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Enrichment of Biogas Production from Kitchen Waste and Cow Dung

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Abstract

A large amount of kitchen waste is generating in Rajiv Gandhi University of Knowledge Technologies – Basar (RGUKT-Basar); nearly this waste is 1500 Kg per day can be transformed into the energy source. A high quality renewable fuel can be generated from waste that reduces carbon-dioxide and methane emissions. In order to estimate the quality and the quantity of biogas production a different mixtures of cow dung and kitchen waste is carried out in 1liter and 2 liter capacity. 2 liter digester used for testing and analytical calculations of Total solids, Volatile fatty acids and pH variations, can affect the biogas production under controlled atmosphere. These digesters have been run for retention period of 52 days. The result shows that biogas produced in all the mixtures, the mixture contains equal ratio of cow dung and kitchen waste observed to be highest.

Keywords: Biogas; Rgukt Basar; Volatile fatty acids; Renewable fuel

Introduction

Destruction of forest for fuel wood is a problem in developing countries like India. Deforestation drop off the fertility by soil attrition. Use of dung and firewood as energy source is a supplementary issue to health of the masses. There is a need of green substitute for fuel wood. Biogas is discrete as compared to other renewable energy resources because of its manifold benefits, one of the 'zero' waste process, it does not have any geographical limitations nor does it require advanced technology. Kitchen waste is organic material having the high calorific value and nutritive value to microbes; due to this the efficiency of methane production can be increased by several orders of magnitude.

Anaerobic digestion is a controlled biological degradation process which allows efficient capturing & utilization of biogas for energy generation. Biogas production is a renowned process from the raw material dung. To increase the production efficiency raw materials like wood waste, agricultural waste, food waste and kitchen waste has been used in combination with cow dung. 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 change with temperature, pressure and water vapor content. The factors that affect the fermentation process are the quantities like nature of organic matter (acidity and alkalinity of substrate), temperature, etc. A compact biogas system is 800 times more efficient than the conventional biogas plant was developed in 2003, and uses starchy or sugary feedstock [1]. In recent times the technology and development reduced the cost of production.

Vipul Vaid et al. concluded that biogas from food waste can save at least 50 % of the LPG gas consumption and also provides substantial amount of manure for gardening [2]. Suyog Vij et al. [3] results shows that a reactor which worked as anaerobic digester system to produce biogas energy. The food waste can be easily biodegradable substrate for anaerobic digestion process [4]. The range of parameters as TS, VS and pH etc. are dependent on type of food, moisture fraction in food. The nutrient contents and balances between COD: N_{tot}: P_{tot} (500:6.7) show that tested food waste represents well balanced feedstock for anaerobic digestion with expected high biological degradation in anaerobic condition [5].

Comparative study of biogas production through cow dung (0.037m^3/kg) and poultry waste (0.07m^3/kg) shows that quantity of biogas is higher in poultry waste because of high nitrogen content in it [6]. The experiments have suggested that the success of biogas production depends on the proper segregation of the kitchen waste; the materials that can pose problems to the efficient running of plant are coconut shells and coir, egg shells, onion peels, bones and plastic pieces etc [7].

Methodology

Present study deals with estimating the amount of biogas produced, lab scale setups, using the Mess food waste (Raw and cooked) produced in RGUKT Basar campus. The proper disposal of kitchen waste is big problem to itself and remedy for this may be the production of biogas which is eco-friendly and cost effective. So work has been 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 set ups; set-up 1, in 1 liter digester, different combinations of Kitchen waste and Cow Dung has been maintained, as shown in the following (Table 1).

Table 1: Different combinations of cow dung and kitchen waste.

S. No.	Kitchen Waste (K) in grams	Cow dung (D) in grams
1	200	0
2	150	50
3	100	100
4	50	150
5	0	200

In set-up 2, 2 liter digester, kitchen waste and cow dung combinations have been maintained as set-up 1, but double in quantities. Set-up 1 purpose is to observe daily production of biogas and set-up 2 purpose is to check daily variation of parameters like total solids percentile, volatile solids percentile, volatile fatty acids, pH and the biogas production with different mixture of ratios of kitchen waste and cow dung [8-9].

Figure 1: 1 liter digesters with manometer set-up.

The produced gas from 1 liter digesters was measured by water displacement technique. For each digester there was arranged with inverted graduate cylinder (120 ml) in the water filled tub. The PVC flexible pipe was connected between digester and water filled tub. As the gas produced in digester, it will come and force the water to displace from cylinder to tub [10]. This was as shown in below (Figure 1) in this installation the manometer set-up was made with 6 mm diameter of PVC flexible pipe. So, the gas produced form digester can cross/pass through this small diameter of pipe with high pressure energy and the gas produced from digester can be easily measured through scales which were arranged to manometer set-up (Figure 1).

Results

Effect of pH on Production of Biogas

The 1 Liter Digesters of varying compositions were allowed to run for a period of 52 days. pH is one of the important parameter for controlling volatile fatty acids (VFA) contents. A regular monitoring of pH was carried out in order to see the performance of anaerobic digestion occurs in a biogas production process (Figure 2).

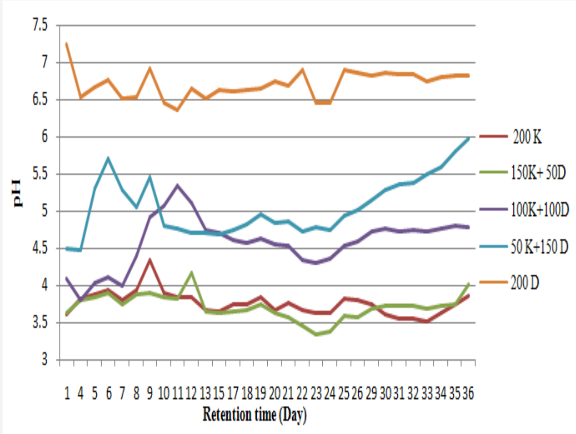

Figure 2: pH Vs. Retention time for 2 liter digesters.

pH drop in anaerobic digestion indicates that acidic intermediates such as VFA are produced in considerable quantities. Lower the pH higher would be the VFA accumulation, which can lead to inhibition of the biogas production during methanogenesis, so a constant pH has been maintained [11-12].

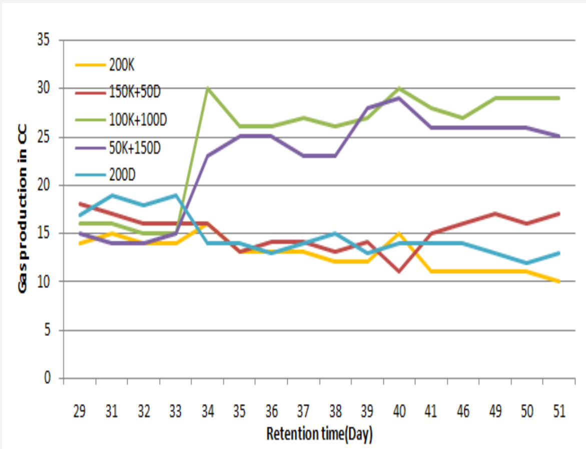

Figure 3: Gas Production vs. Retention time (Days).

The second set-up of 2 liter digesters of varying compositions samples were taken and checked for daily natural variation of pH, i.e., without maintenance of pH. The results of these natural

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variations of pH were showed in Figure 3 the pH values are recorded and observed in the run of period of 36 days retention time. It is observed that the pH increases as the proportion of cow dung increases in 2 liter digester. Greater the proportion of kitchen waste is very acidic in nature and 50 K + 150 D and 200 D digesters nearly the pH values are 6 to 7. These low values of pH indicate the samples were in acidic nature and in the process of hydrolysis and acidogenesis. Low pH values inhibit the production of Biogas. For 200 grams of cow dung digester (pH of 7.0) it will take more number of days by natural buffering to complete the hydrolysis and acidogenesis. So, to enhance the processes of hydrolysis, acidogenesis and methanogenesis we should maintain the optimum pH (pH 6.5-7.5) (Table 2).

Table 2: Biogas production in cc# without monitoring the pH in each digester of 1 liter.

Day	Day/Sample	200 K*	150K+50D	100K+100D	50K+150D	200D**
3	07/03/2016	150	18	13	15	13
4	08/03/2016	50	0	0	0	0
5	09/03/2016	15	10	15	12	15
6	10/03/2016	30	0	10	3	10
7	11/03/2016	0	0	0	0	0

K* = Kitchen waste in grams and D**= Dry Cow Dung in grams cc# = cubic centimeter

Initially at the start of experiment of 1st day, all 1 liter digesters of varying compositions were set to pH of nearly 6.8 to 7.5. After that it is allowed to run for a period of nearly 15 days without maintaining the optimum pH values. The process was taken naturally without disturbing the digesters. On 3rd day of the process the gas produced from 200 grams of kitchen waste is 150 cc; it is more as compared with other combinations. The kitchen waste consists mostly of carbon content and the respiration of microbes will takes place at initial stages of the biodegradation process, the gas produced is other than biogas it was confirmed by flame test. There is inhibition to bio gas production as there is no maintenance of optimum pH values in digesters.

It is observed in Table 1, without monitoring of optimum pH there was no gas production. So, the maintenance of optimum pH is important to enhance and to take the methanogenesis process in digesters and for rapid growth of bacteria. With the maintenance of pH at 6.5 to 7.5 in each 1 liter digester biogas production is observed. The results of the gas production from this set-up were tabulated in Table 2. The results of gas production from 29th day onwards without any leakages is shown in (Table 2) and (Figure 4). The gas production was observed till the 30th day, means the digesters were kept for 30 days of incubation, microbial growth time after this the methanogenic bacteria participate actively and produce biogas. Figure 3 shows that in 200 K and 200 D digesters produced biogas ranging from 10 cc to 15 cc and from these digesters the gas production is continuously decreasing from 15 cc to 10 cc as with the retention period. In 150 K + 50 D digester the gas production range is between 10 to 20 cc, from this digester the gas production increasing to 20 cc as with the retention time (Table 3) and (Figure 3).

Table 3: Biogas production (cc) after monitoring the pH in digesters in U-tube manometer set-up.

Day	Day/Sample	200K	150K+50D	100K+100D	50K+150D	200D
28	01/04/2016	14	18	16	15	17
29	02/04/2016	14	18	16	15	17
30	03/04/2016	14	18	16	15	17
31	04/04/2016	15	17	16	14	19
32	05/04/2016	14	16	15	14	18
33	06/04/2016	14	16	15	15	19
34	07/04/2016	16	16	30	23	14
35	08/04/2016	13	13	26	25	14
36	09/04/2016	13	14	26	25	13
37	10/04/2016	13	14	27	23	14
38	11/04/2016	12	13	26	23	15
39	12/04/2016	12	14	27	28	13
40	13/04/2016	15	11	30	29	14
41	14/04/2016	11	15	28	26	14
42	15/04/2016	11	15	28	26	14
43	16/04/2016	11	15	28	26	14

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44	17/04/2016	11	15	28	26	14
45	18/04/2016	11	15	28	26	14
46	19/04/2016	11	16	27	26	14
47	20/04/2016	11	16	27	26	14
48	21/04/2016	11	16	27	26	14
49	22/04/2016	11	16	27	26	14
50	23/04/2016	11	17	29	26	13
51	24/04/2016	11	16	29	26	12
52	25/04/2016	10	17	29	25	13

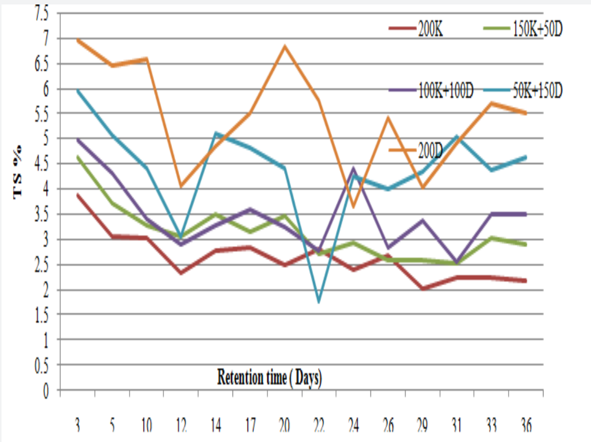

Figure 4: Total Solid (TS %) Vs. Retention time (Days).

In 150 K + 50 D digester the gas production range is between 10 to 20 cc, from this digester the gas production increasing to 20 cc as with the retention time. In 100 K+100D and 50K+150D digester competing in gas production, from these digesters the gas production rate is high and it is between 25 cc to 30 cc. But among all the highest gas production was observed in equal ration of cow dung and kitchen waste digester (100 K+100D). A significant amount of gas production was observed from each digester by monitoring the optimum pH and with the proper installed gas measuring set-up.

Effect of Total Solids (TS) on Biogas Production

Total solids content calculated from each digester samples once in two days. These samples were taken from 2 liter digesters with the natural buffering. The TS% is calculated for each digester of varying compositions for the period of 36 days. From Table 3, with increase in the proportion of cow dung in each digester the TS % also increases. This is due to the decrease in carbon content with the decrease in the proportion of kitchen waste and at the same time nitrogen content also increases. The process of breakdown of carbon containing material is easier than compared with nitrogen containing material. So, as the cow dung proportion increases the process of hydrolysis is observed to be slow. As a result of this

a) If cow dung proportion increases the TS% also increases.

b) If the retention time increases, for each digester the TS% decreases (Figure 4) and (Table 4).

Table 4: Total solids content in each digester of variable compositions (TS %).

Sl. No	Day	200K	150K+50D	100K+100D	50K+150D	200D	Sample weight(g)
1	3	3.87	4.63	4.97	5.96	6.96	20
2	5	3.06	3.72	4.31	5.07	6.45	20
3	10	3.02	3.27	3.40	4.42	6.59	40
4	12	2.34	3.06	2.91	3.06	4.09	20
5	14	2.78	3.49	3.29	5.11	4.86	20
6	17	2.85	3.15	3.60	4.82	5.51	20
7	20	2.49	3.47	3.24	4.42	6.85	10
8	22	2.79	2.71	2.78	1.76	5.77	15
9	24	2.39	2.93	4.40	4.27	3.67	15
10	26	2.69	2.57	2.85	4.01	5.43	15
11	29	2.02	2.57	3.36	4.34	4.05	15
12	31	2.25	2.52	2.56	5.05	4.93	15
13	33	2.23	3.03	3.49	4.37	5.71	15
14	37	2.19	2.90	3.49	4.62	5.51	15

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Table 5: Volatile Fatty acids (mg/L) for each digester of variable compositions.

Sl. No	Day	Day/Sample	200K	150K+50D	100K+100D	50K+150D	200D
1	3	07/03/2016	3205	3000	2100	2040	1890
2	5	09/03/2016	3161	3161	3150	2700	2250
3	10	14/03/2016	2880	2550	2325	2250	885
4	12	16/03/2016	2910	2784	2431	2160	975
5	17	21/03/2016	2865	3000	3420	2955	915
6	20	24/03/2016	3810	4800	4310	3245	1050
7	22	26/03/2016	3675	5430	4740	3390	1950
8	24	28/03/2016	3600	5700	4845	3210	945
9	26	30/03/2016	4080	5850	6450	4080	1275
10	29	02/04/2016	5550	5580	6075	3450	750
11	31	04/04/2016	8130	5730	5850	3225	855
12	33	06/04/2016	8430	5815	4770	2640	1125

Effect of Volatile Fatty Acids % on Biogas Production

These volatile fatty acids were measured from each digester of variable composition by titration with HCl and NaOH. And the results were recorded in (Table 5) and (Figure 5).

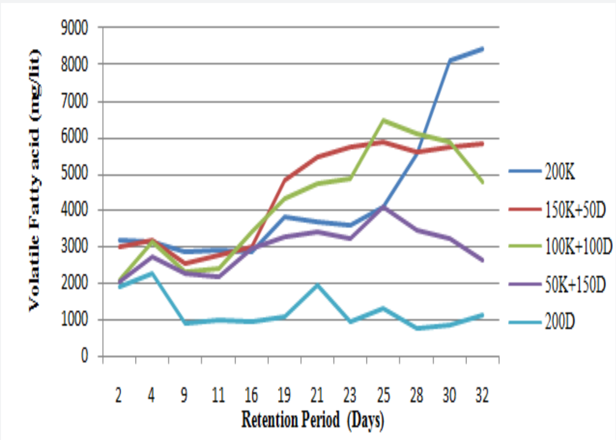

Figure 5: Retention period Vs. Volatile Fatty acid concentration..

The three processes hydrolysis, acidogenesis and methanogenesis will occur simultaneously in each digester. As compared with acidogenesis and methanogenesis the hydrolysis process is the rate determining step and acid-forming stage is very fast and in this stage the pH in digester will low and acidic in nature and the pH values are in the range of 3.5 to 4.5. As from Table 4, for 200 K and 150 K+50 D the volatile fatty acids are continuously increases and this increment of VFA content indicates that it is in the process of acidogenesis where the pH values were in the range of 3 to 4.5. In 100K+100D and 50K+150D the volatile fatty acids concentration increases up to a period of day 25 and after that again there is significantly decrease. In the digester of 200 D the VFA concentration is very low, as compared with other digesters of varying compositions and the concentrations of VFA and is fluctuated in between the values of 1950-750 mg/liter. As with respect to retention period the VFA content is fluctuated and finally decreased to 1125 mg/liter at the day of 32.

Discussion

Digesters of varying compositions of kitchen waste and cow dung run for a period of 36 days. From 1 liter digesters the bio gas production was observed and from 2 liter digesters pH variation, Total solid content, Concentration of volatile fatty acids are calculated and then observed. From the results the following observation are made:

a) There is no much significant change in pH.

b) From Table 4, the series of processes of hydrolysis, acidogenesis and methanogenesis occur at optimum conditions pH of 6.5 to 7.5 and mesophilic (30-40°C) conditions. At these conditions the process of biochemical degradation of organic waste enhances. Table 3 shows that there is no gas production even at the day of 27th, due to poor maintenance of pH.

c) Table 2 shows that equal ratio of kitchen waste and cow dung (100K +100D) gives highest (120 ml) bio gas production as compared to other combinations.

d) From Table 3, as the proportion of cow dung increases in each digester the total solids content (TS %) also increases.

Conclusion

The biogas production was run for period of 52 days. The maximum biogas production was observed in equal ratio of cow dung and kitchen waste digester among all digesters. The conformation of bio gas is done through Flame Test. It is also tested by syringe method for confirmation of biogas. The RGUKT-Basar food waste composition consist of more carbon content as compared with nitrogen content, in hydrolysis process the breakdown of carbon content material is easier than nitrogen content material. So from the results it is concluded that the TS % decreases with the addition of kitchen waste. With the

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maintenance of pH 6.5 -7.5 there is an increase in production of biogas

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