Integrated Waste Management of Smart City Gandhinagar

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Abstract – *Due to the lack of the segregation at source and the lack of the awareness of the public towards the waste disposal at source every day out of 105 tons 46.5 tons is disposed to the landfill site in the Gandhinagar. Majority organic waste is mixed to general waste and after mixing the separation of dry and wet waste is very tedious task and finally result is increase in the dump waste day by day. So in this paper based on the integrated waste management hierarchy if out of 105 tons 40 percent of organic waste say 42 tons organic waste is treated in biogas plant after that how much energy can be yield as well how much amount of waste can be prevented from dumped to landfilled site is discussed with design of biogas plant and its possible outputs.*
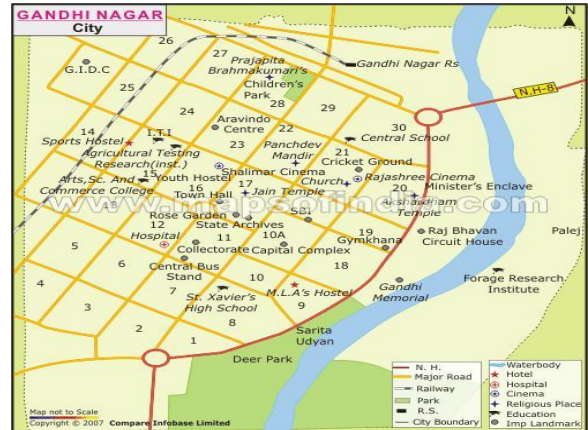
Key Words: **Biogas, GMC, Hydraulic Loading Rate, Landfill, Smart City**

1. INTRODUCTION

The Vibrant Gandhinagar city, the capital of Gujarat, has been shortlisted by Ministry of Urban Development as one among the potential 100 smart cities under the Smart City Mission. At present, Gandhinagar Municipal Corporation (GMC) is in the process of revising the Smart city proposal for second round participation.[4] so, municipal solid waste management play an important role for that smart city proposal.

1.1 Study Area Profile

Gandhinagar is the 8th municipal corporation in Gujarat, having a population of more than 2 lakhs and spread over an area of 56 sq. km. The city is witnessing a major construction / infrastructure boom as well as a steady population increase. It is a growing hub of education, information technology. The Gandhinagar Municipal Corporation (GMC) provides some of basic services to citizens of Gandhinagar such as Gandhinagar, solid waste management, Gandhinagar transportation providing medical are some of the key services. For effective service provision and smooth administration to all citizens. GMC has divided its activities into activities into 6 wards.[3]

Fig -1: map of Gandhinagar city (source: google image)

1.2 Solid Waste Management in Gandhinagar

Almost 105 Metric Tons of solid waste is generated from the city daily. This waste is collected, transported, treated and disposed according to Rules. Nearly 50 percent of the entire waste is collected from municipal bins and from street sweeping. Street Sweeping is carried out on all 365 days by 167 permanent workers from the morning 7:00 am to 12:00 am and 3 pm to 6 pm on all roads of the city. GMC introduced a new concept of door / Gate to dump since July 2014, in which the GMC appointed contractor collects waste from residential units in the morning hours and from commercial units in the evening in closed Hydraulic Euro III vehicles. The waste from these vehicles is transferred to transfer stations from each ward to the treatment plants. The project is successfully covering 100% of all residential & commercial units, on all 365 days of the year. 65 Vehicles have been deployed that start the collection process from 7 am onwards. GMC has identified more than 941 locations as waste collection points. 120 closed body M.S. Community storage bins have been provided on 120 sites for waste collection. These containers are lifted when fully fill up. GMC has developed a fully mechanized transportation system for door to door waste that ensure handling of waste only once. Further GMC has also arranged the secondary waste transportation system & ensure timely & efficient removal of waste from its collection point. GMC has deployed 11 trucks mounted road vacuum sweeping machines and 4 self-rides on road vacuum sweepers for efficient clearing of the city. GMC has deployed 6 tractors trolley, 2 trucks, 5 tractor lifter, dumper placer, 5 compactor, 2 dead animal vans. GMC deploys more than 150 total vehicles / equipment on daily basis for efficient handling of waste cleaning of the city.[3]

Existing SWM facilities in GMC, Gandhinagar has 2 vermi -compost plants in sector 21 and sector 24, 2 refuse transfer station in sector 7 and sector 28. A bio gas plant and the open dumping site is in sector 30.[2]

2. DATA COLLECTION & ANALYSIS

According to Gujarat pollution control board (march2018) waste production in Gandhinagar city is 105 TPD [1]

Table -1: Solid Waste Statistics along with quantities for Gandhinagar City (source: GMC)

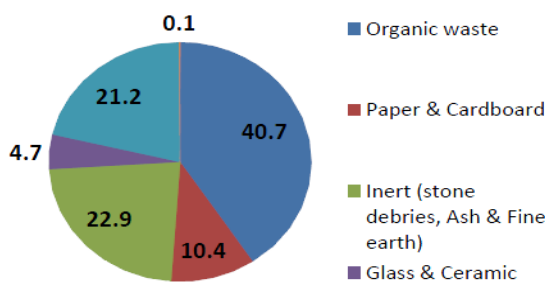| Sr. NO.	Type	Quantity (TPD)
1	vermi compost	16
2	Biogas	2.5
3	Recycle	20
4	C & D	10
5	Road Swipping	10
Total treated waste		58.5
Total untreated waste		46.5

Chart -1: Waste Characterization Gujarat (*Source: GUDC*)

Waste characterization of urban solid waste was carried out by Gujarat Urban Development Company Limited (GUDC) under the state wide project on municipal solid waste management in the year 2008-2009. The state was divided into different clusters and sampling was done at 15 different locations within each of the ULBs. Chart 1 shows the waste characterization averaged at state level. Analysis shows that organic waste constitutes about 40 percent, followed by inert material which constitutes 22.94 percent; plastic, rubber & synthetic and paper & cardboard contribute 21.21 percent & 10.41 percent respectively. Average moisture content is 26.03 percent with calorific value of around 2232.88 calorie/gram.[9]
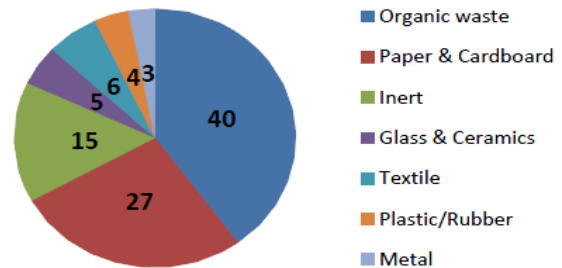

Chart -2: Waste Characterization in Typical Indian City (*Source: State of Environment Report - India*)

Comparing the same with waste composition of typical Indian cities as shown in chart 2 it can be said that cities of Gujarat have higher proportion of inert/stone debris in municipal waste compared to typical Indian waste characteristics. Higher proportion of debris could be due to mixing of street sweeping waste with the general municipal solid waste. Also, in bigger cities which do not have separate collection of construction and demolition waste, it gets mixed with general waste and adds to the proportion of stone and debris in the waste. Proportion of Glass & Ceramic is almost same. Organic waste constitutes almost 40 percent in both the cases while the high percentage of plastic waste in the Gujarat indicates increasing use of plastic products. Due to the changing lifestyles there has been shift in waste composition especially paper, plastic and metal content has increased, and organic content has reduced It is now essential to aggressively enforce source segregation of recyclables not only at household level but also in institutions, commercial establishments.[9]

Total organic waste generated per day is 40% of the total solid waste.[9]

So, Total organic waste   = 40% x 105
                          = 42 TPD

3. DESIGN A BIOGAS PLANT

Daily inflow of the Gandhinagar Municipal waste consisting of kitchen waste, market waste, animal excreta, poultry waste, etc.

➢ Daily organic waste of GMC = 42 TPD
                              = 42000 kg/d
Thus, total weight of the waste after addition of 20% water = 42000 + 8400
       = 50400 kg

The design of the biogas has been divided in four parts. [3][6][7][8]

➢ Part A: Design of Biogas Digester
➢ Part B: Design of Gas Collecting Dome

➢ Part C: Design of Inlet and Outlet Arrangements
➢ Part D: Design of Agitator

PART A: DESIGN OF THE DIGESTER

1) The daily inflow = 50.4 m^3/day.

2) Retention Time = 15 days

3) Volume of the digester (V_D) = daily inflow (m3/day) * Detention Period (days)

$V_D = 50.4 \times 15 = 756 \ m^3$

4) Plan area of the digester
Since the hydraulic loading rate (*HLR*) for an anaerobic digester ranges between 175 -200L/day/m^2 we can take the HLR as 200 L/day/m^2[6]
A = Daily Inflow / HLR
= $50400 * 10^3 / 200$
= $252 \ m^2$

Diameter of the digester can be given by,
$D = \sqrt{(A * \frac{4}{\pi})}$
= 17.9 m
= 18 m (taken)

5) Height of the digester
H_D = volume/ surface area
= 756/252
= 3 m
Provision of a freeboard of 0.5 m and 0.2 m at bottom for hopped sludge deposition depth is recommended.

PART B: DESIGN OF GAS COLLECTING DOME

The design of the gas dome depends upon the volume of gas to be evolved.

Vol. of the gas dome = vol. of gas to be evolved

As the formation of biogas is a chemical process, it depends upon the chemical oxygen demand of the waste in the digester. Thus, the total degradation of the COD of the waste will produce the biogas and the amount of gas that would be evolved will be evaluated as follows,

➢ Volume of waste is 317.55 m^3
➢ COD of the feed = 500 mg/L

Total COD to be digested for the evolution of the gas is
= COD * volume of waste
= 500 x 756 x 1000
= 378×10^6 mg
= 378000 gm.

Now, 1g CH_4 = 4g COD ~ 1.4 L CH_4 [6]

Thus 158775 gm. of COD will produce 132300 L of CH_4 or 132.3 m^3 CH_4 Since, biomass contains 60% (approx.) of CH4
6) Total biogas production
= volume of CH4 / 0.6
= 132.3/0.6
= 220.5 m^3

Thus, volume of gas dome = total biogas production of the day

7) Height of gas dome
= volume of gas dome / area of the digester
= 220.5/252
= 0.875 m

PART C: DESIGN OF INLET AND OUTLET ARRANGEMENTS

8) Design of outlet

Daily inflow = sludge discharge from outlet

Total discharge of the day = 756 m^3/hr.

As the sludge itself is a flowing liquid, can be settled during the discharge thus for ensuring a non-silting velocity of flow, it is recommended for a minimum of 0.8m/sec.

Thus C/S area of the outlet pipe
= sludge discharge / velocity for the flow
= 756 / (0.8*60*60)
= $2625 \times 10^{-4} \ m^2$

Assuming the flow in the pipe is running half full, Therefore, proportionate area ratio can be given as, a/A = 0.5
A = a / 0.5
= 2625×10^{-4} / 0.5
= $525 \times 10^{-3} \ m^2$

Thus, diameter for the pipe = 0.525 m
The inlet pipe recommended would of the same diameter as of the outlet pipe.

9) Feeding chamber = 1.5 x 50.4
= 75.6 m^3

PART D: DESIGN OF AGITATOR

In digesters with capacities higher than 100 m3, it is necessary to install equipment to provide agitation of the contents.[7]

Calculation for the three-blade type agitator were determined by governing the rules of impeller designing, which were calculated based on the [3]
i.   total height of digester = H+H_D= 3 m + 0.875 m = 3.875 m

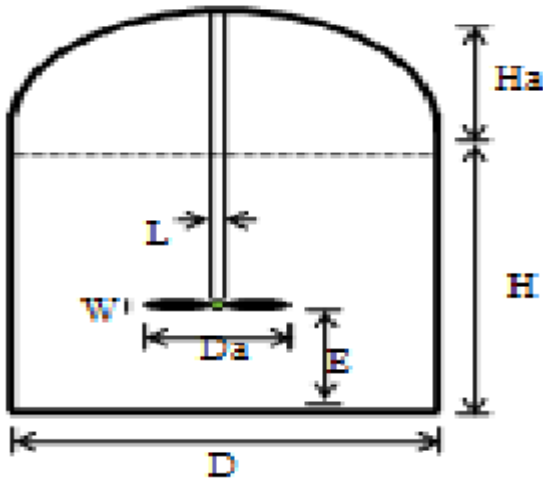ii.   diameter of digester (D) = 18 m.

Fig -2: Biogas plant represent impeller front view

- Diameter of the agitator $D_a = D/3 = 6$ m
- Height of impeller H_a = Height of digester = 3m
- Empty space below the impeller = Total Height – Impeller Height = 0.875 m
- Width of the impeller $W = D_a / 5 = 1.2$ m

4. CONCLUSIONS

- Total 220.5 m³ biogas per day can be generated by providing the biogas plant for total organic waste of 42 TPD
- The waste which is deposited to landfill can be reduced up to 4.5 TPD
- 42 TPD x 365 day = 15330 TPA, using 15,000 tons of biomass per year, the plant produces a total of 500 kW electricity and heat

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