

## International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 6, Special Issue 11, May 2017

# Improvement in Generation of Bio-Gas Assuming Food Waste as Additional Feed

Kumar Mrinal, Punam Agade

Department of Mechanical Engineering, Surabhi Group of Institutions Bhopal (M.P.), Rajiv Gandhi Prodyogiki  
Vishwavidyalaya, India

**Abstract:** Due to scarcity of petroleum and coal it threatens supply of fuel throughout the world also problem of their combustion led to research in different corners to get access the new sources of energy, like renewable energy resources. Solar energy, wind energy, different thermal and hydro sources of energy, biogas are all renewable energy resources. But, biogas is separate from supplementary renewable energies for the reason that of its individuality of by means of, controlling and collecting organic wastes and at the same time producing fertilizer and water for use in agricultural irrigation. Biogas does not have any geographical limitations nor does it require advanced technology for producing energy, also it is very simple to use and apply. Kitchen waste is organic material having the high calorific value and nutritive value to microbes, that's why efficiency of methane production can be increased by several order of magnitude as said earlier. It means higher efficiency and size of reactor and cost of biogas production is reduced.

### I. INTRODUCTION

Deforestation is a very big problem in developing countries like India, most of the part depends on charcoal and fuel-wood for fuel supply which requires cutting of forest. Also, due to deforestation it leads to decrease the fertility of land by soil erosion. Use of animal dung, firewood as energy is also harmful for the health of the masses due to the smoke arising from them causing air pollution. We need an eco friendly substitute for energy. Now days in India an organic waste is a major issue as it is covering up to 40 % of total waste. The organic waste can be hazardous and led to environmental & health issues. Besides it we are generating huge waste but fact is we don't have much area for dumping. BIOGAS forms by microorganism through the bio-degradation of organic material in anaerobic conditions. Natural generation of biogas is a vital part of bio-chemical carbon cycle. It can be used both in rural and urban areas. Natural generation of biogas is an important part of bio-geochemical carbon cycle. It can be used both in rural and urban areas. Biogas is a clean and efficient fuel. It is a mixture of: – Methane (CH<sub>4</sub>) – Carbon dioxide (CO<sub>2</sub>) – Hydrogen (H<sub>2</sub>) – Hydrogen Sulphide (H<sub>2</sub>S). The chief constituent of biogas is methane (65%).

### II. OBJECTIVES

- Overall design factor to compare with typical plants for Optimization of gas production considering effect of various parameters
- To achieve maximum production of methane to maintain temperature at 35° C of slurry supply as well digester for the proposed plant for Mp Nagar zone 1 Bhopal area.
- PH
  -
- Calculation of thermal effect over production of biogas, observing convection and conduction factor.
- Total & volatile solid concentration
- Quantitative relation between Carbon and nitrogen

## International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 6, Special Issue 11, May 2017

### PRIMARY PREPARATION

#### COLLECTION OF KITCHEN WASTE:-

At primary stage for kitchen waste collection is to separate bio degradable waste among others, with identifying various color dust bean or bag.

It will help to separate kitchen waste as well reduce time consumption, and hence it will be easy to carry these to the prepared site. So that the aimed output for methane can be optimized as follows given in table:

**TABLE - 1**

ELEMENTS	VOLUME IN PERCENTAGE
METHANE	55 – 65
CARBON DI-OXIDE	30 – 40
NITROGEN	03 – 07
WATER VAPOUR	0.5 – 1

Separation of material on primary basis according to capability to increase production rate of methane as follows:

**Table – 2 Biogas rate of producing methane**

Materials and their main components	Biogas in m <sup>3</sup> /kg TS	Methane percentage
Leaves	0.251-0.30	58
Brewery liquid waste	.0300-.600	58
Rice	0.790	51
Slurry	1.45	72-75
Protein	0.100	50
Animal dung	0.280-0.285	55-60

### III. CASE STUDY

#### Food waste analysis:

According to BMC, roughly 50 % of the waste was of biodegradable nature, 15-20% comprised of polythene waste and rest was non-biodegradable waste. A study by Katiyar, Suresh, & Sharma in 2013 characterized waste in Bhopal as follows. Approximately 40-45 % of the waste was food and FVW and 10% was inert waste such as dust, sand, soil etc. Metals comprised about 1% of the waste. The study indicated that Bhopal had mixed residue (organic matter mixed with soil, mud and other inert matter) to the extent of 81%. Fig 1 shows the percentage of Carbon & Nitrogen & CN Ratio in components of MSW in Bhopal.

Table 3 Carbon nitrogen ratio

Material	Carbon %	Nitrogen %	Carbon Nitrogen Ratio
Soyabean	41	1.30	32/1
Peanut leaves	11	0.59	19/1
Corn	40	0.75	53/1
Rice	42	0.53	67/1
Wheat	46	0.53	87/1
Leaves	41	1	41/1
Animal dung	7.3	0.60	13/1

#### Observations and findings based over primary study:

The usual practice among restaurant owners and workers to calculate frequency of waste generation in different days. Some of owners dumped wastes besides the road as usual and some of them to municipal container. However, almost all owners had to dispose of some of the fruits and vegetables at the end of the day as they become rotten.

## International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 6, Special Issue 11, May 2017

Meals, juice, braveries, meat, leaves and rotten fruits, eggs and vegetables are the main types of waste. There were different opinions regarding which season generated highest amount of food vegetable waste. Few were who serve fruit juice have different opinion that in rainy season, waste was highest as it is difficult to store the fruits and vegetables for a longer duration and during summer, it was least as less fruits and vegetables were available in the market. This waste is then collected by the corporation workers the next day morning.

Among the Six restaurants which were visited, one restaurant generated approximately 200 kg of food waste per day and also practiced segregation of food and non-food waste. Food waste mainly comprised of rotten food and vegetable peels and was found to be highest during summer season. After segregation, they disposed the waste in corporation bins which would be collected by workers. Another restaurant was found to dispose the waste without segregation. One restaurant claimed to generate waste of insignificant quantity to the tune of 5 to 7 kg per day. Data on quantity of food waste was not maintained in DB mall and it was found that waste was not segregated. As food is served in portions in most of the restaurants inside DB mall, the food wastage was minimal comprising of approximately 10% of the total waste in food court which was mainly comprised of disposables such as plates, spoons, etc.

### Testing for samples:

The raw municipal solid waste (MSW) and food waste was collected from the MP Nagar Zone 1 area. It occupies an area of approx 1 acre. It receives approximately 1500 kg of food waste along with municipal solid waste per day which containing about 80-90% of organic waste. The sample was collected, delivered to the laboratory at Indian institute of agriculture science and Indian institute of forest management. The techniques used for sampling analyses were in accordance with the Standard Method for the Examination of waste. The compositions of the feed sample are summarized in Table

**Table 4 CHARACTERISTICS OF THE PREPAIRED FEED**

S.no.	Elements	Digester 1	Digester 2
1	pH	4.39	≤7.2
2	BOD	13981	300
3	COD	20087	2575
4	TS	1058	672
5	TSS	410	<10

### Study based over Experimental conditions:

For primary design criteria was based to the study of different Biogas yields because everyone has own and different COD concentration at maintained pH and also studied to removal of pollutants. In this study, the batch reactors were filled with fresh prepared slurry feed. The digesters were dozed with N<sub>2</sub>:CO<sub>2</sub>-80:20 for 5 min to minimize air contamination, air tight, and subsequently maintained at 35°C for next 20 days. The digester was maintained in anaerobic conditions and it was allowed to stabilize for one week. During this stabilization period, digester temperature of 26 to 36°C was monitored and pH was maintained in the range of 6.5 to 7.5 by adding sodium hydroxide and COD, TSS and VSS reduction were also monitored. Steady-state condition was identified when the COD value of the effluent and the daily biogas production were measured to be the same for two or three consecutive days. A magnetic stirrer was introduced for vigorous mixing. Each experiment was performed in duplicate to determine experimental benefits and error to improve design.

**Table 5 Average production rate of biogas in different digester**

S no	Biogas Production	Methane Yield	COD Initial	COD Final	Type
1	1.8±1.3	.002±0.0100	21050	7250	Digester1
2	0.6±0.5	0.190±0.020	3204	540	Digester2

All data provided by the lab where we tested our food waste sample for methane generation with following this process.

At the practical level food waste after separation from MSW, a feed was prepared and in the plant of 2000 kg from day one to next 20-30 days, feed (food waste) 10-100 kg at various days. Every evening collected waste from MP

# International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 6, Special Issue 11, May 2017

Nagar area was filled to the chamber and after 24 hour % increase in methane and % of slurry were measured with installed gage mounted over plant in supervision of plant team and me as a visitor.

**Table 6 First biogas plant study for methane generation**

S no	Feed/day	% methane
1	10kg/1 <sup>st</sup> day	0-0.5%
2	20kg/2 <sup>nd</sup> day	0-0.8%
3	20kg/3 <sup>rd</sup> day	0.08%
4	20kg/4 <sup>th</sup> day	0.08-0.09%
5	30kg/5 <sup>th</sup> day	0.08-0.09%
6	50kg/10 <sup>th</sup> day	2.04-2.06%
7	50kg/11 <sup>th</sup> day	2.04-2.06%
8	50kg/15 <sup>th</sup> day	2.04-2.06%
9	75kg/16 <sup>th</sup> day	3.08-4.01%
10	100kg/20 <sup>th</sup> day	4.02-4.057%

**Table 7 Second biogas plant study for methane generation**

S no	Feed/day	% Methane
1	10kg/1st day	0-0.2%
2	20kg/2nd day	0-0.6%
3	20kg/3rd day	0.07%
4	20kg/4th day	0.07-0.09%
5	30kg/5th day	0.07-0.09%
6	50kg/10th day	1.84, -1.92%
7	50kg/11th day	1.52-1.8%
8	50kg/15th day	1.92-2.04%
9	75kg/16th day	2.04-3.25%
10	100kg/20 <sup>th</sup> day	3.20-3.44%

After comparing both working plant after feeding food waste in different quantity on various days, result was more than expected. And this may be because of unutilized contain and vitamins or starch available in waste which increased the production rate of methane in same plant.

Observations were based over two different plants at two different climate and geographical location, first observation from a plant situated to agriculture land and second one was at hilly area, and we can see the difference between these two.

As we know at hill top there is some maintained humidity which affected production rate and the first one situated over agriculture land having best atmosphere support because of maintained temperature and stream flow of wind and less humidity factor.

### Calculation

Energy available in 1m<sup>3</sup> plant at end of the month:

We know that Biogas contains 60% (approx and known value) Methane.

Calorific Value of methane = 58 MJ/kg (approx and known value)

Density of Methane at NTP = 0.668 kg/m<sup>3</sup> (approx and known value)

Therefore, Calorific value of methane = 58 x 0.668 = 38.74 MJ/m<sup>3</sup>

In biogas generation only methane can be used as fuel so;

Calorific value of Biogas = 0.6 x 38.74 MJ/m<sup>3</sup> = 23.24 MJ/m<sup>3</sup>

If a plant of 1 m<sup>3</sup> capacity produces 0.8 m<sup>3</sup> of gas per day.

Total energy in 0.8 m<sup>3</sup> of biogas = 0.8 x 23.24 MJ

Total energy in 0.8 m<sup>3</sup> of biogas = 18.59 MJ

# International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 6, Special Issue 11, May 2017

Assuming that the efficiency of a biogas stove and LPG stove is the same

Energy provided per month = 18.59 x 30

**Energy provided per month = 557.76 MJ**

**Therefore a biogas plant of 1 m<sup>3</sup> capacity is equivalent to 75-80 % of an LPG cylinder per month.**

**Feasibility study for implementing the project in M.P Nagar Bhopal:**

Bhopal, M.P Nagar restaurants meals for many customers & food is prepared as well. If customers buys about 4 cylinders per month which are used only for preparing the one time meal for them or their family as well.

Then,

4 cylinders of LPG = 4 x 738.4 MJ = 2953.6 MJ

Energy required per day = 2953.6/24 MJ = 123.06 MJ

Energy obtained per cubic Meter of biogas = 23.24 MJ

Gas requirement to supplement 50% of gas use = 123.06 x 0.5/23.24 m<sup>3</sup> = 2.64 m<sup>3</sup>

Therefore required size of digester = 2.64/0.7 m<sup>3</sup> = 3.77 m<sup>3</sup> (calculation done with approx values) Therefore 4 m<sup>3</sup> digester and 3 m<sup>3</sup> gas collector should provide 60% of the energy requirements.

## IV. RESULT

During feed of slurry at different digester was maintained 35°C to achieve maximum methane production. To maintain that temperature for slurry and gas holding vessel it was necessary to maintain constant temperature, for that this data has been developed via MATLAB to calculate need of heat supply at slurry

Result of Computations of Heat Losses when Slurry is at 20°C

$$Q = [h_1 A_t (T_D - T_A) + h_3 A_t (T_D - T_G)]$$

$$\text{Slurry Cooling Heat Loss: } Q = m \times C_p \times (T_2 - T_1)$$

$$\text{Slurry to Ground Heat Loss: } Q = h_6 A_W (T_S - T_\infty)$$

**Table 8 Heat Loss Due to Radiation**

Time (hours)	Heat loss via Radiation from top	Heat loss via Radiation from wall
1	139.7	-17.89
2	140.1	-17.98
3	148.8	-22.9
4	110.7	-27.2
5	26.24	-81.5
6	18	-248.5
7	93.7	-652.8
8	189.13	-507.8
9	185	-278.61
10	375.89	12
11	564.12	793
12	745.78	1287.56
13	889.71	1802.8
14	870.37	1674.2
15	877.32	3589.78
16	557.89	4547.65
17	598.78	798.59
18	571	802.5
19	428.75	485.56
20	345.78	409.74
21	267	202.89
22	196.75	107.87
23	207.32	109.27
24	98.78	-19.81

## International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 6, Special Issue 11, May 2017

**Table 9 Heat Loss Due to Convection**

Time (hours)	Heat loss from roof via convection	Heat loss from wall via convection
1	115.56	-312.32
2	139.05	-482.98
3	155.2	-355.78
4	-48.62	-790.31
5	169.45	-698.15
6	205.4	-425.46
7	382.15	16.9
8	685.26	1389.1
9	1089.41	2489.26
10	1537.29	3689.5
11	1739.8	4287.66
12	1632.5	4456.32
13	1438.91	3789.16
14	1381.84	785.92
15	896.7	2238.35
16	759.32	2938.25
17	-42.89	1492.89
18	-56.41	548.63
19	283.72	452.36
20	201.25	394.2
21	-16.89	-12.1
22	87.82	165
23	182.39	-190.1
24	138.88	-301.75

### V. CONCLUSION

Using food waste as a feed from a located area of MP Nagar to harness biogas at certain temperature of 35°C will be optimal. This is because optimum temperature for the anaerobic fermentation lies within the narrow limits (30°C-35°C). As well the gas holder temperature were calculate, experimentally and via programming when slurry is maintained at 20°C. Result shows computational value matches with experimental value, and selected value of heat transfer co-efficient represent real system. Again, gas holder temperature calculated at program when slurry is at 35°C. Heat loss from the biogas plant has calculated at 20°C & 35°C, and then the relational table has been created based on the value and also graphical representation were generated. Energy required to charge daily kitchen waste from 20°C to 35°C has considered. For external heat supply a solar water heater system with auxiliary heater is designed. Experimental results in the month of January shows, average generated gas is 120.9 m<sup>3</sup>/day only (rated 85-100 m<sup>3</sup>/day), this is because of plant is not maintaining optimum temperature for anaerobic fermentation and average feeding is 1200kg/day instead of 2000 kg/day. In conclusion, the result of thermal analysis is used to define a strategy for operating biogas plant at optimum temperatures

### REFERENCES

1. Appropriate Rural Technolgy, Pune.
2. Bhopal Municipal Corporation, Bhopal.
3. Indian Institute Of Agriculture Science, Bhopal.
4. Indian Institute Of Forest Management, Bhopal.
5. CARRASCO ET AL. (2004) studied the feasibility for dairy cow waste.

## International Journal of Innovative Research in Science, Engineering and Technology

*(An ISO 3297: 2007 Certified Organization)*

**Vol. 6, Special Issue 11, May 2017**

6. Katiyar, R. B., Suresh, S., & Sharma, A. (2013b). Characterisation of Municipal Solid Waste Generated by the city of Bhopal, India. International Journal of ChemTech Research , 5 (2), 623-628.
7. MNRE. (2012). Creating wealth from organic waste. Akshay Urja , 5 (6), 38-40.
8. Kale, S.P and Mehele, S.T. kitchen waste based biogas plant.pdf. Nuclear agriculture and Biotechnology/ Division.
9. Karve .A.D. (2007), Compact biogas plant, a low cost digester for biogas from waste starch. <http://www.arti-india.org>.
10. Karve of Pune A.D (2006). Compact biogas plant compact low-cost digester from waste starch. [www.bioenergylists.org](http://www.bioenergylists.org).
11. Shalini sing, sushil kumar, M.C. Jain, Dinesh kumar (2000), the increased biogas production using microbial stimulants.
12. Hilkiah Igoni, M. F. N. Abowei, M. J. Ayotamuno and C. L. Eze (2008), Effect of Total Solids Concentration of Municipal Solid Waste on the Biogas Produced in an Anaerobic Continuous Digester.
13. Tanzania Traditional Energy Development and Environment Organization (TaTEDO), BIOGAS TECHNOLOGY- Construction, Utilization and Operation Manual.
14. The University of Southampton and Greenfinch Ltd. - Biodigestion of kitchen waste
15. A comparative evaluation of mesophilic and thermophilic biodigestion for the stabilisation and sanitisation of kitchen waste.