@ +	118.00	m
Landfill Dimensions :	@ ABL	=	2733	sq m	307	rm t	@ +	123.00	m
SLF Volume :									
	29136.38	+	49278.97						
BBL: Vol - I				X	8.0	=	313661	cum	
		2							
	49278.97	+	36170.82						
ABL: Vol - 2				X	5.0	=	213624	cum	
		2							

	32967.51	+	22050.84						
ABL: Vol - 3				X	5.0	=	137546	cum	
		2							
	19431.93	+	10706.74						
ABL: Vol - 4				X	5.0	=	75347	cum	
		2							
	8678.59	+	2733.06						
ABL: Vol - 5				X	5.0	=	28529	cum	
		2							
	2733.06	+	0.00						
ABL: Vol - 6				X	3.0	=	4100	cum	
		2							
Volume of waste :						=	772807	cum	
Assuming Waste Density :						=	0.85	t/cum	
Quantity of waste :						=	**656886**	**tonnes**	

Kapuluppada Dump Site Pictures

Environmental Conditions of Dump site:

Presently the waste received, gets dumped without any treatment, which has resulted into huge accumulation of waste as mentioned above. The main issues pertaining to the environmental and aesthetic condition are as below:

- **Leachate Pollution**
- **Air- Pollution- smoke, odor and others**
- **Flying of waste such as plastic**
- **Health hazards, breeding of flies and rodents**

Besides these all three sites do not have any peripheral access or organized surface runoff management/ drainage system.

8.4 Reclamation and Reuse Plan

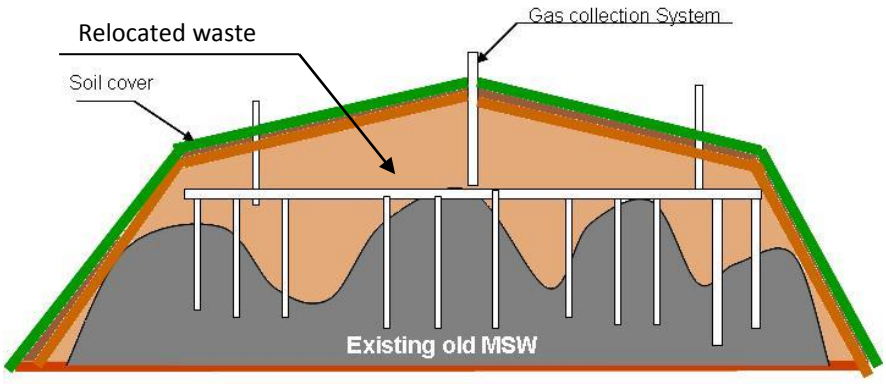
Presently the dump is spread over the site of 70 Acres and part of this dump has to be relocated for creating vacant land for establishing of new facilities. Area requirement for establishing processing facilities is estimated to be around 50 Acres.. It is therefore, necessary to relocate existing waste over this area. The proposed procedure to relocate this spread of MSW is as follows.

Identify and earmark the area required for establishing the new facilities on the 73 acres layout.

Identify the area where the excavated waste from the above site is to be transported and dumped. The locations suggested by us are the valley portions between any two dumps and then profile the entire dump into a single contagious mass with slopes of 1:3.

Heap up the transported waste to as high as possible in the valley portions and also over the existing dumps

Excavators and JCBs should be deployed to transfer excavated waste into trucks/conveyors. This dumping of the transshipped material will be in accordance to the finalized levels of both top and slopes. The transshipped material shall also be subjected to a regular consolidation with spiked & vibratory compactors.



Once the total relocation of waste is completed, the dump will be brought to its final shape. Requisite soil layer will be laid over the final profile. Above the soil covers vegetative soil will be laid to support vegetation.

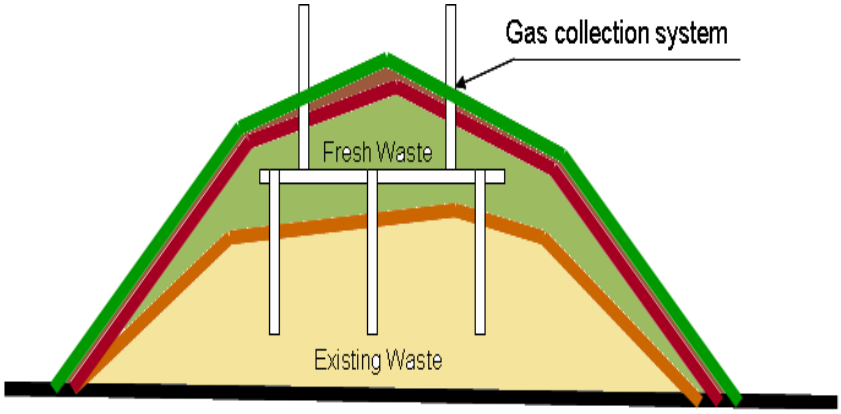
Gas collection and venting system will also be provided to collect the LFG gas generated. If the gas quantities are large the same will be sent to the power plant and if the quantities are less LFG will be vented out or connected to flaring system

The capped portions of this landfill should be maintained throughout the cooperation period.

Handling of Fresh MSW (in Excess) over the first year of construction period:-

This fresh waste should be allowed to be dumped at predetermined locations on the dump by diverting /guiding these vehicles to the respective unloading places.

After sizeable quantity of about fresh waste trucks are unloaded on each of these location, leveling operations in layers of not more than 500 mm thick and duly consolidated by spiked vibratory compactor should be carried out. This process continues till the day's quantity of 920 Tons is dumped, leveled and compacted on each day. After this operation, a daily cover of soil will be spread on this leveled and compacted area and again compacted.



Receipt of Fresh Waste and Capping of the Landfill

Requisite soil layer and vegetative solid layer will be laid over the final profile. Gas collection and venting system will also be provided to collect the LFG gas generated. If the gas quantities are large the same will be sent to the power plant and if the quantities are less LFG will be vented out or connected to flaring system. The capped portions of this landfill should be maintained throughout the cooperation period.

This kind of multilocational operation requires proper hard passages for the free movement of incoming trucks. During this process, every care is taken to ensure proper drainage of storm water to be ultimately discharged into drains after ponding up for a short period without allowing any mix up with leachate.

Detailed procedure of Reuse Plan:

After retrieving area's required for establishing of new facilities and receiving fresh waste the balance dump will be earmarked for partial closure. The completion of the partial closure of landfill by relocating the waste dumped spread across the total site is the most important and priority component of the project because the area required for the setting up of other facilities /components of the project is depending on the completion of the component of partial closure.

The methodology for partial closure encompasses the following sub tasks /activities.

Sub Task –1: Estimation of Waste Quantity

Sub Task –2: Relocation of waste

Sub Task –3: Provision of final cover system

Sub Task –4: Drill and provide gas collection bores and grid to collect Landfill gas for effective flaring / Reuse to Power

Sub Task –5: Leachate extraction and collection net work

Sub Task-6 - The post closure maintenance of the partially closed dump site

throughout the cooperation period.

Each of the subtasks are explained in detail in the following sections

Capping of existing waste lying in the site covered with a varied height shall be done by relocating and consolidating the waste on a footprint of proposed capping area and shall be scientifically capped.

Various tasks involves in capping work are as follows.

Sub Task –1 : Estimation of Waste Quantity:

Estimation of the quantities of waste lying in the site at different locations and assessment & deployment of vehicles (earth moving machinery/bulldozers and tippers) for the relocation of the waste to the area earmarked for the partial closure in accordance with the closure plan. If required Approach road to this closure point to be constructed for hassle free movement of men and machinery during the construction.

Sub Task –2: Relocation of waste:

Devising a plan of action for leveling, compaction and planned relocation of the existing waste (as above) to the area earmarked for capping of the site. Leveling, consolidation and reformulation of slope and surfaces to planned levels and profiles. The proposed procedure to relocate this spread of solid waste is as follows.

Heap up the spread waste to as high as possible in the capping area.

Excavators should be deployed to transfer this heaped waste into trucks wherever the land is more than 100mts and shall be transshipped to within the foot print area. This dumping of the transshipped material will be in accordance to the finalized levels of both top and slopes. The transshipped material shall also be subjected to a regular consolidation with spiked & vibratory compactors.

The closure activity of the dump will be initiated from one end and gradually extended to the top.

Equipment required relocated and leveled are

JCB's – for excavating of waste

Dumpers (10T) – for transportation of waste

Landfill compactors - the garbage can be dry rolled and compacted to a satisfactory level.

Grader - this equipment will be employed to level area and the slopes to given gradient wherever and whenever required.

Sub Task – 3: Provision of final cover system:

A final capping 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 capping cover to be adopted will depend on the gas management system. The final cover system must consist of a vegetative layer supported by a drainage layer over barrier layer and gas vent layer.

Capping of the landfill is taken up at the recommended slope and with the recommended layers. This capping is provided to ensure

Prevention of Infiltration of rain water into the landfill during post closure period.

To eliminate the possibility of explosions due to accumulated gases in the landfill by suitably providing for passive gas venting systems

The various steps to provide final capping to the dump site are as given below.

Level and compact the dump and bring it to final formation of the MSW. The slopes provided will be 1:3.

Provide liner system comprises of combination of barrier materials such as natural clay and amended soils. A drainage layer and leachate collection system is placed over the composite liner system. The effectiveness of barrier layer basically depends on the hydraulic conductivity of the clay/amended soil liner. The final cover 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

Barrier layer with permeability less than 1 X 10--7cm/sec comprising of clay/GCL

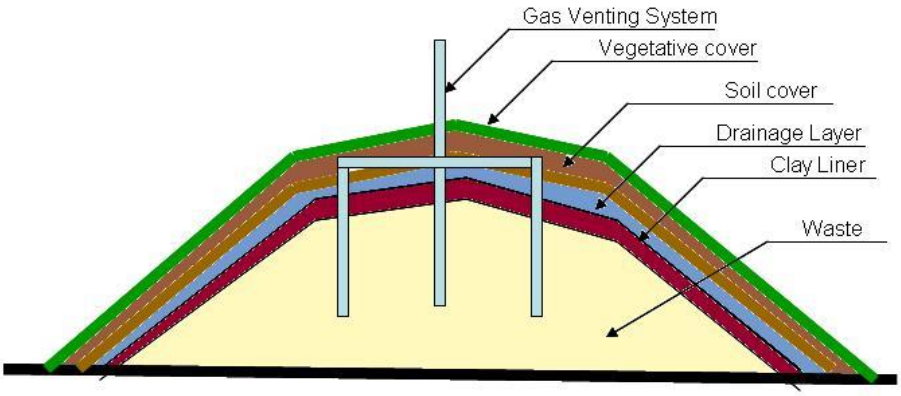
Gravel Layer: This layer will be 20cm thick and made up of C & D debris or gravel as the case may be, both on top and slopes. This layer will be compacted with 5T roller. Light bull Dozer will be used to obtain uniform thickness of the layer.

Top soil: Virgin and rich top soil will be conveyed to the site and spread in an uniform layer of 30cm. This layer after uniformly spreading will be rammed into place with powered earth rammer ensuring moderate compacting for the easy penetration of roots of the proposed shrubs and grass on this layer. This layer will be suitably watered to maintain the required moisture levels till plantation takes place.

Shrubbery and lawns and pathways: Appropriate landscaping plan will be presented for approval. The proposal will be with a minimum of 3 alternatives. The shrubs selected will be hardy and at the same time ornamental and flowering. The lawns will be developed by transplanting with selected variety of dhoop

grass or seeding

The paving will be with 25mm thick precast concrete blocks suitably laid over a bed of sand and cement jointed.



Capped Landfill - Cross section

Landscaping

The landscape concept would be to create a 'park-like' environment within the Dump Site. Lush greenery with extensively landscaped areas are set aside within the site, such as the central commercial hub, entrance plaza, pocket parks and perimeter fringes to ensure that forested, landscape areas achieved. These areas shall not be used for any use other than the prescribed use. However these areas may be used to have natural drains, which are not cemented but lined with inter-locking blocks to ensure percolation of rainwater and such drains will only be used to convey rainwater runoff.

While linear planting is to be carried out along the roads, informal and mass plantings are proposed for the large landscape areas.

The following guidelines are to be followed to achieve the nature of landscape envisaged.

To complement the network of roads, the roadside trees are very important. Large shade trees are planted at 10m center to center to achieve a canopy environment in the shortest possible time. These roadside trees not only provide shade, but also, more importantly, soften facades of all the buildings.

The buffer zone would be densely planted with quick growing trees to have the forested effect. Here, function screening is the main priority, thus heavy foliage and low branching trees are preferred. To create identity, different areas should have different varieties planted – one area for color, one area for form, one area for fragrance and one area for shade.

To the extent possible only native species and locally available species of trees

and plants should be used.

Sub Task – 4: Drill and provide gas collection bores and grid to collect Landfill gas for effective flaring / Reuse to Power

Landfill gas is generated as a product of waste biodegradation. In landfill sites organic waste is broken down by enzymes produced by bacteria in a manner comparable to food digestion. Considerable heat is generated by these reactions with methane, carbon dioxide, nitrogen, oxygen, hydrogen sulphite, carbon dioxide and other gases as the byproducts. Methane and carbon dioxide are the principle gases produced with almost 50 – 50 per cent share.

When methane is present in the air in concentrations between 5 to 15 per cent, it is explosive. Landfills generate gases with a pressure sufficient enough to damage the final cover and largely have impact on vegetative cover. Also, because only limited amount of oxygen are present in a landfill, when methane concentration reach this critical level, there is a little danger that the landfill will explode.

The quantity of gas generated from the landfill can be estimated. (Volume of Gas Generated, V = C X W X [P/100] m3/year ; C = Coefficient of Generation (6 m3/ton/year) ; W = Weight of Waste ;P = Percentage of Organic Component) or the SCSLMOP International LFG model that employs a first-order decay equation identical to the algorithm in the U.S. EPA's landfill gas emissions model (LandGEM) and determined the potential LFG recovery rate for the landfill. The international LFG model is described in detail below.

Gas management strategies would follow the following three plans,

- Controlled Passive Venting
- Uncontrolled Release
- Controlled Collection and Treatment

A gas venting system is proposed for the partial closure at Kapuluppada dump site. This gas will be vented through gas vent pipes of 150mm diameter perforated HDPE pipes. The landfill gas collection is facilitated by installing perforated HDPE pipes of 150 mm dia vertically down reaching about 80% of the dump/fill depth site at 30 mtr center to center distance.

These vertical vent pipes are connected to the gas collection manifold placed at the top of the fill site buried conveniently under top soil cover. The gas from manifold is either flared or energy recovered depending on the quantities available.

The installation of the gas collection and flaring systems is installed simultaneously with the laying of the final cover.

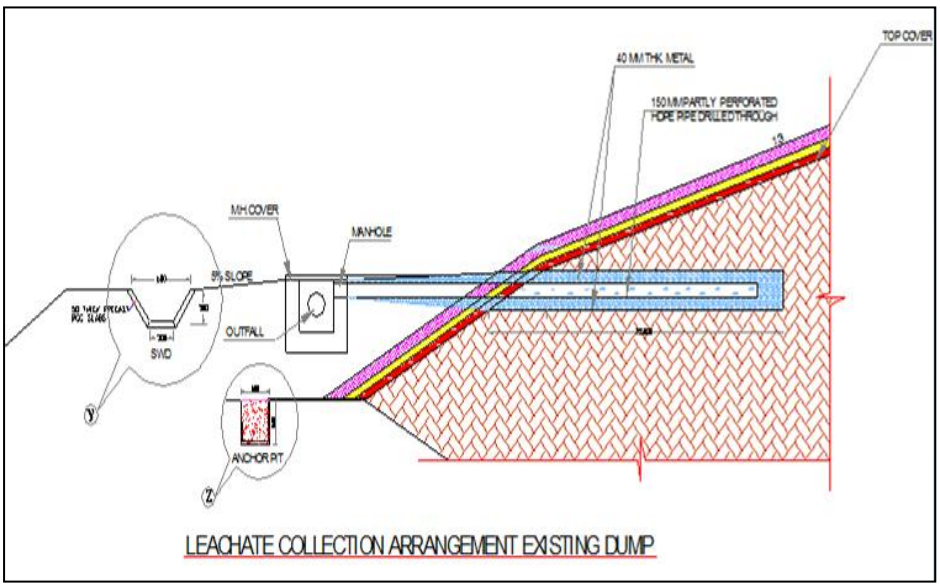
With the help of blower gas through the pipes shall be collected and taken to flar-

ing unit. The collection system is a network of 150mm HDPE perforated pipes connected to flaring unit. The flaring unit consists of collection chamber, blower, ignition mechanism, control valves and sensors.

Sub Task – 5: Leachate extraction and collection net work:

Normally its seen that for all old unlined dump sites /landfill there is a possibility of segregated pondage of leachate in the closed dump site foot print area. In such a case if leachate evacuation if attempted by gravity flow through pipelines from the sides may not be effective and may lead to large quantities of leachate storage within the foot print area wherever the levels are irregular. To avoid this situation it is expected that leachate be pumped out by locating leachate pumping wells within the foot print area of the dump closure where the bottom of the dumpsite shows distinct depressions. During construction works exact location of these wells can be identified. Additional wells will also be provided at periphery if needed.

During the first year of reformation of slopes if there are any specific areas found from where leachate tends to flow from the sides, in all such locations suitable shallow wells will be constructed to remove leachate. All the leacahte from the dump will be collected in leachate collection tanks from where it would be pumped to leachate treatment plant for final treatment and disposal.



Sub Task -6: The post closure maintenance of the partially closed dump site throughout the cooperation period:

As part of the post closure maintenance plan the following activities will be observed by the developer

Periodical inspection of the complete capped portions of the dump site atleast once in every three months

- Monitor
- Land surface care
- Leachate collection
- Methane control by ways of flaring or reuse
- Maintain flaring equipment if provided
- Monitor Air quality
- On and within the capped dumpsite
- Surrounding areas

Air quality parameters monitors are Methane, Sulphurdioxide and Suspended particulate matter

Monitor ground water quality within the capped dumped site and neighboring areas

Under the post closure the various works that would be undertaken along with the frequency is given below:

S.No	Item	Scope of work	Frequency	Responsibility
1	Inspection - Site inspection	To identify areas of subsidence and their repair by levelling the areas with earth and recapping With landfill cover as per the specifications used for closure.	Quarterly	Project Manager
2	Inspection – Gas collection systems	Inspection of gas collection manifold and flaring system; and repair of any malfunctioning units/sections.	Monthly	Project Manager
3	Leachate Collection Systems	Collection and transportation of leachate to the aerated lagoon sites (offsite) for treatment	Daily/regular	Project Manager

S.No	Item	Scope of work	Frequency	Responsibility
4	Landscape Maintenance	Watering and maintenance of landscape areas	Regular	Horticulturist
5	Environmental Monitoring	Environmental monitoring to ascertain ground water and air pollution due to the closed landfill	Monthly	Project Manager

Drainage System:

Surface water runoff is a significant component in a landfill design and shall be clearly designed. The design includes a garland drainage system all around the landfill which shall be lined and shall be connected to a storm water collection pond. Water collected in the pond shall be tested for storm water quality parameters and if it meets the discharge standards shall be discharged, otherwise the same shall be considered as leachate and sent to the leachate treatment plant.

Artificial and natural features at the landfill site control surface water and groundwater when integrated, the artificial and natural features must be effective in controlling run-on and runoff of surface waters as well as preventing groundwater from penetrating the landfill liner. When the landfill is closed, the drainage control system must be designed to function for the long-term use of the site. Rainfall must be removed from the final cover surface without soil erosion or excessive water infiltration. The greatest risk to the site is from ponding of surface waters in areas of land subsidence.

The following features must be included in the design of drainage control facilities:

- Collection and routing of surface waters off the landfill surface in the shortest possible distance;
- Selection of channel and drainage ways that will carry waters at adequate velocities to avoid deposition;
- Use of sufficient surface slopes to maximize the removal of surface runoff and at the same time minimize surface scour; and
- Material specifications for the drainage features that allow repair and replacement as the landfill settles

Layout plan

As per our estimates the total quantity of waste approximately 6 lakh tons shall be relocated and capped to an area of 14 Acres as en marked in the below layout plan. Total height of the proposed capping shall be 28 mtrs and shall be maintained in a slope of 1:3. Detailed cross sections of the drawings are annexed for reference.

9 PLANNING AND DESIGN OF TREATMENT PLANT

9.1 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.

The Treatment plant for Visakhapatnam city is proposed at the Kapuluppada, which is an existing dump yard with area of 73 Acres .Out of total area about 60% of the land, is filled with waste. As per our proposal we shall close the existing waste for land reclamation to create space for treatment plant construction.

As per the proposal, we shall propose Integrated Waste Treatment facility at Kapulupada dump site. Below is the area statement broadly showing the area of each main facility at the integrated facility.

S. No	Facility	Area in Acres
1	Waste Dump Capping	14.80
2	Compost & RDF Plant	10.00
3	Power Plant	10.00
4	RDF Storage area	2.70
4	Other Supporting infrastructure, roads, green belt etc..,	10.00
	Total Area	**47.50**

With the above area statement and looking at the narrow shape of dump site, land for development of scientific landfill for inerts is not sufficient at Kapuluppada dump site.

Scientific landfill for inerts shall be proposed at new site identified by the GVMC at Tanguddipalli, with approx 200 Acres area available and this site is 20 kms far from kapuluppada dump site and 40kms far from city.

9.2 Material Balance

The generated MSW in Visakhapatnam District and the waste reaching to the processing facility may not be same. It will depend on the efficiency of collecting the waste. However by implementing the good MSW practices in Visakhapatnam

District the efficiency of collecting MSW may also increases. As per the records the total MSW generated in Vishakhapatnam city is around 920 TPD. The plant is designed for 951 TPD with cluster approach concept from yelamanchali and Narsipatnam which is explained in earlier chapters.

In this chapter, the design of recycling for the integrated waste management facility is presented in detail. The recyclable unit has been designed to process the recyclables into by products. The inerts (rejects) would be disposed to the landfill whereas the organic material (compostable in nature) would be sent to the compost plant and the light combustibles (RDF fluff) would be utilized to produce energy.

9.3 Design Of Presorting & 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.

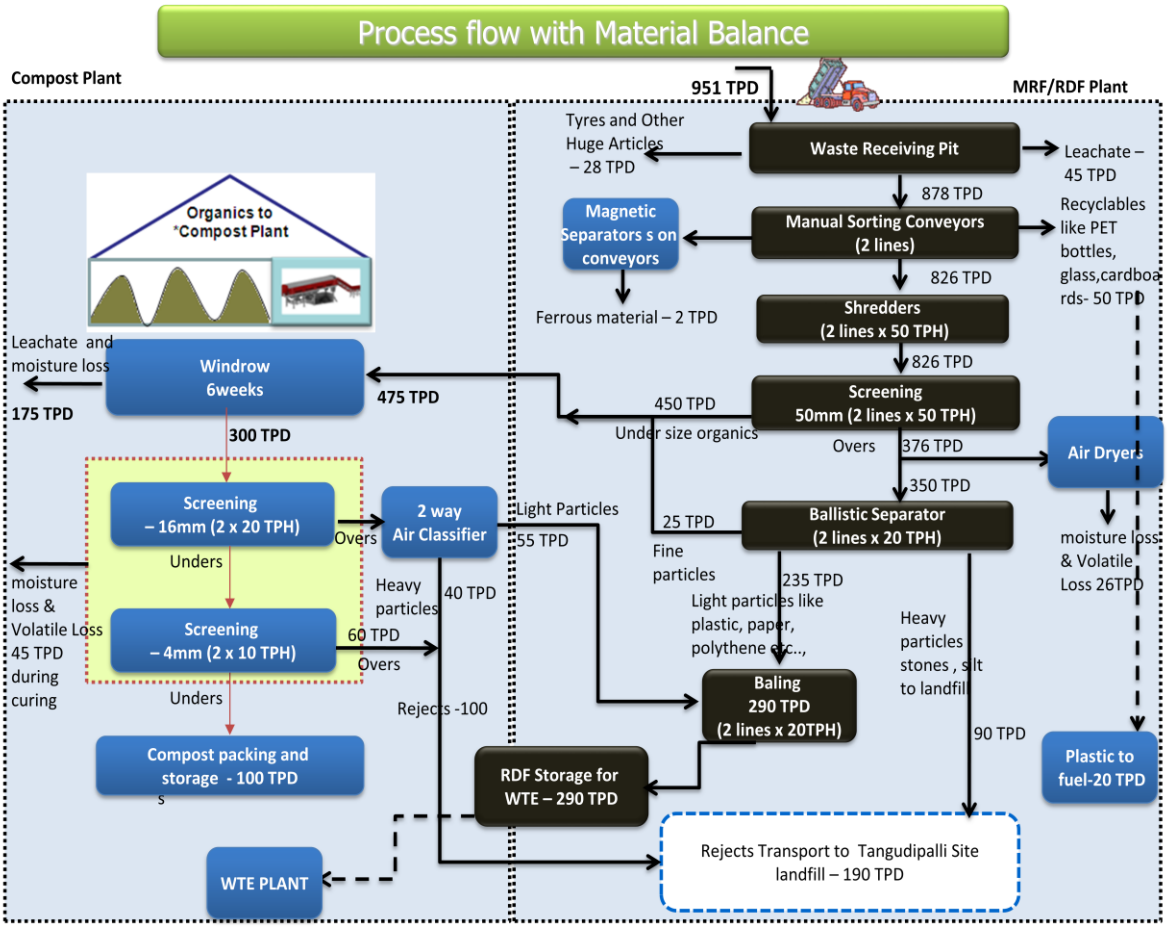


Figure 9-1: Material balance

Component	Tonnage (TPD)	Percentage (%)
Compost	100	11%
RDF	290	30%
Rejects	190	20%
Moisture Loss	291	31%
Recyclables – PET, Glass, Cardboards etc	50	5%
Metals	2	0.2%
Huge articles – tires , boulders etc..,	28	3%
Total	**951**	**100%**

Table 9.1: Material balance

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 inspect 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 9-2: 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 SEPERATORS:-

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 number

Figure 9-3: Magnetic Seperator

SHREDDERS USED FOR HOMOZENINATION:-

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 pre sorting screens.

Figure 9-4: MSW Shredder

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 9-5: 50 mm Tormmel

- Trommels shall be provided on each line of the process 50 TPH capacity.
- Diameter of the Trommel will be 1.5m dia x 10m length
- The Trommel will have 50mm perforated welded mesh openings

- Power required will be 35 Hp with 960rpm.

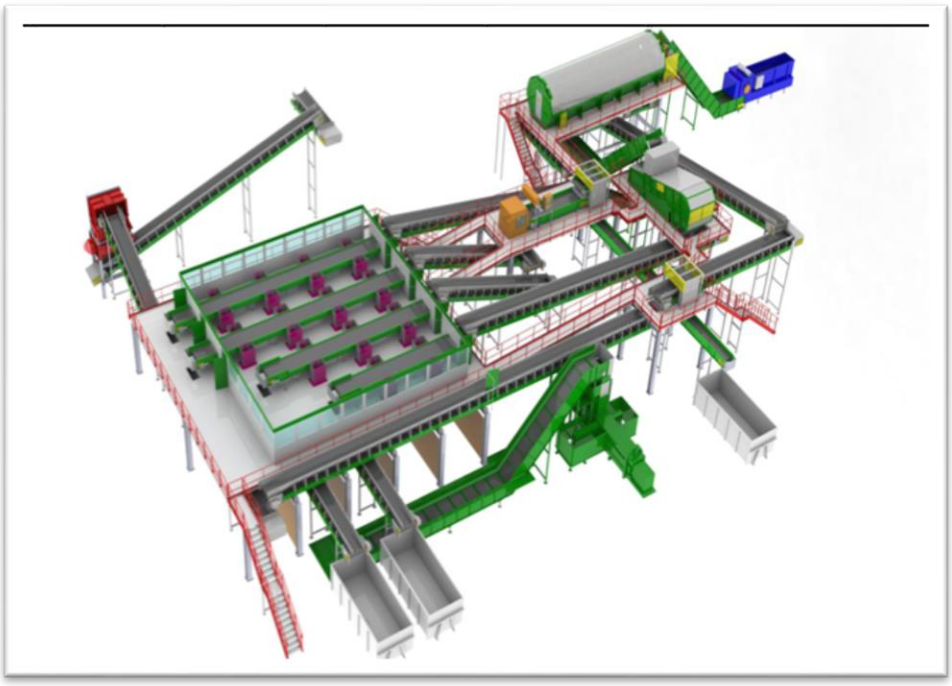


Figure 9-6: Sorting Stations and Screening

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

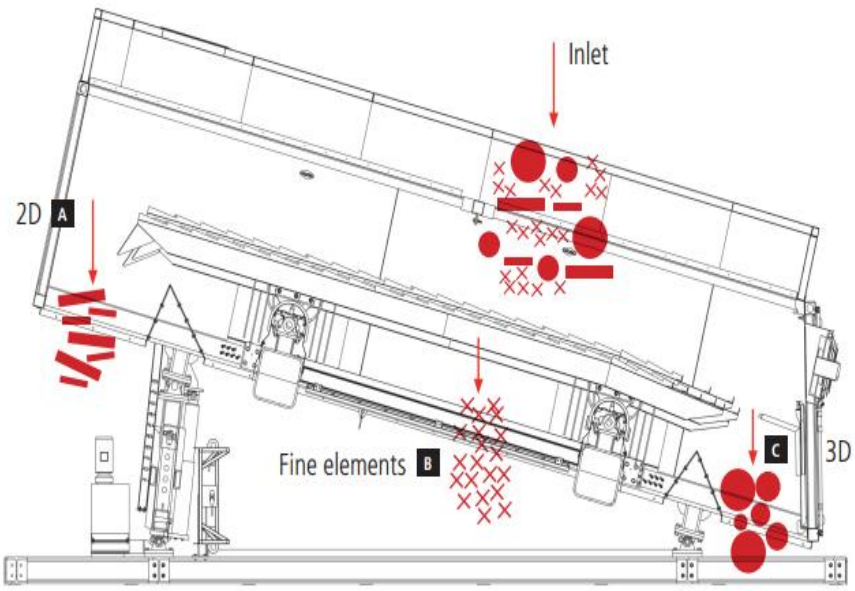


Figure 9-7: Process flow of Ballistic Separator

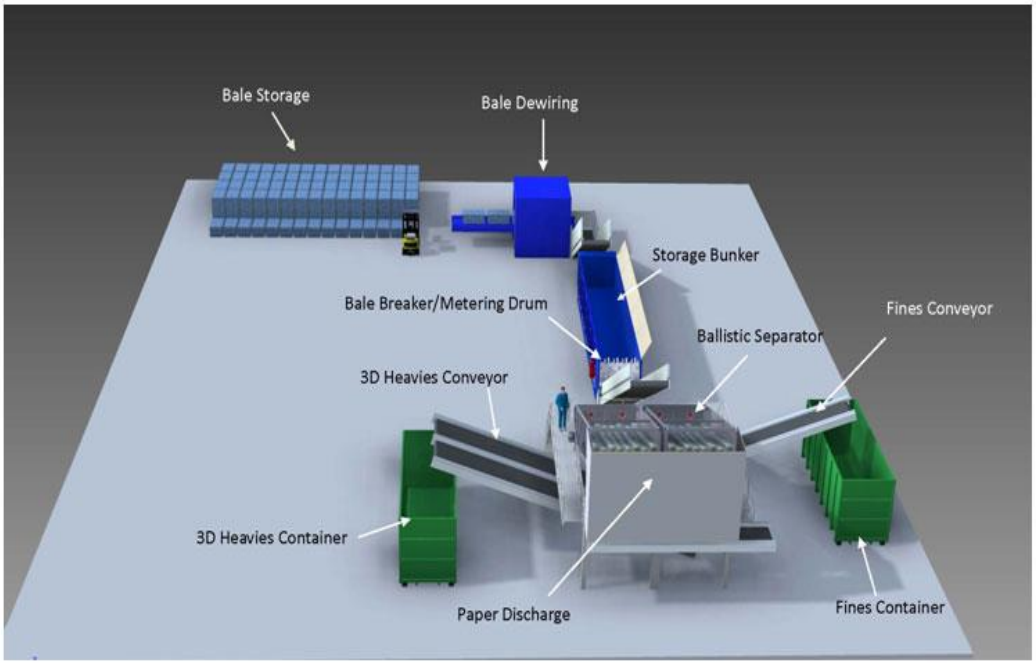


Figure 9-8: Typical view of Ballistic Separator

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 9-9: 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 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 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

Design of Presorting/RDF Plant

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

Waste Receiving Platform:-

Description	Quantity
MSW Incoming waste in to the plant in TPD	951 TPD
Duration	3 days
Total quantity of waste for 3 days	2853 MT
Density of MSW in ton/cum	0.45
Volume of Waste in cum	6340 cum
Stacking Height of waste on windrow plat form in meters	2.5 mtrs
Area required to stack the each day waste on windrow plat form in sqm/day (with base (60m x20m) and top (50m x10m))	0.56 sqm/cum
Area required for windrow platforms in sqm	3580 Sqm
Add extra for working space movement	25%
Total Area required	4475 Sqm
Dimensions of Windrow platform	**90m x 50m**

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 go down:- Size of the shed proposed for storing RDF - **100m x 25m.** The RDF stored will be used for proposed power plant at Kapulupada site.

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

Table 9.2: List of Processing Machineries & Equipments (Mechanical)

Mobile Equipment for presorting and RDF plant operations

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

Table 9.3: Mobile Equipment

9.4 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:

(a) Aerobic Composting.

(b) 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 innoculum will be used to treat the organic waste, which is the key element in our technology. The innoculum 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 windrow 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:

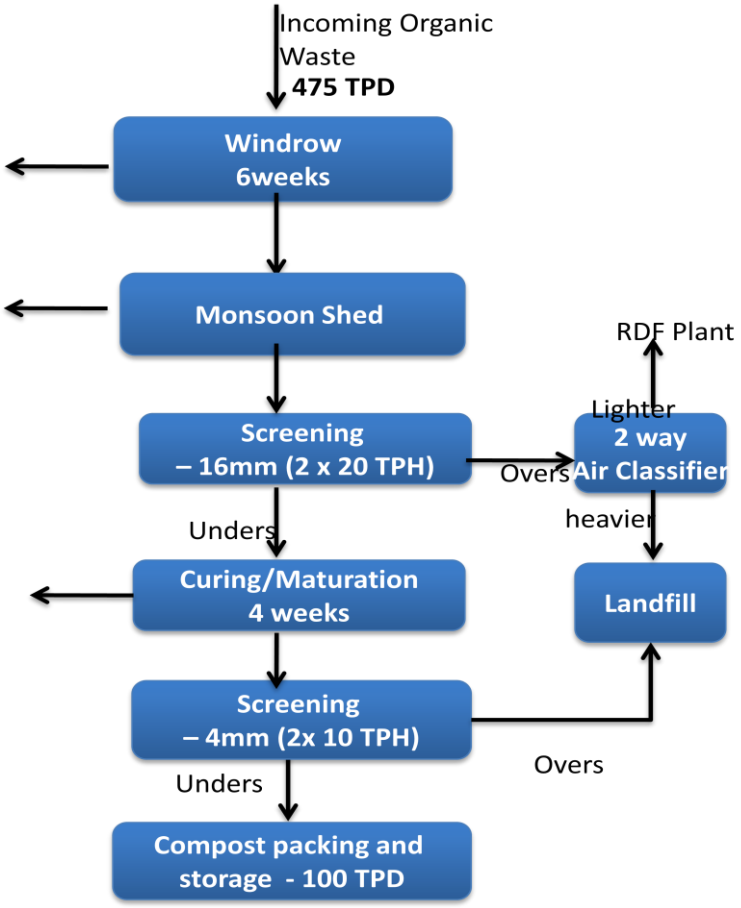


Figure 9-10: Flow of compost process

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 nitro-

gen 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 out side 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 2.5. 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 42 days.
Monsson 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 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 out side 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 2.5.
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 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 15 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 asll 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.

Windrow Platform:-

Description	Quantity
MSW Incoming waste in to the plant in TPD	475 TPD
Duration	28 days
Quantity of waste after 28 days assuming 30% reduction	420 TPD
Total average quantity of waste for 28 days	11305 MT
Density of MSW in ton/cum	0.5
Volume of Waste in cum	22610 cum
Stacking Height of waste on windrow plat form in meters	2.5 mtrs
Area required to stack the each day waste on windrow plat form in sqm/day (with base (30m x20m) and top (20m x10m))	0.60 sqm/cum
Area required for windrow platforms in sqm	13566 Sqm
Add extra for working space movement	30%
Total Area required	17636 Sqm
Dimensions of Windrow platform	**175 m x 100m**

Table 9.4: Windrow Pltform

Monsoon Shed:-

Description	Quantity
MSW Incoming waste in to the plant in TPD	333 TPD
Duration	7 days
Quantity of waste after 7 days assuming 5% reduction	316 TPD
Total average quantity of waste for 7 days	2269 MT
Density of MSW in ton/cum	0.5
Volume of Waste in cum	4539 cum
Stacking Height of waste on windrow plat form in meters	2.5 mtrs
Area required for windrow platforms in sqm	1815 Sqm
Add extra for working space movement	30%
Total Area required	2360 Sqm
Dimensions of Monsoon shed	**25m x 100m**

Table 9.5: Monsoon Shed

Primary Screening Shed: - Size of the shed - 40m x 15m

Curing Shed:-

Description	Quantity
MSW Incoming waste in to the plant in TPD	160 TPD
Duration	15 days
Quantity of waste after 15 days assuming 5% reduction	152 TPD
Total average quantity of waste for 28 days	2340 MT
Density of MSW in ton/cum	0.7
Volume of Waste in cum	3343 cum
Stacking Height of waste on windrow plat form in meters	2.5 mtrs
Area required to stack the each day waste on windrow plat form in sqm/day (with base (10m x20m) and top (10m x0.3m))	0.79 sqm/cum

Description	Quantity
Area required for windrow platforms in sqm	2636 Sqm
Add extra for working space movement	35%
Total Area required	3558 Sqm
Dimensions of Windrow platform	**35m x 100m**

Table 9.6: Curing Shed

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.

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 in-

				noculum slurry on the wind-rows
	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
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 (Re-finement)			***Proposed 2 lines with 8 hrs working***
1	Drag Chain con-veyor	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 convey-or- Z type	2		To carry <4mm screened ma-terial
5	Chain Belt con-veyor- L type	2		to carry screened oversized (<16>4mm) material
6	Grinder	2		to grind digested Organic ma-terial coming out of the Reject conveyor
7	Chain belt convey-or- Z type	2		to transfer the ground Organic material
8	Gravity separator with Aspirator	2		to remove heavy impurities mainly sand and glass pieces
9	Chain Belt con-veyor	2		to carry the screened compost to the godown
10	Chain belt convey-or	2		to carry oversized impurities coming out from Gravity sepa-rator
11	Hydraulic Power Pack	2		to generate Hydraulic Power
12	Front end loader	2		to feed semi finished material

	REJECTS SHIFT-ING			
1	JCB (Loader with Backhoe)	2		to load rejects into the tippers
2	Hydraulic Tippers	4		to transport rejects to the landfill site

Table 9.7: Equipments required for compost plant

Figure 9-11: 35/16mm primary screen & refinement screens for compost

9.5 Market Price Of Compost

The price of compost is varying from Rs l,500 to Rs.2500 per ton in different parts of the country. The price of compost depends on the quality/grade of compost, production process and place where compost sold.

MARKET PRICE OF COMPOST AT VARIOUS PLACES

Place	Manufacturer	Plant(s) At	Price (Rs./Ton)
Nasik (Maharashtra)	Nasik Municipal	Nasik	1,750 (Loose)
	Corporation		2,050 (Packed)
Delhi	Krishi Rasayan	Puri & Delhi;	2500
Delhi	Excell Industries	Ahmedabad, Calicut etc.;	2500
Ahmedabad	Exceil Industries	Ahmedabad, Calicut, etc.;,	2500

Kerala	Various	Various	2500
Andhra Pradesh	Various	Various	1500 - 2500

Table 9.8: Market for compost

9.6 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.

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

S. No	Description	Standards
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

Table 9.9: Composting Standards

10 WASTE TO ENERGY

10.1 Project Background

The proposed RDF to Power Project is approximate 8 MW Power Plant based on incineration of RDF, produced from MSW Processing Facility. The RDF can be fired in a specially designed boiler to produce steam which when passed through a steam turbine connected to an electrical generator will produce electricity through a conventional steam cycle.

An area of about 10 acres is available for setting up of the power plant in existing Kapuluppada dump yard site. Adequate area will be earmarked for the expansion while preparing the layout for the proposed power plant envisaged under this project.

The Project Site is located at Kapuluppada, in Visakhapatnam the site is easily accessible by road, railway lines and by port. Major National highway is at NH-5 (at Madhurawada) which is about 2 kms from the Project Site and the nearest railway station is Visakhapatnam. The Power generated can be transmitted to the nearest Substation at Endada, which is about 19 km. from the Project Site.

Municipal Solid Waste

RDF Production from MSW:

The parameters of RDF properties are directly dependent upon the properties of MSW which by the basic nature is not a single type of fuel, but is rather a mixture of various components. On a generalized basis the various components of MSW are as follows and its utilization is as follows.

S. No.	Component	Percentage	Used to Prepare
1	Organic Material	50 to 52 %	RDF/Composting
2	Recyclables	23 %	Plastics, rubbers etc.
3	Inert Material	25 %	Eco Bricks

Table 10.1: MSW Component

Note: All the above data is based on waste characterization

Process of MSW to RDF Conversion: As it seen it the Dry Organic matter which is converted into RDF. The generalized process is as follows.

- The solid municipal waste is unloaded in the premises of the plant, is stacked as heaps. A specific chemical is sprayed on the heaps to accelerate the bacteriological decomposition, to reduce the volume and to control odor nuisance.
- These chemicals also decompose plastics and polyethyne. The decomposed heap is sorted manually for removal of glass, stones and then allowed on to

the sieves for separation of sand, dust and other inorganic substances. These screened materials are allowed on to the magnetic separators for segregation of iron pieces.

- MSW then is homogenized and taken to the rotary screen for separating different size articles. Large size fractions are passed through magnetic separators before taking into primary shredder for further size reduction.
- MSW in India contains high moisture percentage and requires to be dried up by hot air generated in a hot air generator. It is then screened to separate sand/ grit material. The heavy non-combustibles like stones or glass are separated by Air Density Separator.
- The light combustibles like paper/ textile/ biomass separated in the process are called RDF fluff. RDF fluffs are further processed in secondary shredder and densification unit to produce RDF cakes which have approximate size of about "6 x 6 x 12" inches.

Figure 10-1: RDF Cake

- It is RDF which can be used for incineration to generate steam and subsequently. RDF can be used as an alternate fuel to conventional fuels such as coal. The heat content of RDF depends on the densification of the waste and its combustion characteristics. Hence, RDF yield and calorific value are inversely proportional to each other; higher calorific value requires higher densification which shall subsequently reduce the yield.

10.2 RDF based Power Plant

It is this RDF, solid and liquid (if any) produced from the MSW which shall be used as fuel to generate power. The potential of Power Generation from MSW is as follows:

Period	MSW Generated *(TPD)*	Power Generation *(MW)*

2002	97174	1638
2007	148066	2550
2012	214865	3688
2017	303627	5192

Table 10.2: Power Generation Potential from MSW

Also it is important to note that the similar RDF plants also exist in India which is as follows.

- Hyderabad-6 MW

  Project was implemented in two phases (i) production of fuel pellets from MSW; and, (ii) generation of 6.6 MW of power from pellets.

  The pelletisation plant has the capacity to produce 210 tpd of RDF in the form of fluff / pellets by processing 700 tpd of garbage.

- Vijayawada - 6 MW

  M/s Shriram Energy Systems Ltd., Hyderabad have set-up a 6 MW power generation project at Vijayawada based on combustion of processed MSW.

  About 150 tonnes per day (tpd) of Refuse Derived Fuel is being produced by processing 600 TDP of MSW of Guntur and Vijayawada cities based on the technology developed by the Technology Information Forecasting and Assessment Council (TIFAC), Department of Science & Technology.

- Lucknow (5 MW)

  The project aims to process about 300 tonnes per day of Municipal Solid Waste of Lucknow city to obtain about 115 tonnes per day of dry volatile solids. To produce about 50,000 cubic meter biogas and about 75 tonnes of organic fertilizer per day.

  The produced biogas is to be used in five biogas engines to generate 5MW of grid quality power.

  Commissioning of this project has been terminated by the project developers due to some operational problems.

- Delhi (21 MW)

  Jindal ITF Centre, 28, Shivaji Marg, New Delhi-110015, Timarpur Okhla Waste Management Plant generates 21 MW energy using approximate 1600 to 1700 TPD of municipal solid waste.

  JITF Urban Infrastructure Ltd (Formally Jindal Urban Infrastructure) won the bid to develop the project on a Built Own Operate and Transfer (BOOT) basis,

in a Public private partnership with the Delhi Government as legal Entity: Timarpur Okhla Waste Management Co Pvt Ltd.

The Okhla Waste to Energy (WtE) project is India's first large scale Waste-to-Energy facility that aims to disposes and process 1/3rd of the Delhi garbage and converts into the much-needed Clean Renewable Energy, enough to serving 6 lakh homes.

Regulatory Framework in Power Sector

As per Electricity Act 2003 (Act), any generating company can set up a thermal power station without obtaining any license. SWACHHA ANDHRA CORPORATION intends to sell the power to the state distribution license; certain provisions of regulations of Andhra Pradesh Electricity Regulatory Commission (APERC) would be applicable here. Further, the Act also has laid down provisions which direct the Regulatory Commission to make it binding for the Distribution utilities to buy a specific portion of their energy requirement from renewable sources of energy. Further, the National Tariff Policy also stresses on the aspect of purchase of electricity through non-conventional energy sources and also states that the proportion of purchase from renewable sources must be increased gradually.

APERC was constituted under the provisions of the erstwhile Electricity Regulatory Commission Act, 1998 and is vested with the authority to regulate the working of the electrical utilities in the State and is charged with various functions, inter-alia, including the determination of retail Tariff Rates for the end users of electrical energy. APERC has been issuing a number of order and regulations in compliance to the functions vested in it by the provisions of the laws. APERC has also taken out a policy for promoting Renewable energy whose salient points are as follows.

Any person generating electricity from renewable sources, irrespective of installed capacity shall have mandatory open access to any Licensee's transmission system and/or distribution system or grid as the case may be.

On an application from such person, the transmission licensee or distribution licensee or STU shall provide appropriate interconnection facilities, as feasible, within the time period specified under the standards of performance regulations applicable to respective Licensees.

Such interconnection shall follow the grid connectivity Standards as may be specified by the Authority.

APERC has notified the Andhra Pradesh Electricity Regulatory Commission (power procurement from renewable sources) Regulations, 2004 in which it has mentioned that tariff for purchase of electricity by the distribution licensees. Also as per the provisions of the said Regulations, APERC shall determine the tariff

separately for different technologies and it was also permit an allowance considering various factors including the technology used and social contribution of the project.

The RDF based power generation plant to be developed by Swachha Andhra Corporation at Visakhapatnam for the proposed power plant in Visakhapatnam does not fall in any of the above categories for which tariff has been determined by APERC.

10.3 Fuel Analysis

RDF Fuel Properties

The RDF characteristics produced is actually dependant on the MSW produced by the various cities. Unlike fossil fuel like coal or gas, RDF properties vary from season to season and city to city since it is directly linked to the MSW properties. As already stated earlier in this report, it is the Dry Organic matter of MSW that is primarily processed into RDF and it is this portion which varies.

The RDF Properties of the Pluff which will be used for the plant on a generalized version would be as follows.

S. No.	Description	Unit	Value
1	Moisture Content	%	10.00
2	Ash	%	20.00
4	Volatile Matter	%	63.00
5	Fixed Carbon	%	7.00
6	Calorific Value	kcal/kg	~2250

Table 10.3: Tentative RDF properties

The important to understand that the RDF properties defined above is a generalized average version of the RDF properties obtained from the MSW processing plants in Gujarat, and for each season this RDF property would change. HBE in its MSW processing plants would aim to process the MSW to produce the RDF of the properties outline above. However since there is no control on the type of MSW which is generated by the various cities, the actual RDF could have variations from the properties outlined above. Also as indicated by HBE, broadly the GCV of the RDF will vary between 2000-3000 kcal/kg over the year.

10.4 Site

The tentative land requirement for the main plant and the balance of plant is given below.

S. No	Location	Area in Acres
1.	Fuel Storage Yard	1
2.	Main Plant	3
3.	Fuel Handling System	1
4.	Water pond 1 & 2	2
5.	RO plant +Clarifier + Common Monitoring+ basin+ Ash Silo	1
6.	Cooling water + Circulating Water	2
7.	Total	10

Table 10.4: Land requirement

10.5 Plant Technical Features

Selection of Steam Cycle

The two major considerations for the selection of the steam cycle parameters is:

- Higher Plant gross efficiency
- Consideration of metallurgy of boiler tubing, piping and turbine components based on operating temperature and pressure.

The selected Steam cycle is Rankine cycle with superheat (and no reheat) steam generation and single extraction (for Deaerator heating) cum condensing in a steam turbine for power generation.

Higher the pressure and temperature, higher will be the efficiency, the increase in temperature having a more pronounced effect. The selection of the pressure and temperature depends on various factors like availability and cost of turbines in this range, boiler feed water quality (at higher pressure and temperature the boiler feed water quality requirement becomes more stringent), cost of boiler, etc. The practically attainable limits of temperature are limited by the metallurgy of the boiler tubing, piping and turbine components.

Plant Systems

Power plant process description : The power plant is based on Rankine cycle

with one regenerative heating in which fuel is fired in a boiler, which generates steam. The steam generated in the boiler is expanded in a steam turbine generator to generate electricity. The steam turbine will exhaust steam to a water cooled condenser where it is condensed and fed to the Deaerator by condensate extraction pumps. In the Deaerator the oxygen present in the "feed water to the boiler" is removed by direct heating by steam. The steam for deaerating and heating the feed water is supplied from the steam turbine extraction. The heated feed water is pumped into the boiler-using boiler feed pumps.

Water requirement and availability: The water is required as a make up to the cooling tower based cooling water system as well as steam cycle in addition to the general services requirement of the plant.

Description of RDF fired Boiler

The Boiler will be capable of firing RDF. The RDF will be uniform / non-uniform in size, properties may vary from season to season and calorific value may vary over a narrow range. Various aspects such as corrosion, erosion, clinker formation, etc will be taken into account while designing boiler for firing RDF.

The critical aspect of the boiler is indicated below:

- Pressure parts will be so designed that corrosion and erosion are avoided by avoiding high flue gas velocities and sharp changes in direction of flow. Suitable firing system would be designed to burn RDF and to take care of clinker formation.
- The RDF from the storage to an underground hopper (3 m x 0.5 m) and then to a Belt feeder which in turn feed the boiler receiving chute through a belt conveyor. This chute supplies the RDF to a lower chute through a hydraulic ram. The fuel from the lower chute is conveyed through a drag chain feeder, which in-turn distributes the fuel to an air swept spout and high-pressure air will be used to distribute the RDF uniformly. The rate at which fuel is deposited into the air swept spout is based on the fuel demand.
- The furnace will be water wall type with a protective coating, or refractory lining for furnace walls. In order to reduce the corrosion the boiler will be either refractory lined internally with Silicon Carbide refractory or water wall coated with eutectic coating. Number of passes in the boiler may be decided keeping in view of the erosion properties of the ash in flue gas.
- The Boiler will have a Gas re-circulation system to re-circulate the flue gas thus enabling the reduction in un-burnt carbon, reduction in the excess air required. Thus provision of a gas re-circulation system will increase the Boiler efficiency.
- Super heater will be located either in the convective zone or provided in the

radiant zone with baffle protection arrangement to avoid erosion of tubes.

- Boiler drum will be designed to take into account maintenance and replacement of Boiler bank tubes.
- All other pressure parts like evaporator, economizer, etc will be designed similar to conventional boilers
- Soot removal can be either by steam soot blowing or by continuous rapping and hammering of Superheaters, economizers, evaporators etc. Steam soot blowing is cheaper from investment point of view but the coils near the soot blower will have to be replaced frequently due to erosion by high-pressure steam. In view of the extensive dust deposits expected on tubes, the boiler will have an adequate cleaning system in place to remove combustion dust settled on boiler surface impairing heat transfer, which ultimately affects the steam generation. Steam operated soot blowers or mechanical cleaning devices in adequate numbers may be provided so that effective removal of dust is ensured.
- The boiler is designed to fire 100% RDF, either solid or liquid. Other features of the boiler will be similar to any other conventional boilers.
- The minimum temperature of exit flue gas temperature may be limited to 150 ºC considering sulphur content in the fuel.
- It is important to keep SPM in flue gas as limited to 50 mg/Nm3 which is much below the CPCB requirement. Number of fields in ESP will have one spare field, so that even in case of one field down condition SPM levels are maintained at 50 mg/Nm3.
- Suitable sealing arrangement will be provided in the fuel feeding system and the stoker/traveling grate for preventing cold air ingress into the furnace.
- Required Chimney height will be provided according to the CPCB requirements.

Turbo Generator System

The steam turbine will be horizontal, single uncontrolled extraction condensing type. The turbine is designed for main steam parameters according to the net plant output across the Generator Terminals

All casings and stator blade carriers design will be such as to permit examination of the blading without disturbing shaft alignment or causing damage to the blades.

The casing towards the lower pressure region will have a bottom exhaust arrangement configuration and the exhaust casing will be suitable for connection to the condenser without air leakage and hence suitable for maintaining the con-

denser vacuum.

The turbine will be provided with liberally rated hydrodynamic radial and thrust bearings.

All bearings will be accessible without having to remove cylinder covers.

The glands will preferably be of labyrinth type and sealed with steam.

A pressurized lubrication and control oil system will be provided for the turbo generator unit to supply oil at the required pressure to the steam turbine, gear-box, generator and governing system.

The turbine governing system will be designed for high accuracy, speed and sensitivity of response.

The governing system will have the following important functions:

- Speed control
- Over speed control
- Load control
- Inlet steam pressure control

The governor will be configured to incorporate the controls while operating in parallel with the grid.

Other Mechanical System

Condenser :The condenser shall be of surface type condenser designed as per the requirements of Heat Exchange Institute Standards for Steam Surface Condensers The cooling water for the condenser will be supplied from the cooling tower basin through cooling water pumps and the water will be treated.

Ejector System: One steam operated hogging ejector of single stage will be provided for the initial pulling of the vacuum in the system.

Condensate Extraction Pumps: Condensate Extraction Pumps of suitable type can be provided. The pump shall be selected for a normal continuous flow rate equivalent to the maximum steam flow to the condenser under all operating conditions.

Boiler Feed water Pumps: The pumps will take suction from the feed water storage tank and will supply feed water to boiler through the feed control stations.

Deaerator and feed water storage tank: For de-aerating and heating of the feed water, suitable type deaerating heater will be provided.

Plant water system and Water Balance: The water requirement for the project can be fulfill by using Bore water, river water or sea water.

The water will be stored in a storage tank/reservoir. The raw water from reser-

voir will be treated in water treatment plant.

The treated water will be used for Boiler and other plant requirement.

Waste effluents collected from the plant will be retreated and reused.

The cooling water system shall cater to the cooling water requirements of Condenser, Generator Air cooler, TG Lube Oil cooler, Compressor etc.

Compressed Air System: A suitable air compressor system will be required for meeting the instrument and service air requirements of power plant.

Cranes & Hoists: TG Building will be provided with an EOT Crane with pendant operation, for erection & maintenance requirements of turbo generator.

Ventilation system: TG Building ventilation system would be dry type ventilation with louvers and roof-mounted exhausters.

Air Conditioning System: Air conditioning system will be required for main control room.

HP/LP Piping: The piping for the plant will consist of HP piping and LP piping.

Fuel handling system

The RDF plant will be made available at the Boiler RDF storage shed. A grab crane for loading RDF into the ground hopper will handle the RDF stored in the storage building. Alternatively The RDF will be dosed into a long ground hopper using dozers. The RDF from the long ground hopper will feed a belt conveyor. It would be ensured by manual operation that the dozed RDF falls onto a belt conveyor, which will feed the Boiler RDF receiving bin. The RDF from the RDF receiving bin will be pushed in by a hydraulic ram to a drag chain feeder, which will control the feed of RDF to the boiler. The drag chain feeder will feed the RDF to an air swept spout. From the air swept spout, the RDF will be distributed pneumatically to the boiler traveling grate. The RDF handling system will be provided with all necessary fire protection system and dust suppression system. The belt conveyor will be hooded type.

The RDF handling system will be designed with adequate margin over and above the RDF consumption rate of the boiler.

Ash handling system

Ash generated during the operation in the power plant will be suitably collected and disposed.

Workshop and laboratory facilities

The workshop will be equipped with sufficient machineries to carryout routine plant maintenance requirement like machining, cutting, welding etc. The laboratory will be equipped with instruments and apparatus to carryout analysis water

and effluent.

Fire fighting facilities

Fire protection system will be provided as per LPA norms. The water for the Fire water system (FWS) will be fulfilled by treated water from water treatment plant.

The fire protection for the power plant will be as follows:

- Hydrants covering TG building, boiler areas, fuel-handling plant, pump houses, miscellaneous building etc. The system will be complete with piping, valves, instrumentation and nozzles.
- Portable and mobile fire extinguishers will be provided in strategic locations throughout the plant, especially in the control room and near transformers.
- Fire alarm and detection system will be provided for control room, electrical room and cable galleries.

Electrical Equipment and Systems

General Description: The system consists will consist of one number STG for required 6 to 8 MW power plant, the generation voltage being 6.6 kV.

Design description: The design concept of the electrical system as a whole is based on the requirements for the safe and reliable performance of steam turbine generator set and the interconnected electrical system with provision for easy maintenance and overhauling.

Grounding:

- Generator neutral will be earthed through Neutral grounding resistor (NGR).
- Generator Transformer HV neutral will be solidly earthed.

Generators:

The generator coupled with steam turbine will have the following salient technical features.

Description	Value
Type	Synchronous generator
Rated capacity	10 MVA to suit the Turbine rating
Generator	Air cooled
Secondary cooling	Water
Rated speed	3000 rpm

Table 10.5: Tentative Generator Parameters

Generator will conform to IEC-34. The generator will be capable of withstanding short circuit level as per IEC.

Tentatively The generator winding will be star connected and

Surge diverters and protective capacitors will be provided near STG to protect the insulation of the generators from the onslaught of surges, both from steepness of wave front and magnitude of surge level.

The generator will be provided with either brush less excitation system consisting of exciter with rotating diode assembly along with Permanent Magnet Generator (PMG) or static excitation achieving high degree of operational reliability and minimum maintenance.

The excitation system will have fast response time to meet the system requirement.

AVR response time will be short so that it can control generator during system disturbances requiring rapid changes in excitation to maintain the system dynamic stability margins.

Excitation system will be provided with power system stabilizer for achieving dynamic stability under varying operating conditions. The excitation system will have in-built protective as well as limiting devices so as to safeguard the generator and excitation system against all possible faults, troubles and mal-operation, if any.

The static thyristor excitation system will be equipped with features such as cross current compensation, volt / frequency ratio controller, slip stabilization, rotor angle limiter, stator and rotor current limiter, follow-up circuits, field suppression gear.

The generator will be provided with seal oil system, stator water cooling system and C02 system for purging of hydrogen.

Generator Transformers

The generator transformer will be designed to deliver the total output of the generating unit into the system and will have the following salient technical features. It shall be suitable for Bi directional power flow.

Description	Value
Type	Oil filled, outdoor type
Voltage Ratio	6.6/33 kV
Frequency	50 Hz
Vector Group	YNd11

Percentage Impedance	10% Apprx.
Capacity	10/12 MVA
Cooling	ONAN
Taps Type	OCTC
Taps Range	+/-2.5 %
HV side Grounding	Solidly

Table 10.6: Tentative Generator Transformer Parameters

Auxiliary Transformers

Two numbers of 6.6 kV / 415 V LT transformers are considered.

Description	Value
Type	Oil filled, outdoor type
Voltage Ratio	6.6/0.433 kV
Frequency	50 Hz
Vector Group	Dyn11
Percentage Impedance	6.25% apprx
Capacity	1.25 MVA apprx (to suite site conditions)
Cooling	ONAN
Taps Type	OCTC
Taps Range	+/-5 % in steps of 2.5 %

Table 10.7: Auxiliary transformer parameter

Busducts

LT Busduct: The secondaries of the LT transformers will be connected to the individual 415 V power control centres through 415 V busducts. The busducts will be non-phase segregated type with hard drawn high conductivity electrolytic grade aluminum alloy of electrical grade 63401-WP as per IS 5082. The continuous current rating of the busducts is selected considering the full load secondary current of the transformers.

Busduct Supports & Enclosures: The supports and buses are to be designed to withstand the electro-mechanical and thermal stresses set up during short circuit condition without damage or deterioration of the material. The maximum temperature of the bus and the enclosure will be limited to 90 Deg. and 70 Deg.

respectively.

MCC and PCC

Motor control centers (MCC) and Power Control Centre (PCC) will be of sheet steel cubicle and fully draw-out type Construction with dust &vermin proof and free standing type. The PCC and MCC will consist of vertical sections, each section having separate compartment for individual motors/drives/MCC feeders. Each compartment will have a control unit for a circuit which will comprise switch fuse, contactors, relays, push.-buttons and indicating lamps in the case of MCCs and air circuit breakers, relays, push-buttons and indicating lamps in the case of PCCs.

The buses will be of electrolytic aluminum or copper supported on FRP supports and will be designed to withstand, without damage, for a fault of minimum 50 KA RMS at 415V for one (1) second duration.

Switches will be TP / TPN, air break type capable of safe breaking of the full load current on connected feeders. MCCB will also be used in lieu of switch and fuse.

A few DC motors in the system of emergency services would be provided with starters with DC magnetic contactor, wherever required.

Equipment for Hazardous Areas:

Electrical equipment such as motors, push button stations, lighting fixtures, junction boxes etc. located in hazardous areas will be provided with increased safety or flameproof type enclosures as per relevant standards and area classification requirements.

Protective System

For protection of equipment against abnormal system conditions, adequate protective devices will be installed in the respective switchgears and/or control and relay panels. A group of such protective devices may be necessary to protect the equipment under different abnormal conditions arising in the system. Each equipment will be provided with an unit as well as backup protection.

Besides this, protection against lightning surges will be provided with lightning arresters at suitable locations for outdoor equipment over and above the shielding wires and lightning masts. In any case, proper discrimination and selectivity will be provided so as to isolate only the faulty elements, keeping the healthy part of the system in service. The protective relays will be of numerical type.

The major electrical equipment will be provided with the protections as listed below:

- Generator Protection
- Over & Under voltage

- Under & Over frequency
- Field failure
- Reverse power
- Low forward power
- Voltage restrained over current
- Generator differential
- Stator standby earth fault detection
- Local breaker back up / struck up
- Negative sequence
- Rotor earth fault protection
- Ground differential or sensitive directional stator earth fault relay with necessary instrument transformers / CBCTs.
- Transformer and 33 kV Line Protection will be as follows:
- Transformer differential
- Restricted earth fault relay
- Distance relay of numeric type
- Directional over current and earth fault relays
- Non-directional over current and earth fault relays for primary & secondary
- Transformer HV side standby earth fault relay
- Over fluxing relay
- Under / Over frequency & dF / dt relay

Grounding and Lightning Protection:

The plant grounding system will be designed as per the requirements of IEEE-80/IEEE 142 / IS-3043. Earthing system will include earth pits, forming earthing bus and connections to earth. Earthing grid and interconnections of all equipment requiring earthing to the grid will be arranged. The main earthing grid will be formed with GI conductors of size not less than 50x6 mm. Sizes of other equipment will be as per the IS and statutory regulations.

The earth mat of the station will be designed such that the total ground impedance does not exceed 1.0 ohm. Each large structure and building complex will have a ground loop around its perimeter. The ground loops around each structure will be connected to the ground grid and interconnected with each other.

The fence within the ground grid will be bonded to the plant ground system. The power plant ground grid will be tied together with the switchyard ground grid. The grounding system will be connected to all metallic equipment, electrical as well as non-electrical (except underground pipelines), located at the plant site. All these will be connected at two distinct points. This will include all structures, buildings, towers, etc.

The chimney and powerhouse building will be equipped with lightning protection. Lightning protection conductors located on the top of the structures will be connected to the ground loop surrounding the structures with down comers as per the provisions contained in the latest issues of Indian Electricity Rules and IS 2309.

Lightning protection system will be complete with Horizontal / Vertical conductor/spikes, earthing electrodes and Installation accessories as per the codes and practices for lightning protection IS 2309 and recommendations of IS 3043. Lightning protection will be envisaged for the tall structure, including chimney, boiler, TG hall and Cooling tower.

Power and Control Cables

HT cables will be of aluminum conductor XLPE insulated, screened, sheathed, armored and over all extruded FRLS, PVC sheathed. The outer sheath of the cable will be supplied by extrusion over the armoring and will be of fire retardant low smoke (FRLS) type PVC compound confirming to the requirements of type ST2 compound of IS: 5831.

The LT cable will be of 1100 volt grade, single or multi core, stranded aluminum conductor, extruded HR Type C PVC armored with galvanized steel wire or strip for multicore cables and aluminium wire or strip armoured for single core cables, outer sheathed with extruded HR Type C PVC type complying with IS: 1554 Part I &II.

1100 volt grade, multi core, stranded annealed high conductivity copper conductor (class 2 as per IS 8130) extruded PVC compound type A insulated, cores identified by numerals, cores laid up, inner sheathed with extruded PVC compound type ST1 armoured with galvanized steel wire / strip and outer sheathed with extruded FRLS PVC compound type cable complying with IS: 5831.

Illumination System

The plant lighting system will comprise the following categories.

- Normal 240 V single phase AC lighting system
- Normal-cum-Emergency 240 V Single phase AC lighting system
- Emergency DC lighting system

- Normal 415 V AC Lighting System

Normal 240 V single phase AC lighting system: In this system, the lighting circuits will be fed by the 1 phase, 2 wire normal AC supplies available from the normal lighting distribution boards. The plant lighting (illumination level) is varying at different locations of the Plant depending on the utility and nature of work expected to be carried out at that area.

Normal cum Emergency 240 V AC lighting system: Certain lighting fixtures considered essential should be connected to this system. In this system the lighting circuits will be fed from another lighting distribution board from normal / emergency section of the 415 V main switchboard. The lighting fixtures connected to this system will be available whenever normal supply is available in the plant and also whenever emergency DG set supplies the power to this bus section during blackout conditions. During blackout conditions, the lighting fixtures connected to this system will go off and will come back as soon as the DG set starts feeding power to the 415 V normal emergency bus section.

Emergency DC Lighting System (Emergency self contained battery backup) : These lights will be with portable self-contained battery / automatic charger units. These portable emergency light units will be switched on automatically in the event of loss of normal AC supply.

Normal 415 V AC systems: For these systems, the distribution will be by 415 V, 3 phase, 4 wire, 50 Hz supply with effectively earthed neutral. This supply will be derived from 415 V, 3 phase, 3 wire, 50 Hz unit service switchgear by providing a 415 / 433 V delta / star lighting transformer of 25 KVA (Dry type). The transformer will be Class B, EPOXY encapsulated. The secondaries of lighting transformers will be connected to 415 V 3 phase, 4 wire, AC lighting distribution boards (MLDB / LDBS). The MLDB / ELDBs will be provided with number of outgoing circuits controlled by MCBs to feed the LDB'S covering all indoor & outdoor Areas.

Lighting Supply Distribution System: LDB will have 3 phase, 4 wire incomer and number of 1 phase outgoing circuits controlled by MCBs. Lighting panels feeding the lighting fixtures in indoor areas will be controlled from the respective lighting panels located in various buildings in the plant.

Station DC System

The DC power system provides DC power to protection and control requirements and the essential loads that are required to function on a loss of AC power. The DC system comprises of:

- 110 V DC battery
- Battery chargers (float cum boost charger)

- DC distribution boards

Battery: The batteries will be sized for the required load and one hour duty cycle duration, taking into account approximate temperature correction, design margin and ageing compensation factors. The battery will be maintenance free lead acid type conforming to latest version of IS and suitable for indoor operation. The plates will be designed for maximum durability during all service conditions including high rate of discharge and rapid fluctuation of load.

Battery Chargers: Two sets of battery charger (float cum boost) of suitable capacity will be provided for quick boost and trickle charging. The charger will be natural air cooled, solid state type with full wave, fully controlled, bridge rectifiers. The charger will be provided with automatic voltage regulation, current limit circuitry, smoothing filter circuit and soft-start feature. Voltage control will be stepless, smooth and continuous. The charger will be self-protecting against all AC and DC transients and steady state abnormal currents and voltages.

DC Distribution Boards: The main DC distribution boards and other DC switchboards will be suitably designed to meet the requirement of the plant and these boards will have short-circuit ratings consistent with the available short circuit current.

Uninterruptible Power Supply System

The uninterruptible power supply (UPS) system furnishes a reliable and interruption free source of required voltage, three/single phase power to equipment/instrument vital for plant control and emergency shutdown.

2 X 100%, 230 V AC Single Phase, 50 Hz, UPS System, complete will be furnished for the Power Plant sized to feed essential AC loads like DCS and other C&I equipment. The DC supply for the UPS system will be sourced from station DC system.

The UPS system will be provided with two (2) nos. 100% capacity inverter. An alternative 230 V A.C. single phase source through by pass transformer and stabilizer is provided through a static transfer switch to feed the vital A.C. loads during the failure of both the inverters. The changeover from inverter to by-pass transformer will not be more than 5 ms.

Emergency DG Set

1No. 315 kVA emergency DG sets will be provided to cater the loads during emergency conditions. Emergency Diesel Generator would be feeding all emergency loads of SG / STG.

The emergency generator will be provided with the following controls:

- A local control and relay panel will be provided for emergency generator located in building.

- Remote control facility to operate Emergency Generator from the Main Control Room will be provided.
- DG set will be installed indoor and housed in a separate building.

Cable Installation System

The system comprises of cable trays and concrete encased underground trenches. The tray and conduit system provides support and mechanical protection for cables. The cable trays will be of the steel pre-fabricated type, connected together as an integrated unit. The vertical spacing between any two cable trays will be 300 mm minimum. Separate cable trays will be used for HT power, LT power, and control & instrumentation cables. All outdoor runs of cables will be routed on overhead trays or buried directly in ground depending upon the layout considerations to be worked out during detailed engineering.

33 kV Switchyard

33 kV Switchyard will be provided, as power will be evacuated at 66 kV level. The generator is connected to the 33 kV switchyard through a generator transformer. The 66 kV switchyard will be provided with the following bays in single bus configuration 1 No. Generator Transformer cum Line Feeder. The switchyard will be of outdoor air insulated type. The outdoor switchyard layout shall be designed on the clearances as per CBIP manual. The equipment buses will be with ACSR conductor. For the outgoing 66 kV line, the terminal point shall be the Take-off gantry in the switchyard

The switchyard will be of outdoor air insulated type. Provision for Future expansion of one more bay is considered in the switchyard. The switchyard will be provided with necessary current transformer, capacitor voltage transformers, surge arrestors, protective relays etc.

All electrical equipment and system shall be designed, constructed, tested and installed in accordance with the latest edition of IS and/or IEC codes and standards and shall comply with Indian Electricity rules and their latest amendments, wherever applicable. In addition, recommendations made in CBIP (Central Board of Irrigation & power) will be followed for good engineering practice.

The switchyard will be complete with Circuit Breaker, Disconnecting switches, Voltage Transformers, Lightning arresters, Current Transformers, ACSR, Insulators, Clamps, Connectors and other necessary hardware and Galvanized steel structures.

Cable trenches will be provided in the switchyard to accommodate power and control cables from marshalling kiosk in the yard to the respective panels in the Switchyard Control Room. The cables entering the control room will be laid in pipes with suitable sealing at wall openings to prevent entry of water into the building through the cable Trench.

The control, monitoring and operation of the 33 kV switchyard will be through a dedicated operator interface station in the Central Control Room of the power plant.

Current Transformers: The current transformers will be single phase, core type, oil immersed, self cooled outdoor hermetically sealed type. The current transformers will be used for relaying and metering of 50 Hz, 3 phase system having a nominal system voltage of 33 KV.

Voltage Transformers: The voltage transformers will be single phase two limbed core type, oil immersed, self-cooled outdoor type suitable for use on the stipulated electrical system. The voltage transformers will be used for metering operated as a group of these, star connected pm 50 Hz, 3 phase system.

Lightning Arrestors :The lightning arrestor will be heavy duty, station clam type, discharge Class III, gapless Zinc Oxide type rated for 30 KV and suitable for use in 33 KV solidly earthed neutral system, 10 kA current rating.

Busbars: Busbars and electrical connections in the outdoor area will be of aluminum. Busbars will be in continuous lengths between supports and provision will be made for expansion and contractions with variation in conductor temperature including sliding supports where necessary. Busbars and connections will be so arranged and supported that under all circumstances, including short circuit conditions, the clearances specified will be maintained. The tubular buses will be of aluminium alloy for electrical purposes. The tubes will be hard drawn extruded from pure electrolytic aluminium rods and will conform to IS: 5082.

Stranded conductors - The stranded conductors will be ACSR,

Insulators and Hardware: The porcelain used for string and post insulators will be sound, free from defects, thoroughly vitrified and smoothly glazed. Insulators will have a good luster and of uniform brown colour.

Clamps, Connectors, Fittings and Accessories: The connectors and clamps will be made of aluminium alloy casting conforming to A6 of IS: 617. All bolts, nuts and washers will be of mild steel and hot dip galvanized.

Control and Instrumentation

For ease of operation the entire plant has been divided in the following sub plants like:

- Steam Turbine Generator (STG) along with its auxiliaries, vacuum and condensate system etc. (Operation, Control and Monitoring from DCS at CCR).
- Steam Generator (SG) along with its auxiliaries air & flue gas system, fuel feeding system etc. (Operation, Control and Monitoring from DCS at CCR).
- Auxiliary Electrical System (Operation, Control and Monitoring from DCS at

CCR).

- Compressed Air system (Control from Local with status monitoring at DCS.
- Fire Alarm and detection system (At Fire House and Repeat Alarm at CCR.
- Cooling Water System (Operation, Control and Monitoring from DCS at CCR.
- The I&C System will be configured to perform the following basic functions.

Automatic sequencing of the start-up and shutdown of major equipment and auxiliaries including group/plant level start-up to minimize operator's intervention under normal operating conditions would be present.

Regulation functions for various valves and dampers to achieve guaranteed performance and to achieve the most fuel-efficient operation.

Acquisition, display and archiving of plant data and generation of reports.DCS based Control System [both binary sequential and modulating] synthesized from one general family of identical, interchangeable and multifunction hardware has been envisaged for the plant.

The entire unit operation and monitoring i.e., start up, loading, normal operation; shutdown etc. will be possible through operator's CRTs located at Central Control Room.

The Central Control Room (CCR) will house operator's stations, printers, auxiliary console for emergency stop/reset push buttons and critical parameter annunciation, console for Electrical System and engineering station together with Generator control and protection panel, Automatic Voltage Regulator (AVR) Panels, Generator Metering and Synchronizing Panels, Switchyard Relay Panels, Switchyard Metering Panels, Electrical Control panels, Fire Detection and Protection panel, plant communication system panel, etc.

All electronic system cabinets for DCS, interposing relay cabinets, Uninterruptible Power Supply (UPS) cabinets and power distribution boards, UPS Inverter Panels, Battery Charger and electrical interface panel if any, etc. will be located in the Control Equipment Room (CER) adjacent to the CCR.

Both Central Control Room (CCR) and Control Equipment Room (CER) will be air-conditioned and false ceiling & false flooring for convenience of cable marshalling.

In the event of loss of a major plant item, activities of binary and analog controls will be coordinated to ensure that the plant is automatically brought to a safe holding condition consistent with maintaining maximum generation permissible under reduced plant availability. Local monitoring and control facilities will be provided for operations, which demand local attention.

Local monitoring will be provided in cases where such indications are required

for maintenance [like discharge pressure gauge for pump], commissioning and tuning of equipment and where recommended by equipment manufacturers for local supervision in case of emergency.

All control valves will be provided with hand wheel and local monitor to perform local operation.

Instrumentation Special Requirements

This section provides the instrumentation requirements, measurement philosophy and concepts applicable for the project.

An indicative DCS system Architecture will be provided.

For hardware configuration, the following guidelines will be followed:

- For protection of Boiler, Turbine and Generator modular redundant hardware will be considered.
- For balance protection, all control loops and sequential logic and related measurement, redundant hardware will be considered.
- For Open Loop Controls all Trip contacts will be based on single sensor, fail safe type. However dual redundant sensors with provision for on-line selection may be considered for few critical applications only.
- For balance measurements, non-redundant hardware will be considered. Separate sensor for control & protection and separate sensor for monitoring purposes will be considered.
- For critical controls 1 out of 2 redundant sensors/transmitters will be used.
- Other closed loop controls and interlocks logic for main plant and utility packages (like water treatment, air compressor, fuel handling and ash handling system etc.) will be implemented with single sensors.
- Group wise as well as individual start-up through CRT will be provided for plant start-up. Basic safety protection will be maintained for individual drive start/stop. During group operation, all protections will be maintained. Provision will be there to over-ride non-safety related interlocks from operator's console.
- Plant Operation will be carried out through CRT based operation.
- All Signal and Control Cables will be of FRLS type and heat-resistant in hot zones. All cables from field to junction box will be through flexible conduit upto tray/sub-tray/rigid conduit. For Network Cables GI Conduit will be provided. All junction boxes will be provided with 20% spare inlet & outlet ports. Clip-on type Elmex or equivalent make terminal blocks will be provided with 20% spare. All unused cable entry ports will be shielded with rubber grom-

mets. JB housing will conform to IP-65 and JB covers will be provided with handles.

- Field termination of all inputs/outputs is necessary in marshalling cabinet. No cable will be directly terminated in cards/modules. System will be able to accept both grounded/ungrounded type inputs.
- Contacts inputs will be dry/potential free type. Alarm contacts will be either close or open to alarm (configurable). Contact inputs will be provided with contact bounce filtering to protect against input device bounce and electrical noise on input lines. All inputs will be taken through interposing relays for isolation and contact multiplication.
- Contacts outputs will be provided for various drives such as solenoid valves, MCC / Switchgear control circuits etc and the contact rating will be 5 amps at 230 V AC, 50 HZ inductive. Provision in output card will be such that use of external snubber resistors will not be required. Each output will be fed through an independent interposing relay having minimum 2 NO & 2 NC contacts (mounted in separate relay panel).
- All Instrumentation cable trays will be closed and vertical type and will be preferably located beside walkways. All sub-trays will be perforated Gl or Al. All cable entry points to instruments, junction boxes and panels will be provided with suitable dust and water tight double compression type glands.
- For Testing of the DCS, Factory Simulation Test should be carried out apart from standard inspection and testing procedures.
- I&C equipment, installed in hazardous area, will be intrinsically safe in accordance with relevant standard. All intrinsically safe equipment will be certified by recognized national and international agencies.
- Safety earthing and I&C system earthing will be separate. Safety earthing bus will be connected to main plant earthing pit. Separate earth pit/s will be provided for system earthing bus (electronic earth). Electronic earth will be cabled directly to the corresponding earth bar. Separate earthing will be provided for intrinsically safe system.

Civil Works

Power block area: The Powerhouse and control room will be a RCC framed structure or steel structure. The Powerhouse roof will be of steel truss with colour coated steel sheeting. Necessary provision will be made for EOT cranes with approach platform, ladders etc. The wall cladding will be of brickwork up to roof. Necessary Rolling shutter/Door/window opening as per Factory Manual norms will be provided. All the floors will be covered with RCC slabs. Mezzanine and STG floor openings will be provided at maintenance bays and all round platforms

considered. The control room is fully Air-conditioned with false Ceiling and under deck insulation has been considered. Cable cellar room, switchgear, battery & battery charger floors also considered in the control building. The adequate number of service rooms with toilet facilities etc. will be provided for personnel. Suitable staircases, handrails and plinth protection will be provided. The foundations on which the building structures rest will be isolated spread foundation as per the soil conditions.

TG foundations will be of RCC framed type as per the requirements and foundation structures will be isolated from floor slab. The foundations on which the boiler and supporting structure rests will be suitable for the soil conditions. Geo technical investigation is yet to be carried out at the site, post the investigation supporting structures would be designed accordingly

The bunker will be a structural steel framed structure of appropriate length and width, having steel floors and roof at required levels as per design requirements. The traveling conveyor feeder will be located above the bunkers. A staircase up to the roof level will be provided.

ESP structure will be of steel structure with all-round maintenance platform of minimum 1.2m width at ESP bottom level. Foundation for the ESP will be supported on suitable foundations as per soil condition.

Chimney: RCC chimney will be provided with suitable foundation and sizes of the chimney will be 1.80 M dia. & 70.0 M height. The specific design criteria for chimney will conform to the following: -

- Wind load in accordance to IS: 875 (Part 3): & IS: 4998 (Part I):
- In the analysis of wind loads, computations for along wind and across wind loads will be made by both simplified method and random response method as required by IS: 4998 (Part I).
- Seismic loading in accordance with IS: 1893-2002- Zone II: The seismic analysis for the chimney will be carried out by response Spectrum Method conforming to IS: 1893 for stack like structures.
- The permissible stresses in concrete and steel for the different load combinations will be as per IS: 4998 (Part I).
    - Shell; the chimney shell will be of reinforced concrete. The shell will be of 70 meters height above grade level.
    - Aviation Lighting: The aviation lighting will warn aircraft the chimney obstruction to air navigation during daylight, twilight, and night hours. The aviation lighting will be flashing high intensity lights during daytime with reduced intensity for twilight and nighttime operation. Intensity step changing will be controlled by a photoelectric light detector. The lighting

will conform to the standards of the Civil Aviation Department of the Government of India, the NAA / DARA, the ICAO, and IS: 4998.

- Lightning Arrestor: Lightning protection system complete with air terminal rods, circumferential conductor, down conductors duly earthed or connected to the general grounding system for the plant will be provided in accordance to the provisions of IS: 2309.
- Platforms and Access: External Platforms: These will be provided at various levels as per operation & maintenance requirements. GI caged ladder will be provided on the outer face of the shell above sampling port platform.
- Internal painting - Two coats of acid / alkali & heat resisting paint over one coat of primer.
- External painting - For full height two coats of polyurethane enamel paint over an epoxy sealing coating 3m wide alternate bands of red and white.

RDF Storage: The RDF storage will be RCC construction and storages capacity shall be as per system requirement. Suitable capacity of Grab crane will be considered. The storages will be covered with tubular truss with suitable ventilation sheets.

Other Equipment Foundation: All equipment foundations (inside & outside buildings) & fan foundations are block foundation. Staircase and other pedestals are also to be taken independent of flooring / pavement.

Ash Silo: Ash silos will be steel hopper supported on RCC with RCC framed structure.

Pipe racks: The steel pipe racks are designed as rigid frames in the transverse direction and braced in the longitudinal direction. Pipe rack columns will be supported on RCC foundations with bottom of base plates at 300 mm above ground level as considered. The Tier deck will be suitably designed as per system requirement.

Raw water reservoir: The reservoir will have compartment accommodating raw water. The reservoir will be earthen with necessary pitching. High-density polythene film of sufficient thickness will be used to prevent any seepage.

Raw water Pump house: The pump house will be of RCC framed structure above the sump. The sump will rest on suitable soil strata below the ground level. The wall cladding will be of brickwork and necessary Rolling shutter/Door/window openings as per factory manual norms will be provided.

Treated Water system: The Water Clarifier will be of circular shape with RCC wall partially below GL and partially above GL. Clarified water reservoir tank will be partially over ground closed at top. The pump will be mounted on pedes-

tals adjacent to the tank. The Pump house will accommodate pumps for fire protection, DM plant etc. The size of the building will be decided based on the size of pumps, their maintenance, handling requirement etc. The building will be designed as a RCC framed structure with brick / solid / hollow block cladding.

DM water plant will be housed in open type. Wherein the vessels and exchangers are located outside with suitable foundation. DM Plant electrical/control room will be of RCC framed structure and sidewalls will be with brick / solid / hollow blocks. The DM water storage tank outside the DM plant will be supported on sand bitumen pad with ring wall.

ETP, the treated effluent from D.M. plant building and other treatment areas will be discharged to a common sump. Similarly service water from Boiler/STG areas will be collected in a sump, treated and pumped to the guard pond. The treated effluent will conform to the requirement of pollution control board. The treated water can be used for gardening/ development of green belt.

Chemical house will be housed in RCC framed structure and protected by anti-corrosion paint. Chlorination plant will be provided with RC roof slab & partial side cladding to protect against rainwater. Sides will be kept open partially for the flumes to escape out. A safety shower also is considered.

Chemical / Environmental laboratory floor finish, doors, windows etc. will be as per standard. Testing platform finished with ceramic tiles, washbasin, piping, wooden shelves, etc. will be provided as per requirement.

Guard pond will be in RCC construction and open to sky with necessary piping, pump room, etc., complete. For other details refer to mechanical section of this document. Effluent water will be pumped and conveyed by CI / RCC pipes class NP2. The pipe will be buried and minimum-filling cover over the pipe will be 1.2 m. Discharge point will be protected from erosion by providing suitable concrete lining.

RDF Handling System: Transfer tower will be of structural steel framed structure supported on RCC pedestals. At ground level it will be provided with RCC paving inside the structures and 1m wide plinth protection all around. Belt conveyor will be of structural steel with steel columns, steel gantries and AC sheet roofing and will rest on RCC pedestals and RCC footings.

Switch yard Structures: Necessary roads and drains will be provided in switchyard area. Towers, masts, equipment supporting structures and trenches will all be of RCC foundation. Trench wall will project 150 mm above the paved / graded level to prevent ingress of storm / rain water. All trench, floors will be given a slope of minimum 1 in 750 and the slope will lead to a sump, where pump can be installed for drainage. Cover for cable trenches will be as per standards. Oil soak pits, Oil separation pits, Oil drains to the oil separation pits will be

provided.

Transformer yard: Transformer foundations such as Generator Transformer, Unit transformers / Auxiliary transformers, will be founded on isolated spread footings and pedestals depending on the final soil investigation report. Individual transformer foundations will have its own pit which would cover the area of the transformer and cooler banks, so as to collect any spillage of oil or oil drainage in case of emergency. The oil pit will be filled with granite stones of 50 mm size uniformly graded to a depth of minimum 150 mm. The individual oil pits will be connected to an oil collection pit, which will be sized to accommodate oil volume of the largest transformer connected to it, without backflow. The Oil pit will be connected to an oil water separator, with a separate chamber for separated oil, with provision for pumping and reuse of oil. Dimensions of the discharge pipe will consider rainfall intensity also. The water will be discharged into the nearest drain by gravity flow or pumping. The area around the transformer will be covered with gravel and galvanized chain link fence with MS angle fence posts with painting will be erected. A curb wall of 300 mm height above gravels will be provided. The portion of the fence covering the rail track will be made of removable type for movement of transformer during erection / maintenance. For small transformers of width not exceeding 5 meters, a gate will be provided for access of transformer. In addition a small gate, 1.2 m wide will be provided for man entry. The gates will have provision for locking. These gates will not be self-locking. Cable trenches will be of RCC construction and with chequered plate covers, where panels are located. Chequered plate cover will also be provided over the balance width not occupied by panels. Pre-cast cover to be provided over cable trenches, where there is no MCC / PCC or control panels installed. Sufficient slope will be provided in the base slab of cable trenches to drain out seepage water / floor wash water.

D.G shed: The D.G shed will be of RCC framed structure with under slung crane. The dimension of the building will be decided by taking into account the maintenance requirement. The foundation of DG will be isolated from the floor. Alternatively acoustic enclosure type DG can be also be used depending upon the manufacturer.

Stores & Workshop: The dimensions of the building will be decided by taking into account the maintenance requirement. Side cladding will be brickwork. The foundation of equipment will be isolated RCC footing. Adequate ventilation and lighting will be provided with steel glazed side hung windows. Main door will be of adequate size to allow entry of lathe and other equipments. Dimension of the building will be decided at the time of detailed engineering.

Non Plant Building: The Administration building will be of RCC framed structure and air-conditioned. All internal partitions will be partially in half brick masonry

and partially glazed in Aluminum frames. Canteen building will be of RCC framed structure with brick / block masonry curtain walls and air-conditioned. Joinery and finishing of structures will be as per specifications. The Gate complex will be provided with Iron Gate, painted as per specifications. The Cycle & Scooter/Car parking Area will be of precast RCC "Y" shaped frame with AC sheet roof, and the sides are kept partially cladding and partially open. Flooring will be paved with precast cement blocks. Security and Time office with two Dormitories will be of RCC framed structure and sidewall will be of brick/solid/hollow block masonry. The Watch Towers at all corners of the plant boundary will have RCC elevated platform with roof.

Roads & Drainage: All roads in the plant area will be well-designed bitumen roads. The main roads from the plant entry up to the main plant area are 7.5m wide with 1.5 m wide berm to accommodate large truck movement. Secondary roads will be 4.0m wide with 1.0 m berm. The crown of the road will be minimum 200mm above FGL. The final finished road will have a camber of 1 in 60. Camber on top of water bound macadam surface will be 1 in 40.

Paving: Boiler and transformer areas will be paved with RCC slab 100mm thick in M15 grade concrete, and 230 mm thick rubble soling will be provided below the paving. Higher thickness as required will be provided in area of vehicles movement.

Drainage: Surface drainage will be designed based on the maximum rainfall intensity prevalent in the area over the last 25 years. Building will be provided with plinth protection all around, sloped towards side drains. The side drains will be connected to the main drains on either side of the roads. For pipe drains, concrete pipe class NP2 confirming to IS: 458 will be used. However for road crossing, class NP3 pipe will be used. If sufficient clearance cannot be provided between the top of pipe and road top, the pipe will be encased in PCC/RCC. For the process drain, catch pits will be provided at the source location and they will be interconnected by buried RCC / CI pipelines and connected to waste water treatment plant.

Sanitary & Plumbing Fittings: All sanitary fittings and plumbing fixtures will be of the best quality and make with water conserving features. All water supply fittings in toilets, kitchen etc viz., Bib cocks, pillar cocks, P-traps, towel rail, shower rose, gratings etc., will be of best quality chromium plated brass of approved make. All water supply pipes for internal plumbing of buildings will be of GI pipe of medium class conforming to IS-1239 of approved make. Galvanizing of pipes will conform to IS-4736.

Sewage system & Compound Wall: For the plant area sanitary sewerage disposal, separate septic tank will be provided at suitable locations near each building areas. Effluent from the septic tank will be connected to the common wastewater

treatment plant. The treated effluent will be utilized for watering the trees within the plant. Sewage generated from the plant and canteen wastewater will be treated in a full-scale treatment system to satisfy the standards prescribed by the pollution control board.

Compound Wall: Boundary wall will be constructed around the proposed power plant areas. Boundary wall will be of brick masonry, with barbed wire fencing above.

The figure given below shows schematic diagram of waste to energy power plant:

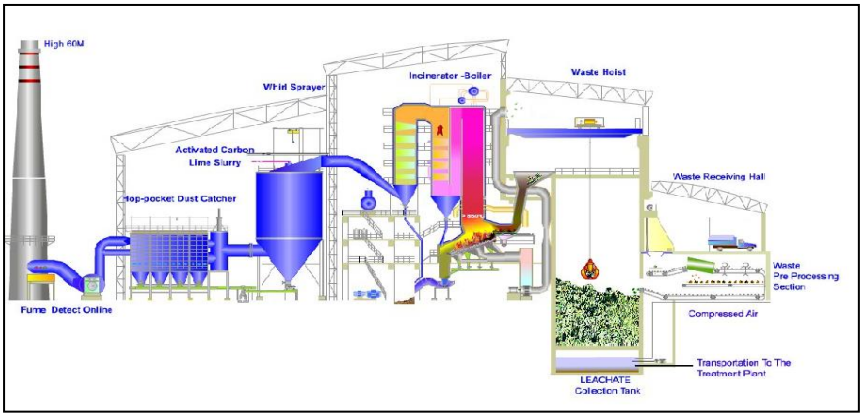


Figure 10-2: RDF Based WTE Plant

10.6 Project Cost and Financial Analysis

Project Estimation

The project cost has been estimated based on the following parameters

- Cost of land development has taken as Rs 1 Crore per acre.
- Plant equipment has been estimated based on the quotes received from the reputed EPC contractor/ manufacturers;
- Plant & Machinery costs are inclusive of Spares cost;
- Tentative Transmission Charges has been taken as Rs 20 Lakhs per MW as per APERC guidelines;
- Certain estimates have been taken as per the prevailing market rates and available in house data;
- Preliminary expenses have been considered for fees for Review Engineering, Project Management, Travel expenses and all statutory expenses.
- Taxes and duties have been considered in the price;

The summarized position of the project cost estimate is as follows.

Component	Cost (Rs. Cr.)
Site Development	1
Civil Construction	4.5
Plant & Machinery	24
Transmission	1.5
Preliminary Expenses & Preoperative Expenses	1
Total	32

Table 10.8: Tentative project cost

The total project is Rs 32 Cr which is Rs. 4 Cr per MW.

10.7 Project Implementation

Development Methodology

The project development can be divided into three (3) phases which is

- Pre Development
- Supply, Erection /Construction and Commissioning.
- Operation & Maintenance

Considering the above, it is proposed that Pre Development activities such land acquisition and necessary project clearances/ allocation shall be taken care by the Owner, while the plant construction would be done through an EPC contractor. Post commissioning of the plant, Operation & Maintenance of the Plant would either be done through in a house team or a separate O&M contractor who will run the plant for Owner.

Plant Supply and Construction

The plant construction would be done through a reputed EPC contractor who will take complete responsibility of Supply of Material, Erection of E&M items, Civil and Structural construction and Commissioning of the plant including offsite works such Raw Water pump house and its pumping station and Transmission line.

The EPC Contractor shall be responsible for all basic and conceptual engineering, detailed systems engineering, design and drawings of all mechanical and electrical systems, detailed designs and drawings for all civil works, manufacture of equipment as applicable. The EPC contractor shall also be responsible for design and engineering, supply and erection of any bought out items or any sub contrac-

tor appointed by the EPC contractor for specialized items. The contractor shall also be responsible for project planning, project management, quality control and expediting to maintain the contract schedule.

In order to ensure that the power plant is completed in time and performs at the expected level throughout its operating life, adherence to a high standard of quality will be ensured during all phases of project execution from the initial design stage till commissioning and take over. All necessary features required for trouble free operation and convenience of maintenance will be taken into account at the initial stages itself in EPC Contractor's basic engineering, detailed designs and drawings. During EPC contract engineering stage, EPC contractor's design and drawings will be checked by the Consultant in order to ensure compliance with the specified quality requirements and good engineering practice. EPC Contractor will also be required to submit an overall quality plan covering specified quality requirements, manufacturer's standard quality assurance procedures and statutory requirements. Separate quality plans will be finalized with the EPC Contractor for both shop manufacturing activities and site activities.

The various categories of engineering personnel required during construction are detailed below:

Discipline	Nos. required	Experience
Site In-charge	1	15-20 years of experience in power plant of minimum capacity 5 MW.
Engineers / Supervisors		
Mechanical Engineer	2	6-8 years of experience in Boiler, Turbine and Aux. & BOP in Power Project of minimum capacity 20 MW.
Electrical Engineer	1	6 – 8 years of experience in Power Project of minimum capacity 20 MW
C&I Engineer	1	6 – 8 years of experience in Power Project of minimum capacity 20 MW
Civil Engineer	1	6 – 8 years of experience in Power Project of minimum capacity 20 MW
QA / QC Engineer	1	6 – 8 years of experience in Power Project in QA / QC discipline and NDT Test (minimum NDT Level-1)
Planning / Pro-	1	6-8 years experience in Power Project

gress Report		Sites
Materials Management	1	6-8 years experience in Power Station Sites

Table 10.9: Manpower Construction

Project Schedule

The project schedule of 16 months is assumed for the EPC contract considering prudent Project execution practice. The schedule is given in**Table 10.13**.

Operation & Maintenance

Operation & Maintenance of the Power Plant is envisaged to be done by a separate O&M contractor who will have the sufficient skilled and unskilled manpower to carry out the same.

The O&M group will be inducted during the project execution stage, so that they are aware of the plant design features, operation & maintenance futures of the plant systems and equipments. The Plant Manager heading O&M Contractor will have the prime responsibility for the operation & maintenance of the power station. He will be assisted by a team of operation & Maintenance Engineers as indicated in O & M Group Organization chart. The plant manager will be supported be supported by Personnel from Finance & Administration to carry out day to day activities of Power Project.

The O&M manpower requirement is as follows:

Discipline	Nos. required	Experience
Power Station Superintendent	1	15-20 years of experience in power project of minimum capacity 20 MW
Maintenance Engineers (Mechanical / Electrical / C&I)	5	7-8 years of experience in power project of minimum capacity 20 MW
Shift Engineer	4	7–8 years of experience in power project of minimum capacity 20 MW
Control Room Operators	4	5-6 years of experience in power project of minimum capacity 20 MW
Control Room Operators		
Plant Operators	20	5-6 years of experience in power project of minimum capacity 20 MW

Technicians	10	5-6 years of experience in power project of minimum capacity 20 MW
Workmen-Skilled	20	Apprx
Workmen- Unskilled	50	Apprx
Aux Staff	16	Administrative, Accounts and Misc works

Table 10.10: Manpower O&M

10.8 Risk Perception

Risk Analysis

The Project of such unique nature possesses different kind of risk. The primary risk lies in the movement of RDF to the plant and its consumption and its associated cost. While there is proven technology for burning of RDF for power generation, the inherent risk of change in basic raw material, i.e MSW can happen from season to season and city to city. The other primary risk is the approval of the provisional tariff from the Regulator for the project, any deviation from the proposed tariff would require a reassessment of the project viability

Broadly the project would need to be risk perspective which is as follows

Description	Risks	Remarks
Regulatory	Low	No Regulatory barrier exists.
Market	Low	Regulatory pressure of power off take
Land	Low	No barrier
Water	Low	Nearby River source and available
Environment	Low	No barriers exists
Fuel Transportation	Medium	Transportation of RDF
Equipment	Medium	RDF properties varies with season
Transmission	Low	Nearness to evacuation centre
Fuel	Low	Captive fuel
Economics	High	Tariff approval from APERC

Table 10.11: Risk Analysis

Clearances

The various statutory and non statutory clearances required for the project is as follows

Clearance	Type	Agency
Registration of Company	S	Registrar of Companies
Water Supply Arrangement	S	District Collector, State Govt.
Pollution Clearance	S	APPCB
Environment Clearance	S	APPCB
Chimney Height Clearance	S	National Airports Authority
Land Acquisition	NS	Private Discussion
Right of Way	NS	Local Authorities
Tariff Approval	NS	APERC
Transmission	NS	APTRANSCO/ Distribution Utility
Installation	NS	Electorate Inspector
Start of Operation	NS	Electorate Inspector

Table 10.12: Clearances

Conclusion

In any project development, inherent risks do remain. However in case of this project, the primary risk in any power project which is fuel, is getting mitigated considering the fuel would be sourced from its own company with which it would sign a Fuel Supply Agreement. Also considering that in the future, there cannot be any forseaable decline of production of Municipal Solid Waste, hence availability of fuel is not a concern. Since all the elements of the project including land, water, technology, and fuel are available the project should be taken up for development.

TNTATIVE BAR CHART FOR 1 X 8 MW RDF BASED POWER PLANT

		----- Clearanc-es-----	----------EPC EXECUTION----------																	
S. No	Description of activity	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	Remarks
Owner Preparation																					
EPC Contract Works																					
1	Award of Main Plant Contract	Zero Date																			
2	Basic Engineer-ing BTG																				
3	Basic Engineer-ing BOP																				
4	Layout marking																				

5	Detailed Engineering BTG																		
6	Detailed Engineering BOP																		
7	Procurement BTG																		
	Supply of Boiler parts																		
	Supply of Turbine																		
8	Procurement BOP																		
9	Supply of Structure & Equipment																		
10	Mechanical works																		
11	Drum Lifting																		First Milestone Drum

																				lifting
12	Electrical works																			
13	Instrumentation works																			
14	Hydrotest of boiler																			Second milestone Hydrotest of Boiler
15	Pre commissioning																			
16	Commissioning																			
17	Boiler Light Up																			
18	Turbine Barring gear																			
19	Performance tests																			Third Milestone Commercial operation date

20	Commercial operation date																		COD	

Table 10.13: Implementation schedule

11 PLANNING AND DESIGN OF SANITARY LANDFILL

11.1 Introduction

Disposal of Solid 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 can be done following proper norms. Landfill sites shall meet the specifications as given in schedule III of the CPHEEO manual.

The basic steps essential for the landfill designs are:

- Landfill sizing
- Site layout
- Landfill layout
- Leachate management
- Landfill gas management

11.2 Proposed landfill site description

The landfill site is proposed at Tangudipalli village which is 40kms from city and 20 kms from kapuluppada dump site. Tangudupalli site is a fresh land with approximate 200 acres area available to develop landfill facility.

11.3 MoEF guidelines for Landfill Design

Main aspects covering the landfill Design & Construction are:

- To minimize the possibility of contaminating surface and ground water.
- To have control over gaseous emissions.
- To maximize resource productivity.

Leachate control by liner system within a landfill involves prevention of percolation of leachate from waste in landfill to the subsoil by a suitable protective system (liner system). The liner system is a combination of drainage layer and barrier layers. As per CPHEEO manual a competent liner system should have low permeability, should be robust and durable and should be resistant to chemical attack, puncture and rupture. A liner system comprises of combination of barrier materials such as natural clay, amended soils and flexible geo membrane made of HDPE.

As suggested by MoEF a composite liner of two barriers made of different mate-

rials, placed in immediate contact with each other provides a beneficial combined effect of both the barriers. The liner system suggested by MOEF is a geo membrane layer over clay or amended soil barrier. A drainage layer and leachate collection system is placed over the composite liner system. The effectiveness of barrier layer basically depends on ***the hydraulic conductivity of the clay/amended soil liner*** and ***density of the geomembrane against puncture.*** The clay/amended soil liner is effective only if it is compacted properly and geo membrane liner is effective only if it has the density or mass per unit area (minimum thickness is specified) is sufficient enough against punctures.

As per MSW Rules'2000		
Layer No.	**Material Description**	**Thickness**
Layer 1	Barrier soil layer comprising of clay or amended soil with permeability coefficient less that 1 x 10^{-7} cm/sec	100 cms
Layer 2	High density polyethylene (HDPE) geo membrane	1.5 mm
Layer 3	Drainage layer	30 cm
	Total Thickness	**130 cms**

Table 11.1: Layer configuration is proposed for the bottom of the landfill

The cross-section of the bottom liner system is given below

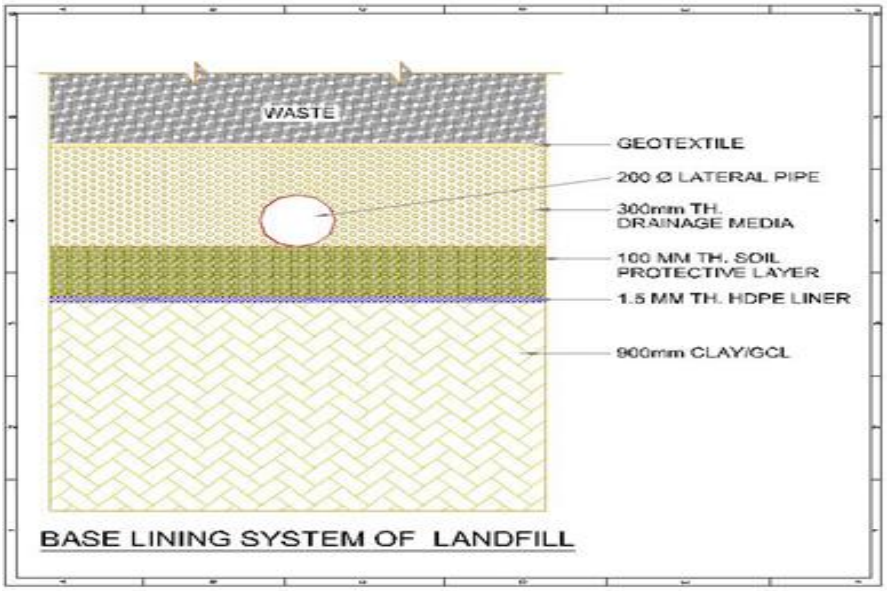


Figure 11-1: RDF Based WTE Plant

Property			Value
1	Thickness		1.5mm
2	Density		0.94 gm/cc
3	Roll Width X Length		6.5 X 171mm
4	Tensile Strength		
	a	Tensile Strength at Yield	23 N/mm
	b	Tensile Strength at Break	43 N/mm
	c	Elongation at Yield	13%
	d	Elongation at Break	700%
	e	Secant Modulus (1%)	
5	Toughness		
	a	Tear Resistance (initiation)	187 N
	b	Puncture Resistance	530 N
6	Durability		
	a	Carbon Black	± 2%
	b	Oxidation induction time in Mins	> 100
	c	Accelerated Heat Ageing	Negligible Strength Changes after 1 month at 110^0C
7	Chemical Resistance		
	a	Resistance to Chemical Waste Mixture	10% Strength Change Over 120 days
	b	Resistance to Chemical Reagents	10% Strength Change Over 7 days
8	Environmental Stress Crack Resistance		1500hrs
9	Dimensional Stability		2%
10	Seam Strength		80% or more (of Tensile Strength)

Figure 11-2: Typical Property Values for Geo membrane

11.4 Design of Landfill and Landfill Sizing

The volume of waste to be dumped in the landfill is worked out based on quantities that will be send to landfill. The table below shows the quantity of inerts going to landfill each year.

Year	TPD	Percentage of inerts	Total Inerts per annum in MT
1	951	0.20	69423
2	970	0.20	70811
3	989	0.20	72228
4	1009	0.20	73672
5	1029	0.20	75146
6	1050	0.20	76649
7	1071	0.20	78182
8	1092	0.20	79745
9	1114	0.20	81340
10	1137	0.20	82967
11	1159	0.15	63470
12	1182	0.15	64739
13	1206	0.15	66034
14	1230	0.15	67355
15	1255	0.15	68702
16	1280	0.15	70076
17	1306	0.15	71477
18	1332	0.15	72907
19	1358	0.15	74365
20	1385	0.15	75852
21	1413	0.10	51579
22	1441	0.10	52611
23	1470	0.10	53663
24	1500	0.10	54737

25	1530	0.10	55831
26	1560	0.10	56948
27	1591	0.10	58087
28	1623	0.10	59249
29	1656	0.10	60434
30	1689	0.10	61642
			2,019,919

The quantity of inert material proposed for the landfill design for 30 years period is 18.90 lakh tones. From the table it can be observed that the percentage of inerts have been proposed from 20% to 10% due to introduction of innovative technologies like brick making from inerts, use of fly ash in roads or used to fill low lying areas or soil cover etc..,.

11.5 Landfill design parameters & Volume Calculations

Basic Data :					
Capacity of LF :			2800000.00	cum	
Size of LF :			550 x 387	M	Approx.
Location :	VSKP				
Likely shape of Landfill :	Rectangular in plan				
Assuming density : Total Tonnage:			0.75 2100000	t/cum Tons	
Bund Details :					
Ht. of Main Bund :		3.0	M		
Ex. Below GL :		1.5	M	Avg.	
Top Width of Bund :		5.0	M		
Berm Width :		4.0	M		
No. of Berms :		1.0	Nos		
SLF Slopes :					

Main Bund Outer Slope :		2	:	1	
Main Bund Inner Slope :		3	:	1	
Slope of Dump Above Bund Top :		4	:	1	
LF Final Slope :		20	:	1	

SLF Dimensions :									
			Area		**Perimeter**			**EL**	
Total Landfill Area :			**218508**	sqm	1898	rmt	@ +	100.00	m
LF Garland Drains :					1890	rmt	@ +	100.00	m
Landfill Dimensions :	@ BBL	=	169338	sqm	1678	rmt	@ +	98.50	m
Landfill Dimensions :	@ GL	=	176970	sqm	1714	rmt	@ +	100.00	m
Landfill Dimensions :	@ BL	=	192720	sqm	1786	rmt	@ +	103.00	m
Landfill Dimensions :	@ ABL	=	158600	sqm	1626	rmt	@ +	108.00	m
4 m wide Berm - LF Dimensions :	@ ABL	=	152160	sqm	1594	rmt	@ +	108.00	m
Landfill Dimensions :	@ ABL	=	121880	sqm	1434	rmt	@ +	113.00	m
4 m wide Berm - LF Dimensions :	@ ABL	=	116208	sqm	1402	rmt	@ +	113.00	m

Landfill Dimensions :	@ ABL	=	89768	sqm	1242	rmt	@ +	118.00	m
4 m wide Berm - LF Dimensions :	@ ABL	=	84864	sqm	1210	rmt	@ +	118.00	m
Landfill Dimensions :	@ ABL	=	0	sqm	0	rmt	@ +	123.00	m

SLF Volume Calculations:			**Cumulative**	
SLF Volume Phase. 1	238521	cum	238521	cum
SLF Volume Phase. 2	219773	cum	458293	cum
SLF Volume Phase. 3	364114	cum	822407	cum
SLF Volume Phase. 4	446160	cum	1268567	cum
SLF Volume Phase. 5	330825	cum	1599392	cum
SLF Volume Phase. 6	446160	cum	2045552	Cum
SLF Volume Phase. 7	296991	cum	2342543	Cum
SLF Volume Phase. 8	400530	cum	2743073	Cum
Total Design Tonnage with 0.75 T/Cum			**2057304**	**Ton**

Phase 1 - SLF Volume :								
	20026.50	+	28518					
BBL: Vol - I				x	2.5	=	60681	Cum
		2						

	28518.00	+	16458					
ABL: Vol - 2				x	5.0	=	112440	Cum
		2						
	14430.00	+	6210					
ABL: Vol - 3				x	5.0	=	51600	Cum
		2						
	4950.00	+	570					
ABL: Vol - 4				x	5.0	=	13800	Cum
		2						
	0.00	+	0.00					
ABL: Vol - 5				x	5.0	=	0	Cum
		2						
Volume of waste :						=	238521	Cum
Assuming Waste Density :						=	0.75	t/cum
Quantity of waste :						=	**178890**	**tonnes**
Phase 2 - SLF Volume :								
	40053.00	+	53107.5					
BBL: Vol - I				x	2.5	=	116451	Cum

		2						
	53107.50	+	34287.5					
ABL: Vol - 2				x	5.0	=	218488	Cum
		2						
	30907.50	+	15927.5					
ABL: Vol - 3				x	5.0	=	117088	Cum
		2						
	2175.50	+	331.50					
ABL: Vol - 4				x	5.0	=	6268	Cum
		2						
	0.00	+	0.00					
ABL: Vol - 5				x	5.0	=	0	Cum
		2						
Volume of waste :						=	458293	Cum
Assuming Waste Density :						=	0.75	t/cum
Quantity of waste :						=	**343720**	**tonnes**
Phase 3 - SLF Volume :								

	62361.00	+	78979.5					
BBL: Vol - I				x	2.5	=	176676	Cum
		2						
	78979.50	+	54879.5					
ABL: Vol - 2				x	5.0	=	334648	Cum
		2						
	50443.50	+	30183.5					
ABL: Vol - 3				x	5.0	=	201568	cum
		2						
	26515.50	+	10095.5					
ABL: Vol - 4				x	5.0	=	91528	cum
		2						
	7195.50	+	0.00					
ABL: Vol - 5				x	5.0	=	17989	cum
		2						
Volume of waste :						=	822407	cum
Assuming Waste Density :						=	0.75	t/cum

Quantity of waste :						=	**616805**	**tonnes**
Phase 4 - SLF Volume :								
	84669.00	+	101287.5					
BBL: Vol - I				x	2.5	=	232446	cum
		2						
	101287.50	+	77187.5					
ABL: Vol - 2				x	5.0	=	446188	cum
		2						
	72751.50	+	52491.5					
ABL: Vol - 3				x	5.0	=	313108	cum
		2						
	48823.50	+	32403.5					
ABL: Vol - 4				x	5.0	=	203068	cum
		2						
	29503.50	+	0.00					
ABL: Vol - 5				x	5.0	=	73759	cum
		2						

Volume of waste :						=	1268567	cum
Assuming Waste Density :						=	0.75	t/cum
Quantity of waste :						=	**951425**	**tonnes**
Phase 5 - SLF Volume :								
	106977.00	+	127159.5					
BBL: Vol - I				x	2.5	=	292671	cum
		2						
	127159.50	+	97779.5					
ABL: Vol - 2				x	5.0	=	562348	cum
		2						
	92287.50	+	66747.5					
ABL: Vol - 3				x	5.0	=	397588	cum
		2						
	62023.50	+	40323.5					
ABL: Vol - 4				x	5.0	=	255868	cum
		2						

	36367.50	+	0.00					
ABL: Vol - 5				x	5.0	=	90919	cum
		2						
Volume of waste :						=	1599392	cum
Assuming Waste Density :						=	0.75	t/cum
Quantity of waste :						=	**1199544**	**tonnes**
Phase 6 - SLF Volume :								
	129285	+	149467.5					
BBL: Vol - I				x	2.5	=	348441	cum
		2						
	149467.50	+	120087.5					
ABL: Vol - 2				x	5.0	=	673888	cum
		2						
	114595.50	+	89055.5					
ABL: Vol - 3				x	5.0	=	509128	cum
		2						
	84331.50	+	62631.					

			5					
ABL: Vol - 4				x	5.0	=	367408	cum
		2						
	58675.50	+	0.00					
ABL: Vol - 5				x	5.0	=	146689	cum
		2						
Volume of waste :						=	2045552	cum
Assuming Waste Density :						=	0.75	t/cum
Quantity of waste :						=	**1534164**	**tonnes**
Phase 7- SLF Volume :								
	149311.50	+	172693.50					
BBL: Vol - I				x	2.5	=	402506	cum
		2						
	172693.50	+	138573.50					
ABL: Vol - 2				x	5.0	=	778168	cum
		2						
	132133.50	+	101853.50					

ABL: Vol - 3				x	5.0	=	584968	cum
		2						
	96181.50	+	69741.5					
ABL: Vol - 4				x	5.0	=	414808	cum
		2						
	64837.50	+	0.00					
ABL: Vol - 5				x	5.0	=	162094	cum
		2						
Volume of waste :						=	2342543	cum
Assuming Waste Density :						=	0.75	t/cum
Quantity of waste :						=	**1756907**	**tonnes**
Phase 8 - SLF Volume :								
	169338.00	+	192720					
BBL: Vol - I				x	2.5	=	452573	cum
		2						
	192720.00	+	158600					
ABL: Vol - 2				x	5.0	=	878300	cum

		2						
	152160.00	+	121880					
ABL: Vol - 3				x	5.0	=	685100	cum
		2						
	116208.00	+	89768					
ABL: Vol - 4				x	5.0	=	514940	cum
		2						
	84864.00	+	0.00					
ABL: Vol - 5				x	5.0	=	212160	cum
		2						
Volume of waste :						=	2743073	cum
Assuming Waste Density :						=	0.75	t/cum
Quantity of waste :						=	**2057304**	**tonnes**

Therefore Total area required for landfill is 54 Acres

11.6 Assessment of Leachate Quantity

Leachate refers to the liquid that has passed through or emerged from solid waste and contains dissolved and suspended materials removed from the solid waste. The leachate generation is primarily a function of precipitation and it is directly proportional to rainfall intensity and surface area. Leachate is basically generated by the following two means,

From active landfill area

After closure of landfill site

Leachate quantity can be estimated for Landfill and the leachate network is en-

visaged in such a way that leachate from the processing facility and landfill will be conveyed to the centralized treatment plant to be treated to meet disposal standards.

Formula			
$I = P - PC_{R/O} - AET +/- S$			
Where,			
I -	Rate of Infiltration		
P -	Precipitation		
$PC_{R/O-}$	Coefficient of Runoff		
AET -	Actual Evapo-Transpiration		
S -	Soil Moisture Content Retention Capacity		
Empirically,			
For Capped portion of landfill:	I =	0.01	P
For Uncapped Portion of landfill:	I =	0.7	P
Landfill with temporary cover:	I =	0.3	P

Using the above formulae leachate quantity is assessed.

Leachate quantity estimation from landfill:

As per the records the average annual rainfall in Vishakhapatnam is 975mm.

Formula: I = P – PCR/O – AET +/- S

Where,

I - Rate of Infiltration

P - Precipitation

PCR/O- Coefficient of Runoff

AET - Actual Evapo-Transpiration

S – Soil Moisture Content Retention Capacity

Empirically,

For Capped portion of landfill:	I =	0.01 P
For Uncapped Portion of landfill:	I =	0.7 P
Landfill with temporary cover:	I =	0.3 P
Average total precipitation per	=	975 mm/year

year			
	=	0.975	m/day
	=	9.4E-08	m/sec
Total area of the landfill	=	218508	Sqm
Area of the landfill			
Operated landfill	=	13110	Sqm
Closed landfill	=	196657	Sqm
Temporary closed landfill	=	8740	Sqm

Volume of the leachate for:			
Operated landfill	=	74.6	Cum/day
Closed landfill	=	16.0	Cum/day
Temporary closed landfill	=	21.3	Cum/day
		111.8	Cum/day
Leachate generation per day =		**110**	**Cum**

Leachate Treatment is explained in detail below sections

11.7 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.

11.8 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

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

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)

11.9 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	=	656886 Tons/Annum

P = Percentage of Organic Component	=	05
Volume of Gas generated	=	197065 m3/year

11.10 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.

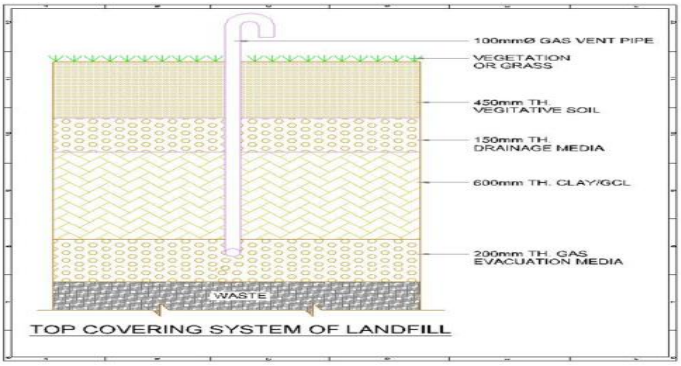


Figure 11-3: Landfill Sequence

11.11 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.

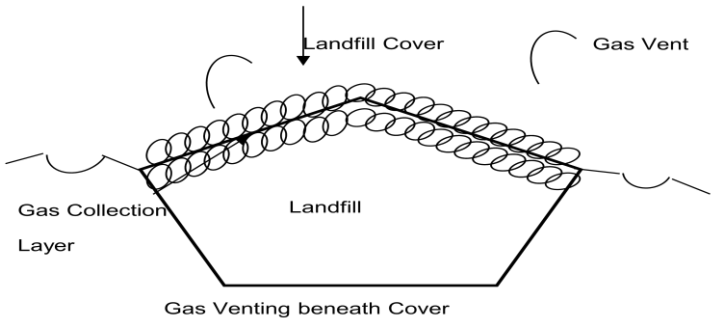


Figure 11-4: Landfill Pattern

11.12 Land filling Operations

The solid waste generated shall be sent to the landfill at any point of time. The sampling procedure and testing will be standardized in consultation with the In-dependent engineer and will be closely, regularly monitored.

Secured Landfill is provided to dispose off solid waste material. The most important design feature of a landfill apart from other constructional aspects is its volume, which depends on the area available, and other environmental aspects which limit the depth and height of the landfill. The design further deals with the prevention of infiltration of the leachate into the ground water by proper lining and under drainage system to collect the leachate and pump the same for the treatment and disposal.

Main aspects covering the landfill Design & Construction are:

- To eliminate the possibility of contaminating surface and ground water.
- To have control over gaseous emissions.
- To maximize resource productivity.

The development of the landfill site shall be undertaken as proposed in the plan. This includes the following activities

- Daily waste inspection
- Daily waste segregation.
- Daily waste spreading/placement.
- Waste compaction and leveling.
- Daily covering of waste with soil.
- Traffic movement within the site.
- Collection and handling of Leachate.
- Treatment and disposal of leachate.
- Collection and handling of Landfill Gas (LFG).

- Maintenance of surface water drainage system.
- Excavation/import and transportation of covering (earth) material for daily covering.
- Stock piling of covering materials.
- Soil compacting.
- Transportation of construction and demolition waste.

Provision for daily cover, final cover, intermediate cover

Daily and intermediate covers of soil will be placed over the wastes on a regular basis to ensure that odour generation is minimized. Waste is covered at the end of each working day with soil or alternatively a daily cover by means off geo-textiles, geo-membrane, etc. Most importantly, the leachate generation is also reduced. It is a conventional practice to level and compact the waste as soon as it is discharged at the working areas.

Due to the high cost, and difficulty of obtaining approval for Landfill sites, it is desirable to explore all options to maximize the use of airspace to extent the life of operating facilities. Better compaction is a valuable tool in achieving this objective.

Compaction offers many benefits including, enabling the maximum amount of waste to be emplaced within the space available, reducing the impact from litter, flies, vermin, birds and fires and minimizing short-term settlement. The waste should be compacted to a density of about 0.9 to 1.1 tonnes/m3 is the optimum.

Daily Cover / Intermediate cover / final cover

The soil of 4 to 6 inches should be applied on the waste coming in. Waste will be covered at the end of each working day with a daily cover. If a stretch of waste is not to be filled over in the immediate future (for example - for one week), it will be covered with a thicker interim cover. Prior to the commencement of monsoon season, an Intermediate cover of 40-65 cm thickness of soil should be placed on the landfill with proper compaction and grading to prevent infiltration during monsoon. The landfill cover system will extend above the elevations denoted in drawing.

The total height of the waste when completed filled to the planned height; the Landfill will be capped as per the MSW 2000 Rules. Passive Gas vents will be suitably placed in this layer so that the small quantity of gas that is formed would be released to flare. The possibility of having large quantity of landfill gases is very less as the waste going into the landfill would be of inert nature. 450mm thick soil layer would be placed for vegetation.

The drainage layer of gravel 300mm would help in draining of the excessive wa-

ter entering the topsoil layer. A separate drainage outlet provided for such water by way of drainage chutes.

11.13 Vegetative Cover

The main aim of the vegetative cover is to see that topsoil cover is not eroded. In order to do so, the MSW 2000 Rules, suggest a vegetative cover that should be provided over the completed site in accordance with the following specifications:

- Selection of locally adopted non-edible perennial shrubs which are resistant to drought and extreme temperatures
- Shrubs grown should be such that their roots do not penetrate more than 30 mm. This condition shall apply till the landfill is stabilized.

Selected plants should have ability to thrive on low-nutrient soil with minimum nutrient addition.

Gas vents – The quantity of gas generated is quite low. One vent is provided.

11.14 Construction of Landfill

Laying of bottom liners & Sub layers

The base liner at the landfill will be a composite liner comprising of the section below

- The base of the landfill shall be a minimum of 2 m above the highest ground-water level.
- Clay liner of 1000mm thick of low permeability of 10-7cm/s is placed at the base of the landfill.
- HDPE liner of 1.5 mm thick will be laid as per the design considering the height of the landfill.
- 300m drainage layer for leachate collection system
- A geo-textile barrier shall be placed over the drainage media to ensure only liquid percolates into the drainage layer and thus ensuring that the drainage media does not get clogged.
- The base of the landfill shall be effectively graded to attain a clear slope of 2% towards the Leachate collection sump.
- A network of perforated lateral HDPE pipes of requisite size as per design and header pipe shall be placed in the landfill for effective collection of any Leachate generated in the landfill as per the standards.
- The Leachate collection pipes shall be embedded in a drainage media of 300 mm for effective collection of Leachate and final discharge in to Leachate sump.

- Daily and intermediate covers of soil shall be placed over the wastes on a regular basis to ensure that odour generation is minimized. This also facilitates easy movement of waste dumping trucks into the landfill. It further minimizes the bird menace if any by way of minimizing the exposure of waste. These layers also minimize rain water infiltration into the Land Fill.
- The land filling is generally taken up in a phased manner (Cells) to facilitate phased closing and for each year in this core.
- When each cell is completed an intermediate cover is laid out.
- When all the cells are full, capping of the landfill is taken up at the recommended slope and with the recommended layers. This capping is provided to ensure
  - → Prevention of Infiltration of rain water into the landfill during post closure period.
  - → To eliminate the possibility of explosions due to accumulated gases in the landfill by suitably providing for passive gas venting systems
  - → To provide aesthetics.
- When the final levels are arrived a cover is provided comprising of
  - → Gas collection layer of 450 mm thick
  - → Barrier layer of clay 600mm thick
  - → Drainage Layer with thickness of 300 mm.
  - → Over this shall be placed a layer of 300 mm soil and 150 mm top soil for vegetation growth to improve aesthetics in the area and also for minimizing soil erosion.

Clay Liner

While the clay is being compacted, measures should be taken to avoid the formation of cracks and fissures. A thick layer helps to maintain the integrity of the liner against desiccation cracks. It is advisable to compact the clay liner using a sheep foot roller, in lifts not exceeding a maximum compacted thickness of 30 cm, and the above parameters (proctor density and moisture content) should be monitored for each lift.

QA/QC – Clay Liner / HDPE Liner

The clay liner should be tested periodically prior to placement of Geo membrane-HDPE liner for adherence to prescribed standards. Testing methods used to characterize proposed liner soils should include grain size distribution, Atterberg limits, and permeability. The quality control of the HDPE liners will be ensured by the following:

Prior to acceptance of the liner from the manufacturer/supplier, it would be verified that it meets the required specifications tested by an independent laboratory for the lots of materials procures. The installed HDPE liner should meet the following criteria against the test methods.

Criteria for HDPE liner and test methods

S.No	Property	Value	Test method
1	Thickness Density	1.5mm (60 mil) 0.94 gm/cc	ASTM D5199, D5994.D1593
2	Roll Width	7 m wide	
3	Tensile Strength (a) Tensile Strength at yield (b) Tensile Strength at Break (c) Elongation at Yield (d) Elongation at Break	24 kN/m 42kN/m 15% 700%	ASTM D638
4	Toughness: (a) Tear Resistance (initiation) (b) Puncture Resistance (c) Low Temperature Brittleness	200 N 480 N -94°F	ASTM D1004 ASTM D5494 ASTM D746
5	Durability: (a) Carbon Black (b) Carbon Black Dispersion (c) Accelerated Heat Ageing	2% A-1 Negligible Strength Changes after	ASTM D1603 ASTMD3015
6	Environmental Stress Crack Resistance	1500hrs	ASTM D1693
7	Dimensional Stability	±2%	ASTM D1204
8	Seam Strength (Shear)	80% or more (of tensile	ASTM D4437

Monitoring wells

The main purpose of monitoring wells is for periodic monitoring of the quality of ground water in and around the landfill facility. The monitoring wells shall be two nos. in the upstream and two nos. in the downstream directions of ground water flow. The cross-section of a monitoring well is shown in **Figure 11-5**

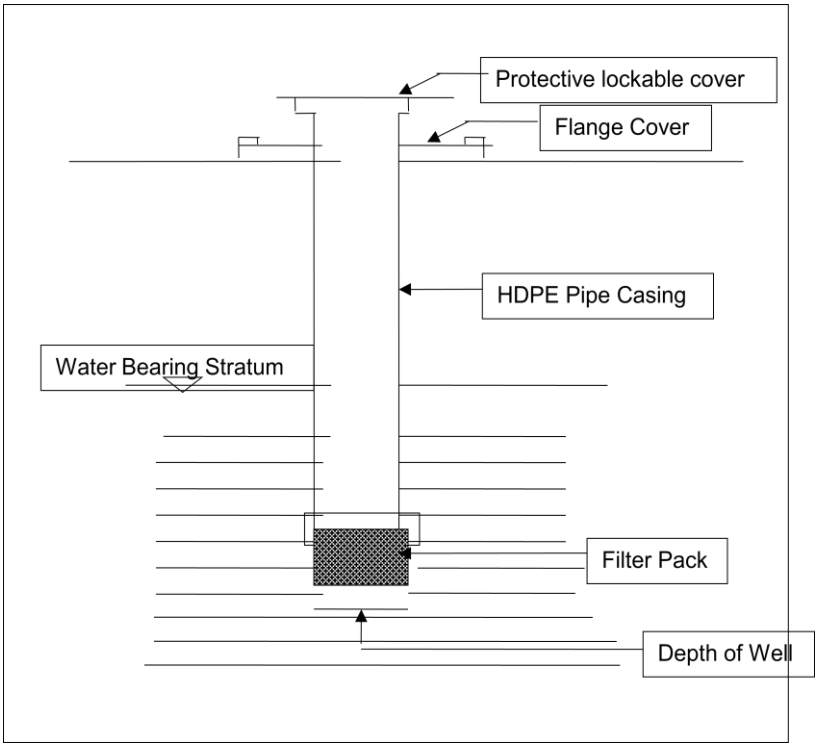


Figure 11-5: Details of monitoring well

11.15 Supporting infrastructure

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

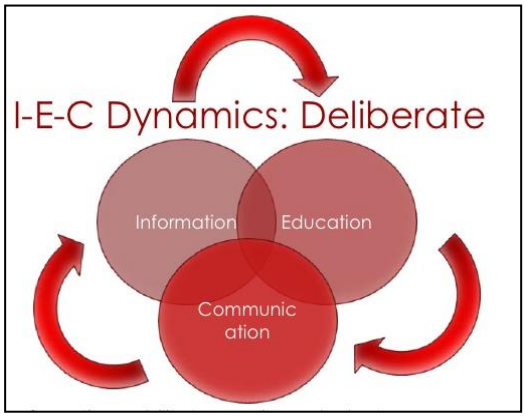
- Gate
- Guard Room
- Weighbridge and scale room
- Admin building , lab & rest rooms (G+1)
- Electrical panel room & DG
- Workers Dining
- Vehicle workshop
- Storage shed
- Vehicle wheel wash
- Wash rooms
- Process plant area
- Presorting & RDF Unit
- Compost process unit
- Waste capping area
- New landfill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

- Roads & drains
- Boundary wall
- Green belt

12 INFORMATION, EDUCATION AND COMMUNICATION (IEC)

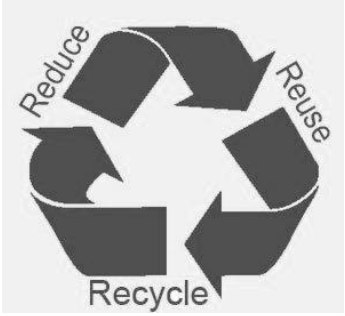
12.1 Introduction

IEC & Public Awareness on waste management is an extremely important component for any successful Solid Waste Management programme, in addition to 'proper legislation, technical support and funding. This has also been a key strategy under the Swach Bharath Mission of Govt of India. This targets the "Behavioral Change communication" to ensure that waste management is mainstreamed with the general public at large. It also covers issues of proper management of municipal waste. The focus of the program is on the households, commercial establishments, etc. Sensitization of community towards efficient waste management and its related health and environmental consequences is the key because a clean community is a direct reflection of a clean city / town.



Goals of IEC Program

a) To raise the awareness among the people about importance of cleanliness, solid waste management
b) To Motivate people positive behavioral changes
c) To propose source segregation
d) To promote principle of 3 R's



3 R's:

One of the goals behind IEC is to make principle of 3 R's as a part of life at every stage of waste management. The 3 – R's (Reduce, Re-use and Recycle) have produced demonstrative cost effective methods in handling of urban waste and also in conservation of resources.

The solid waste management hierarchy has been globally recognized as per the following illustrative diagram.

Enhancing Reuse & recycling and minimization of generation with source segregation are essential to the success of any Solid waste management program. It hinges on voluntary participation from the members of community (waste generators) and requires a robust awareness program on a continual basis.

MSW has got a direct relationship with pollution of air, water, soil and sanitation, hence it is extremely essential to impart a need based education and awareness to various levels of society.

Strategy of IEC:

Following steps needs to be followed for development of effective Strategy for IEC:

a) Need Assessment
b) Goal Setting
c) Framework of IEC
d) Development of IEC activities
e) Development of Dissemination Plan
f) Evaluation of Dissemination plan

12.2 Identification and Orientation of Resident's Welfare Committees:

Management of solid waste and its effectiveness is primarily dependent on the attitude, co-operation and participation of the local community. People in all walks of their day-to-day activities generate waste, which however, can be collected only once or maximum twice in a day. The other critical aspect of waste management is the location of waste management facilities such as dumper bins or the disposal site. There have been number of cases where in the community has objected to the location of these facilities in their neighbourhood. Popularly known as 'Not in My Back Yard (NIMBY) Syndrome', it is the general perception of the public that location of any of these solid waste facilities will create the problem of health and hygiene. In light of the above facts, it becomes imperative that a successful implementation of any solid waste management system will need effective cooperation and co-ordination of the local community in various aspects of waste collection, transportation and disposal.

The steps involved in implementing and ensuring community participation will

comprise of the following activities;

Identification of Resident Welfare Associations (RWAs) whose members can contribute expertise or resources and can share the responsibilities of planning and implementing the program.

Identification and mobilisation of Non-Governmental Organisations or other social welfare groups in the city

Identification of areas of SWM where community participation is elicited like schools, institutions, offices, commercial areas, common community areas (parks), etc.

Orient the citizens, key personalities, social activists, politicians and local corporators towards environmental education and solid waste management

Conduct sanitation campaigns in various parts of the city emphasising on areas where their co-operation / participation is sought

Carry out mass media campaigns on various aspects of solid waste management

It is also important to identify areas where the active involvement of community participation is elicited and work out the modalities of the same. Some of the areas that have emerged from experience elsewhere in the country, in which the community can contribute to waste management, are,

Avoid indiscriminate throwing of waste by residents, shop keepers, etc on the streets

Segregate and store the waste at source

Hand over the waste to the sanitary workers

Understanding the importance of dumper bins at various localities of the city and their criticality in the efficient management of waste and therefore co-operating while the shifting of dumper bins

Understanding the importance of Reduce, Reuse, Recycle and Recovering of various recyclables in the waste and their utility.

Once the above is explained to the representatives of RWA's the same will be conveyed to the community directly or through various means of technology, so that a sense of community 'ownership" is developed. People involved in planning and implementing a project will feel that the program belongs to them. Community ownership helps to ensure greater participation on collection day as well as community pride about the outcome of the program.

12.3 Identification and Mobilization of NGOs or Social Welfare Groups NGO involvement

The success of IEC is largely depending on the voluntary participation of the

community at large. The local government, the developer and Non-Government Organizations (NGO's) etc have a large role to play in this regard. In recent years it can be observed that NGOs have taken up initiatives to work with local residents to improve sanitation. They have been playing an active role in organizing surveys and studies in specified disciplines of social and technological sciences. In the field of garbage management, such studies are useful in identifying areas of commercial potentials to attract private entrepreneurs. They can play an important role in segregation of waste, its collection and handling over to local authorities.

Many NGOs are committed to improve SWM practices to protect the environment and have been very active in this field, hence are successful in creating awareness among the citizens about their rights and responsibilities towards solid waste and the cleanliness of their city. These organizations promote environmental education and awareness in schools and involve communities in the management of solid waste. They may be persuaded to actively support the new strategies recommended in this report and associate in public awareness campaigns. Any organization willing to perform independently in conducting programs for sections of public on the new SWM strategies should be encouraged to do so through direct support or through use of the corporation resources / facilities.

A few visuals to capture mass awareness programs in Hyderabad

The corporation can involve NGO's as 'pressure groups' which can bridge the gap between government and civic society in waste management. The NGO programmes can be tailor made to suit the requirement of the city, so as it serves the purpose of

Creating mass awareness, ensuring public participation in segregation of recyclable material and storage of waste at source. The awareness programs should be suitably designed to take the concept of SWM and source segregation into the community through audio-video means and through folklore methods so that the message percolates deep down into the society.

Provide employment through organizing door-to-door collection of waste.

Ensure public participation in community based primary collection system.

Encourage minimization of waste through in-house backyard composting, vermi-composting and biogas generation.

Most of the slum pockets can be covered by staging street plays to educate the slum dwellers and general public.

Use of Schools and Colleges

Children are powerful communicators and most of the information received at schools is sure to influence their parents and the respective households. To get more response to the efforts in MSW management, the corporation may motivate schools in the city to display posters, messages in the class rooms, school campus and if possible take rallies early mornings carrying placards, banners which convey brief messages against littering and illicit dumping of waste in the city. The strategy should be channelized into each lane and by lane so as the message is received strongly by the people. Large number of schools if involved simultaneously would be an added advantage to publicize the big picture in a short duration and more effectively. Important environmental events like environment day, earth day, water day, etc can be utilized as platforms to gather children along with their parents to convey this message.

12.4 Orientation of Key Personalities, Social Activists and Policy Makers Involvement of Professional Communicators

If messages are not conveyed in the right way, they may not yield the desired results. Professional inputs are necessary in developing a strategy for effective communication of strategies. If key community leaders / personalities participate in the planning process, they can help build community acceptance and support for the project. In addition, local officials will know the mood and interests of the community and can help avoid or overcome sensitive issues.

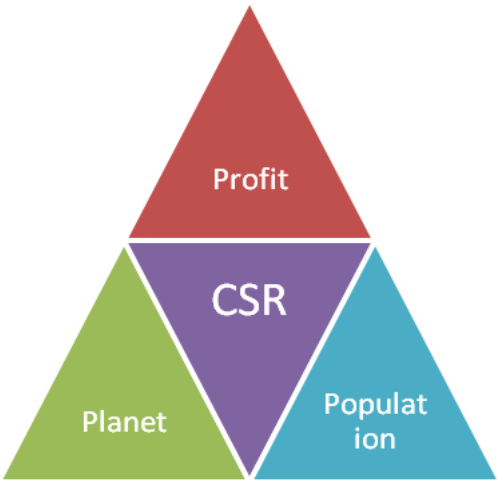
Most large advertising agencies have Social Marketing experts to convey civic messages effectively. They can be contacted at the city level to create suitable

messages with catchy titles for various uses, preferably free or at cost as a public service, so as these messages get the "best buy" tag by getting publicized through well known personalities.

Involving Commercial Sponsors

Firms and organizations can be encouraged to adopt certain areas of waste management and sponsor the cleanliness drive. An incentive mechanism can be introduced to reward the Good Samaritans or the associations championing the program in the communities and contributing towards civic cleanliness.

Waste Management & Corporate Social Responsibility: CSR has become an integral part of operations in any organization because CSR is a responsibility of an enterprise for their impact on the society. Hence, options may be explored in getting sponsorships from the CSR funds of organizations or check in fitting waste management into CSR, because it reduces the impact on the environment and contributes to employment and development of green economy. This will inturn enhance the brand image and reputation of the sponsoring organization. Therefore, CSR can become a communicating and dialogue arm of sustainable waste management in the city.



12.5 Conduct Sanitation Campaigns

People's attitudes influence not only the characteristics of waste generation, but also the effective demand for waste collection services. Attitudes may be positively influenced through awareness-building campaigns and educational measures on the negative impacts of littering, improper segregation at source, inadequate waste collection with regard to public health and environmental conditions, and the value of effective disposal. While many current initiatives lead to visually cleaner areas, it does not encourage sustainable practices that reduce littering and illegal dumping in the long run. More emphasis is required on awareness creation relating to the implementation of the waste hierarchy. As such, waste minimization and waste separation at source needs to be encour-

aged to enhance reuse and recycling activities. Willingness to pay for waste services will also improve with increased awareness as a result of increased insight into the benefits of waste services, as well as the actual cost thereof.

Such campaigns should also inform people of their responsibilities as waste generators and of their rights as citizens to waste management services. Corporation should undertake massive public awareness campaigns on sanitation and establishing its link to public health, hygiene and the environment through various means including - radio, social media, documentaries, plays, workshops, etc. For this purpose a dedicated environmental awareness section is required which can function with the Medical and Health Section in the corporation whose prime responsibility is to continuously undertake awareness campaigns and drive home the point like

- Clean-up campaigns in schools;
- Printing of pamphlets on different topics;
- A waste message in the municipal newsletter / newspaper;
- Celebration of environmental days/events;
- Training and workshops for generators of waste;
- An hour slot per month on the local radio station to discuss different environmental issues and answer queries;
- Display slogans on transport vehicles and containers to encourage the public to keep their town/ city clean.
- Door to door education: This involves the deployment of some of the community members (who were given training themselves before going out) to go to people's houses talking to them about environmental issues, including waste management, especially illegal dumping.
- Introduce innovative ways of attracting the involvement of stakeholders, wherever there is incentive people will participate. However, the focus should be on preventing littering and not incentives for cleaning after littering. The latter might drive a wrong behaviour.
- Promote Reuse and Recycling techniques by instructing operators producing domestic and non-domestic products, food as well as non-food to seriously endeavor to use re-usable packaging materials so that after the delivery of goods, the packaging materials could be collected back and used over and reused again.
- Direct operators to promote incentive and product discount to consumers for the return of packaging or bottling materials in good condition, to the waste producers or retailers to promote re-use. The cost of packed articles and article without the packaging material could be kept different with a choice to the consumers to take the article without the packaging material at low cost.
- Should suggest manufacturers to introduce the Multi-use bottling practices. Hard-to-recycle packaging like PET bottles metalized plastic films and multi-

film packs must be phased out unless producers take responsibility for their recall and recycling or re-use.

- Promotion of viewing the waste as a resource, thereby encouraging economic competitiveness through resource efficiency. Efforts should be made to encourage collection of such re-usable material through waste collectors, waste producers, NGOs and private sector instead of allowing reusable waste to land up at the disposal sites. Bottles, cans, tins, drums, cartons can be reused and excess packaging materials can be recycled.

12.6 Media Campaigning and Environmental Awareness

Information Hot-line

The key to success of any public-education, awareness and motivation program is to provide maximum means of communication for the public to interact, promptly and conveniently with the policy-makers and to seek clarification / share ideas or give suggestions which can be constructively used in the waste management program. A telephone hot line or Post Box number for written communications could be an ideal way to have inputs from people. This should be manned during working hours (or even later) by polite, responsive and dynamic persons who are well informed and have a liking for the subject at all times. These communication channels (one or more) can be set up and monitored by using suitable in-house staff or linking it to the environmental awareness section.

This awareness wing should be financially independent by allocating appropriate budget for the associated activities, as below

Publicity through local cable network may be 20 times a day on alternate days in the first year and twice a week in the following year.

Advertisement in all local newspapers twice in the first quarter and to be repeated once in a quarter subsequently.

- Distribution of pamphlets and display of banners over a period of one year.
- Organize one street play in every slum through NGOs for one year.
- Organize 4no's of rallies by students per year for two years.
- Awareness training to municipal staff. 1/2 day for sweepers & 1 day for supervisors.
- Awareness campaigns through group meetings over a period of one year

Use of Cable TV and Cable channels:

This is a very powerful medium and can be used to advise citizens not to litter and instead keep two bins for the storage of waste at source, one for biodegradable waste and another for recyclable waste. Citizens may also be advised to cooperate in handing over their waste to the waste collector on a day to day basis

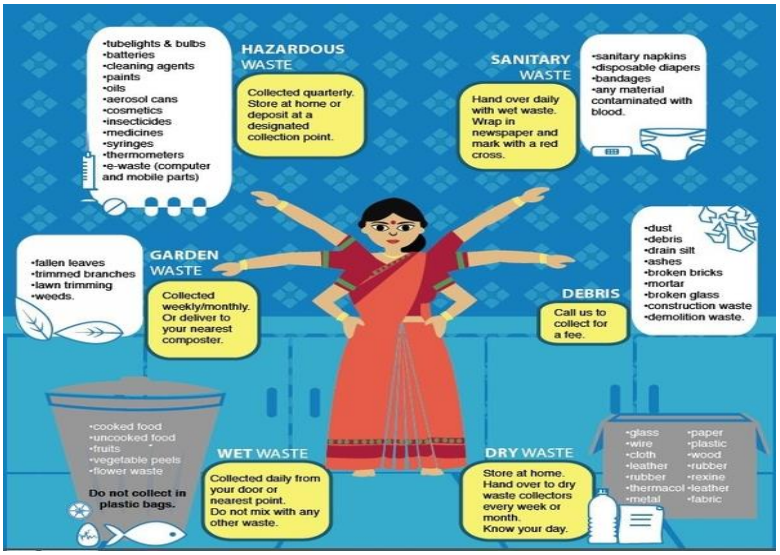
as per the collection arrangements and timings prescribed by the municipality. This network can also publicize the contact numbers of the officials for addressing their grievances on Solid Waste Management.

Use of Hoardings/banners:

Special Hoardings/banners may be put in the town covering messages seeking public participation. Alternatively, all Municipal-licensed Hoardings should have a space reserved for civic messages. This will add a "socially-aware" image to the advertisers and will not reduce the usefulness of the hoarding to them at all. The messages can be those developed by advertising agents to promote any of the recommendations of this new waste-management policy. The Hoardings should also publicize the hot-line numbers etc.

Advertisements in Newspapers:

Advertisements may be given in local news papers from time to time to create public awareness. Local newspapers can also be requested to start a regular Suggestion Box on the city page to improve Solid Waste Management services in the town. They may also be requested to give coverage to successful initiatives that have overcome such problems in a constructive way.



Issue of handbills:

Council may get handbills printed with photographs showing the new system of waste management and advise the people to cooperate in making their town clean and healthy. Such handbills could be prepared from the professionals for effective delivery of message. Council can use newspaper delivery services for distribution of handbills besides distributing the same through health department network.

Use of networking websites and instant message sharing technologies

Council may use the emergence of latest message sharing technologies like whatsapp, facebook, twitter, etc to disseminate information, take complaints and address the grievance of the general public.

12.7 Success Story of PRAJAVANI (a web based public grievances system in VISAKAPATNAM)

Prajavani is an e-governance initiative by the combined efforts of District Administration and National Informatics Centre (GOI) in Visakhapatnam District. PRAJAVANI system not only gives citizens an avenue to track the progress on their grievance, but also provides the District Collector an effective tool to monitor the performance of various departments.

- A new grievance mechanism is highly useful to those who are living in remote areas of the district to send their complaints across the authorities without much ado;
- The petitioner will know to which officer the complaint is marked and what is the time frame for response;
- The software was designed in local language "Telugu" for easy access to urban and rural people.

The District Collector has envisaged the prajavani system and stream lined with well-planned systematic approach adopted in receipt of petitions from public.
The following procedure is followed:

- Instant response to the petition
- Ascertaining the information from the officers concerned on the spot
- Giving time frame for redressal of grievance,
- Handing over acknowledgement to the petitioner.

The monitoring system to expedite the redressal of grievances

- Prajavani operators work under the supervision of petition monitoring section at Collectorate. They play a major role in timely disposal of complaints. They check daily unmarked petitions and they send to concerned officer, and also make time frame for disposal. Prajavani operator feeds the disposals in

the computer and complaints get disposed off.

- The District Collector reviews the District Officers in monthly review meetings.
- Special Officers are entrusted with the follow up action on grievance petition by reviewing the Mandal level Officers.

Aims of the District Administration:

- Implementation of Government programmes and schemes to the public with utmost importance with a speedy disposal.
- Respond to the public problems and grievances and to gear up the government mechanism for redressal of the same.
- Reduce the pain of public going to Collectorate for follow up action off.

13 CAPACITY BUILDING

13.1 Introduction

The subject of Solid Waste Management has remained neglected for the past several decades with the result that the level of service is highly inadequate and inefficient. For improving the Solid Waste Management (SWM) services it is essential to adopt modern methods of waste management methods with right choice of technologies, which can work in the given area successfully. Simultaneously, measures to be taken for institutional strengthening and internal capacity building so that the efforts made can be sustained over a period of time and the system put in place can be well managed. For sustainability of waste management practices in any given area, training and capacity building of the employees and everyone responsible for Solid Waste Management in the Urban Local Bodies is the most important aspect without which the effective waste management would be unattainable.

In Solid Waste Management (SWM) the people, partnerships, coalitions, resources and skills are essential to its successful implementation and hence all these are included under the large umbrella of the term "*capacity*".

13.2 Capacity Building Methods

There are many approaches to providing capacity building services, like:

- Providing access to repositories of information and resources (for example, databases, libraries and web sites)
- Trainings (public, customized or on-line)
- Consultation (for example, facilitating, expert advice and conducting research)
- Publications
- Web based forum for interaction among different players

13.3 Capacity Building In Solid Waste Management

The approach to capacity building in SWM should be not only about technology and economics but also about:

- Understanding the administration systems for waste management and related activities (multidisciplinary and cross-sectoral).
- Understanding the need for human resource development to achieve better results in SWM.
- Focus on building sound institutions and good governance for attaining improved SWM. Delineating strategies for sustenance of achievements.

13.4 Strategic Framework For Capacity Building

The following diagram illustrates the capacity building framework in general. The framework is premised on four core areas: (i) situation analysis (ii) creating

the right vision and mission (iii) drawing up the correct strategy and corresponding action, and (iv) measures for sustainability.

13.5 Training Needs

The plan should invariably indicate the target group or agencies to be capacitated for effective implementation. The major key factor for any training is depend on identification of target groups, for effective waste management implementation there are various groups/levels of people in the community who are major target groups.

The following are major target groups:

- Senior level officers-Decision makers
- Middle level officers-Managers and technical staff
- Junior Level –Technical staff
- Unqualified ground-level staff
- Elected members
- Members of NGOs and private participants if any

Appropriate training programmes have to be organized for staff on the concepts of SWM, health, environmental, legal implications and functional aspects depending on the knowledge levels and their organizational positions. Every person involved for the SWM in ULBs has to be well-versed with the process, methods of SWM implementation.

13.6 Proposed Course Contents For Training

Training needs should be identified for various levels including top and middle management, supervisors and ground staff. The training should be customised to the level of competence and awareness of the manpower involved in the SWM system. Training needs could be identified at each organizational level. A training calendar could be devised with course content depending on the need assessment.

General contents of the training courses at various levels are outlined below.

The suggested general course content for training the various levels of people in the SWM system is as given below:

- Introduction to SWM
- Sources and types of solid waste, waste generation rates density, composition
- Ill-effects waste generation and improper disposal in terms health and environmental aspects
- Importance of SWM
- Salient features of the Municipal Waste (Management & Handling) Rules 2000
- Practices in other parts of the country through audio visual presentations, films
- Waste reduction and material recovery
- Importance of segregation & storage, primary collection systems
- Rag picker activity and the role of informal sectors
- Role of governing bodies
- Planning an efficient sweeping and collection system,
- Tools and Equipments for SWM
- Transfer depots, container collection,
- Transportation- vehicle selection, alternatives for collection vehicles, vehicle routing
- Processing options, composting, market for compost
- Sanitary land filling,
- Statutory and environmental requirements, site selection and procurement, site development, operation, monitoring and closure of sites
- Role of community, NGOs and their participation

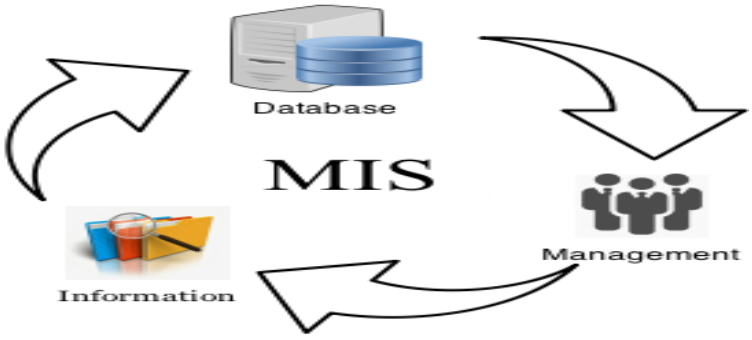
- Private Sector participation
- Technical and Financial aspects of SWM
- Institutional aspects of SWM and their strengthening
- Management Information System of SWM

As per the training need assessment and the targeted audience. The training content has to be updated regularly and frequently so that latest developments could be included in the material.

The training programmes for the workers could be conducted in an informal manner and in the local language.

13.7 Management Information System

Good management is the key for effective implementation and success of Solid Waste Management. This requires collection of critical information which is not just for keeping the records up to-date but used effectively for taking corrective measures as well as proper planning for future. Existing information has to be collected to have an overall idea of the prevalent situation and develop an effective management system for the future. Information that highlights any deficiency in the existing system can be used in taking corrective measures and such information has to be collected at regular intervals to monitor the system.



Geographic Information System (GIS) and MIS has to be integrated into the SWM system. Similarly, citizen interface could be maintained by frequently seeking their feedback and suggestions.

Information that needs to be recorded and studied includes relevant information of the

department for planning process as well as specific information related to employee performance, effectiveness of the training programmes, availability, adequacy, operation and maintenance of the equipments and vehicles involved in SWM, the performance of the processing plants, information related to landfill sites etc.

A list of items on which the data should be collected and kept on record for planning purpose and monitoring the activities done by various sections of SWM has to be prepared and be utilized by the local bodies. A check list/format would be developed for data collection for the records and information. (Sample format attached)

The following information needs to be collected and updated from time to time:

1.	**Profile of the Town**
a	Area of the town/city;
b	Population of the town/city;
c	Decadal growth of population;
d	Number of wards, their area and population
e	Ward-wise information in regard to
	Population density in different wards; No, of Households, shops and Commercial 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 and width Percentage of area covered with under-Ground sewage system Percentage of area having surface Drains Percentage of area having no drainage Facility
2.	**WASTE GENERATION**
a	Seasonal variations in daily waste generation
b	Total quantity of waste produced annually during last 3 years
c	Breakup of the quantity of wastes generated Household, shops and establishment waste; Vegetable and food market waste; Meat, fish and slaughter house waste; Construction & demolition waste Hospital waste Industrial waste

d	Average quantity of waste produced each day.
e	Average number of carcass removed each day
3.	**STAFF POSITION**
a	Number of sanitation workers deployed in the city for the collection of waste
b	Number of sanitation workers deployed for the transportation of waste
c	Ward-wise allocation of sanitation workers
d	Sweeper-population ratio in each ward
e	Sweeper-road length ratio in each ward
f	Sweeper-supervisor ratio in each ward
4.	**OTHER MANPOWER INVOLVED**
	Contract workers NGO / CBO - Voluntary workers Private players and their detailed information Welfare Measures for workers like Uniforms, Housing, Healthcare, Loan for education.
5.	**WASTE STORAGE DEPOTS**
a	Number of sites designated/notified for temporary waste collection (Dust bins/open sites etc.)
b	Type and size of Dustbin/open site provided in each ward.
c	Ward-wise Quantum of waste generated each day
6.	**TRANSPORTATION**
a	Number of vehicles available with the local body for the transportation of waste, their type, size and age.
b	Number of trips made by each vehicle in one shift.
c	Number of vehicles used in: First shift Second shift & Third shift
d	Quantity of waste transported in each shift.
e	Total quantity of waste transported each day.

f	Percentage of waste transported each day.
7.	**COMPOSITION OF WASTE GENERATED**
a	Total quantity of Organic Waste
b	Total quantity of Inorganic Waste
c	Toxic Material Content
d	Recyclable waste
8.	**WASTE PROCESSING AND DISPOSAL**
a	Number of waste processing and disposal sites in the city.
b	Their distances from the Centre of the city.
c	The area of these sites
d	The quantity of waste treated/disposed of at each site
f	The expected life of each land filled site
9.	**FINANCIAL ASPECTS**
a	Operating cost Cost of collection per ton/day Cost of transportation per ton/day Cost of disposal per ton/day
b	Allocation of revenue and Capital budget for SWM Vis a Vis the City Corporation's budget

13.8 Monitoring of SWM Services:

For the day-to-day monitoring of SWM services, the following data may be collected, compiled and analyzed.

Daily Reports:

Daily reports of the following to be sent by supervisors to higher officials

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 under his supervision
- 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
- 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 of 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 secondary waste collection points

- Number of sites in the area
- Number of 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 where there was unauthorised dumping
- Action taken
- Daily Report to be sent by Zonal Engineers

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 un-cleared and
- Arrangements made or proposed to be made for clearing the backlog

Quantities of waste transported

- Number of vehicles deployed during the day or night
- 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

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. Mobile phones or other communication networks essential for effective communication and monitoring of services should be provided to Zonal Engineers & supervisors.

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 production 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 were 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

Training Programme Monitoring

- Topic of the training
- Date of training programme
- Type of training programme
- Targeted organization level
- No. of attendees
- Feedback from the attendees

Complaint Redressal Mechanism

- Name of the complaint cell

- Ward/Location of the complaint cell
- Nature of complaint
- Details of the complaint
- Action taken

Monitoring and Evaluation of Daily Reports

Monitoring & Evaluation Monitoring and evaluation (M&E) of activities provides with better means for learning from past experience, improving service delivery, planning and allocating resources, and demonstrating results as part of account-ability to key stakeholders. It also help as a tool for focused improvement and to identify key issues.

Tools such as Performance Indicators, Formal surveys, Rapid Appraisal Methods, Participatory Methods, Cost-benefit and cost-effectiveness analysis, Impact Evaluation etc could be used for monitoring and evaluation. The output as well as outcome will be thoroughly monitored using the appropriate tool. This will help proper evaluation of the capacity building activities and taking corrective action, as found required.

14 ENVIRONMENT MANAGEMENT PLAN DURING CONSTRUCTION STAGE

14.1 Introduction

Construction Environmental Management Plan (CEMP) is aimed at mitigating the possible adverse impact of a project during Construction Phase and for ensuring to maintain the existing environmental quality. The CEMP converses all aspects of planning and construction of the project, which are relevant to environment. It is essential to implement the CEMP right from the planning stage and then continuing it throughout the construction stage. Therefore the main objective of the CEMP is to identify the project specific activities that would have to be considered for investigation of the significant adverse impacts and the mitigation measures required.

The impacts due to development works construction will be first minimized by adequate planning and taking construction activities as per PERT and CPM Chart. The specific measures that shall be put to practice to minimize the impact on the environment are discussed below:

14.2 Air Environment

Provision shall be made for sprinkling of water on loose soil to avoid dust generation. The debris and unutilized construction material and earth from the construction site shall be removed immediately to recycle within the project so that no nuisance dust is generated due to wind. The vehicles employed by the developers shall be checked for vehicular emissions. The developers shall also impress upon the service agencies to get vehicles regularly checked for vehicular emissions. Construction Activities shall not be allowed at Night.

The mitigation measures shall include regular maintenance of machinery and provision of personnel protective equipments to workers where needed. The steps shall be taken to reduce the impact of noise by carrying out plantation from the very beginning.

A Leachate Treatment Plant with tertiary level of treatment shall be provided to avoid any odor pollution from the Leachate generated from the Plant. Extensive plantation to mitigate the impact of noise and to improve the ambient air quality shall be provided.

14.3 Water Environment

Construction work requires large quantities of water to be used in various processing plants for material preparation; curing purposes, cooling water in equipments, domestic usages in colonies, etc. wastewater will be generated in various forms in the processing plants and workshops. Additionally, during the construction work, muck transportation and transportation of materials; large quantities of suspended particulate matter will be generated to end up in the water body. As the construction period is long such impacts can permanently dete-

riorate the water quality in the area, if adequate mitigation measures are not adopted.

The run-off during development shall be controlled by removing construction related solid waste as construction debris, loose soil etc. quickly. Further land clearing activity shall be kept to the absolute minimum by working at the specific sites one by one where construction is to take place. A septic tank shall be provided with toilet facilities to meet the daily needs of labor during working hours. Workers shall be discouraged from toilet in open.

Both roof top rainwater harvesting and storm water run-off shall be tapped for recharging the aquifers and storage.

14.4 Land Environment

To avoid erosion of the top soil the development shall be planned to be done in the shortest possible time and land clearing activity shall be kept to the absolute minimum by working at the specific sites one by one where construction is to take place so as to increase detention and infiltration.

The activities that result in soil being laid bare shall be scheduled in such a way that some type of vegetative cover appropriate to the site shall be established prior to onset of monsoons. Natural waterways/drainage pattern shall be maintained by providing culverts where needed. The solid waste generated from the construction activities shall be effectively recycled within the project.

14.5 Noise Levels

The sound will be generated during almost all the construction activities such as tunneling, blasting, movement of vehicles, operation of construction machines and equipments, repair and maintenance work, operation of DG sets, etc. Continuous exposure of workers to high sound levels may result in annoyance, fatigue, and may cause temporary shift of threshold limit of hearing and even permanent loss of hearing.

Construction phase will generate noise at various locations in the project area and is likely to affect residents and construction workers. The simultaneous operation of some equipment may increase the noise manifolds, however, resultant increase in noise levels will depend upon location of such equipment with respect to habitation, availability of the silencers/ mufflers, condition of the equipment, losses during transmission, etc. Increase in vehicular traffic in the area will also contribute to high sound levels in the area.

Sound attenuates with the distance and even if all the attenuation factors are removed, direct sound levels reduce by 6 dB(A) with every doubling of distance. Further, the sound level reduces substantially when the wave passes through a barrier. Therefore, if location of construction equipment is planned keeping in view the safe distance from habitation, impact can be greatly reduced on large

section of population. Workers who are directly exposed need to use Personal Protective Equipments (PPEs) to reduce the impact.

14.6 Mitigations

The best way of impact mitigation is to prevent the event occurring. All efforts should be made to locate the developmental activities in an area free of agricultural lands, ecologically sensitive, erosion, forests, flooding, human settlements, landslides, natural scenic beauty, water logging. However, practically, this is not possible as project design criteria govern the location of various activities. Therefore, the next step is to look at the raw materials/technologies/ processes alternatives which produce least impact i.e. adopting or using processes or technologies which are efficient and produce recyclable wastes/ minimum waste/wastes that can be easily disposed, without seriously affecting the environment. However, if the developmental activities produce the adverse impact, action has to be taken to mitigate the same. Following are some of the recommendations on mitigation measures for various Environments and Noise Levels.

Air Pollution Mitigation:

- Locate stockpiles of sand in sheltered locations or provide wind breaks.
- Keep the stockpiles to the minimum practicable height and use gentle slopes.
- Ensure that all dust generating materials transported to and from site (i.e. in trucks) are covered by tarpaulin.
- Keep site vehicles and plant well maintained and regularly serviced. All vehicles must comply with the Traffic Licensing Directorate emission standards at all times.
- Do not burn waste materials on-site.
- Use covered containers for organic waste and empty frequently before decomposition.
- Take account of the wind conditions when arranging activities that are likely to emit aerosols, fumes, odors and smoke.
- Educate the personnel at site on the above issues through tool box meetings

Water Pollution Mitigation:

- Segregation of different types of wastes at source and avoid their mixing up in the river.
- Accumulation of oil wastes in depressions should be minimized in order to avoid possible contamination of the ground water system.
- Surface runoff from oil handling areas/devices (workshops and DG operation areas) should be treated for oil separation before discharge into the envi-

ronment.

- If oil wastes are combined with sanitary sewage, oil separation will be necessary at the wastewater treatment facility.
- The growth of aquatic weeds is to be monitored in the reservoir and excess weeds shall be removed.
- The proposed plant includes an RO system in the design.

Land Pollution Mitigation:

- Proper and secure bunding.
- Minimize the amount of land disturbance, develop and implement stringent erosion and dust control practices.
- Consolidate infrastructure requirements (e.g., roads and drains) for efficient use of land.

Noise Pollution Mitigation:

- Location of the construction equipment to be decided keeping in view the safe distance from habitation.
- Contractors will be required to maintain properly functioning equipment and comply with occupational safety and health standards.
- All the construction equipment will be required to use available noise suppression devices and properly maintained mufflers.
- Staging of construction equipment and unnecessary idling of equipment within noise sensitive areas to be avoided, whenever possible.
- Minimize the use of noise producing equipment during night hours to avoid the disturbance to locals and wild animals of surrounding area.
- Monitoring of noise levels will be conducted during the construction phase of the project. In case of exceeding of pre-determined acceptable noise levels by the machinery will require the contractor(s) to stop work and remedy the situation prior to continuing construction.
- Noise from the DG set should be controlled by providing an acoustic enclosure or by treating the enclosure acoustically.
- Educate the personnel at site on the above issues through tool box meetings

14.7 Safety Measures

Occupational Health, Safety and associated risks:

- The organization shall identify the occupational health and safety (OHS) hazards and the associated risk on ongoing basis, to facilitate setting of OHS ob-

jective and targets, control risk and to keep this information up to date.

- While identifying occupational health and safety (OH&S) hazards and risk during initial OH&S review the following criteria should be considered.
  - All activities where previous records of Incidents, Accident occurred.
  - Inputs from regular Plant visit and meetings.
  - All activities routine and non-routine, where substantial hazards and risks are involved including contracted & company own activities / facilities.
  - Evaluation of feedback from investigation of previous incidents/accidents
  - Examination of all existing OH&S procedure and practice.
- While identifying significant OH&S risks consideration shall also be given to
  - Chemical hazards.
  - Physical hazards, Biological hazards. o Monotonous work.
  - Hazard Due to layout and design deficiency.
- Prepare a Register of OH&S hazards and associated risks, which shall include the departments &Facility layout chart.

EHS & Social Roles and Responsibility:

Define and communicate role, responsibilities and authority for effective functioning of EHS & Social management systems:

- Organization shall comply with the relevant applicable policies such as environmental, quality and fund standard guidelines.
- Shall define roles, responsibilities and authorities w.r.t EHS and applicable social guidelines from statutory bodies.
- Monitoring of effective implementation, Compliance to rules/acts.
- Initial training needs to be addressed and provide awareness and competence.
- Calibration and Maintenance of EHS equipment.
- Maintenance of updated On – Site Emergency Plan.
- Handling and investigation of incidents/ accidents, non-conformities, taking action to mitigate impacts and completing corrective and preventive actions.
- Conduct internal EHS & social compliance audits.

Training & Awareness.

To lay down the procedure for identification of training needs and providing appropriate training to all Employees and contract employees to ensure effective

implementation of EHS & Social management systems at all levels and functions. The organization shall do the necessary training need identification at all level and functions.

The training shall in general address the following areas:

- General Awareness Training
  - General awareness and employees roles and responsibilities in achieving conformance with policy, objective and targets.
  - Relevant EHS & Labour laws rules and regulations.
- EHS & Social induction training o Policy goals and objectives.
  - Applicable legislative requirements.
  - Requirements that are conditions of employment. o Benefits of improved personal performance.
  - The potential consequence of deviation from specified operating procedures.
  - Emergency Preparedness and Response.
- Job Specific Training
  - The potential consequence of deviation from specified operating procedures.
  - SOP/WIs for the work areas and occupational hazards of their activities.
  - Emergency Preparedness and Response.

Communication & Consultation:

To lay down the procedures for consultation and communication, both internal & external in relation to EHS

- Suggestions from all employees through suggestion.
- Internal Communication.
- Policy will be communicated to all employees through training and displaying at various prominent locations.
- External Communication.

Emergency Preparedness & Response Plan.

To establish and maintain procedures in order to identify potential foreseeable accidents/ emergency situations and to prevent, control and mitigate the associated environmental impacts and Occupational Health & Safety risks and to test effectiveness of such procedure. If required review/revise such procedures periodically.

- Some of the key measures include:
- Maintain all fire extinguishers in working condition. Provide training to employees on fire fighting.
- Explosion Prevention.
- Explosive Mitigation.
- Corrective and Preventive action.
- Avoidance of Major Spillage of any chemical.
- Prepare emergency response plan and disaster management plan as per applicable norms.

Non Conformity, Corrective & Preventive Actions.

The organization shall establish, maintain documented records of accidents, incidents, operating procedures defining the responsibilities and authority for identifying and investigating non conformance and taking action to improve the EHS & SMS Performance.

- Non conformance which may affect the EHS performance shall be identified through :
  - Reporting incidents (including near misses).
  - Carryout investigation to find out the root causes of accidents and incidents.
  - Maintaining corrective & preventive action & maintaining records. o The SOPs shall be suitably amended to address the reason for change.
  - Suggestions shall be drawn for mitigating the consequences of accidents and avoiding the reoccurrence of accidents/incidents.
  - Establishing procedures for identification on non conformance. o Results of mock drill of onsite emergency plan.

General Measures:

- Vehicle speed will be restricted to 15 km/hour at site to minimize potential for dust generated in the surroundings.
- Appropriate measures will be employed to minimize windblown litter and dust during transportation by either covering trucks or transporting wastes in enclosed containers.
- Heavy Goods Vehicles holding areas to be provided for vehicles waiting to deliver loads at work sites so as to avoid queuing on other connecting roads.

- Fixed noise sources to be located away more than 50 m away from the site fencing.
- Site workers working near high noise equipment to use personal protective devices like ear muff/plugs to minimize their exposure to high noise levels.
- Maintain clearance between electric lines and work spaces / nearest service lines, ensure enough space for maintenance.
- Adequate precautions shall be taken to prevent the accidents and from the machineries. All machines used shall confirm to the relevant Indian standards.
- Protective footwear and protective goggles to all workers employed on mixing of materials like cement, concrete etc.
- Welder's protective eye shields shall be provided to workers who are engaged in welding works.
- Earplugs shall be provided to workers exposed to loud noise, and workers working in crushing, compaction, or concrete mixing operation.
- The contractor shall supply all necessary safety appliances such as safety goggles, helmets, safety belts, earplugs, mask etc to workers and staffs.
- For safety of people occupying the site, regulations concerning fire safety to be followed. Some of the requirements include:
    - Installation of fire extinguishers.
    - Provision of water sprinklers for unpaved roads. o Emergency exit.
    - Proper labeling of exit and place of fire protective system installation; o Trained personal to use fire control systems.
    - Display of phone numbers of the city/local fire services, nearest hospital, ambulance facility, etc.
    - A readily available first aid unit including an adequate supply of sterilized dressing materials and appliances as per the Factories Rules in every work zone.
    - Availability of suitable transport at all times to take injured or sick person(s) to the nearest hospital.

14.8 Environment Management Plan During Operation Stage Introduction

Purpose of Project:

Visakhapatnam has witnessed a rapid growth over the past two decades. With an average decadal growth rate of 91% during the period 1901-2011, the city has grown from a population of 9.81 to 18.83 lakhs in 2011.The Solid Waste genera-

tion in the GVMC area is around 920 metric tons per day. With rapid urbanization and growth of industry & business has led to increased waste generation but the infrastructure development for MSW management has never kept pace. Alternatives like Land Filling for waste disposal in open space leads to the paucity of urban land. Poor MSW management is associated with increased health problems in all sections of population. General environmental impacts are loss of vegetation due to site clearance, odor nuisance, stray animals and rodent problems, etc. So burning wastes to reduce their volume and weight makes sense. Combustion reduces the volume of material by about 90 % and its weight by 75 %. The heat generated by burning wastes has other uses, as well, as it can be used directly for heating, to produce steam or to generate electricity. The Project proponent wants to set up plant to convert Waste to Energy.

Overview of Project:

Generals of proposed project

The proposed project is the Waste to Energy- CFB power plant of the Visakhapatnam Municipal Solid Waste Treatment Plant.

Project Name: Visakhapatnam Municipal Solid Waste to Energy Power Plant.

Project Site: The project site allotted by GVMC is at outskirts of Visakhapatnam city.

Construction Contents and Scale: One 920 t/d MSW Processing plant will be constructed in terms of main work of the project; the facility in the plant includes production facilities such as comprehensive plant building, booster station, ignition oil pump room, leachate disposal station, industrial pump room and cooling tower etc and supporting production facilities as well as production office buildings and guard room etc within the power plant area. See below table for project composition.

15 PROJECT COSTING

15.1 Introduction

The cost estimates for integrated solid waste management system for GVMC is worked out based on the detailed study done by Feedback Infra and its assessment of the MSW management operations in Visakhapatnam. The existing infrastructure available with the GVMC has been taken into account and costing for up-gradation of the system is worked out. The additional investments thus required to increase the efficiency of the system and to meet the norms prescribed by the MSW (Management and Handling) Rules, 2000

The Total project cost required for Visakhapatnam Integrated waste treatment plant is given below:

S. No.	Item Description	Amount in Rs Lakhs
1	MSW collection & Transportation	3807.00
2	MSW Treatment & Disposal (Compost & RDF)	8333.00
3	Power Plant	3200.00
4	Contingences	767.00
	Total Project Cost	**16107.00**

Breakup of each cost is given below

15.2 Capital Cost of MSW Collection & Transportation

The capital cost of MSW Collection & Transportation if arrive after taking into consideration of existing vehicles. The cost shown below is year wise capital investment.

S.no	Type of Vehicle	Unit Price in Rs	Cost in Rs in lakhs - Year Wise				Total Cost in Rs
			2016	2017	2018	2019	
	Primary Collection						
I	***Auto tippers - No's required***		70	213	0	41	
	Auto tippers – Cost	450000	315	959	0	185	1458

II	***Tricycles -- No's required***		0	0	126	225	
	Tricycles – Cost	17000	0	0	21	38	60
III	***Bins - No's Required***		1610	45	84	325	
	Bins – Cost	17500	282	8	15	57	361
	Secondary Transportation (To Transfer station)						
IV	***Rear End Loaders-No's Required***		12	4	3	26	
	Rear End Loaders-18 cum	3100000	372	124	93	806	1395
	Tertiary Transportation (To Dump site)						
V	***Taras vehicle - No's Required***		0	0	0	12	
	Taras vehicle – Cost	3200000	0	0	0	384	384
VI	Transfer Station Civil Cost					150	150
	Total Cost in Rs in Lakhs						**3807.87**

15.3 Operation & Maintenance cost of MSW Collection & Transportation

S.no	Item Description	Amount in Rs Lakhs Per Annum
1	Diesel	310
2	Manpower	3030
3	Repair & maintenance	311
4	Other Miscellaneous	72
	Total Cost Per Annum	**3723**

15.4 Capital Cost of Treatment & Disposal

Cost of Civil & Site development works at Kapuluppada Site

S. No	Description of Item	Nos	Qty	Units	Amount in Rs
1	Guard Room	1	11.97	Sqm	314,714
2	Scale Room	1	15.43	Sqm	367,229
3	Weigh bridge Platform	1	54.00	Sqm	408,811
4	Weigh Bridge Equipment - 40 MT	1	1.00	Nos	1,200,000
5	Admin, Lab & Rest Rooms (G+1)	1	295.92	Sqm	4,647,634
6	Electrical Panel Room & DG	1	66.42	Sqm	940,983
7	Wash Rooms	1	21.00	Sqm	577,285
8	Storage Shed	1	100.00	Sqm	1,414,735
9	Vehicle Workshop	1	217.18	Sqm	2,538,152
10	Vehicle Wheel Wash	1	64.00	Sqm	488,691
11	Under Ground Sump (50 kl)	1	60,000.0	Liters	513,538
12	Compost Plant	1	32,760.0	Sqm	255,493,742
13	Dump Capping				
a)	Capping	1	59,991.2	Sqm	88,024,142
b)	Leachate collection sumps	2	14.00	Nos	376,986
14	Leachate Collection Pond	1	375.00	Sqm	573,142
15	Leachate Treatment Plant	1	1.00	LS	10,000,000
16	Boundary Wall	1	2,948.00	Rmt	16,842,352
17	Truck Parking	1	750.00	Sqm	937,500

18	Car Parking	1	100.00	Sqm	550,000
19	Road - 7.0 m Wide (BT)	1	19,145.0	Sqm	22,816,191
20	Storm Water Drain	2	2,735.00	Rmt	18,575,083
21	Transformer Yard	1	100.00	Sqm	150,000
22	Green Belt	1	6,000.00	Sqm	1,050,000
23	Bore Well (Process Water)	1	1.00	Nos	150,000
24	Monitoring Bore Well	5	1.00	Nos	875,000
25	Plumbing & Sanitary works	1	1.00	LS	548,000
26	Electrical Works (Internal)	1	1.00	LS	32,130,000
	Grand Total Amount in INR :				**462,503,910**
	Grand Total Amount in Lakhs :				**4,625**

Cost of Civil & Site development works at Tangudupalli Site

S. No.	Description of Item	Nos	Qty/Area	Units	Amount in Rs
1	Site Development - 85 Acres	1	344,375.00	sqm	6,026,562
3	Entry & Exit Gate	1	1.00	nos	150,000
4	Security Room	1	11.97	sqm	249,476
5	Under Ground Sump	1	57.50	cum	391,978
6	Scale Room	1	15.43	sqm	282,151
7	Weigh Bridge Platform (Civil Work)	1	36.00	sqm	471,384
8	Administration Building	1	147.96	sqm	3,764,398
9	Electrical Panel Room & DG Room	1	105.41	sqm	1,054,221

10	Vehicle Workshop	1	200.00	sqm	1,316,200
11	Vehicle Wheel Wash	1	200.00	sqm	1,238,400
12	Wash Rooms	1	18.00	sqm	311,886
13	Leachate Collection Pond	1	425.00	sqm	538,475
14	Leachate Treatment Plant (90 kld)	1	1.00	LS	12,500,000
15	Secured Landfill (Phase -1)				
a)	Landfill	1	218,508.00	sqm	47,279,669
b)	Leachate collection sumps	8	14.00	cum	151,718
16	Compound Wall	1	2,400.00	rmt	7,816,800
17	Septic Tank With Soak Pit - 50 Users	1	1.00	LS	180,000
18	Truck Parking	1	750.00	sqm	600,000
19	Car Parking	1	450.00	sqm	562,500
20	Internal Road & Drains				
a)	BT Road - 7.00 m Wide	1	3,000.00	rmt	17,583,300
c)	Drain	1	6,000.00	rmt	12,642,000
21	Bore Wells (Process Water BW)	1	1.00	nos	150,000
22	Monitoring Bore Well (MBW)	5	1.00	nos	1,500,000
23	Substation and Outdoor Lighting (Street Light-ing & Electrical Items (Panels, DG Set, etc.)	1	1.00	nos	7,000,000
24	Transformer Yard (Civil Works)	1	100.00	sqm	150,000

25	Green Belt	1	85,000.00	sqm	5,984,000
26	Weigh Bridge Equip-ment - 60 MT	1	1.00	LS	800,000
27	Fire and Safety Equip-ment	1	1.00	LS	750,000
28	Sign Boards	1	1.00	LS	210,000
29	Leachate collection pumps & Others	8	1.00	nos	140,000
	Grand Total Amount in INR :				**131,795,118**
	Grand Total Amount in Lakhs :				**1,317.95**

Cost of MSW process Equipment:

S.no	Item Description	Nos	Unit Cost in Lakhs	Total Amount in Lakhs
I	**Presorting & RDF Process**			
1	Hoppers	2	5	10
2	Mannual sorting Conveyors	2	8	16
3	Magnetic Separators	2	25	50
4	Shredders	2	150	300
5	Trommels - 50mm	2	35	70
6	HAG/Air Dryer unit	2	125	250
7	Ballastic Separators	2	75	150
8	RDF Bailing machine	2	30	60
9	Conveyors	12	5	60
	Total Presorting & RDF			**966**

II	**Compost Process unit with all necessary Equipment for primary/secondary process and compost packing unit**	475 TPD	LS	**550**
III	**Waste Handling Vehicles**			
1	Grab loaders	4	25	100
2	Front End loaders with back hoe	8	28	224
3	EX-70 for windrow turning	4	30	120
4	Bob cat	4	18	72
5	Forklift	2	20	40
6	Tippers	2	27	54
7	Tractor Trailers	2	10	20
8	Water Tanker	1	10	10
9	MUV	1	10	10
10	Landfill Compactor/Excavator	2	55	110
11	Small tools & Spares	1	5	5
12	Workshop Equipment	1	10	10
	Total Waste Handling Vehicles			**775**
IV	**Other Equipments**			
1	Lab Equipments	1	10	10
2	Transformer & Switch yard	1	75	75
3	DG Set	1	15	15
				100.00
	Grand Total of Process			**2391.00**

	Equipment			

Total Cost of MSW Processing (Compost & RDF) – 8333 lakhs

15.5 Operation & Maintenance Cost of Compost, RDF & Landfill

S.no	Item Description	Amount in Rs Lakhs Per Annum
1	Power	190
2	Diesel	269
3	Manpower	137
4	Repair & maintenance	160
5	Admin Costs	30
6	Inoculums & Additives	14
7	Air/ground water Monitoring	9
	Total Cost Per Annum	**809**

16 PROJECT STRUCTURING

16.1 Possible PPP Options

Design-Build (DB) or Build-Transfer (BT)

Under this model, the private partner designs and builds the facility in accordance with the requirements specified by the government. Once completed, ownership and responsibility for operation and maintenance are transferred back to the public agency.

Strengths	Weaknesses
Access to private sector expertise.	Loss of owner control
Possibilities for financial savings and Innovation in design.	Difficulty and increased cost of changing contract or including additional features into design
Flexible procurement procedures potential for more efficient construction	A more complex award procedure
Reduced construction time	If life-cycle approach not taken, there is the possibility of higher operating and maintenance costs, which may offset the benefits of lower capital costs to the public sector
Transfer of risk from public to private sector	
single point of accountability	
Fewer construction claims	

Design-Build-Operate (DBO) or Build-Transfer-Operate (BTO)

Here, ownership of the facility is transferred back to the public sector upon completion of construction. However, the public body then leases it back to the private company for a specified period, usually a long-term lease, giving the private organisation the opportunity to recover its investment and generate a reasonable rate of return.

Strengths	Weaknesses
Access to private sector expertise.	In the event of default of performance or bankruptcy, it is potentially extremely difficult to terminate the contract or re-
Potential cost savings.	
Ownership of the asset remains in the public sector.	

Contracting out of operations may potentially limit any provincial or Central taxes.	move the private company.
Authority over levels of service and fees charged are retained by the public agency.	
It avoids legal, regulatory and tort liability issues (in contrast to the BOT model below).	
Government retains control over service standards, operational performance and asset maintenance.	
There is the possibility to terminate the relationship if agreed upon levels of service or performance standards are not met.	
Potential savings in the areas of design, construction and architecture, as well as operation.	

Build-Operate-Transfer (BOT) or Build-Own-Operate-Transfer (BOOT)

Under this model, a private partner is awarded a franchise by the government to finance, design, build, operate, maintain and charge fees on the service for a specified time period. Once the franchise relationship is concluded, ownership of the asset returns to the public sector.

Strengths	Weaknesses
Private sector financial resources are maximized.	Transfer of operations and financial responsibility back to the public sector may occur at a time when operating costs are increasing.
It ensures that the facility constructed is the most efficient and effective possible, based on life-cycle costs.	Loss of public sector control over capital, construction, and initial operations.
It enables the private sector body to assume responsibility for operations for a predetermined duration.	If the initial contract is not well drawn up, the arrangement may be unable to address future difficulties.
The community can benefit from the	Unless the public sector subsi-

development of the project without incurring sizeable debts, or having to make a large, upfront expenditure	dises the costs of service use, fee levels can be set by the private entity.
The private sector entity assumes responsibility for all start-up problems	Compared to the BTO model, there is less public control over the service
Possible cost savings arise from access to private sector experience, management, labour, equipment and innovation	In the event of default of performance or bankruptcy, it is potentially extremely difficult to terminate the contract or remove the private company.
Risk to the public sector is reduced, as this is shared with the private company	

Design-Build-Finance-Operate/Maintain (DBFO, DBFM, or DBFO/M) or Build-Own-Operate (BOO)

Under this structure, the private organization finances, designs, builds, operates and maintains the project. It is paid by the government throughout the duration of the contract, according to the services delivered and whether these meet specified standards of performance. There is no requirement that the private company will transfer ownership of the facility back to the public body.

Strengths	Weaknesses
The public sector plays no role in either provision or operation of the facility.	There is no guarantee that the private company will operate the service in the 'public good'.
It allows public sector regulation of the private sector's delivery of a 'regulated' or 'monopolistic' service area.	Unless the service is specifically regulated, the public sector cannot set or adjust its price.
The service can be operated by the public sector in the most efficient manner, both in the short and long term.	All federal, provincial and municipal tax regulations apply.
The public sector does not have to put up capital to finance the project.	Due to the lack of competition, it is necessary to develop rules and regulations concerning operations and pricing.
Private facilities generate public revenues in	

the forms of income tax and property tax.	
The long-term nature of the arrangement gives the private developer an incentive to invest large amounts of capital.	

Wrap Around Addition (WAA)

Here the private partner is contracted to construct an addition to an already existing public asset or facility. It may then operate that addition for a specified period of time or until there has been a reasonable return on the investment.

Strengths	Weaknesses
The public sector does not have to find the capital to finance the upgraded service.	It may be difficult to incorporate at a later date any future upgrades of the facility not included in the original contract.
The private partner assumes the financial risks.	Altering existing contracts with the private partner can be expensive.
The public sector gains the construction expertise of the private entity.	Perceived loss of control.
There is the potential for fast-tracked construction, using techniques such as design-build.	Contract awarding procedures become more complex.
Procurement processes can be more flexible.	
Construction can be made more Efficient.	
The time period needed for Implementation can be reduced.	

Lease-Develop-Operate (LDO) or Buy-Develop-Operate (BDO)

Under this model, a private sector organization purchases a facility from the public sector, modernizes or improves it, and then assumes operational responsibility under a contract with the local government. It is expected that the private partner will invest in modernization and then be given a specified period of time in which to realize a return on the investment.

Strengths	Weaknesses
The local government benefits from a significant cash infusion when the Private company buys the facility.	Loss of control of the service or Infrastructure, either perceived or actual.
Capital for financing the upgrade is provided by the private rather than Public sector.	There is potential difficulty in valuing assets for sale or lease.
Both parties gain opportunities for Increased revenue.	Issues may arise if selling or leasing Public assets that have received grant funding.
Users benefit from improved services and facilities.	In cases of private company failure, the local government may need to revert to providing the service or facility.
The public sector has access to the construction expertise of the private Organization.	It may be difficult to incorporate at a later date any future upgrades of the facility not included in the original Contract.
There is the potential for fast-tracked construction, using techniques such as design-build.	
Procurement processes can be more Flexible.	
The time period needed for Implementation can be reduced.	

Among these different approaches to structuring PPPs, there are variations in regard to the extent of participation by the private sector in public service provision, the different amounts of risk transferred to the private partner, varying natures of assets and facilities, and in the different arrangements for ownership of these. The degree of private involvement required by a particular project is determined by the public agency. Factors influencing this decision include the project's goals and objectives, the level of control the government requires, and the PPP consortium's ability to provide the service needed. Such decisions will also be constrained by the existence of regulation and legislation affecting the arrangement, and the need to attract private resources and generate future revenue.

16.2 Project Financing Options

Scheme for financial support to Public Private Partnerships in Infrastructure (Viability Gap Funding):

The Government of India recognizes that there is significant deficit in the availability of physical infrastructure across different sectors and that this is hindering economic development; whereas the development of infrastructure requires large investments that cannot be undertaken out of public financing alone, and that in order to attract private capital as well as the techno-managerial efficiencies associated with it, the Government is committed to promoting Public Private Partnerships (PPPs) in infrastructure development; and the Government of India recognizes that infrastructure projects may not always be financially viable because of long gestation periods and limited financial returns, and that financial viability of such projects can be improved through Government support. Now, therefore, the Government of India has decided to put into effect the following scheme for providing financial support to bridge the viability gap of infrastructure projects undertaken through Public Private Partnerships.

This scheme will be called the Scheme for Financial Support to Public Private Partnerships (PPPs) in Infrastructure. It will be a Plan Scheme to be administered by the Ministry of Finance. Suitable budgetary provisions will be made in the Annual Plans on a year-to- year basis.

In this scheme, unless the context otherwise requires:

Eligibility

In order to be eligible for funding under this Scheme, a PPP project shall meet the following criteria:

- The project shall be implemented i.e. developed, financed, constructed, maintained and operated for the Project Term by a Private Sector Company to be selected by the Government or a statutory entity through a process of open competitive bidding; provided that in case of railway projects that are not amenable to operation by a Private Sector Company, the Empowered Committee may relax this eligibility criterion.
- The PPP Project should be from one of the following sectors:
    a. Roads and bridges, railways, seaports, airports, inland waterways;
    b. Power;
    c. Urban transport, water supply, sewerage,
    d. solid waste management and other physical infrastructure in urban areas;
    e. Infrastructure projects in Special Economic Zones; and
    f. International convention centers and other tourism infrastructure projects;
- The Empowered Committee may, with approval of the Finance Minister, add or delete sectors/sub-sectors from the aforesaid list.

- The project should provide a service against payment of a pre-determined tariff or user charge.
- The concerned Government/statutory entity should certify, with reasons:
  a. That the tariff/user charge cannot be increased to eliminate or reduce the viability gap of the PPP;
  b. That the Project Term cannot be increased for reducing the viability gap; and
  c. That the capital costs are reasonable and based on the standards and specifications normally applicable to such projects and that the capital costs cannot be further restricted for reducing the viability gap.

Government Support

The total Viability Gap Funding under this scheme shall not exceed twenty per-cent of the Total Project Cost; provided that the Government or statutory entity that owns the project may, if it so decides provides additional grants out of its budget, but not exceeding a further twenty percent of the Total Project Cost.

Viability Gap Funding under this scheme will normally be in the form of a capital grant at the stage of project construction. Proposals for any other form of assistance may be considered by the Empowered Committee and sanctioned with the approval of Finance Minister on a case by-case basis.

Viability Gap Funding up to Rs. 100 Crore (Rs. One hundred Crore) for each project may be sanctioned by the Empowered Institution subject to the budgetary ceilings indicated by the Finance Ministry. Proposals up to Rs. 200 Crore (Rs. Two hundred Crore) may be sanctioned by the Empowered Committee, and amounts exceeding Rs. 200 Crore may be sanctioned by the Empowered Committee with the approval of Finance Minister.

Unless otherwise directed by the Ministry of Finance, the Empowered Institutions may approve project proposals with a cumulative capital outlay equivalent to ten times the budget provisions in the respective Annual Plan.

In the first two years of operation of the Scheme, projects meeting the eligibility criteria will be funded on a first-come, first served basis. In later years, if need arises, funding may be provided based on an appropriate formula, to be determined by the Empowered Committee, that balances needs across sectors in a manner that would broad base the sectoral coverage and avoid pre-empting of funds by a few large projects.

Approval of project proposals

Project proposals may be posed by a Government or statutory entity which owns the underlying assets. The proposals shall include the requisite information necessary for satisfying the eligibility criteria.

Projects based on standardized/model documents duly approved by the respective Government would be preferred. Stand-alone documents may be subjected to detailed scrutiny by the Empowered Institution.

The Empowered Institution will consider the project proposals for Viability Gap Funding and may seek the required details for satisfying the eligibility criteria.

Within 30 days of receipt of a project proposal, duly completed as aforesaid, the Empowered Institution shall inform the sponsoring Government/ statutory entity whether the project is eligible for financial assistance under this Scheme. In case the project is based on stand- alone documents (not being duly approved model/standard documents), the approval process may require an additional 60 (sixty) days.

In the event that the Empowered Institution needs any clarifications or instructions relating to the eligibility of a project, it may refer the case to the Empowered Committee for appropriate directions.

Notwithstanding the approvals granted under this scheme, projects promoted by the Central Government or its statutory entities shall be approved and implemented in accordance with the procedures specified from time to time.

In cases where viability gap funding is budgeted under any on-going Plan scheme of the Central Government, the inter-se allocation between such on-going scheme and this scheme shall be determined by the Empowered Committee.

Procurement process for PPP Projects

The Private Sector Company shall be selected through a transparent and open competitive bidding process. The criterion for bidding shall be the amount of Viability Gap Funding required by a Private Sector Company for implementing the project where all other parameters are comparable.

The Government or statutory entity proposing the project shall certify that the bidding process conforms to the provisions of this Scheme and convey the same to the Empowered Institution prior to disbursement of the Grant.

Appraisal and monitoring by Lead Financial Institution

Within four months from the date on which eligibility of the project is conveyed by the Empowered Institution to the concerned Government/statutory entity, the PPP project shall be awarded in accordance ; provided that upon application made to it by the concerned Government/statutory entity, the Empowered Institution may extend this period by not more than two months at a time.

The Lead Financial Institution shall, within three months from the date of bid award, present its appraisal of the project for the consideration and approval of the Empowered Institution; provided that upon application made to it by the concerned Government/statutory entity, the Empowered Institution may extend this period by not more than one month at a time.

The Lead Financial Institution shall be responsible for regular monitoring and periodic evaluation of project compliance with agreed milestones and performance levels, particularly for the purpose of disbursement of Viability Gap Funding. It shall send quarterly progress reports to the Empowered Institution which will make a consolidated progress report once every quarter for review by the Empowered Committee.

Disbursement of Grant

A Grant under this scheme shall be disbursed only after the Private Sector Company has subscribed and expended the equity contribution required for the project and will be released in proportion to debt disbursements remaining to be disbursed thereafter.

The Empowered Institution will release the Grant to the Lead Financial Institution as and when due, and obtain reimbursement thereof from the Finance Ministry.

The Empowered Institution, the Lead Financial Institution and the Private Sector Company shall enter into a Tripartite Agreement for the purposes of this scheme. The format of such Tripartite Agreement shall be prescribed by the Empowered Committee from time to time.

India Infrastructure Project Development Fund (IIPDF)

To support the development of credible and bankable PPP projects, a revolving fund with an initial corpus of Rs. 100 Crores has been set up in the Department of Economic Affairs, Ministry of Finance, GoI during 2007-08, to be offered to the private sector. The India Infrastructure Project Development Fund (IIPDF) provides financial support for quality project development activities. The Sponsoring Authority will thus be able to source funding to cover a portion of the PPP transaction costs, thereby reducing the impact of costs related to procurement on their budgets.

Eligibility:

- The proposals for assistance under the Scheme would be sponsored by Central Government Ministries/Departments, State Governments, Municipal or Local Bodies or any other statutory authority.
- To seek financial assistance from the IIPDF it would be necessary for the Sponsoring Authority to create and empower a PPP cell to not only undertake PPP project development activities but also address larger policy and regulatory issues to enlarge the number of PPP projects in Sponsoring Authorities' shelf.
- The PPP project should be from the sectors that are eligible for viability gap funding under the Government of India's scheme for Financial Support to PPPs in infrastructure or any other sectors with the approval of the Finance Minister.
- The IIPDF is available to the Sponsoring Authorities for PPP projects for the purpose of meeting the project development costs which may include the expenses incurred by the Sponsoring Authority in respect of feasibility studies, environmental impact studies, financial structuring, legal reviews and development of project documentation, including concession agreement, commercial assessment studies (including traffic studies, demand assessment, capacity to pay assessment), etc required for achieving Technical Close of such pro-

jects, on individual or turnkey basis, but will not include expenses incurred by the Sponsoring Authority on its own staff.

- The IIPDF will be available to finance an appropriate portion of the cost of consultants and Transaction Advisors on a PPP project where such consultants and Transaction Advisors are appointed by the Sponsoring Authority either from amongst the Transaction Advisors empanelled by Department of Economic Affairs or through a transparent system of procurement under a contract for services.

The IIPDF will fund up to 75 percent of the project development expenses to the Sponsoring Authority as an interest free loan. 25 percent will be co-funded by the Sponsoring Authority. On the successful completion of the bidding process, the project development expenditure would be recovered from the successful bidder. However, in the case of failure of the bid, the loan would be converted into grant. In case the Sponsoring Authority does not conclude the bidding process for some reason, the entire amount contributed would be refunded to the IIPDF.

To seek project development funding from the IIPDF, the Sponsoring Authority will apply to the PPP cell in DEA through the Memorandum for Consideration accompanied with the Preliminary Report of the project (in six copies). The MFC would provide justification for understanding detailed feasibility studies to be taken up for financing out of the corpus of the Fund in the prescribed Proforma. The proposals that do not envisage VGF can also be submitted for funding. Proposals for funding under these Guidelines would cover the entire gamut of PPP projects.

16.3 Project cost & revenue model

Breakup of cost of Collection & Transportation of MSW phase is given below

Abstract Cost of Project in Rs Lakhs						
S. No	**Item**	**Year**				
		2016	**2017**	**2018**	**2019**	**Cumulative up to 2019**
1	Primary Collection	315.00	958.50	21.42	222.75	1517.67
2	Primary Transportation					
3	Secondary Collection	281.75	7.88	14.70	56.88	361.20

4	Secondary Transportation	372.00	124.00	93.00	806.00	1395.00
5	Transfer Stations - civil works				150.00	150.00
6	Taras Vehicles				384.00	384.00
	Total	**968.75**	**1090.38**	**129.12**	**1619.63**	**3807.87**

Break-up of MSW Processing plant Capital Cost is divided in to two parts:

Part –I:

MSW Processing plant cost break up is given as below.

S. No.	Item	Amount in Crores (INR)
1	Common Infrastructure	1.7
2	Processing Plants – Civil(including land)	5.5
3	Processing Plants - Plant and Machinery	29
4	Scientific Landfill	2.25
5	Vehicles and Equipment	1.35
6	IDC	1.2
	Total	**41**

Part- II:

RDF Based Power Plant cost break up is given as below.

S. No.	Item	Amount in Crores (INR)
1	Civil Cost	4.3
2	Plant and Machinery	30.96
3	Pre ops & Contingency	2.66
4	IDC	3.95
5	Margin Money for Working Capital	1.13
	Total	**43**

* Land cost included in the capex was informed by the GVMC during the kick off meeting initially but the price may vary during the purchase of land.

* The above costs are considered taking into consideration that the plant would

be Integrated solid waste management consisting of Composting, Recycling, waste to energy and SLF of 15%-20%.

* In case if technology used is Incineration/ Gasification/ Plasma then capex would be hiked by 80%-125% approximately.

*Tentative Project cost for Gasification Technology would be approximately INR 150 Crores.

* Tentative Project cost for Plasma Technology would be approximately INR 195 Crores.

Based on assumptions made for GVMC, Tipping Fee Model is the viable one.

Tipping Fee:

The Tipping Fee Model, in which municipalities pay private MSW companies a tipping fee for every ton of waste collected, processed and dumped. This is the most prevalent model in India. The drawback of the model is that the private companies enrolled have low incentives to reduce waste going into landfill sites, increasing the financial and environmental burden on municipalities. Given that baseline information on waste quantity and quality tend to be sketchy, it is critical for ULBs to take this risk by assuring a committed Minimum assured Quantity or have a two part tipping fee with a fixed portion and a variable portion, where the fixed portion (paid irrespective of quantity of waste handled) insulates the Operator from Waste Availability risk.

If GVMC can structure an assured compost buy-back either for its own urban forestry or through other Government owned institutions or agricultural cooperatives in the adjoining areas, this can help the GVMC bring down the tipping fee levels. Initiatives like this can potentially improve project viability and help get in efficient price discovery.

- The Tipping Fee in India typically varies in a wide range between Rs. 150 – 2000.
- For GVMC the tipping fee proposed is Rs. 150/ MT

17 References:

[i] Paper on "Urbanization and solid waste management in India: Present practices and future challenges", Dimpal Vij, International Conference on Emerging Economies – Prospects and Challenges.

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[iii] Action Plan on Management of Municipal Solid Waste by CPCB on 5th Feb 2015.

[iv] International Journal of Geology, Earth and Environmental Sciences ISSN: 2277-2081.

[v] Manual on SWM, NEERI 1996.

[vi] J Holmes – Managing Solid Waste in Developing Countries.