Sustainable And Integrated Solid Waste Management Framework For Guwahati 2050

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Abstract - **Guwahati the largest metropolitan city in Northeast India is facing increased municipal solid waste (MSW) generation challenges, marked by inefficient collection, poor segregation and open dumping near ecosensitive location like Deepor Beel due to the rapid urbanization and population growth like any other Indian cities. This study develops a sustainable and integrated MSW management framework for Guwahati upto 2050, employing geometric population projection methods to forecast a 67% rise, enabling year-wise MSW estimates at 0.60 kg/capita/day per CPHEEO norms. Secondary data from Guwahati Municipal Corporation, Guwahati Metropolitan Development Authority and Central Ground Water Board, supported by primary geotechnical tests (Proctor, specific gravity, permeability) on locally available clay, informed designs for hauled container systems, sanitary workforce (7,262 by 2050), phased sanitary landfills across three sectors (e.g., 206,045 m² gross area for Sector I), leachate/gas collection and Rotary Drum Composters (up to 20 units/Sector I). The framework ensures environmental protection, resource recovery and a scalable roadmap for urban sustainability**.

Keywords - **Municipal solid waste, Segregation, Population forecast, Sanitary landfill, Rotary drum composter and Resource recovery.**

I. INTRODUCTION

The urban demography of India has changed in a dramatic way in recent decades, the rapid urbanization, population influx towards the urban region and economic development are the main driving forces behind this. With the increase in living standards and economic opportunities, there is a rapid increase in municipal solid waste (MSW) generation is observed. Changing consumption pattern like greater reliance on multilayer packaged goods, disposable/ one time use plastic products and processed food have not only increased waste volumes but also its collection and processing challenges. Which has increased the demand for innovative and environmentally sound strategies. Guwahati - the gateway of Northeast India and the largest metropolitan city of the region which is the vital administrative, commercial and transportation hub, mirrors these national challenges on a regional scale. As the gateway to the North-Eastern states, it has experienced accelerated population influx not only from the state but also from the neighbouring states, economic activities and rapid infrastructure booms, leading to rapid rise in MSW output. However, the solid waste management framework has not been developed in the same pace and hence it has failed to deliver the expected outcome. The inadequate source segregation inefficient collection system (covering approximately 80%), inefficient transportation system and open dumping are the primary challenges in this regard.

The waste disposal facility at Boragon dumpsite is very close to the ecosensitive Deepor Beel Ramsar wetland. Uncontrolled leachate seepage from the dumpsite has caused contamination of shallow groundwater, often the uncontrolled open burning releases toxic gases, continuous foul odors in the nearby area has caused serious health concern and direct impact on flora and fauna of the region are the major challenges. The current scenario of MSW production in the city is about 0.60-0.65 kg per capita per day, which will increase at a rapid rate in future. This has increased the burden on the existing system.

National guidelines from the Central Public Health and Environmental Engineering Organization (CPHEEO) underscore the urgency of well planned, integrated approaches for waste generation forecasting, segregation, resource recovery and design of engineered landfills. This study fills critical gaps in planning of Guwahati by forecasting population and MSW to 2050 via standard growth models, analyzing historical trends and estimating future quantities based on per capita norms. It has included the infrastructure needs like number of hauled container systems, collection

vehicles, transfer stations, composting plant capacity and sanitary workforce. Moreover, it provides preliminary engineering designs for scientific sanitary landfills (for non-biodegradable and unsegregated biodegradable waste) and a Rotary Drum Composter (RDC) for segregated organics, tailored to local hydro-geological conditions and CPHEEO standards.

II. LITERATURE REVIEW

A. Current situation in India

In a developing country like India, solid waste management is a major concern. The current solid waste disposal scenario has become a considerable threat as compared to earlier times, because of the change in character of the waste from majorly organic to other forms now (Gour et al., 2022). The main problem in the mitigation of solid waste is in the urban area, i.e., Municipal Solid Waste (MSW). This is mainly due to the lack of source segregation, improper planning/road-map, lack of civic sense, insufficient labor force, and lack of use of modern technology like sanitary landfills, incinerators, and rapid compost plants.

It is observed that low-income Tier III cities produce more biodegradable waste, which has high calorific value in contrast to high-income Tier I cities (Gour et al., 2022). This can be used in Waste to Energy (WTE) conversion, which is a viable idea for economical Municipal Solid Waste Management (MSWM). Studies show that small steps like seg regation at source can significantly increase the feasibility of employing WTE (Gour et al., 2022). The municipalities need to collect waste from door to door as per MSW rules 2000 (Anagal, 2009). In the Chandigarh Municipal Corporation, door-to-door collection is performed as primary collection, followed by segregation in Sahaj Safai Kendras, which has increased waste management efficiency (Gupta & Gupta, 2015).

B. Population forecasting

The urban population is increasing faster than the total population in the world. A study in Kathmandu used linear regression equations to forecast the population, and the SPSS platform was used to create formulas for predicting waste production (Khanal, 2023). For population and waste forecasting, the compound interest method is also used in some studies, such as in the city of Prayagraj (Dubey et al., 2025).

During 1950–2010, the urban population increased from 427.27 million to 924.7 million, which is nearly a two-fold increment; meanwhile, in developing countries, it increased eight-fold from 309.52 million to 2569.9 million (Dubey et al., 2025). By the end of 2025, it's expected that the amount of solid waste generated per person in India will be 0.7 kg per day, an increase from the 0.35 kg per day seen in 2020 (Gour et al., 2022). In Guwahati, the per capita production of municipal solid waste (MSW) is projected to be 0.65 kg per day by 2025 (Chaitanya et al., 2019).

The Committee on Urban Wastes (1975) suggested a standard of 2.8 sanitary workers for every 1,000 people (Gupta & Gupta, 2015). However, the number of sanitary workers hasn't reached this goal, even though the population has grown in a way that isn't a straight line.

C. Waste characteristics

The typical composition of MSW in developing country is biodegradable waste (42%), paper (6%), plastic (4%), glass (2%), metal (2%), textile (4%) and others (40%) (Awasthi et al., 2023). Hence, the major fraction of MSW consists of biodegradable waste which can be composted to produce manure if the waste is well-segregated. However, the non-recyclable biodegradable portion must be disposed of with utmost care.

In India, most MSW is open-dumped, creating environmental hazards and serious health issues for neighboring flora and fauna. When waste is dumped in open areas, rainfall and runoff contaminate surface water, while infiltration causes groundwater con tamination, affecting the overall hydrological cycle (Dutta and Gayathri, 2012). Non segregated MSW in India produces methane gas during summer in dumping grounds, which catches fire; open burning produces heavy smoke with excess oxides of sulphur and nitrogen, leading to respiratory problems (Anagal, 2009). As per CPCB 2019 data, 93% of the total MSW produced in Pune is open dumped (Anagal, 2009), while in Jaipur, it is approximately 50% (Kumar et al., 2016)

D. Study on engineered landfill and bio-composting

The most effective way to mitigate these problems is the use of engineered landfills. Landfills reduce surface and groundwater pollution effectively through proper systems for the collection and removal of leachate (Dutta and Gayathri, 2012). Since dumping in a landfill is not open dumping, it reduces other environmental concerns. As per MSW rules 2000, landfills should be used only for non-biodegradable inert waste and other waste not suitable for recycling or biological processing.

The segregated biodegradable waste can be composted using various methods like windrow composting and drum composting. In a modern perspective, the rotary drum composter is an efficient decentralized system that ensures proper aeration, mixing, and agitation, enabling rapid decomposition without odor or leachate issues (Kalamdhad et al., 2009). However, MSW characteristics in India remain challenging due to the lack of source segregation. These concerns must be addressed properly before planning infrastructure for these issues.

III. MATERIALS AND METHODS

As per the methodology adopted in the study involves collection of both primary and secondary data from various sources, analyzing it and develop an integrated facility including planning and designing of various waste management/ mitigation strategies.

The collection of data includes the secondary data from Guwahati Municipal Corporation (GMC), Guwahati Metropolitan Development Authority (GMDA) and Central Ground Water Board (CGWB); primary data includes lab test

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data on various experiments conducted during the study at Assam Engineering College and Gauhati University. Interpretation, analysis and design approaches were applied on these data.

A. Collection of secondary data

1. *Guwahati Metropolitan Development Authority (GMDA)*
   Data collected from the official GMDA website include:
• Population of Guwahati city
• Total geographical area of the city
• Details of all the 74 no.s of GMDA sub-units

Table 1 : Population of Guwahati 2025 as per GMDA

Planning Sub Unit No. as per GMDA master plan	Proposed population - 2025 as per GMDA master plan
1	36189
2	48898
3	11100
4	13654
5	19538
6	9815
7	20739
8	10813
9	7868
10	25831
11	24126
12	48572
13	34997
14	22859
15	15194
16	34558
17	67191
18	8000
19	16241
20	12831
21	7111
22	16453
23	11934
24	17272
25	19982
26	17124
27	11605
28	10638
29	9160
30	8184
31	6077
32	11086
33	11395
34	3708
35	12950
36	16216
37	15740
38	10714
39	17185
40	8465
41	24440
42	25642
43	12359
44	16357
45	16925
46	25380
47	13626
48	15873
49	28472
50	13122
51	97435
52	20730
53	19725
54	34330
55	19752
56	40330
57	19026
58	58827
59	58955
60	53598
61	4378
62	24440
63	4933
64	1597
65	4009
66	66329
67	21625
68	142740
69	11633
70	11895
71	122596
72	80000
73	160000
74	160000
Total	21,63,092

2. *Guwahati Municipal Corporation (GMC)*
   Data related to solid waste management and urban administration were collected from the Solid Waste Management (SWM) Cell of the Guwahati Municipal Corporation (GMC).
   The key information obtained from the SWM Cell are -
• Manpower: Number of sanitary workers involved are 426 as of 2026.
• Waste Generation: 550 MT was recorded as of 2011 and a projection of 749 MT for the year 2020.
• Collection Efficiency: Approximately 80% of the total waste generated is collected by the GMC

3. *Central Ground Water Board (CGWB)*
   Groundwater table data for various locations in the Guwahati region are obtained to analyze subsurface water level to ensure environmental safely in waste management planning.

Table 2 : Depth of Groundwater table in Guwahati

Sl no.	Location	Zones Encountered (m)	Zones Tapped (m)
1	Sakhati E.W. 25º57′15″ 91º 04′ 00″	19-21 44-48 57-59 69-77 80-88	30

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		108-116 119-127 132-181.50	
2	Rani E.W. 26º 02′ 42″ 91º 34′ 30″	13-90 93-98 148-160 170-187 194-200	39
3	Garigaon E.W. 26º 09′00″ 91º 39′ 30″	25-35 45-49 60-66 83-86 119-123 174-179 186-189	31
4	Sonapur E.W. 26º07′00″ 91º 58′ 02″	13-16 23-26 52-66 66-71	12
5	Khetri E.W. 26º07′30″ , 92º 07′ 00″	0-6 44-52 58-63 68-81	18
6	Khanapara E.W. 20º08′24″ 91º 49′ 24″	5.5-18 27.5-36.5 55-72	15
7	Circuit House, Guwahati E.W. 26º11′31″ 91º 45′ 06″	21-27 30-47 50-56	22
8	Changsari E.W. 26º19′45″ 91º 40′ 09″	-	36
9	RBI Colony, Geetanagar	-	21
10	Science Museum Khanapara	12.70-28 31-34 46-55	12
11	Jambari (EW)	-	15
12	Bamuni gaon (EW)	-	32–44 53-57 73-77

B. Population growth model used

The Geometric Increase Method has been adopted to project the population of Guwahati and its sub-units up to the year 2050. The population projection was done using the formula as per the Municipal Solid Waste Management Manual, Part II by the Central Public Health and Environmental Engineering Organization (CPHEEO) under the Ministry of Urban Development (Section 1.4.5.1.2, Page 57)

$$P_n = P \ (\ 1 + I_g/100)^{2.5}$$

2001	818,809	+38.5%
2011	962,334	+17.5%
2021	1,135,000	+17.9%

Where, I_g = 22.93 %
   n = 2.5 (from 2025 to 2050 forecasting for 25 years i.e 2.5 decade)
$P_n = P \ (\ 1 + 22.93/100)^{2.5}$
   = 1.67 P
Where:
P_n = Population after n decades
P = Base year population
I_g = Average geometric growth rate (%)
n = Number of decades

C. Estimation of MSW generation

Per capita method is adopted in this study to estimate the waste quantity. MSW generation rate was assumed as 0.60 kg per capita per day as per the recommendations of the Municipal Solid Waste Management Manual, Part II published by the Central Public Health and Environmental Engineering Organization (CPHEEO) under the Ministry of Urban Development, as specified in Section 1.4.3.3 (Page 44). The estimation is based on the following relationship:

$$W_t = P_t \times C$$

Where, W_t = Total quantity of MSW generated per day in year t (kg/day)
P_t = Projected population of Guwahati city for year t
C = Adopted per capita waste generation rate (0.60 kg/capita/day

D. Decentralized collection system design

1. **Hauled Container System (HCS)**

As per the Municipal Solid Waste Management Manual, Part II by CPHEEO under Ministry of Urban Development (Section 2.3.8.3.1, Page-177 & Section 2.3.11.1.1, Page 180), 7.5 ton capacity medium size container is selected. Required number of container for each planning sub unit is obtained by dividing the waste generated for each sub unit per day by the one container capacity i.e. 7.5 ton.

2. **Sanitary workforce requirement**

Number of sanitary workers was estimated based on recommendation of National Environmental Engineering Research Institute (NEERI) guidelines, which is 2-3 sanitary workers per 1000 population. In our study 2 workers per 1000 population is adopted. The formula for calculation of number of sanitary worker is as follows-

No. of sanitary workers = (Projected Population x 2)/1000

E. Preliminary geotechnical test

1. **Proctor test**

Clayey soil sample are collected from the selected landfill site and Proctor Compaction Test is conducted in accordance to IS 2720 (Part 7)– 1980: Methods of test for soils; Part 7: Determination of water content-dry density relation using light compaction and IS 2720 (Part 2)– 1980: Methods

of test for soils; Part 2 to determine the Maximum Dry Density (MDD) and Optimum Moisture Content (OMC).

2. *Specific gravity test*

Specific gravity is an important parameter in geotechnical investigation. It is done as per IS 2720 (part 3/ section 1) 1980 Methods of test for soils: Part 3 Determination of specific gravity; section 1

3. *Permeability test*

This test evaluates weather the locally available clay soil is suitable for landfill liner and cover system. It is preferred to have a permeability of less than 1×10^{-7} cm/sec for landfill design. Falling head permeability test is conducted for clay as per IS 2720 (Part 17)- 1986 Methods of test for soils: Part 17 Laboratory determination of permeability of soils.

F. Methods involved in landfill design

1. *Site selection criteria*

It is done as per the guidelines prescribed in the Municipal Solid Waste Management Manual,Part II. Factors which influence the site selection for landfill are distance from ecosensitive area, water bodies like pond river, highway, airport, habitation, groundwater table, etc.

2. *Landfill capacity*

Estimation of quantity of waste to be disposed in the landfill is done for a period of 25 years. Based on this assessment, the flow diagram is shown below :
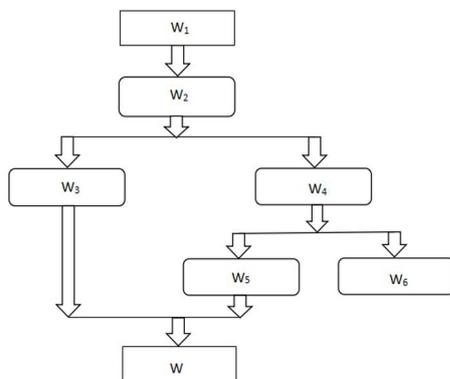
Fig 1: MSW segregation flowchart

Where,
W_1 = Total waste generated in 25 years of time period (kg).
W_2 = Collected waste (80% of W_1 as per GMC) (kg).
W_3 = Non-biodegradable waste (25% of W_2) (kg).
W_4 = Biodegradable waste (75% of W_2) (kg)
W_5= Biodegradable waste unable to undergo segregation (40% of W_4) (kg).
W_6 = Segregated biodegradable waste (60% of W_4) (kg).
W = Waste amount to be dumped in landfill (kg)

The volumetric calculations adopted are as follows:

Total volume of waste (V_1) = W / 1.2 m³

Total volume of daily cover (V_2) = 0.1 V_1 m³

Total volume of liner and final cover (V_3) = 0.25 V_1 m³

Total volume of landfill (V) = V_1 + V_2 + V_3 = 1.35 V_1 m³

The area requirement for the landfill was determined using the following relationships:

Total area covered by landfill (A) = V / (H_1 + H_2) m²
where,
H_1 = Height of landfill above ground (m)
H_2 = Depth of landfill below ground (m)

Gross area required for the landfill site (A′), including management buildings and treatment facilities,
A′ = A / 0.8 m²

3. *Liner system and Cover system*

As per Clause 4.5.2.5 of the Municipal Solid Waste Management Manual, Part II, a single composite liner system is provided for the MSW landfill. The components of the liner system are arranged from bottom to top:
• Subgrade soil
• Separator and filter layer
• Mineral sealing liner
• Geomembrane layer
• Protective layer
• Leachate collection layer

As per Clause 4.5.2.9 of the Municipal Solid Waste Management Manual, Part II, the components of cover system arranged from bottom to top:
• Gas drainage layer
• Separator and filter layer
• Mineral clay layer
• Water drainage layer
• Vegetative soil layer

4. *Leachate and Gas collection system*

In the study non circulatory leachate collection system is adopted which includes a separate leachate collection well for each phase, perforated High Density Polyethylene (HDPE) leachate collection pipes, leachate header pipe and leachate collection tank.

Gas collection system is designed to control gas accumulation and release. The system includes gas vent for each phase and gas collection pipes.

5. *Methods involved in Rotary Drum Composter design*

To determine the required capacity of the Rotary Drum Composter (RDC) and the number of units needed for both present and future requirements, the annual and daily quantities of waste generation are calculated and projected. Considering the substantial increase in waste generation anticipated between the years 2025 and 2050, adequate provisions for future expansion of the project are essential.
W_1= Total waste generated in the year (kg).
W_2= Segregated biodegradable waste to be composted (kg). (60% of W_1)
W_3= Compostable waste per day (kg).
ρ = Specific gravity of waste (considered as 0.8 T/m³)

To ensure efficient composting of the maximum possible quantity of waste, the Rotary Drum Composter (RDC) units are designed in accordance with the guidelines presented in

Mixed Organic Waste Composting Using Rotary Drum Composter by A. S. Kalamdhad (2008).

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Design Steps of Rotary Drum Composter (RDC):

• Diameter of the drum = D
• Length of the drum = L
• Total volume of the drum (V′) = $\pi D^2 L / 4$
• Usable volume of the drum (V) = 70% of V′
• Capacity of one RDC unit = V × ρ
• Daily processing capacity (C′) = (Capacity of one unit / 10), considering a retention period of 10 days
• No. of RDC unit required (N) = W_3/ C′

IV. RESULT AND DISCUSSION

A. Population forecasting, MSW estimation, Waste collection system design

As discussed in the methodology population is forecasted for each sub unit for the year 2050, MSW production is also estimated for 2050 in the same manner, the collection system includes estimation of number of sanitary worker and hauled container system requirement. The following table includes all these results obtained by following the methodology.

Table 3: Integrated population, MSW generation and collection system requirements for 2025 and 2050

Zone	Planning Sub Unit No. As per GMDA master plan	Population forecasting till 2050	MSW production per day by 2050 (in kg) (Taking 0.60 kg/ capita/ day)	No. of Hauled container required by 2050 (capacity of one container 7.5 tons)	Sanitary worker required by 2050
I	11	40291	24175	4	81
	14	38175	22905	4	77
	18	13360	8016	2	27
	19	27123	16274	3	55
	20	21428	12857	2	43
	21	11876	7126	1	24
	23	19930	11958	2	40
	25	33370	20022	3	67
	26	28598	17159	3	58
	27	19381	11629	2	39
	28	17766	10660	2	36
	29	15298	9179	2	31
	30	13668	8201	2	28
	31	10149	6090	1	21
	32	18514	11109	2	38
	33	19030	11418	2	39
	34	6193	3716	1	13
II	15	25374	15225	3	51
	16	57712	34628	5	116
	17	112209	67326	9	225
	22	27477	16487	3	55
	24	28845	17307	3	58
	55	32986	19792	3	66
	56	67352	40412	6	135
	57	31774	19065	3	64
	58	98242	58946	8	197
	59	98455	59073	8	197
	60	89509	53706	8	180
III	51	162717	97631	14	326
	52	34620	20772	3	70
	53	32941	19765	3	66
	54	57332	34400	5	115
	64	2667	1601	1	6
IV	46	42385	25431	4	85
	61	7312	4388	1	15
	62	40815	24489	4	82
	63	8239	4944	1	17
V	10	43138	25883	4	87
	12	81116	48670	7	163
	13	58445	35067	5	117
	65	6696	4018	1	14
VI	3	18537	11123	2	38
	4	22803	13682	2	46
	5	32629	19578	3	66
	6	16392	9836	2	33
	7	34635	20781	3	70
	8	18058	10835	2	37
	9	13140	7884	2	27
VII	1	60436	36262	5	121
	2	81660	48996	7	164
VIII	66	110770	66462	9	222
	67	36114	21669	3	73
	68	238376	143026	20	477
IX	69	19428	11657	2	39
	70	19865	11919	2	40
	71	204736	122842	17	410
X	35	21627	12977	2	44
	36	27081	16249	3	55
	37	26286	15772	3	53
	38	17893	10736	2	36
	39	28699	17220	3	58
	40	14137	8483	2	29
	41	40815	24489	4	82
	42	42823	25694	4	86
	43	20640	12384	2	42
	44	27317	16391	3	55
	45	28265	16959	3	57
	47	22756	13654	2	46
	48	26508	15905	3	54
	49	47549	28530	4	96
	50	21914	13149	2	44

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N I	72	133600	80160	11	268
N II	73	267200	160320	22	535
N III	74	267200	160320	22	535
Total		36,12,397	21,67,439	289	7262
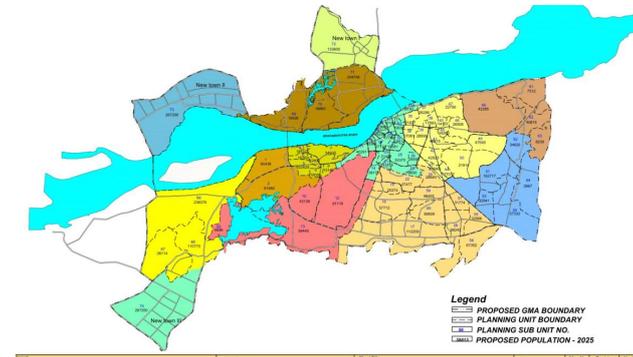
Fig 2: Population distribution map of Guwahati-2025 (Source: GMDA master plan 2025)
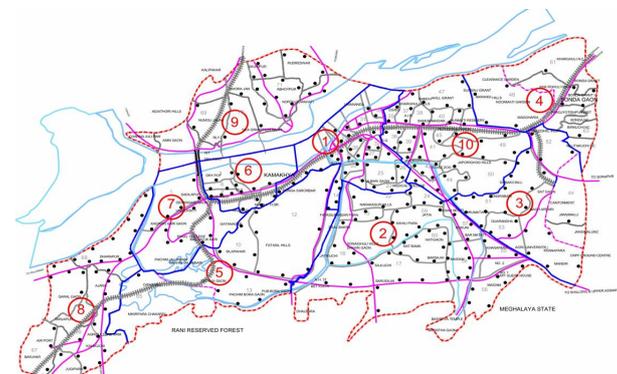
Fig 3: Distribution of hauled container (Plotted) (Original map source: GMDA master plan)

B.   Analysis of preliminary geotechnical test
1.   Sample I (Site- Nargaon, Near Rani):
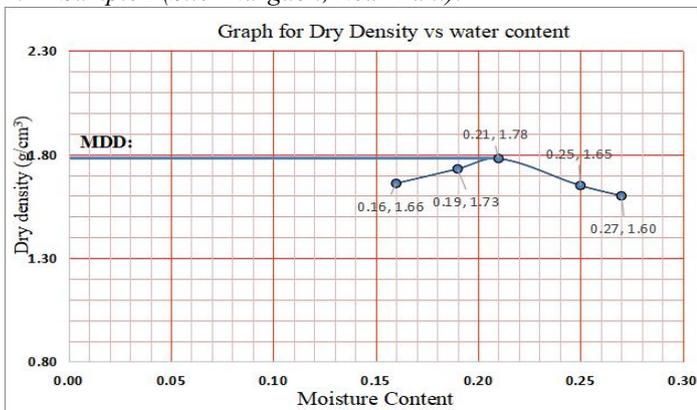
Fig 4: Sample I proctor test graph

Result : MDD (Maximum dry density) = 1.78 g/cm^3
OMC (Optimum moisture content) = 21%
Specific gravity = 2.65
Permeability = 4.10 x 10^{-7} cm/sec

2.   Sample II (Site- Near Sonapur):
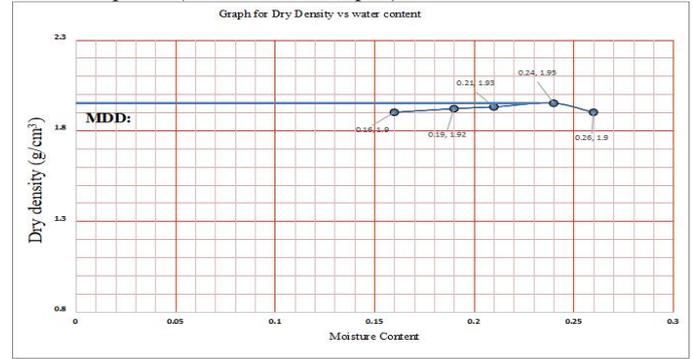
Fig 5: Sample II proctor test graph

Result: MDD (Maximum dry density) = 1.96 g/cm^3
OMC (Optimum moisture content) = 24%
Specific gravity = 2.64
Permeability = 2.66 x 10^{-7} cm/sec

3.   Sample III (Site- Near Changsari):
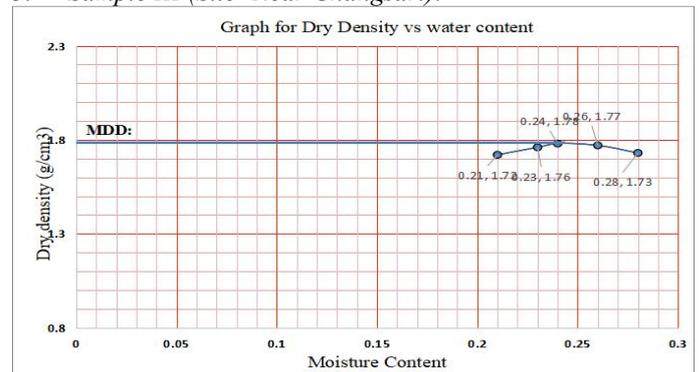
Fig 6: Sample III proctor test graph

Result: MDD (Maximum dry density) = 1.79 g/cm^3
OMC (Optimum moisture content) = 24%
Specific gravity = 2.62
Permeability = 3.69 x 10^{-7} cm/sec

Fig 7: Falling head   Fig 8: Procotr test
permeability test

C.   Landfill design
1.   Site selection for Sector I, II, III
The GMDA map has been divided into three sectors for easy disposal of MSW into the landfills.

Here, Sector 1: Zone I, Zone V, Zone VI, Zone VII,
          Zone VIII & N III
      Sector 2: Zone II, Zone X, Zone III & Zone IV
      Sector 3: Zone IX, N I & N II

Sector I : For Sector I, the landfill site has been identified at Nargaon (near Rani), located at 26°02'37" N latitude and 91°33'20" E longitude.The groundwater table at the site occurs at a depth of approximately 13 m below ground level. Site is within 20 km of the Lokpriya Gopinath Bordoloi International (LGBI) Airport. However, landfill construction within this zone is permissible with NOC from Civil Aviation Authority.

Sector II : For Sector II, the landfill site has been identified near Sonapur, located at 26°10'05" N latitude and 91°50'24" E longitude.The groundwater table at the site is located at a depth of approximately 13 m below ground level.

Sector III : For Sector III, the landfill site has been selected at Changsari, located in the Changsari area Kamrup district, at 26°15'47" N latitude and 91°40'31" E longitude.

2. Landfill capacity calculation and model design

Table 4:

| Particular	Sector 1	Sector 2	Sector 3
Total waste generated in 25 years, W_1(MT)	6660047	6566363	2874048
Total waste to be dumped in the Landfill, W (MT)	2930420	2889200	1264581
Total volume of waste, V_1 (m³)	2442017	2407667	1053818
Total volume of Landfill, V (m³)	3296723	3250050	1422654
Height above ground, H (m)	15	15	15
Depth below ground, D (m)	5	5	5
Side Slope	4 : 1	4 : 1	4 : 1
Total area covered by Landfill, A (m²)	164836	162503	71133
Length of Landfill, L (m)	515	515	350
Breadth of Landfill, B (m)	320	320	205
Gross area req. for landfill site (incl. management building & treatment facilities), A' (m²)	206045	203129	88916
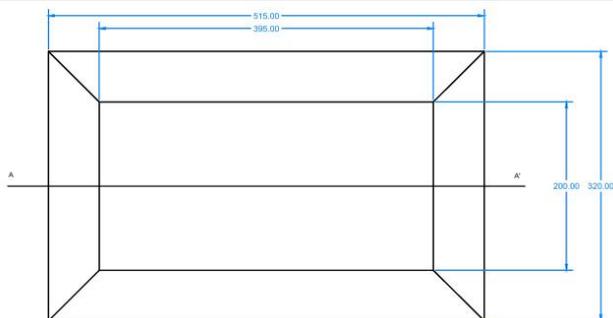
Fig 9(a): Top view of landfill for Sector I&II

Fig 9(b): Cross sectional view of landfill for Sector I&II
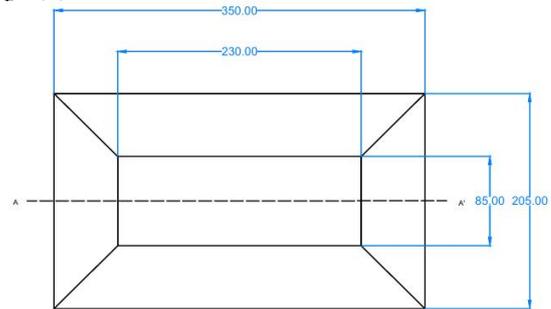

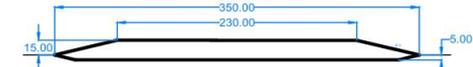Fig 10(a): Top view of landfill for Sector III

Fig 10(b) Cross sectional view of landfill for Sector III

3. Phasing of landfill

It is done to ensure the systematic and efficient waste disposal mechanism for the MSW. One phase is operated for one year and during the operation period phase for the next year is prepared. In our design it needs 25 phases for 25 years. Again during operation period a daily cover of 15 cm thickness with locally available clay is provided.
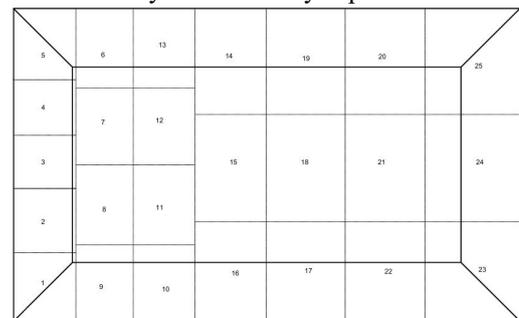
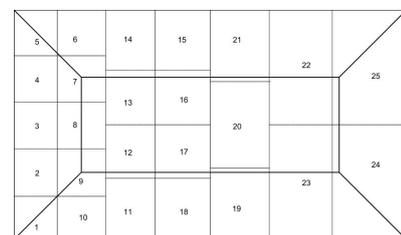

Fig 11(a): Phasing of landfill for Sector I&II

Fig 11(b): Phasing of landfill for Scetor III

Fig 12: Cross sectional view of an active landfill

4. Liner system design

It is designed as per the criteria discussed in the methodology. Following are the design layers from top to bottom of liner :
i. 30cm thick leachate collection layer (Sand)
ii. 1.5mm thick geomembrane (HDPE)

iii. 90cm thick compacted clay (amended) ($k \leq 1 \times 10^{-7}$ cm/s)
iv. Separator (Sand)
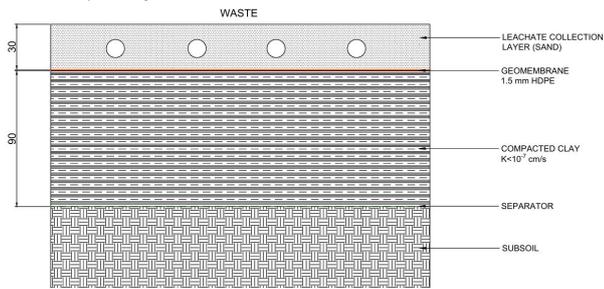v. Subsoil (Compacted to achieve 90% of MDD

Fig 13: Liner system coss section

5. Cover system design

It is designed as per the criteria discussed in the methodology. Following are the design layers from top to bottom of cover :
i. Vegetation (Grass/Shrub)
ii. 45cm thick top soil (Local soil)
iii. 15cm thick side surface drainage (Sand)
iv. 60cm thick compacted clay (amended) ($k \leq 1 \times 10^{-7}$ cm/s)
v. 30cm thicl gas collection layer (Gravel)
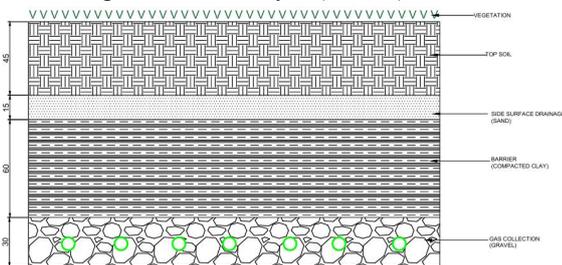
Fig 14: Cover system cross section

6. Leachate collection system design

It is done as per the design criteria discussed above in the methodology.For each landfill total 25 numbers of leachate collecting well are designed with 7 leachate collecting pipes, which further connected to the leachate header pipe.
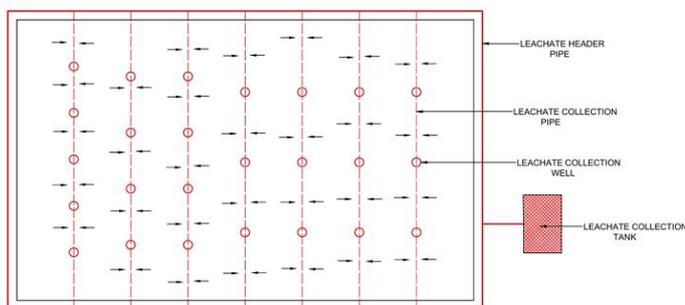

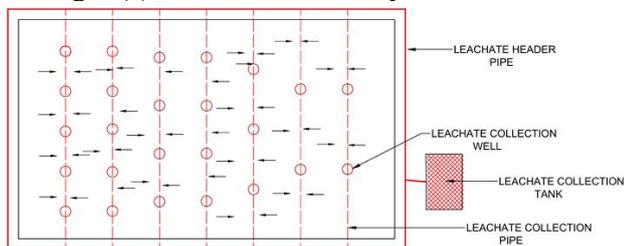Fig 15(a): Leachate collection system Sector I&II

Fig 15(b): Leachate collection system Sector III

7. Gas collection system design

It is done as per the designed criteria discussed above in the methodology. For each landfill total 25 numbers of gas collecting vents are designed with 7 gas collecting pipes, which further connected to the main pipe and gas collection chamber.
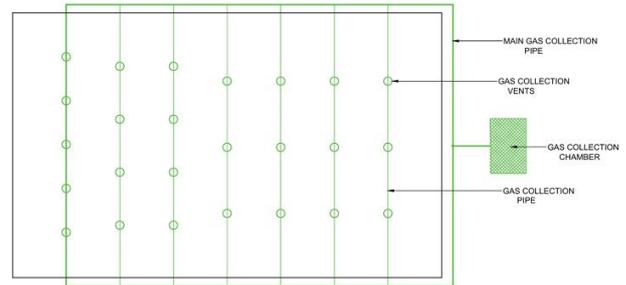

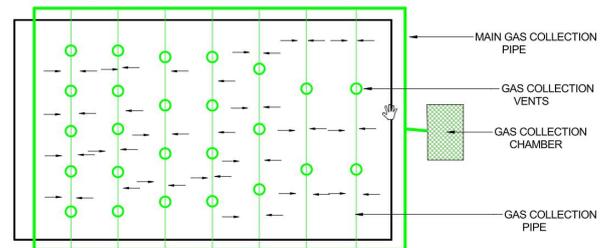Fig 16(a) Gas collection system Sector I&II

Fig 16(b) Gas collection system Sector III

8. Rotary Drum Composter (RDC) design

Table 5: Waste production for year 2025&2050

Sector	Year	W_1 (T)	W_2 (T)	W_3 (T)
1	2025	195957	117574	322
	2050	327053	196231	537
2	2025	193200	115920	318
	2050	322452	193471	530
3	2025	84562	50737	139
	2050	141136	84681	232

Where, W_1 = Total waste generation (per year)
W_2 = Segregated (60%) Biodegradable waste to be composted (per year)
W_3 = Compostable waste per day
ρ = Specific Gravity of waste = 0.8 T/m³
  Design of Rotary Drum Composter:
D = 3.5 m
L = 35 m
Total Volume, V' = $\pi D^2 L/4$ = 337 m³
Usable Volume, V = 70% × V' = 70% × 337 = 236 m³
Capacity, C = V × ρ = 236 × 0.8 = 189 T
Retention Period = 7 days
Capacity per day, C' = 189/7 T = 27 T

Table 6: Required number of RDC unit per sector

Sector	Year	Number of unts
1	2025	12
	2050	20
2	2025	12
	2050	20
3	2025	6
	2050	9

V.   CONCLUSION

This research proposes a sustainable and integrated framework for MSW management for Guwahati for the year 2050. Geometric projection of population growth shows a substantial increase of 67% during the course of 25 years i.e. from 2025-50. This will result in rapid increase in waste generation in the city, will increase the burden on the existing waste management facility. Hence there is a urgent need of re-frame and redesign of the solid waste management facility of the city by integrating all the components like collection, segregation and disposal of waste.

The study projects and distributes number of sanitary workers and hauled containers required for efficient waste management. The decentralization of the system to 74 GMDA planning sub-unit is the key feature of the study. For waste disposal also sector division is done and engineered sanitary landfills are designed dedicated to each sector. Moreover to manage the biodegradable waste, Rotary Drum Composting (RDC) units are designed.

Integrating the collection system, landfill and rotary drum composting unit; decentralized integrated waste management frameworks has been designed for Guwahati.

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