Laboratory Scale Studies on the Biogas Production using RGUKT Basar Marvel Mess Food Waste

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Abstract—*Anaerobic digestion is a controlled biological activity which allows efficient capture of CH_4 for energy production. Biogas is produced by bacteria through biodegradation of Organic matter under anaerobic conditions. Its properties changes as there are variations in temperature, pressure and water vapour content. The factors that affect the fermentation process are the quantity and nature of organic matter (acidity and alkalinity of substrate), temperature, etc. Present study deals with estimating the amount of biogas produced, through the lab scale setups, using the Mess food waste (Raw and cooked) produced in RGUKT Basar campus. The study was performed in two steps, where in the first step the feed stock contained the different concentrations of the food waste and cow dung in 3 different proportions were set-up in 1 liter bottles; in-order to find the maximum biogas production. The 3 different proportions were 50:150, 100:100 and 150:50. Parameters like pH, temperature, % of gas production and % solids were monitored regularly. The main constraint of the present study was that the feed used was highly acidic in nature with the initial pH ranged from 6.6 which further decreased to 4.74 (for 50:150 and 100:100) and 3.62 (for 150:50) during acidogenesis. Hence, it took more than the required time inorder to attain the stability and gas formation. The feed stock containing 150:50 proportion the values of CH4 gas production was always higher than 80%.Later the feed stock was transferred to 20 ltr digester, in order to estimate the gas production in the larger container. It was found that 30.85 ml of gas was produced on an average. Hence, it was found that the food waste produced daily (around 600kg) has the potential to produce biogas (21 kg/day) for cooking purpose which may reduce monthly 33 LPG cylinders (of 19 kgs) usage.*

Keywords*: Anaerobic Digestion, Biogas, Methane, RGUKT Basar, Lab scale set up.*

1. INTRODUCTION

Scarcity of non-renewable sources is more concern in present energy dependent world; we have to look for renewable sources. Biogas energy production is the one of the 'zero' waste process. Biogas production is a well-known process from the raw material dung, but searching for alternative raw materials like wood waste, agricultural waste, food waste and kitchen waste etc. in combination with cow dung is presently done to increase the production efficiency. Anaerobic digestion is a controlled biological activity which allows efficient capture of CH_4 for energy production. Biogas is produced by bacteria through biodegradation of Organic matter under anaerobic conditions. Its properties changes as there are variations in temperature, pressure and water vapour content. The factors that affect the fermentation process are the quantity and nature of organic matter (acidity and alkalinity of substrate), temperature, etc.

In 2003, Dr. Anand Karve (President ARTI) developed a compact biogas system that uses starchy or sugary feedstock material and the analysis shows that this new system is 800 times more efficient than conventional biogas plants. In recent times the technology and development decreased the cost of production. Different types of methods are developed to increase the speed of fermentation and increasing the scale of production. Vipul Vaid, and his co-workers from Delhi Technical University concluded that biogas from food waste can save at least 50 % of the LPG gas consumption of the campus and also provide substantial amount of manure for gardening purposes in the campus. Suyog Vij (2010-2011), collected Kitchen waste from different hostels of National Institute of Technology, Rourkela's 14 Mess as feedstock and set-up a reactor which worked as anaerobic digester system to produce biogas energy.

Sedlacek S, and his associates, performed a laboratory study which presented that the food waste was easily biodegradable substrate for anaerobic digestion process. The range of parameters as COD, P, TS, VS and pH is relatively wide and depends on type of used meals, portion of moistures foods (soups, sauces etc.). The nutrient contents and balances between COD:N:P (500:6.7) show that tested food waste represents well balanced feedstock for anaerobic digestion with expected high biological degradation in anaerobic condition. The biogas production during the long-term tests with only food waste as feedstock was around 930 L of biogas from 1 kg VS of food waste with average methane contents of 52.5 %. The average specific biogas production of 700 L/kg VS of food waste was measured in the laboratory system of

co-digestion food waste with treatment sludge. Addition of food waste to sludge causes decrease of methane content from 60-65% (only sludge) to 55-60% (sludge + food waste).

Kale S P, along with his co-ordinates ,concluded that there should be a separate container for coconut shells, coir, egg shells, onion peels and bones. These will not be processed in the biogas plant. It must be noted that such segregation is of utmost importance for the smooth running of the biogas plant

Present study deals with estimating the amount of biogas produced, through the lab scale setups, using the Mess food waste (Raw and cooked) produced in RGUKT Basar campus. The proper disposal of RGUKT IIIT BASAR's Hostels kitchen waste is big problem to itself and to the university and remedy for this may be the production of biogas which will be done in eco-friendly and cost effective way, so work carried on various proportions of cow dung and kitchen waste to get the best combination in terms of efficiency. The study was performed in two steps, where in the first step the feed stock contained the different concentrations of the food waste and cow dung in 3 different proportions were set-up in 1 liter bottles; in-order to find the maximum biogas production.

2. MATERIALS AND METHOD

Marvel Mess of RGUKT has a capacity of serving 1000 students daily. On an average the daily food waste generation rate in this mess is 600 kg/day. The LPG gas cylinders of 19 Kg, used everyday for the food preparation are 10.

Hence in-order to reduce the LPG cylinder usage, Biogas could be produced from the food waste generated daily from the Marvel mess of RGUKT Basar, the composition of the food waste generated is shown in Figure. 1.

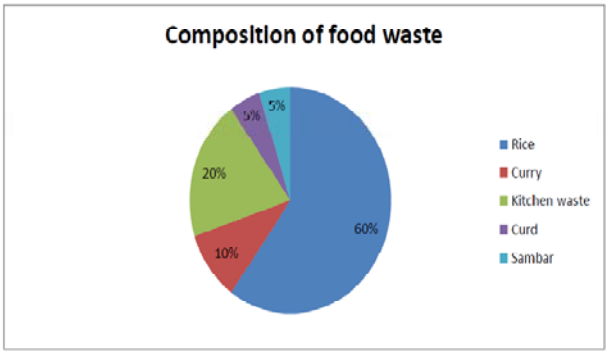

Fig. 1: Composition of Food waste used for 1 L digester

2.1. 1- Liter digesters

In lab scale model 1 Ltr digesters are prepared of different compositions of set 1 contains 50 gms of food waste, 150 gms of cow dung, set2 contain 100 gms of food waste, 100gms of cow dung, set 3 contains 150 gms of food waste, 50 gms of cow dung. The experimental set up is shown in Fig. 2.

Fig. 2: Lab scale 1L digester set up

2.2. 20 liter Digester

Contents of previous experimental set ups (5L) were used as inoculums for digester of 20Ltr. Capacity. It contains the required microorganism for anaerobic digestion. After the inoculation the digester was kept for some days and gas production was monitored and then after few days when the gas production started decreasing, kitchen waste of 3 kg, cow dung of 2 kg and water around 8L were added in order to have efficient gas production. The composition of 20 L capacity digester is shown in Fig. 3.

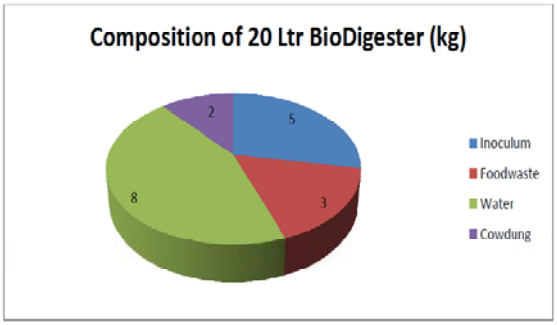

Fig. 3: Composition of 20 L Digester

During the course of project pH, temperature, Total Solid contents and Volatile Solid contents were monitored regularly. Syringe method was used for the measurement of amount of methane and carbon dioxide produced daily.

3. RESULTS AND DISCUSSION

The 1 L digesters of varying compositions were allowed to run for a period of 32 days. A regular monitoring of pH and Temperature was carried out in-order to see the performance of anaerobic digestion which occurs in a biogas production process. pH is one of the important parameter for controlling VFA contents. pH drop in anaerobic digestion, most likely indicates that acidic intermediates such as volatile fatty acids (VFA) are produced in considerable quantities. Lower the pH higher would be the VFA accumulation which can lead to inhibition of the biogas methane produced during methanogenesis. Table 1 show the pH and temperature values

in 1 L digester. The average temperature was found to be 30.5^0C indicating mesophyllic conditions.

Gas production for the lab scale set up of 3 proportions 50:150, 100:100 and 150:50 was monitored. Table 2 shows gas production for 3 different set ups. In addition to these 3 experimental set up's one 1L cow dung anaerobic digestion was also kept to check if there is any gas production occurring due to cow dung which is used in the feed stock. From the table it can be clearly observed that there is no gas production occurring in cow dung and the maximum gas production was observed in 150:50 proportion of food waste and cow dung.

The gas production was observed from the second day of experimental set up. The % of methane production in Set 1& Set 2 are low when compare with Set 3,as 3 ml of gas absorption explains that about 30% of gas is absorbed, which indicates the balance of 65-60% is methane.

As a result, set 3 values were always found to be higher than that of Set 1& Set 2. The feed stock containing 150:50 proportion the values of CH_4 gas production was always higher than 80%

Table 1: pH and Temperature (^{0}C) analysis for L Lab scale Experiment

DAY	SET 1 (50:150)		SET 2 (100:100)		SET 3 (150:50)	
	pH	Temp(0C)	pH	Temp (0C)	pH	Temp (0C)
16/2/15	6.6	----	6.2	----	6.2	
17/2/15	4.8	30.0	4.2	30.1	3.9	30.1
18/2/15	4.9	32.0	4.1	31.7	3.8	31.9
19/2/15	4.6	33.2	4	32.8	3.9	33.0
20/2/15	5.0	30.4	3.9	30.2	3.9	30.1
23/2/15	4.9	31.0	4.3	30.8	3.4	30.7
26/2/15	4.7	30.2	4.8	30.0	3.5	30.0
27/2/15	4.8	31.2	4.7	31.1	3.5	31.2
02/3/15	4.7	27.5	4.8	27.3	3.6	27.5
03/3/15	5.0	29.1	4.8	29.1	3.7	29.0
05/3/15	4.8	29.1	4.7	29.1	3.6	28.8
09/3/15	4.9	29.5	4.8	29.2	4.1	29.4
10/3/15	5	28.4	4.9	28.3	4.3	28.2
12/3/15	5.7	32.2	5.2	32.2	4.6	32.3
13/3/15	5.5	32.3	5.1	31.9	4.5	32.2
16/3/15	5.3	33.1	5.1	32.9	4.5	32.7
17/3/15	5.3	33.0	4.9	33.2	4.6	33.2
23/3/15	5.1	36.1	4.9	35.9	4.3	36.0
25/3/15	5.1	35.9	4.8	36.1	4.4	35.7
01/4/15	6.5	34.6	4.9	34.5	4.6	34.1

and a distinctive blue flame was observed in comparison with the other two set ups. Hence set 3 was found to be most desirable ratio for production of biogas from the Marvel mess food waste.

Table 3 shows the Total Solid % for 3 different proportions. It can be observed that the TS % values decreases as the time increases. It can be said that this occurs because of the utilization of the Carbon contents present in the waste

Table 2: Gas Production analysis for 1 L Lab scale Experiment

Date	SET1 50:150 (ml)	SET2 100:100 (ml)	SET3 150:50 (ml)	Cow Dung (ml)
18/02/15	3.0	2.0	1	0
19/02/15	2.5	1.0	0.8	0
20/02/15	2.5	3.0	1.0	0.3
23/02/15	3.0	3.0	1.2	0.5
26/02/15	2.0	3.0	1.0	0
27/02/15	2.0	2.8	1.2	1.0
02/03/15	1.2	1.0	1.0	0.2
03/03/15	1.2	0	1.0	1.0
05/03/15	1.8	0.2	1.0	1.0
09/03/15	1.4	1.0	1.6	0.8
10/03/15	1.2	1.0	1.8	0.9
12/03/15	1.8	1.0	1.9	0.8
13/03/15	1.6	1.2	2.0	0.6
16/03/15	0.6	0.8	0.5	0
17/03/15	0.8	1.0	0.8	0.4
23/03/15	1.2	0.8	1.0	0
25/03/15	1.8	1.0	1.2	0
01/04/15	1.0	0.8	1.0	0

Table 3: Total Solid (%) concentration for 1L Lab Scale Experiments.

DATE	SET1 (50:150) %	SET2 (100:100) %	SET3 (150:50) %
18/02/15	9.3	9.30	9.29
20/02/15	9.08	9.16	9.18
27/02/15	9.23	9.19	9.11
03/03/15	9.17	9.23	9.11
12/03/15	9.11	9.19	9.21
16/03/15	9.21	9.07	9.17
23/03/15	9.27	9.27	8.77

Table 4: Gas production and pH analysis for 20 L digester

No. of Days	Gas Production (ml)	pH
1	24	6.9
2	26	6.6
3	30	5.4
4	32	5.9
5	30	5.8
6	36	5.9
7	38	6.2
Average	30.85	---

Later the feed stock was transferred to 20 ltr digestor to find the gas production in the larger container. From Table 4 it can be observed that the average gas production was 30.85 ml and the pH value initially decreased to 5.4 from 6.9 and then there was an increase in pH to 6.2. A blue flame was also observed after 5^{th} day.

4. CONCLUSION

A complete lab scale study was carried out on 1L and 20 L digesters. The food waste from Marvel mess of RGUKT Campus was used during the course of study. Since the food was acidic in nature, initial start up period for the anaerobic digestion was longer and it was around 32 days during the set up of 1 L digester. The biogas formed in 150:50 proportions was found to be 80%. As a result the biogas production in this proportion is greater than the other 2 Lab scale set ups i.e. 50:150 and 100:100.

Later the contents from the 1 L set ups were transferred to 20 L digesters and it was allowed to undergo anaerobic digestion. pH and gas production was monitored regularly and an average gas production of 30.5ml was observed.

The food waste produced in Marvel mess of RGUKT on daily basis is around 600kg; would have a potential to produce biogas of 21 kg/day for cooking purpose which may reduce monthly 33 LPG cylinders (of 19 kg) usage. Hence, it can be stated that the food waste from kitchen waste could be one of the source for production of biogas which is an efficient fuel of a very high calorific value.

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