

Design of Digester for Biogas Plant for Kadi Sarva Vishwa Vidhlya Gandhinagar Gujarat

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ABSTRACT: The design of proper digester is required for better production of biogas. For that purpose the design of digester is carried out and calculations of various parameters are carry overed. By applying this design to the digester the maximum generation of biogas is possible. Total 9 m³/day biogas can be achieved by this design.in Kadi Sarva Vishwalya Gandhinagar Gujarat.

KEYWORDS: Digester size, Ratio of solid content, Gas proposition rate, Material selection

I. INTRODUCTION

Biogas has become an important alternative fuel because it is an integrated system with multiple benefits, including diversification of cooking fuel supply, reduction of local pollutants, improved indoor air quality, sanitation and crop yield improvement. In this paper the biogas is generated by waste management method and the raw material for the generation of biogas is garbage of college and wastages from drainage system from the LDRP-ITR college. The government roles are to support to increase the production of the alternative energy, especially to build amount number of the bio-digester units in villages.

1.1 MECHANISM OF BIOGAS FERMENTATION

There are two types of biogas microbes.

- 1.Non methane generatic type bacreria
- 2.Methane generatic type bacteria

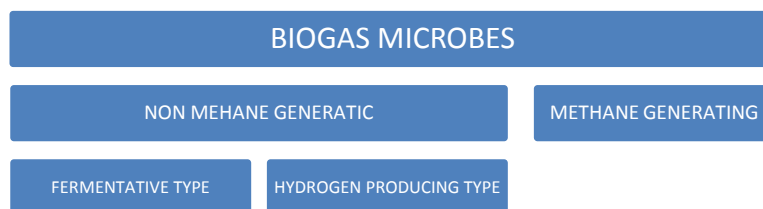


Fig 1.1 Mechanism of biogas fermentation

1.2 **WASTE MANAGEMENT METHOD :** Residential waste and commercial waste can be utilized effectively for biogas generation .The chart of the process is as follows:

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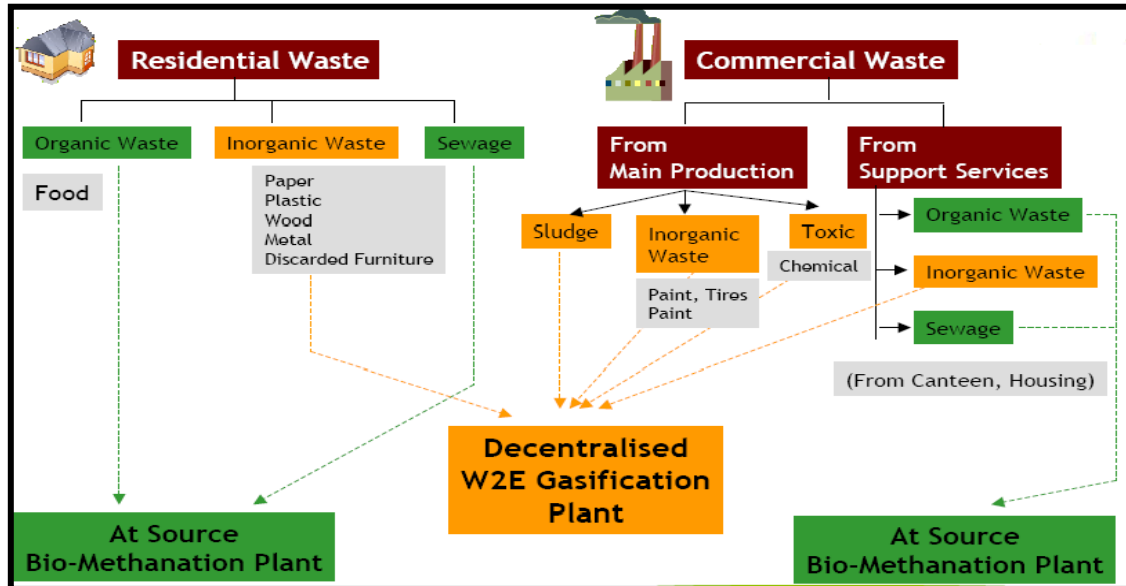


FIG 1.2 SOLUTIONS TO WASTE MANAGEMENT

As mentioned in the above figure the residential waste and commercial waste is used for the generation of biogas. For that purpose Organic and Inorganic wastages are used. The wastages are decentralised and the methane gas formed from the wastage.

1.3 STATUS OF SOLID WASTE IN INDIA

Sr. No.	Metro city	Municipal population	Municipal solid waste (tones/day)
1	AHMEDABAD	28,76,710	1,683
2	BANGALORE	41,30,288	2,000
3	BHOPAL	10,62,771	546
4	BOMBAY	1,22,88,519	5,355
5	CALCUTTA	1,06,43,211	3,692
6	COIMBATORE	8,16,321	350
7	DELHI	84,19,084	4,000
8	HYDERABAD	40,98,734	1,566
9	INDORE	10,91,674	350
10	JAIPUR	14,58,483	580

TABLE 1.1 STATUS OF MUNICIPAL SOLID WASTE GENERATION IN METRO CITIES IN INDIA (CPCB,1999) [3]

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 7, July 2015

II. DESIGN PARAMETER

(A) Selection of materials (B) Total solid (TS) contains calculations of organic materials Organic Materials Solid part :Total solid contained in a certain amount of materials is usually used as the material unit to indicate the biogas - producing rate of the materials. Most favorable TS value desired is 0.8% Liquid part : As per Annexure-I (C)Favourable temperature,PH value & Carbon to nitrogen ratio fermentation Temperature:Mesophilic;20 °C to 35 °C (Annexure -II).PH value : Neutral PH and ranges 6.8 to 7.2 C/N ration :Ranges from 20:1 to 30:1 (Annexure-VI) (D) Hydraulic retention time (HRT) -For Mesophilic digestion where temp. varies from 20 o C to 35 o C and HRT is greater than 20 days.[2]

2.1 TOTAL SOLID VALUE OF FRESH DISCHARGE

Kinds	Body weight (Kg)	Discharge per day	TS values of fresh discharge(% by weight)	water to be added to fresh discharge to make TS 8%
Human	50	0.5	20	0.75
Cow	200	10	16	10
Chicken	1.5	0.1	20	0.15
Pig	50	1	20	7.5

Table 2.1 Table showing discharge per day, TS value of fresh discharge and water to be added to make favourable TS condition [8]

The above table 2.1 mentioned the fresh discharge by weight from different sources. As the water added to the fresh discharge and the process of biogas generation will start.

2.2 ABOUT LDRP COLLEGE WASTE CONTAIN DATA OF STUDENTS

In LDRP college Gandhinagar Gujarat about 3000 students are studying in various disciplines. So total waste is calculated for 3000 students.

The average discharge of 5 student is 0.5 Kg and the biogas generation is calculated for 3000 students.[10]

2.3 RELATIONSHIP BETWEEN TEMPERATURE, HRT & TS VALUE OF 8%

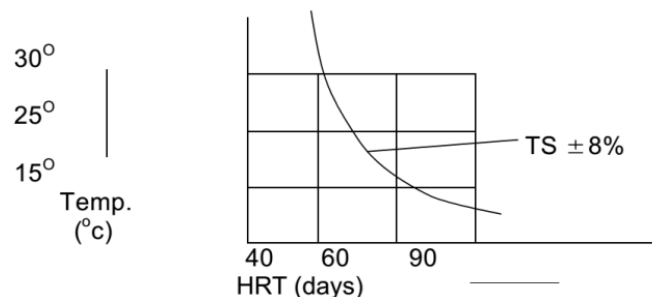


Fig 2.1 Graph of Temperature vs HRT days

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 7, July 2015

2.4 CROSS SECTION OF A DIGESTER

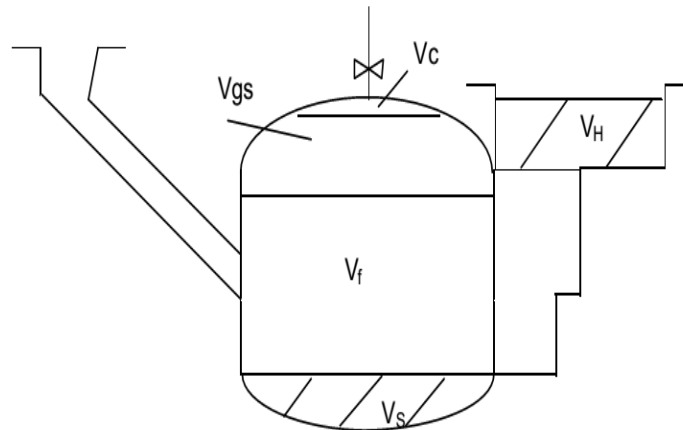


Fig 2.2 Dimension of the digester[7]

- a) Volume of gas collecting chamber = Vc
 - b) Volume of gas storage chamber = Vgs
 - c) Volume of fermentation chamber = Vf
 - d) Volume of hydraulic chamber = Vh
 - e) Volume of sludge layer = Vs
- Total volume of digester $V = Vc + Vgs + Vf + Vs$ [3]

III. GEOMETRICAL DIMENSIONS OF THE CYLINDRICAL SHAPED BIOGAS

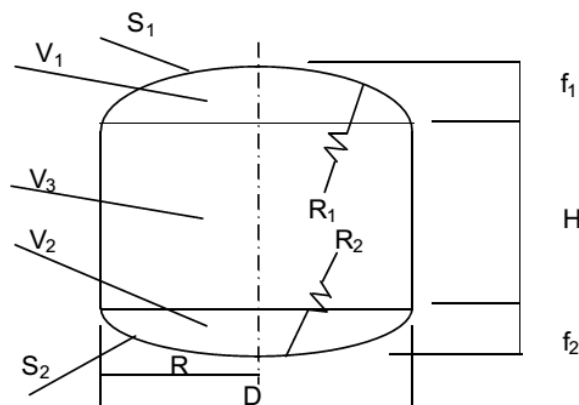


Fig 3.1 Dimension of the body[11]

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 7, July 2015

3.1 ASSUMPTIONS [12]

For Volume	For Geometrical dimensions
$V_c \leq 5\%$ $V_s \leq 15\% V$ $V_{gs} + V_f = 80\% V$ $V_{gh} = V_H$ $V_{gs} = 0.5(V_{gs} + V_f + V_s) K$ Where K = Gas production rate per m ³ digester volume per day. For Bangladesh K = 0.4 m ³ /m ³ d	$D = 1.3078 \times V^{1/3}$ $V_1 = 0.0827 D^3$ $V_2 = 0.05011 D^3$ $V_3 = 0.3142 D^3$ $R_1 = 0.725 D$ $R_2 = 1.0625 D$ $f_1 = D/5$ $f_2 = D/8$ $S_1 = 0.911 D^2$ $S_2 = 0.8345 D^2$

Table 3.1 table for parameter's Assumption

IV. EXPERIENCES AND RESULTS

4.1 Volume calculation of digester.

As per data of LDRP-ITR campus 3000 students wastages is available.[4]

(1) Total discharge = $0.5 \times 3000 = 1500$ kg

(2) Let HRT=40 days (for temp. 30 OC) Total solid of fresh discharge = $1500 \times 0.20 = 300$ kg

(3) Now water will be added to fresh discharge to make Ts value 8% as per table number 3,
 $300 \times 100/8 = 3750$ Kg, So total influent required = 3750 Kg.

(4) Water to be added to make the discharge 8 % concentration of Ts, $3750 - 1500 = 2250$ kg.

(5) Working volume of digester ($V_{gs} + V_f$) = total influent required \times total days ,So $3750 \times 40 = 150 \text{ m}^3$ (1000 kg = 1 m³)

(6) From Geometrical data,

$$V_{gs} + V_f = 0.80 V$$

$$V = V_{gs} + V_f / 0.80$$

$$V = 150 / 0.80 (V_{gs} + V_f = 150 \text{ m}^3)$$

$$V = 187.5 \text{ m}^3$$

(7) From Geometry,

$$D = 1.3070 \times V^{1/3} = 1.3070 \times (187.5)^{1/3}$$

$$D = 7.40 \text{ m}$$

(8) Now $V_3 = 3.14 \times D^2 \times H / 4$ [5]

From Geometrical dimension

$$V_3 = 0.3142 D^3$$

$$H = 0.3142 D^3 \times 4 / 3.14 D^2$$

$$H = 2.96 \text{ m}$$

Values of D and H are available so,

$$f_1 = D/5 = 7.40 / 5 = 1.48 \text{ m}$$

$$f_2 = D/8 = 7.40 / 8 = 0.92 \text{ m}$$

$$R_1 = 0.725 \times D = 0.725 \times 7.40 = 5.36$$

$$R_2 = 1.062 \times D = 1.062 \times 7.40 = 7.8625 \text{ m}$$

$$V_1 = 0.0827 \times D^3$$

$$V_1 = 0.0827 \times (7.40)^3 = 40.5224 \text{ m}^3$$

$$V_c = 0.05 \times V = 0.05 \times 187.5$$

$$V_c = 9.375 \text{ m}^3$$

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 7, July 2015

Total generation of biogas = 5% of total volume
Biogas(generation)= $187.5 \times 5/100 = 9.3 \text{ m}^3$ [6]

For brief ideas about Fermentation of materials, Carbon –nitrogen ration, wastages discharged per day by human and animal and biogas generation rate table 4.1 to 4.5 are accomplished.

Materials	Dry matter content (%)	Water content (%)
Dry rice straw	83	17
Dry wheat strawstraw	82	18
Corn stalks	80	20
Green grass	24	76
Human excrement	20	80
Pig excrement	18	82
Cattle excrement	17	83
Human Urine	0.4	99.6
Pig Urine	0.4	99.6
Cattle Urine	0.6	99.4

Table 4.1 The total solid content of common fermentation materials in rural areas Bio gas producing rates of some fermentation materials and their main chemical components [14].

Materials and their main Compo.	Yield of Biogas m3/kg TS	Methane content(%)
Animal barnyard manuare	0.260 -0.280	50 - 60
Pig manure	0.561	52
Horse droppings	0.200-0.300	51
Green grasss	0.630	49
Brewery liquid waste	0.300 - 0.600	58
Carbohydrate	0.750	49
Liquid	1.440	72
Protein	0.980	50

Table 4.2 Carbon-Nitrogen ratio of some common fermentation(Approx)[14]

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 7, July 2015

Material	Carbon content of material (%)	Nitrogen content of materials (%)	Carbon nitrogen ration (C/N)
Dry wheat straw	46	0.53	87:1
Dry rice straw	42	0.53	67:1
Corn stalks	40	0.75	53:1
Fallen leaves	41	1.00	41:1
Soybean stalks	41	1.30	32:1
Wild grass	14	0.54	27:1
Peanut stems and leaves	11	0.59	19:1
Fresh sheep droppings	16	0.55	29:1
Fresh cattle dung	7.3	0.29	25:1
Fresh horse droppings	10	0.42	24:1
Fresh pig manure	7.8	0.60	13:1
Fresh human wastes	2.5	0.85	29:1

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Dry rice straw	42	0.53	67:1
Corn stalks	40	0.75	53:1
Fallen leaves	41	1.00	41:1
Soybean stalks	41	1.30	32:1
Wild grass	14	0.54	27:1
Peanut, stem, leaf	11	0.59	19:1
Fresh, sheep drop	16	0.55	29:1
Fresh cattle dung	7.3	0.29	25:1
Fresh horse drop	10	0.42	24:1
Fresh pig manure	7.8	0.60	13:1
Fresh human wastes	2.5	0.85	29:1

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 7, July 2015

Table 4.4 Amount of human and animal wastes discharged per day [14]

Kinds	Body weight (kg)	Daily amount of excrement (kg)	Daily amount of urine (kg)	Annual amount of excrement discharged (kg)	Annual amount of excrement collection (kg)	Daily yield of biogas per capita (m ³)
Pig	50	6	15	2190	1752	0.18 □ 0.25
Ox	500	34	34	12410	9928	0.36 □ 0.96
Horse	500	10	15	3650	2920	0.40 □ 0.60
Sheep	15	1.5	2	548	438.4	0.20 □ □ 0.48
Chicken	1.5	0.10	0	36.80	29.44	0.0076
Human	50	0.50	1	182.50	146.00	□ □ □ □ □ □ □ □ 0.028

Table 4.5 Amount of biogas generation [14]

V.CONCLUSION

Biogas generation rate can be increased by proper waste material is added to the digester. Correct proposition of wet section should be added for proper digestion of waste material. Nitrogen and other gases generation rate and CO₂ gas ratio must be maintained for better generation of CH₄. From the wastage of LDRP-Campus, gas generation rate is 9.3m³ per day.

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