CHARACTERISTICS OF SOLID WASTE GENERATED FROM GUWAHATI CITY AND FEASIBILITY SOLUTIONS FOR ITS MANAGEMENT

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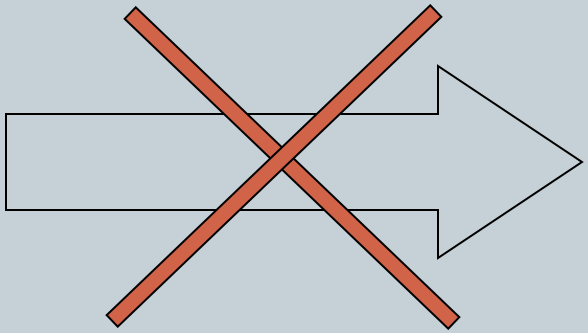
CHARACTERISTICS OF SOLID WASTE



Quantity &
Quality of waste

Reduction
in Quantity

Recycling/Transformation centre

- Recycling of paper, plastic, rubber etc.
- Waste to energy
- Organic compost production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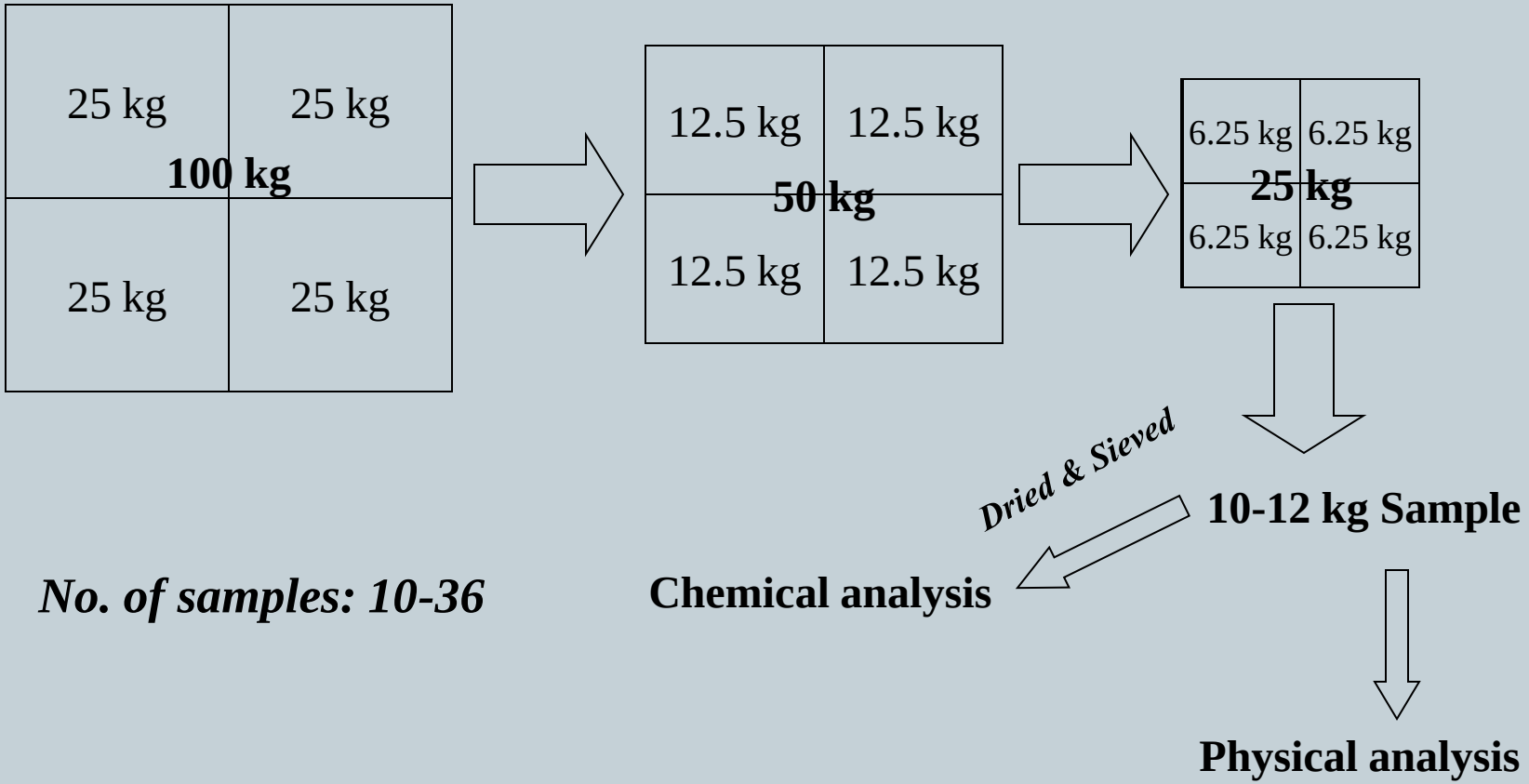
SAMPLING OF SOLID WASTE

Quartering Method



No. of samples: 10-36

PHYSICAL PROPETIES OF SOLID WASTE

❖ Solid waste generation: Load-Count analysis

Specific Weight (Density)

Specific weight is defined as the weight of a material per unit volume. Generally higher waste density (400-600 kg/m^3) is observed in India may be because of high amount of inert material. Density is helpful to know the collection vehicle capacity and landfill capacity also.

Moisture Content

Moisture content defined as weight loss after drying at 105^oC for 24 h. Generally higher moisture (40-70%) observed in India may be because of high amount of food/vegetable wastes.

Physical composition

The collected sample is physically sorted out on a sorting platform into various ingredients i.e. paper, plastic, glass, plastic etc. the individual components are stored in bins and weighted. The weights are expressed as a percent on the original sample on a wet weight basis.

CHEMICAL PROPETIES OF SOLID WASTE

Information on the chemical composition of the components that constitute MSW is important in evaluating alterative processing and recovery options.

Proximate analysis

The *proximate analysis* is important in evaluating the combustion properties of waste or waste derived fuel (refuse derived fuel). The fractions of greatest interest are:

- ***Moisture content***
  (Loss of moisture when heated to 104^{o}C for 24 h)
- ***Ash***
  (Weight of residue after combustion at 550^{o}C in an open crucible)
- ***Volatile matter***
  (Additional loss of weight on ignition at 700-950^{o}C in a covered crucible)
- ***Fixed carbon***
  (Combustible residue left after volatile matter is removed)

Moisture (%) + Ash (%) + Volatile (%) + Fixed carbon (%) = 100%

Significance of Proximate analysis

• Moisture adds weight to the waste/fuel without increasing its heating value and the evaporation of water reduces the heat released from the fuel.

• Ash also adds weight without releasing any heat during combustion.

• Volatile matter is that portion of the waste that is converted to gas before and during combustion. The gases are passed through a combustion chamber where rapid combustion occurs.

• Fixed carbon represents the carbon remaining on the surface of grates as char. Waste or fuel with a high proportion of fixed carbon requires a longer retention time on the furnace grates to achieve complete combustion than does waste/fuel with a low proportion of fixed carbon.

Ultimate analysis

The *ultimate analysis* is useful during mass balance calculation for chemical and thermal process. Ultimate analysis of waste is carried out to determine the proportion of carbon, hydrogen, oxygen, nitrogen and sulphur (C, H, O, N and S). It can analyze by using CHONS analyzer.

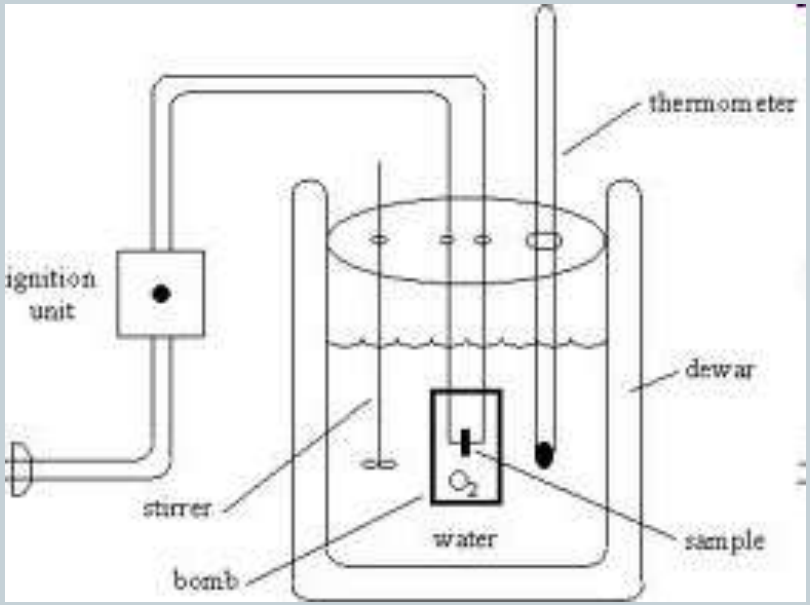
Energy content (BTU/lb): 145 C + 610 (H_2-1/8 O_2) + 40 S + 10 N

1 BTU = 1055.06 J
1 BTU/lb * 2.326 = 1 kJ/kg

• Wastes containing energy content more than 2000 kJ/kg are good for waste to energy plant

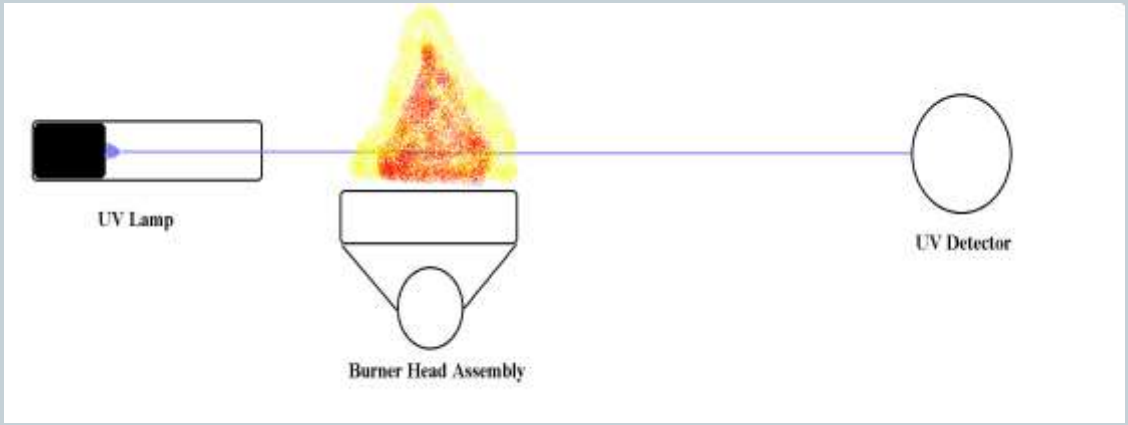
Energy content (Calorific value)

The energy content of the organic components in MSW can be determined i) by using a full scale boiler as a calorimeter ii) by using laboratory bomb calorimeter iii) by calculation. Because of difficulty in instrumenting a full-scale boiler, most of the data on the energy content of the organic components of MSW are based on the results of bomb calorimeter tests.



Metal content (Trace elements)

The metal content (i.e. Cd, Cr, Hg, Ni, Zn, Mn, Pb, As etc.) should also be determined because of its potential harmful environmental effects.



BIOLOGICAL PROPETIES OF SOLID WASTE

The most important biological characteristic of the organic fraction of solid waste is that all of the organic components can be converted biologically to gases and relatively inert organic and inorganic solids. The production of odor and generation of flies are also related to the putrescible nature of the organic materials.

Biodegradability of organic waste components

Volatile solids content is often used as a measure of the biodegradability of the organic fraction of solid waste.

Alternatively, the lignin content of a waste can be used to estimate the biodegradable fraction, using the…..

$$BF = 0.83 – 0.028\ LC$$

Production Odors

Typically, the formation of odors results from the anaerobic decomposition of the readily decomposable organic components found in solid waste.

Breeding of Flies

In the summertime and during all seasons in warm climates, fly breeding is an important consideration in the on-sight storage of wastes. Flies can develop in less than two weeks after the eggs are laid. If larval (maggot) develop, they are difficult to remove when the containers are emptied.

GUWAHATI CITY

(Funded by GMC, Guwahati)

- Area of Guwahati city: 264 sq. km.
- Area under GMC: 216 sq. km.
- Population (as per 2001 census): 8,09,895
- Floating population: 30,000-40,000
- Slum Population: 1,60,371(19.8% of total population)

Estimated population: 11,00,000 (approx)

- No of households (as per 2001 census): 1,84,454
- No. of zones: 20
- No. of Wards: 60
- No of Slums: 26

Solid Waste Generation

Using ***load-count analysis***, the number of individual loads (trucks) and the corresponding waste locations (i.e. residential, commercial, market, institutional, street sweeping, drain cleaning etc.) are noted over a specified time period at disposal site. Weight and density data of each individual loads will also recorded. The data collection carried for 7 days in a week to calculate the load and density at workday and weekends.


ASHOK LEYLAND
MUNICIPAL CORPORATION
07 05 2011


TURBO INTERCOOLER
07.05.2011

Day	No. of trucks			Waste collected (Tonne/day)	Total generation (Tonne/day)	Density (kg/m^3) Range (average)	Generation rate (kg/capita/ day)
	Haul type container	Stationary type container	No. of trips				
Weekday	18-19	4-5	146-166	483-566	532-623	49.2-327.8 (197.2)	0.42-0.49
Weekend	17-18	4-5	117-129	488-515	440-464	41.2-319.7 (191.1)	0.34-0.36

The total quantity of solid waste generation was recorded at 543±68 tonne/day with a weight density of 41-327 kg/m^3.

The per capita solid waste generation of 0.43±0.05 kg/day in the Guwahati city.

Expected population and total waste generation from Guwahati city

Year	Population	Waste generation (kg/capita/day)	Total waste generation (Tonns/day)
2011	1260419	0.430	541.98
2016	1531282	0.461	705.92
2021	1860353	0.495	920.87
2026	2260141	0.531	1200.14
2031	2745844	0.570	1565.13
2036	3335923	0.611	2038.25
2041	4052810	0.656	2658.64

Based on the geometric growth rate in the population of Guwahati city, the medium projection growth rate of 3.97% per annum has been adapted and used for population distribution in the city.

Based on a study conducted by Urban Development, East Asia and Pacific Region of the World Bank, the relation between GNP and per capita waste generation rates will grow at an exponential rate of 1.41% per annum.

Sampling

Sampling locations: 4 dustbin from residential area (One from each LIG, MIG, HIG and slum area), 1 each dustbin from commercial area and fruit/vegetable market

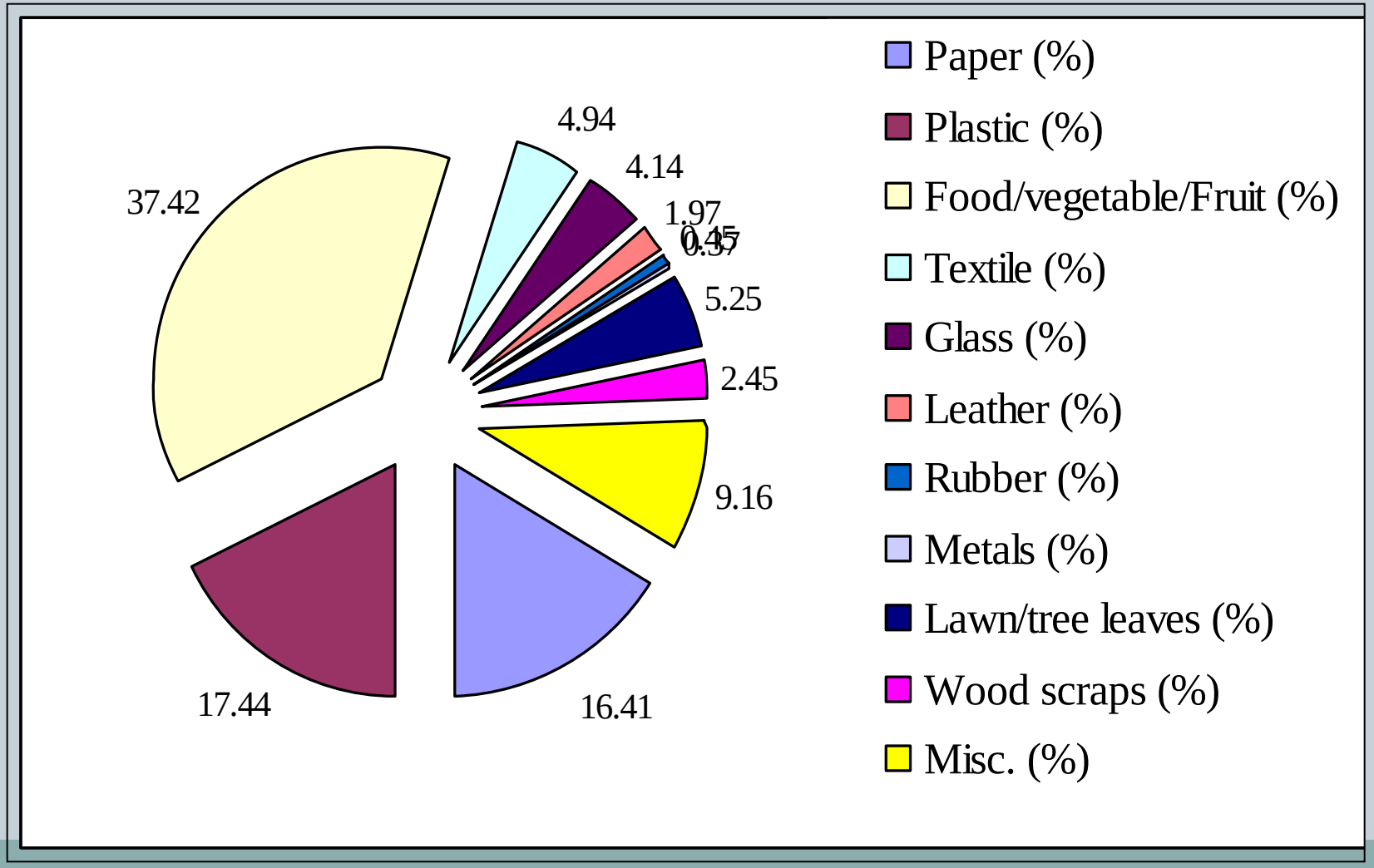
Sampling period: 7 days in a week

Sorting location: IITG campus

Site specification	Location	Date
Landfill site	Boragaon landfill site	07-13 May
HIG	Near Passport Office, B. N. Siakia Road	15-21 May
MIG	National Games village or Gita Nagar, Zoo Narangi	23-29 May
LIG	Near GMC Garage, Islampur Road	31 May – 6 June
SLUM	Uzzan Bazaar Slum, Kadampukhari	8 – 14 June
Commercial	Fancy Bazaar, Near Khubchand liquor, Kamarpatti	16 – 22 June
Fruit/Vegetable market	Fancy Bazaar, Near Sharma sweet	24 -30 June
Others	Restaurant and Railway dumping site	2 – 8 July

Physical composition of solid waste for Guwahati city

Waste collection area	Paper (%)	Plastic (%)	Food/ vegetable / Fruit (%)	Textile (%)	Glass (%)	Leather (%)	Rubber (%)	Metals (%)	Lawn/ tree leaves (%)	Wood scraps (%)	Misc. (%)
HIG	12.56± 4.86	16.47± 7.43	49.91± 16.86	5.11± 4.96	2.24± 1.64	0.13± 0.30	0.57± 1.53	0.27± 0.60	3.54±3 .66	1.14± 2.44	8.05± 8.76
MIG	16.05± 2.61	18.54± 3.58	45.44± 7.98	4.63± 3.04	6.97± 3.27	0.77± 1.84	0.05± 0.08	0.74± 0.54	2.00±1 .47	1.06± 1.52	3.75± 7.26
LIG	12.46± 4.77	22.88± 10.33	33.66± 10.54	5.48± 3.40	3.74± 5.41	1.59± 3.70	0.12± 0.32	0.60± 0.79	8.36±9 .14	2.43± 2.77	8.67± 10.85
Slum	12.94± 8.63	16.55± 7.20	29.77± 11.44	6.10± 9.12	5.80± 6.74	2.56± 4.25	0.28± 0.40	0.10± 0.17	3.46±3 .25	2.65± 2.49	19.76 ±5.57
Commercial	19.07± 4.64	15.09± 4.99	33.85± 12.36	2.78± 2.01	4.03± 5.55	6.13± 6.69	0.49± 0.88	0.47± 0.64	6.60±6 .66	1.13± 1.77	10.35 ±8.64
Vegetable Market	25.38± 12.74	15.09± 5.22	31.88± 18.51	5.53± 6.51	2.06± 2.34	0.65± 1.73	1.20± 2.23	0.04± 0.07	7.53±6 .37	6.28± 7.57	4.34± 8.73
Average	16.41± 5.10	17.44± 2.95	37.42± 8.20	4.94± 1.16	4.14± 1.94	1.97± 2.21	0.45± 0.42	0.37± 0.28	5.25±2 .58	2.45± 2.00	9.16± 5.80


4.94
4.14
1.97
0.45
0.37
5.25
2.45
9.16
16.41
17.44
37.42
Paper (%)
Plastic (%)
Food/vegetable/Fruit (%)
Textile (%)
Glass (%)
Leather (%)
Rubber (%)
Metals (%)
Lawn/tree leaves (%)
Wood scraps (%)
Misc. (%)

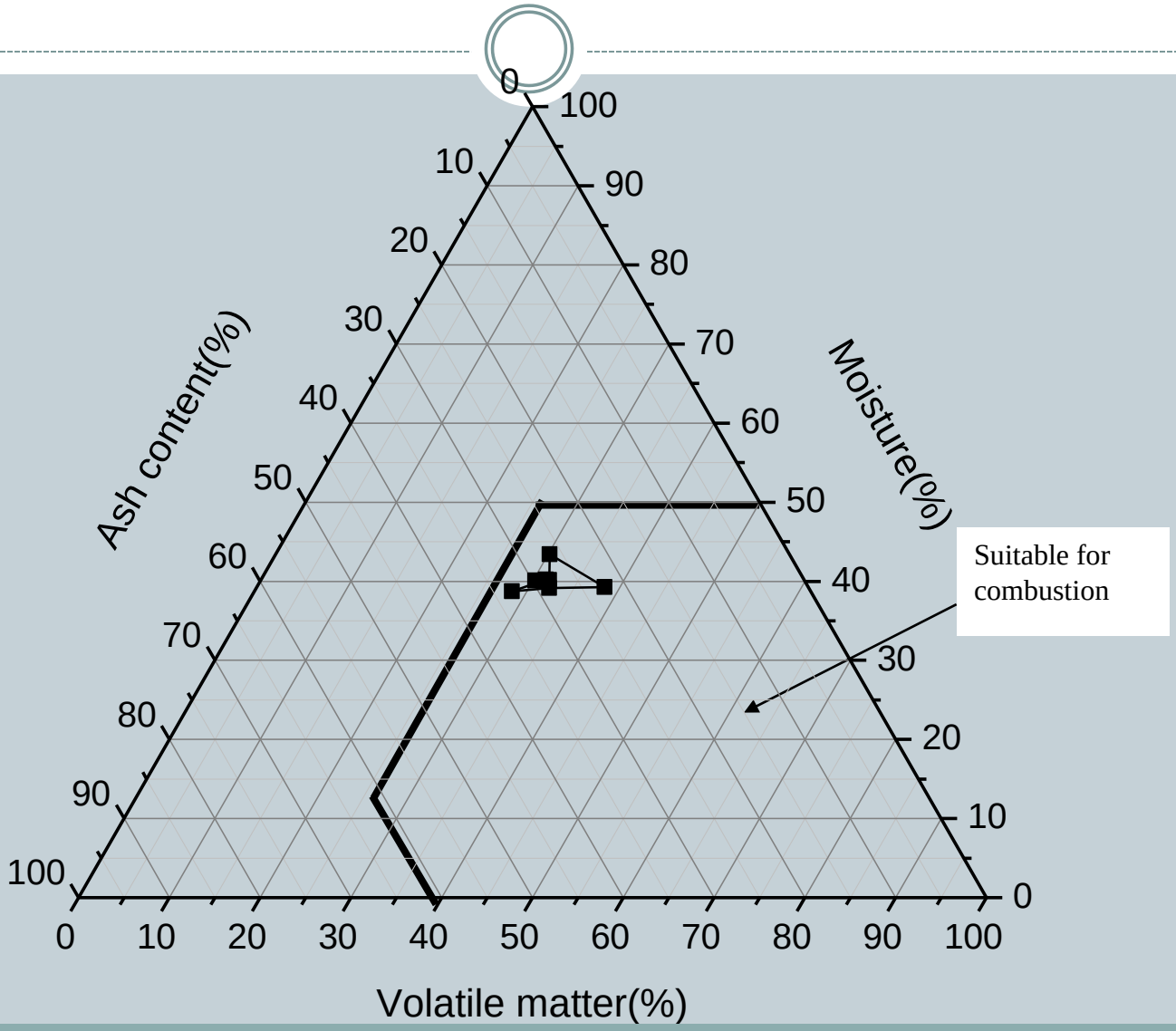
Percentage compositions of organic, compostable, recyclable and combustible materials

Waste collection area	Organic (%)	Compostable (%)	Recyclable (%)	Combustible (%)
HIG	89.44±9.59	53.45±15.24	32.25±12.08	35.99±11.44
MIG	88.54±7.31	47.44±8.11	43.11±3.75	41.09±3.98
LIG	86.98±10.78	42.02±7.14	41.39±13.73	44.96±11.64
Slum	74.32±7.21	33.23±12.84	38.23±7.05	41.09±11.46
Commercial	85.15±8.20	40.45±13.37	45.27±10.86	44.69±11.52
Vegetable Market	93.56±10.78	39.41±20.19	44.42±13.48	54.14±12.99
Average	86.33±8.98	42.67±12.82	40.78±10.1	43.66±10.5

Proximate Analysis

Area	Moisture content (%)	Ash content (%)	Volatile matter (%)	Fixed carbon (%)
HIG	64.21±6.61	47.56±14.71	48.50±14.53	3.93±1.49
MIG	65.35±6.27	46.14±21.37	50.94±19.43	2.91±2.40
LIG	61.08±3.70	51.93±5.11	44.76±4.84	3.30±2.19
Slum	62.93±6.46	45.97±9.49	51.95±8.34	2.25±1.96
Commercial	62.29±10.23	35.60±13.83	60.81±9.99	4.52±6.02
Vegetable Market	73.11±3.00	44.41±10.70	50.87±7.93	4.72±3.96
Average	64.83±6.05	45.27±12.52	51.31±10.84	3.61±3.01

Tanner's Diagram



Ultimate Analysis

Area	Carbon (C) (%)	Hydrogen (H) (%)	Nitrogen (N) (%)	Sulfer (S) (%)
HIG	28.42 1.24	3.14 2.21	2.35 0.18	1.06 1.19
MIG	24.81 9.00	3.79 1.40	1.86 0.82	0.35 0.16
LIG	21.73 1.53	2.09 1.49	1.26 1.14	1.28 1.41
Slum	26.30 2.00	3.59 0.53	2.18 0.41	0.43 0.12
Commercial	35.49 9.89	5.06 0.73	2.29 0.32	0.34 0.13
Vegetable market	24.99 2.87	3.52 0.51	1.78 0.18	0.35 0.12
Average	26.95 4.42	3.53 1.14	1.95 0.51	0.63 0.52

Heavy Metal Analysis

Area	Zn (mg/kg)	Cu (mg/kg)	Pb (mg/kg)	As (mg/kg)	Cd (mg/kg)	Fe (mg/kg)
HIG	82.8±29.6	30.5±4.8	ND*	8.4±2.9	ND	4816.8±1877.4
MIG	45.9±16.8	28.0±5.5	ND	8.7±4.2	ND	4150.0±1305.6
LIG	146.4±111.9	28.4±12.1	120.0±99.4	1478.5±578.4	5.2±0.5	12757.7±4934.8
Slum	172.1±90.0	54.8±40.6	60.8±20.8	2191.1±390.2	22.6±55.8	17156.0±4667.7
Commercial	109.6±31.7	45.4±14.4	22.0±7.3	2604.3±668.5	6.2±1.2	14783.4±5775.2
Vegetable Market	142.0±25.5	40.8±9.3	212.5±23.3	3040.0±543.4	ND	7543.4±1397.1
Average	116.6±50.8	38.4±14.5	69.2±25.2	1555.2±364.6	5.7±9.6	10201.2±3326.3

Energy Content (Calorific Value)

Area	Calorific value (kcal/kg)	Energy content (MJ/kg)	Energy content (BTU/lb)
HIG	2603.3±197.3	10.9±0.8	4686.0±355.1
MIG	1824.7±187.4	7.6±0.8	3284.5±337.3
LIG	2163.8±326.5	9.1±1.4	3894.8±587.6
Slum	2533.1±297.1	10.6±1.2	4559.6±534.7
Commercial	3473.5±796.9	14.5±3.3	6252.3±1434.5
Vegetable market	2591.9±600.2	10.8±2.5	4665.5±1080.3
Average	2531.7±553.4	10.6±2.3	4557.1±996.0

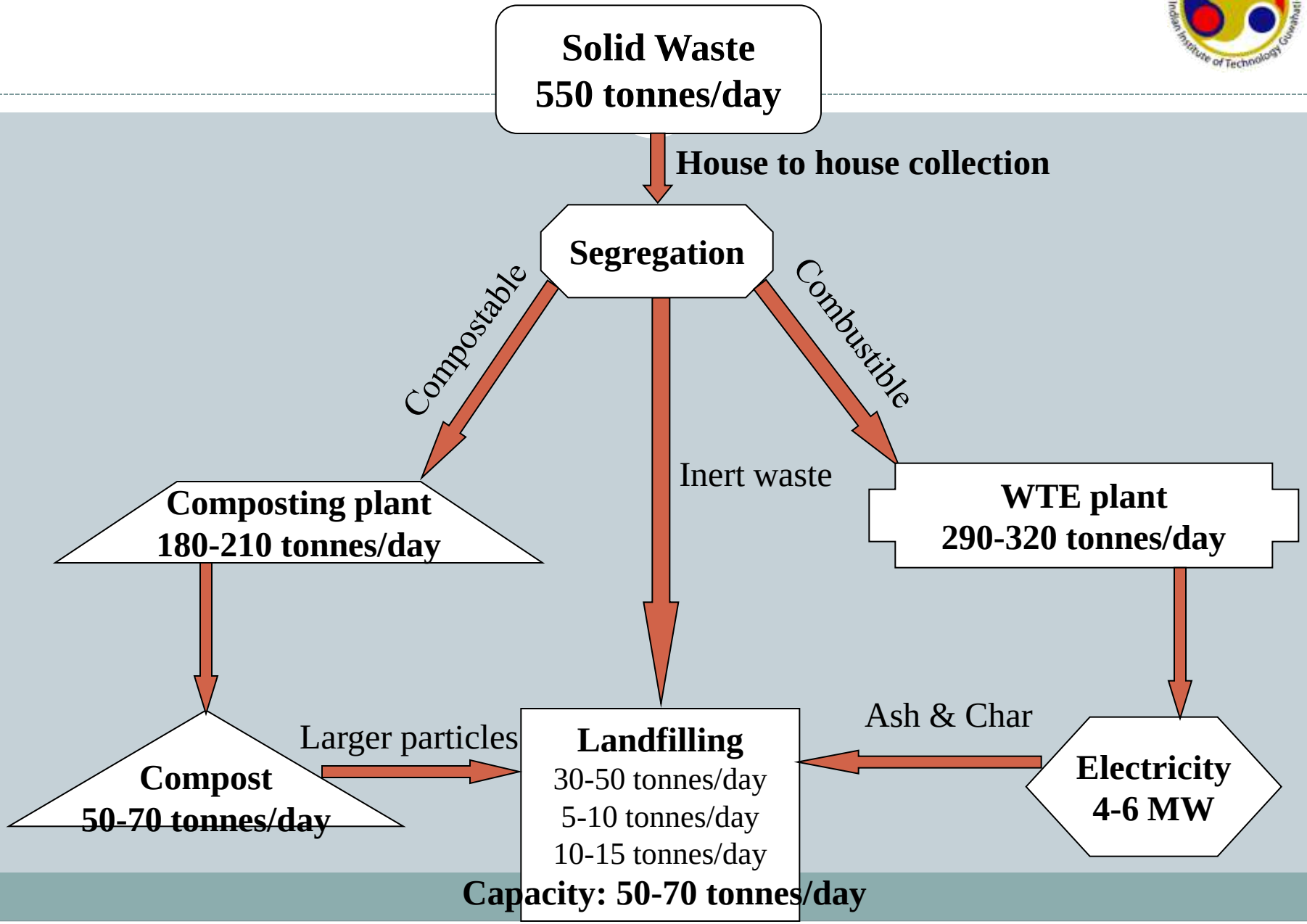
FEASIBILITY SOLUTIONS

The Guwahati city is generating 543±68 TPD of MSW equivalent to 0.43±0.05 kg/capita/day currently. Based on population and GNP, total quantity of waste generation is expected 705 TPD by 2016 and 920 TPD by 2021. The size and capacity of waste treatment plants i.e. composting plant, waste to energy plant and landfill should considered the future expected waste generation.

Around 43% of mixed waste measured as compostable due to large amount of food waste, it can be higher if house to house collection can possible in segregate way.

41 and 44% of total mixed waste can be considered as recyclable and combustible materials because of paper, plastic, textile, leather, rubber etc. (it can be higher if house to house collection can possible), it will again depends upon the moisture content in the waste materials and seasonal variation.

More than 50% of mixed solid waste can be considered as volatile matter, indicates that the requirement of secondary combustion chamber.


Solid Waste
550 tonnes/day
House to house collection
Segregation
Compostable
Inert waste
Combustible
Composting plant
180-210 tonnes/day
WTE plant
290-320 tonnes/day
Compost
50-70 tonnes/day
Larger particles
Landfilling
30-50 tonnes/day
5-10 tonnes/day
10-15 tonnes/day
Ash & Char
Electricity
4-6 MW
Capacity: 50-70 tonnes/day

PHOTOGRAPHIC SURVEY

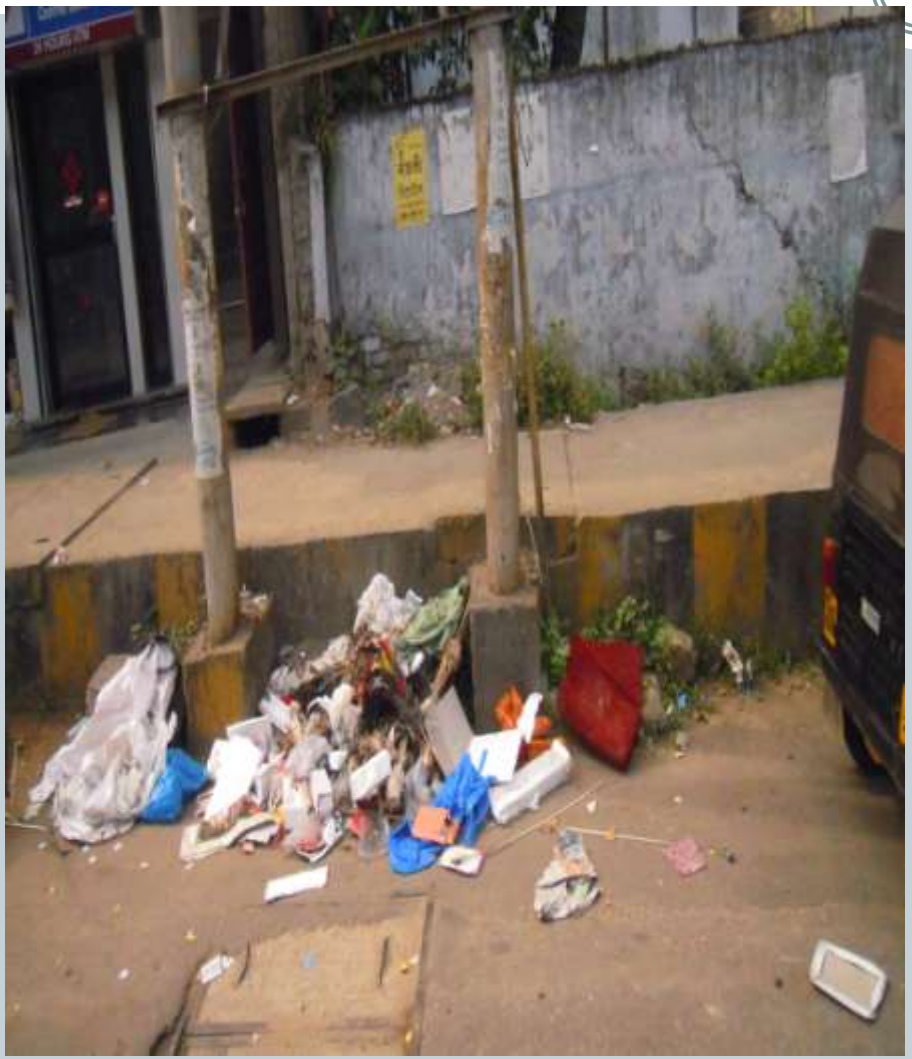
MAJOR COMMERCIAL PLACES LACK WASTE DISPOSAL FACILITIES

PHOTOGRAPHIC SURVEY

WRONG PLACEMENT

INADEQUATE CAPACITY

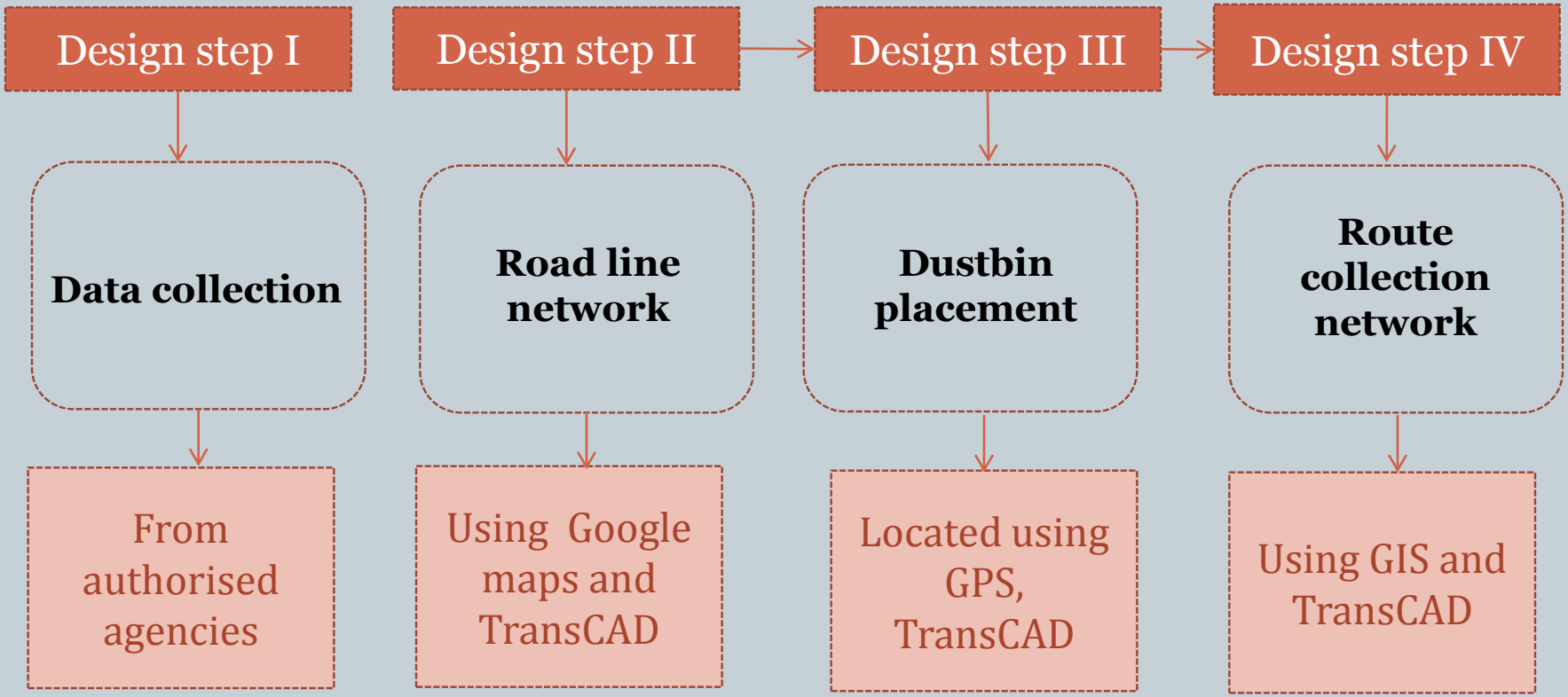
PHOTOGRAPHIC SURVEY



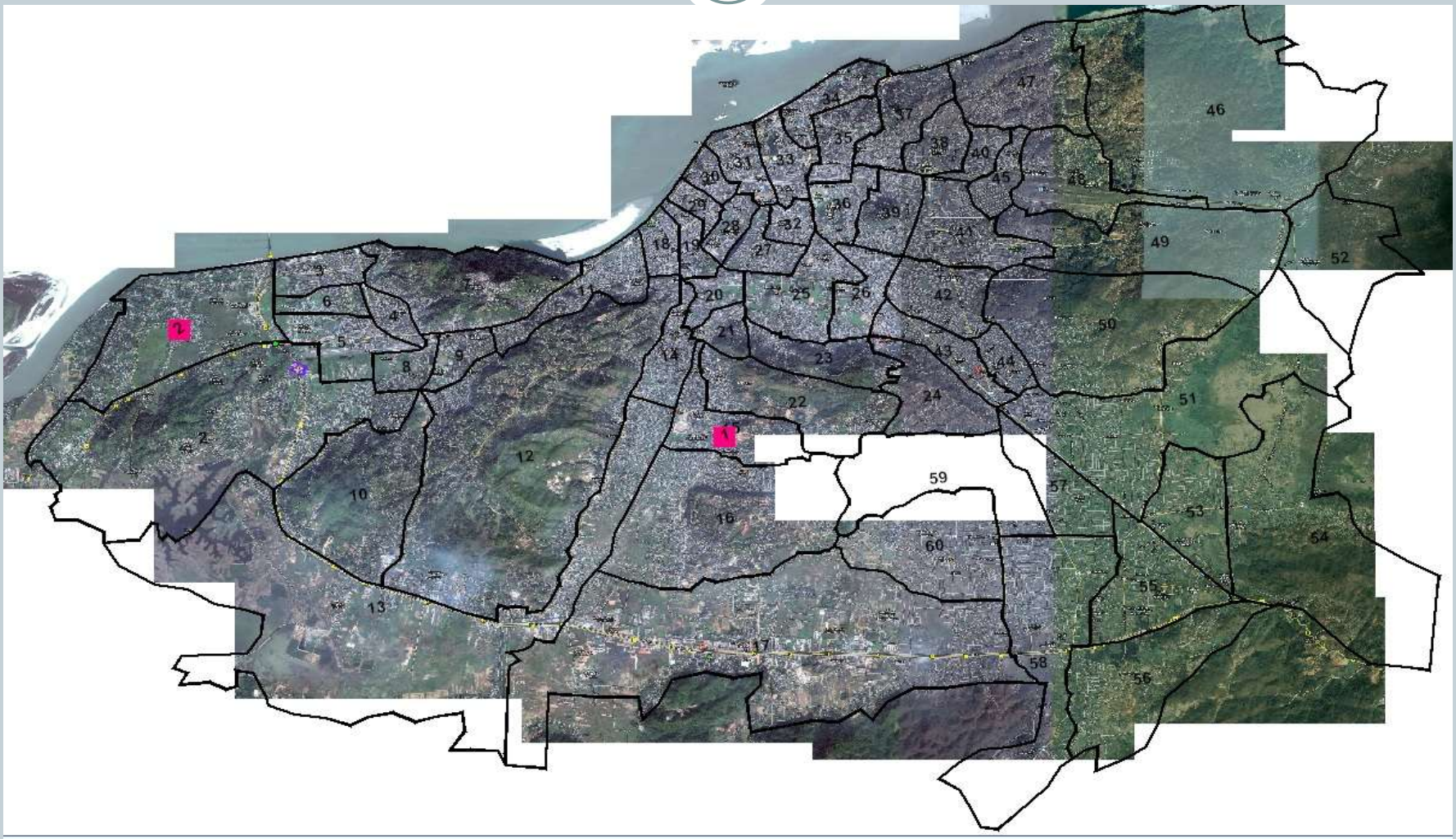
ROAD SIDE LITTERING

CLOGGING OF DRAINS

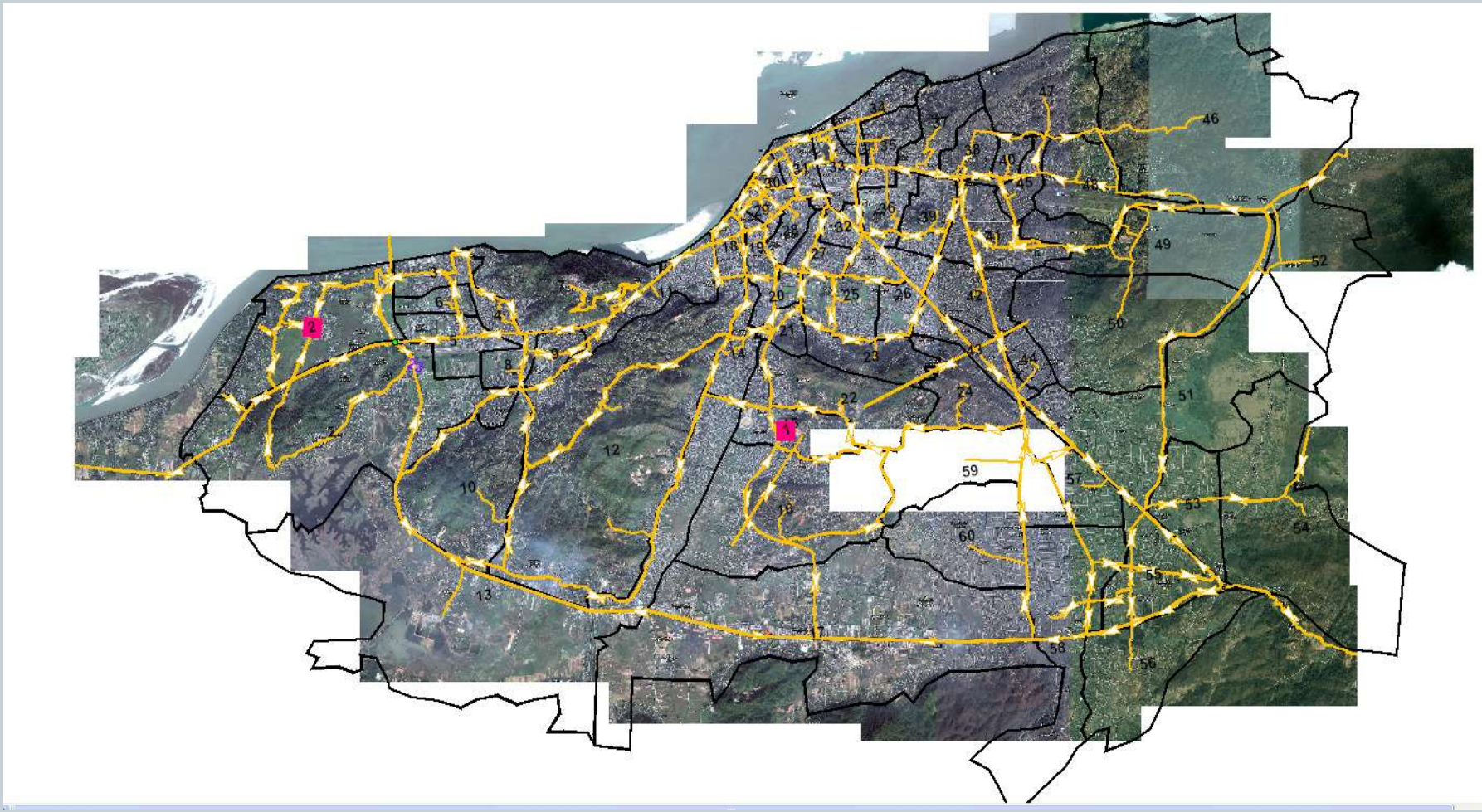
DESIGN STEPS



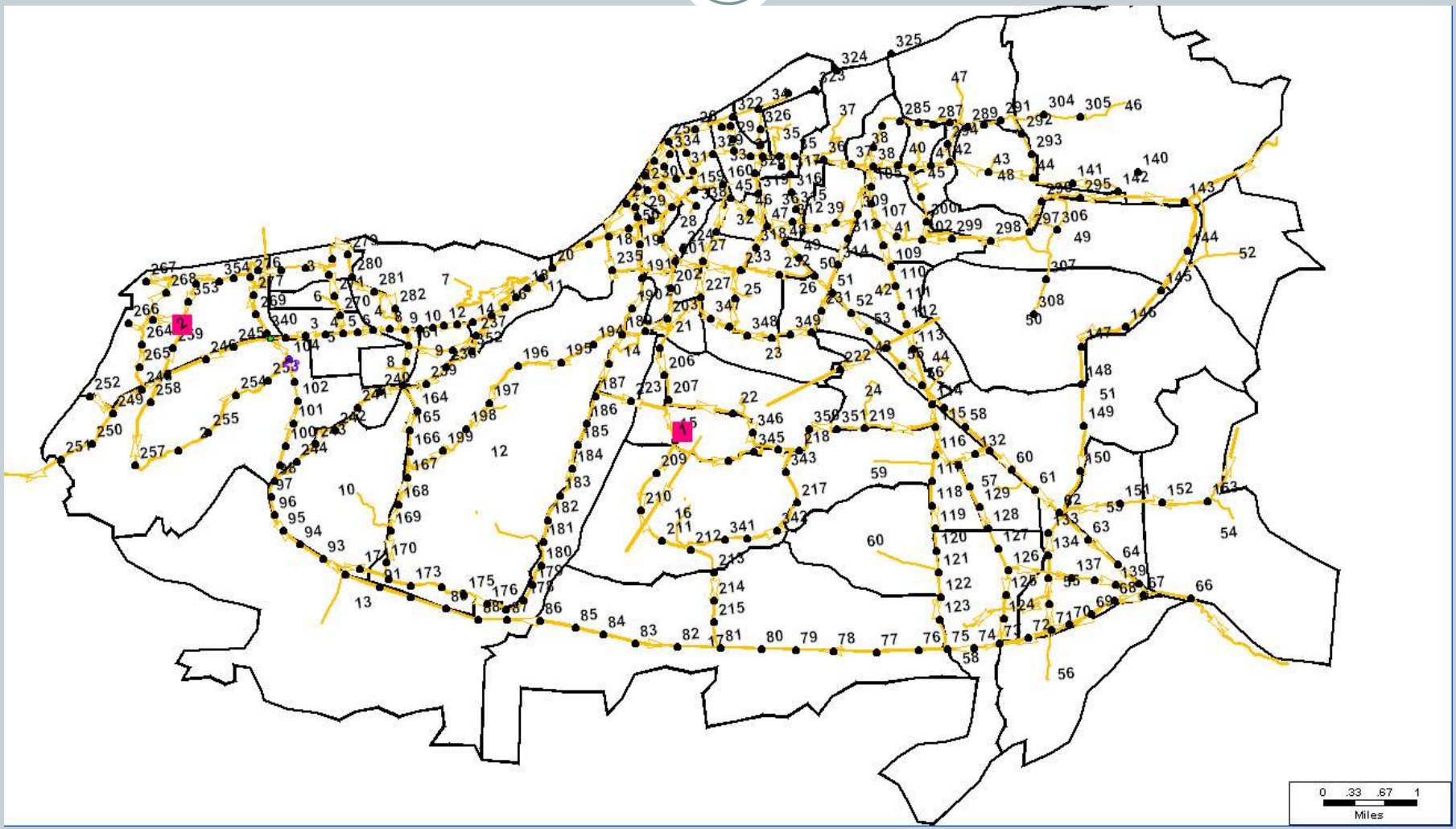
WARD MAP OF GUWAHATI



ROAD NETWORK OF GUWAHATI

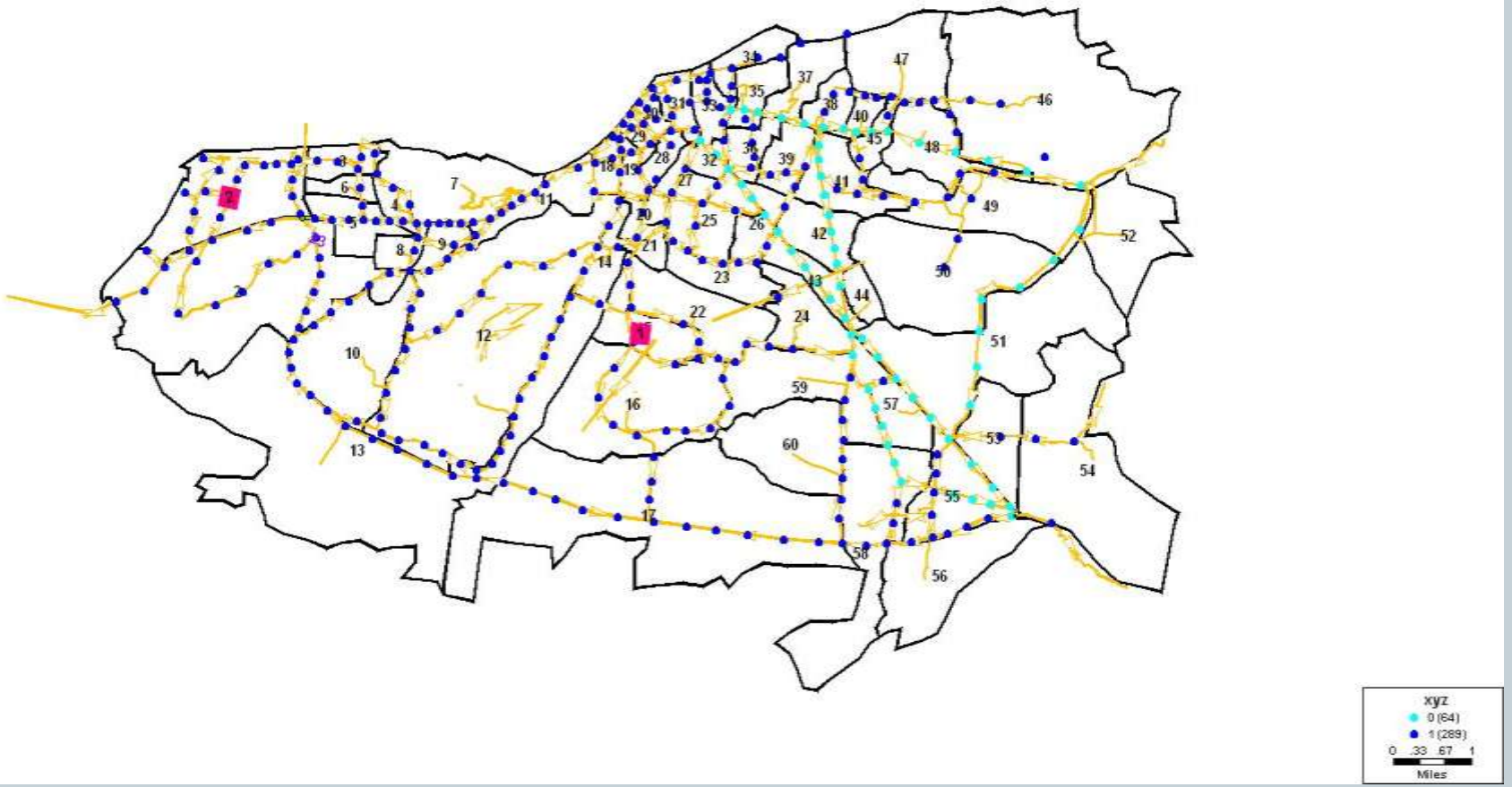


DUSTBIN LOCATION ALONG ROAD NETWORK



TOTAL NUMBER OF DUSTBINS REQUIRED = **330**

DUSTBIN LOCATION AS PER COLLECTION SYSTEM



WARD WISE DISTRIBUTION OF DUSTBINS

WARD 1	WARD 2	WARD 3	WARD 4	WARD 5	WARD 6	WARD 7	WARD 8	WARD 9	WARD 10	WARD 11	WARD 12
245	249	272	281	3	270	9	161	23	242	17	164
246	250	273	282	4	271	10	162	236	244	18	165
247	251	274	8	5		11	163	238	243	19	166
248	252	278		6		12		252	244	20	167
259	253	279		7		13			92	154	168
261	254	280				14			93	237	169
262	255					15			94		170
263	256					16			95		171
264	257								96		172
265	258								97		173
266	99								98		174
267	100										175
268	101										176
269	102										
276	103										
277	104										
353											
354											

WARD 13	WARD 14	WARD 15	WARD 16	WARD 17	WARD 18	WARD 19	WARD 20	WARD 21	WARD 22	WARD 23	WARD 24
177	188	204	209	213	155	192	201		221		22
178	189	206	210	214	156	193	202		344		219
179	190	207	211	215	235	157	203		346		351
180	191	208	212	76	21	337			218		114
181	20	221	341	77					350		
182	223	345	342	78							
183			216	79							
184				80							
185				81							
186				82							
187				83							
87				84							
88				85							
89				86							

WARD 25	WARD 26	WARD 27	WARD 28	WARD 29	WARD 30	WARD 31	WARD 32	WARD 33	WARD 34	WARD 35	WARD 36
232	48	225	338	22	24	25	45	27	321	33	312
234	49	226	224	23	332	26	46	28	323	34	315
227	50	233	200	336	335	329	47	29	326	35	316
228	349	248	159	158	334	330	319	30	327		
229	230	318		333		331		31	320		
347						160		32	320		
348								328			

WARD 37	WARD 38	WARD 39	WARD 40	WARD 41	WARD 42	WARD 43	WARD 44	WARD 45	WARD 46	WARD 47	WARD 48
	283	309	40	105	109	52	113	41	140	288	292
	284	310	286	106	110	53		42	141	289	293
	285	311	287	107	111	54		294	142	290	295
	37	313		108	112	55		301	143	291	296
	38			299	51	56			304		43
				300					305		44
				302							
				303							

WARD 49	WARD 50	WARD 51	WARD 52	WARD 53	WARD 54	WARD 55	WARD 56	WARD 57	WARD 58	WARD 59	WARD 60
297	307	57		151	152	133	68	128	124	116	120
298	308	58		63	153	134	69	129	125	117	121
306	145	59		64		135	70	130	126	118	122
144	146	60		65		136	71	131	127	119	
	147	61				137	72	132	73	343	
	148	62				138			74	217	
		149				139					
		150									

SUMMARY

- No of dustbins required= 330
- Both Stationary and haul collection system

HAUL COLLECTION SYSTEM				
No of trucks	**No of dustbins**	**Capacity of dustbin**	**No of trips/day**	**Avg. time/trip (in h)**
9	**84**	**3.5 m^3**	**49**	**1.4**

STATIONARY COLLECTION SYSTEM				
No of trucks	**No of dustbins**	**Capacity of dustbin**	**No of trips/day**	**Avg. time/trip (in h)**
8	**246**	**0.24 m^3**	**36**	**1.8**

ROUTE COLLECTION SYSTEM

- STATIONARY COLLECTION SYSTEM
- HAUL COLLECTION SYSTEM

Collection system file

COMPOST AT BORAGAON

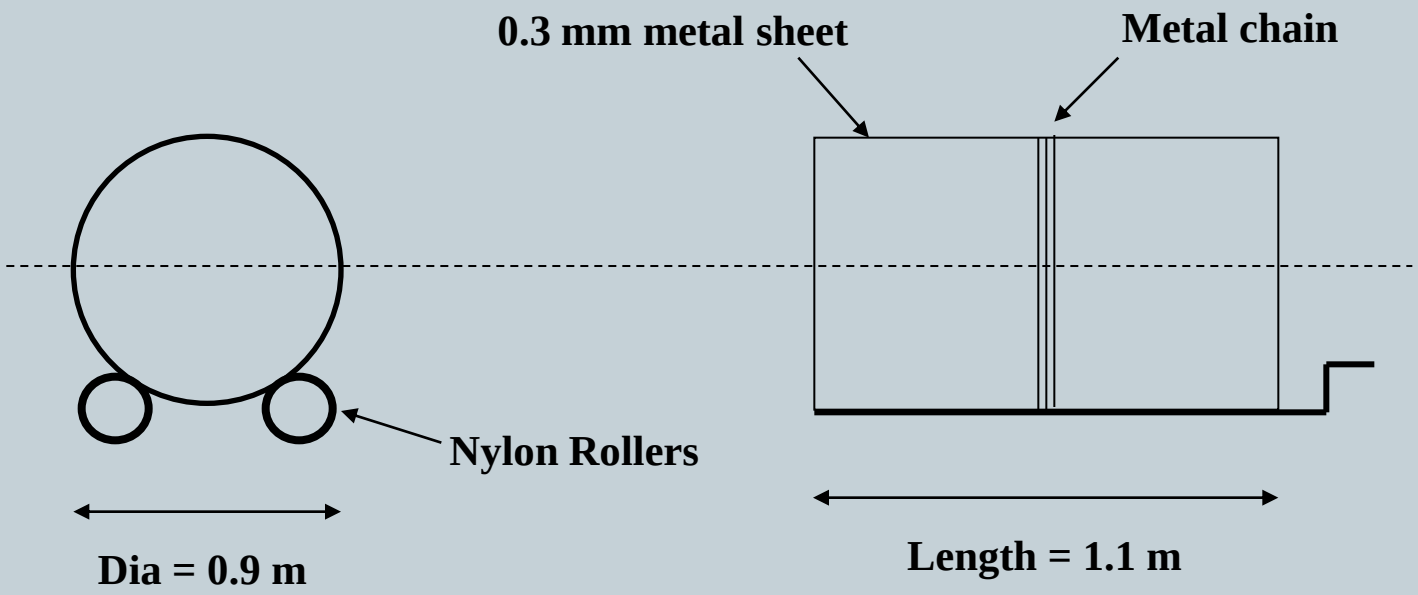
Total Nitrogen (%)	0.7- 0.84
NH_4-N (%)	0.0024-0.0026
Available phosphorous (%)	0.0934-0.118
Total Phosphorous(%)	0.495-0.547
Sodium (g/kg)	1.04-1.05
Potassium (g/kg)	5.49-5.87
Calcium (g/kg)	7.65-8.66
Magnesium (g/kg)	6.27-6.62
Total Metals (g/kg)	
Zn	0.619-0.624
Cu	0.303-0.331
Mn	0.451-0.488
Fe	2.868-3.272
Ni	0.177-0.233
Cd	0.065-0.072
Pb	0.27-0.36
Cr	0.072-0.074

COMPOSTING AT IITG

- Vegetable waste
- Water hyacinth (Metka)
- Sewage sludge
- Pulp and paper mill waste
- Phumdi from Loktak lake Manipur

COMPOSTING REACTORS

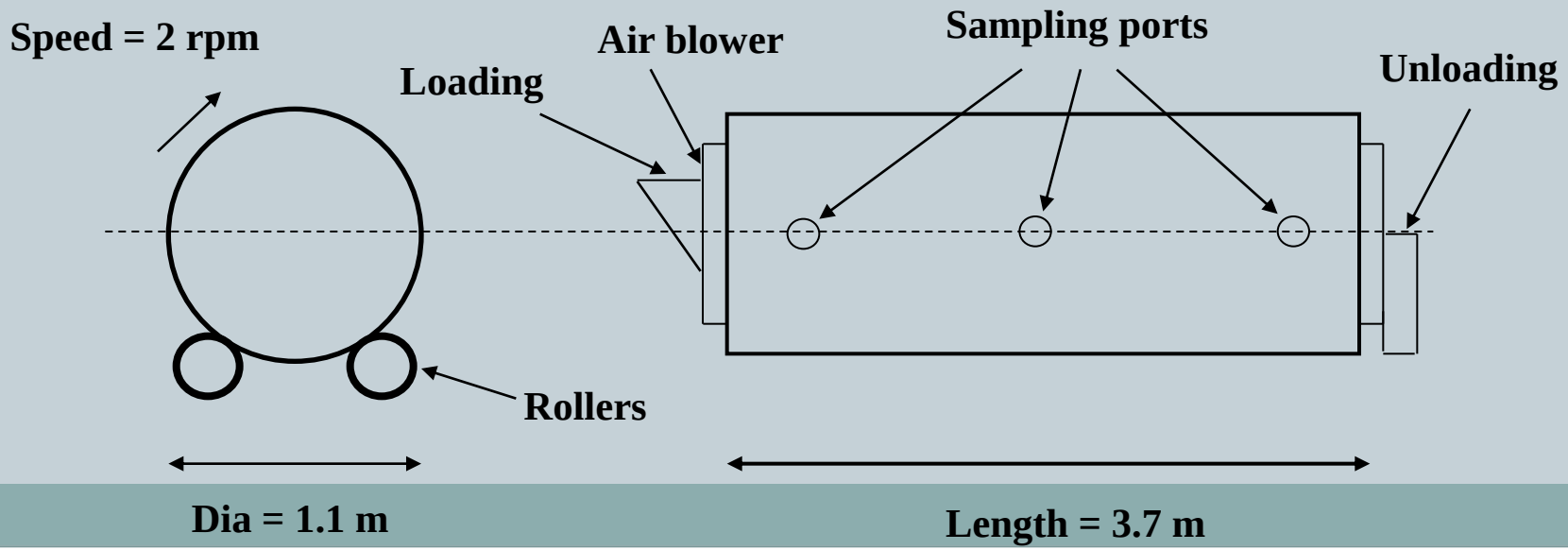
Batch operation: Pilot-scale rotary drum composter



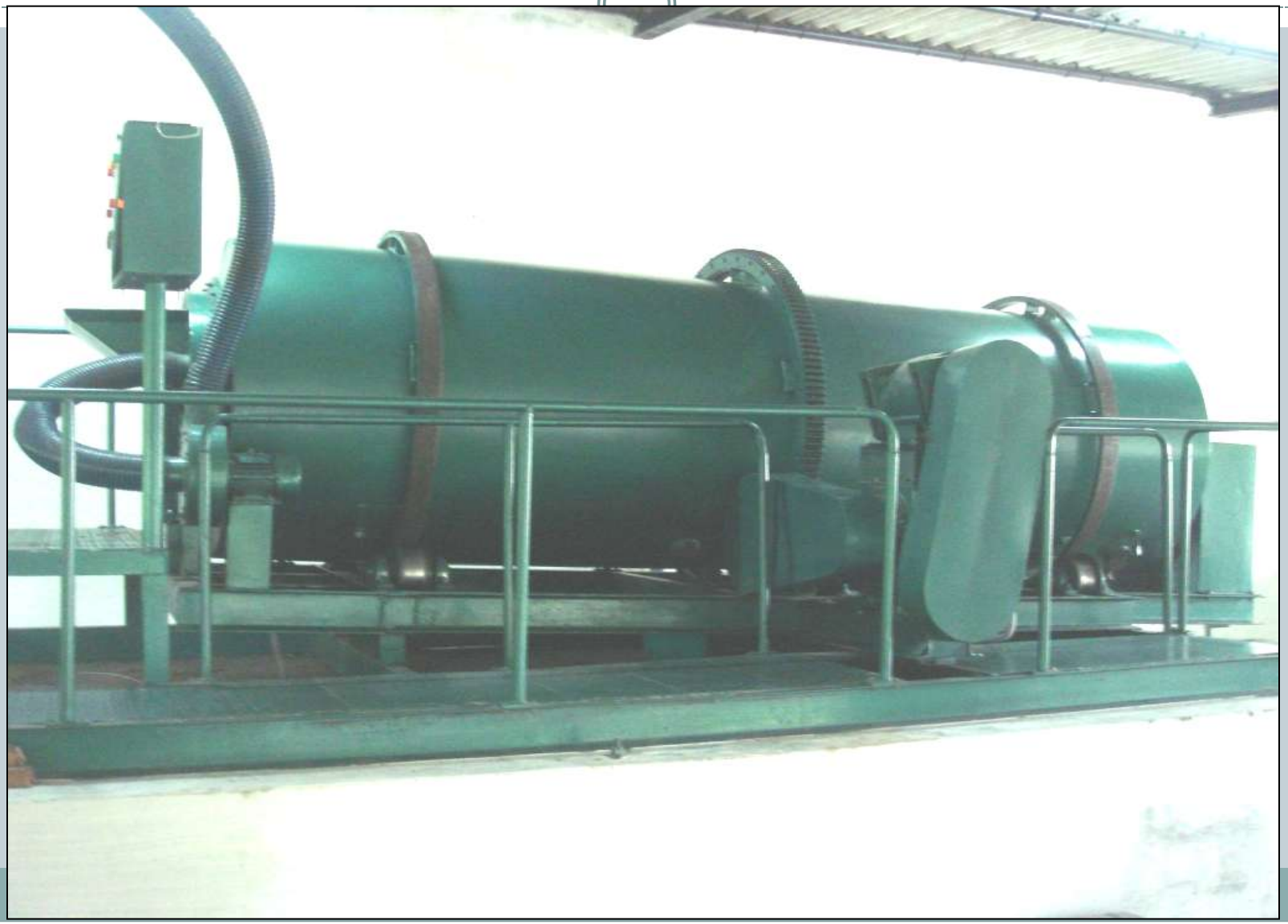
ROTARY DRUM COMPOSTER

Rotary drum composting provides agitation, aeration and mixing of the compost, to produce a consistent and uniform end product.

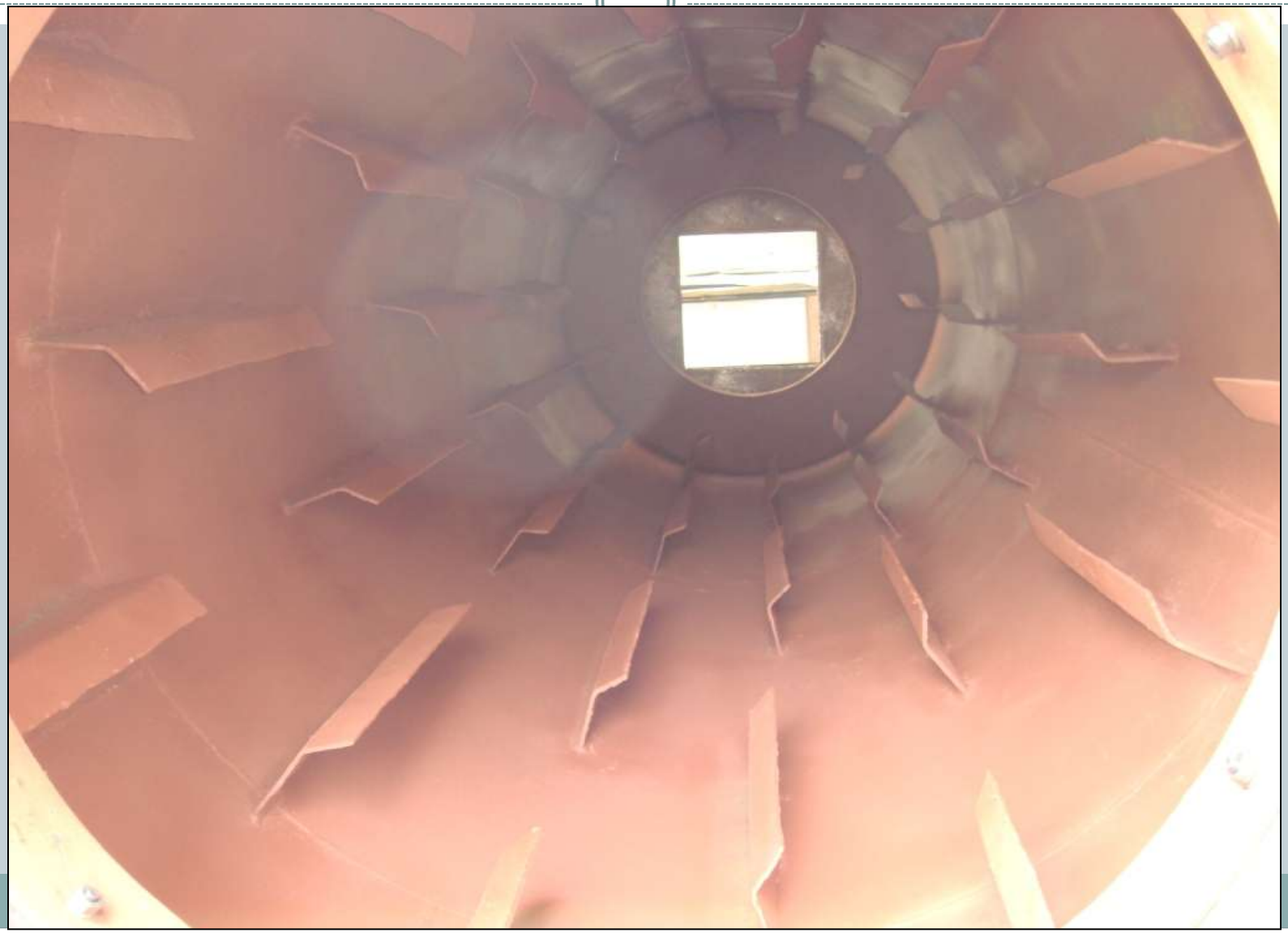
In warm, moist environments with ample amount of oxygen and organic material available, aerobic microbes flourish and decompose the waste at a quicker pace.



Side view

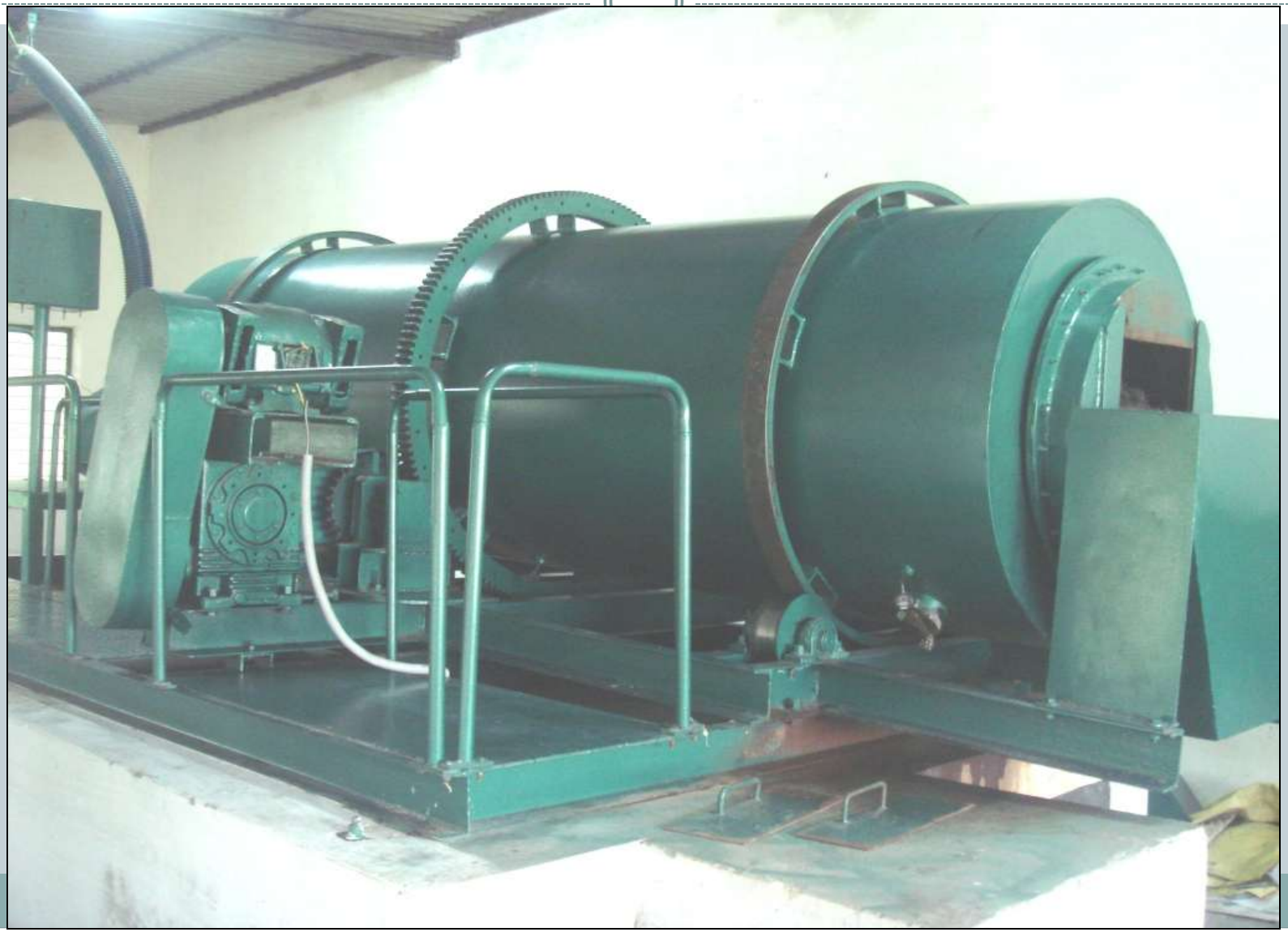


Inside view



Front view

Rear view

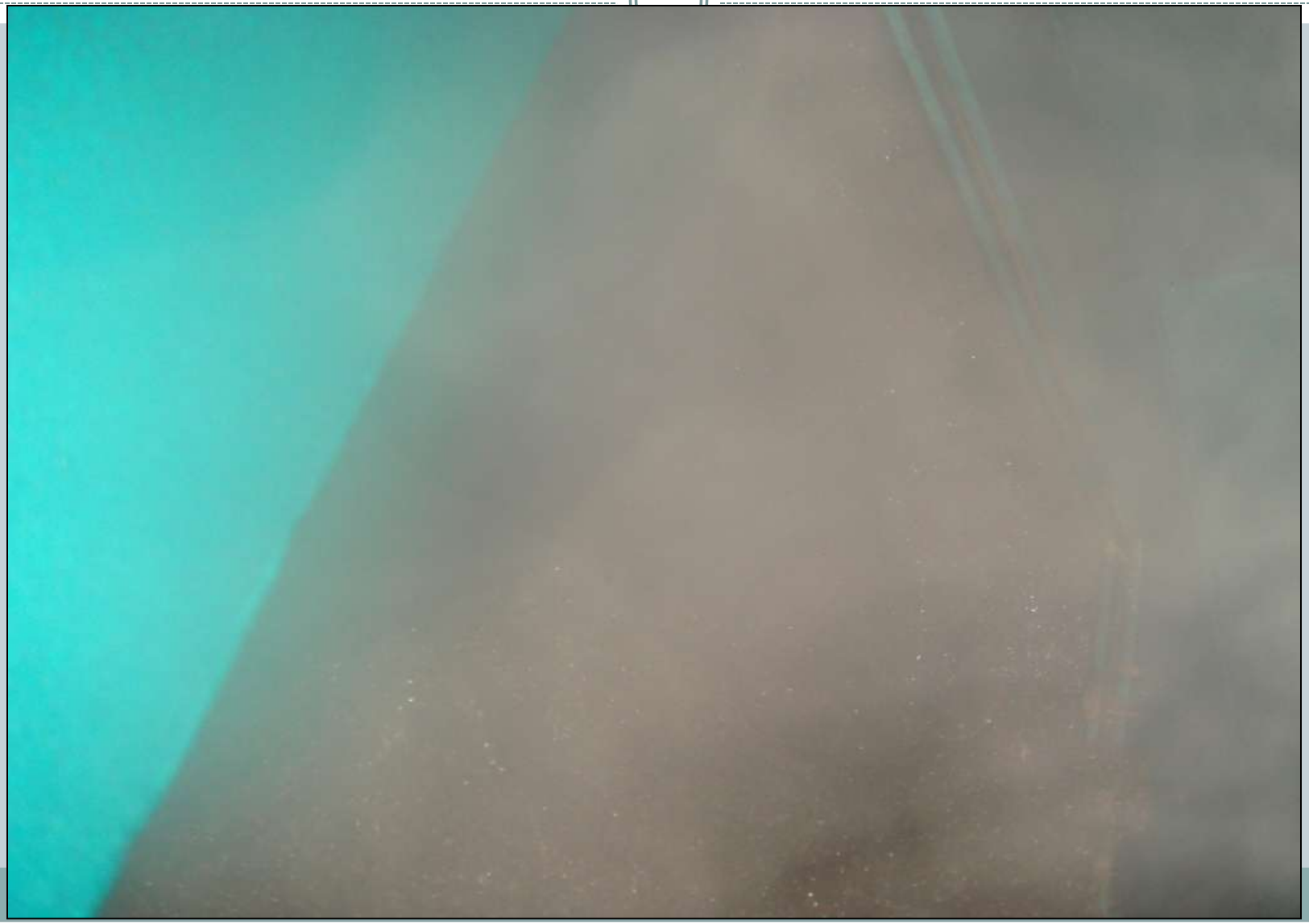


Composting shed

Feeding into drum

Waste within drum

Water Vapors after turning




01/01/2005


01/01/2005


01/01/2005

Feeding

Inside

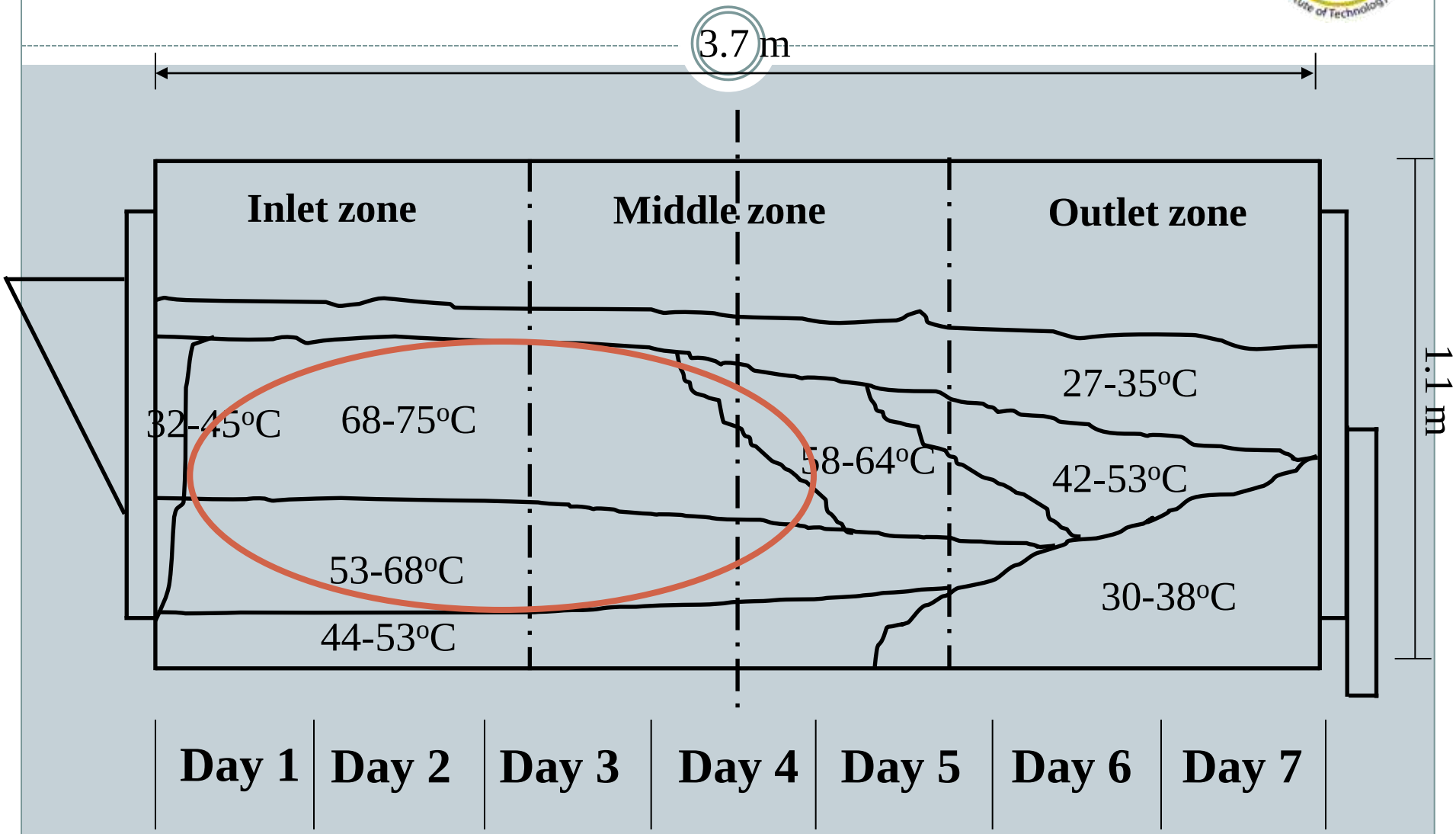
Outlet

Curing

Sieving

Compost

TEMPERATURE PROFILE



VERMICOMPOSTING

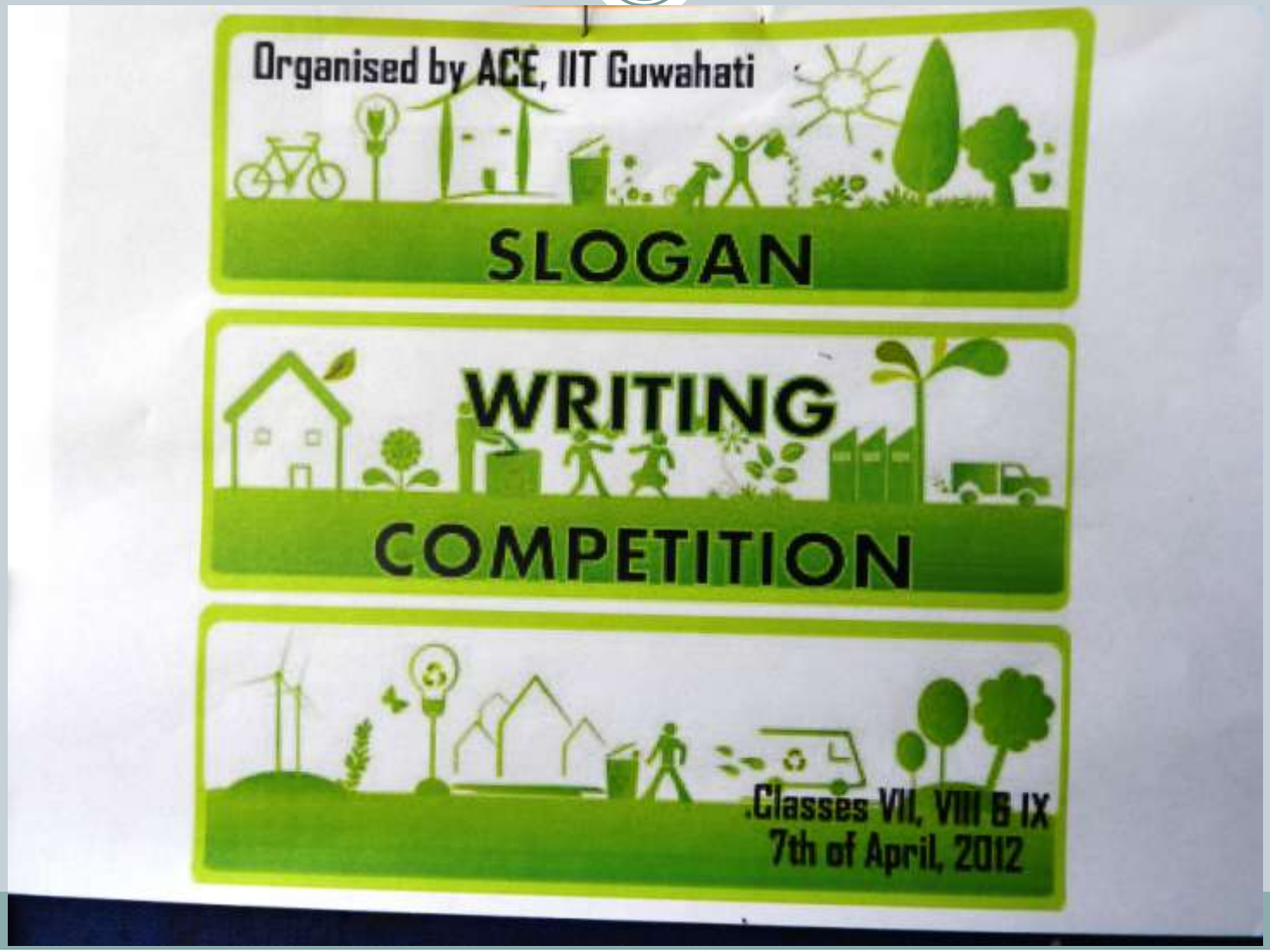
Eisenia fetida

Eudrilus eugeniae


14.08.2011 12:06


14.08.2011 15:34

AWARENESS PROGRAM AT SCHOOL




PAINTING COMPETITION
Organised by ACE, IIT Guwahati
"HEAL THE EARTH,
HEAL THYSELF "
.For classes VI, VII, VIII & IX
7th April, 2012


PAINTING COMPETITION
SLOGAN
WRITING
COMPETITION
ESSAY COMPETITION


02.03.2013 13:30


02.03.2013


SYMPOSIUM
ON
SOLID WASTE MANAGEMENT AT IIT GUWAHATI


Collection &
Segregation


SYMPOSIUM
ON
6th APRIL 2014

Ongoing projects at IITG

Composting and anaerobic digestion

1) Composting of water hyacinth funded by **DST (SERB)**.
2) Composting and anaerobic digestion of kitchen waste funded by MoDW&S.
3) Composting of phumdi from Loktak lake Manipur funded by CSIR.

Other research programs

1) Microbiology during composting of water hyacinth**,** kitchen waste and anaerobic digestion**.**
2) Heavy metal removal during composting.
3) **Template preparation for evaluation of solid waste PPP projects.**
4) **Decision support system for solid waste PPP projects.**

THANK YOU