Study on Biogas Production from Kitchen Waste

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***Abstract*— The world is facing crisis of fossil fuels on which the large population is dependent and is likely to be exhausted in a few years. In these circumstances, the focus of the government of the several countries is on the renewable sources of energy. Biogas is one such fuel. Kitchen waste which is rich in organic content can be good source of feed material to the biogas plant and is likely to increase the efficiency. In this work, an attempt has been made to design floating head digester for 0.401 m^3 of biogas generated per day. For this, several parameters like pH, loading rate, total solids content etc. have been investigated.**

***Index Terms*— Biogas, digester, loading rate, kitchen waste, total solids.**

I. INTRODUCTION

The crisis of the fuel seen in the recent years and subsequent increase in the demand of the fuel led the world towards the research and development of the alternative source of the fuel like biogas, bio-ethanol, solar, wind energy etc. which do not get exhausted with time. Among such renewable sources of fuels, bio gas has distinct features like; it can be generated from the waste organic matter like animal dung, kitchen, municipal and agricultural waste etc., ease in the collection of the feedstock, does not require advance technology, provides effluent which can be used as manure etc.[5]. The organics is the source of the many contaminants and diseases and is causing air, water and land pollution. The landfill where such organic matter is dumped becomes source of methane gas emission which is major greenhouse gas. So we need to handle such waste in a righteous way [8].The aerobic digestion takes place in presence of oxygen. The aerobic digestion produces lager amount of carbon dioxide and also cost of supply of oxygen is more in case of small plants [8]. Anaerobic digestion (AD) is historically one of the oldest processing technologies used by mankind. Anaerobic digestion is a biological process that happens naturally when bacteria breaks down organic matter in environments in the absence of oxygen. Anaerobic digestion is a microbial decomposition of organic matter into methane, carbon dioxide, inorganic nutrients and compost in oxygen depleted environment and presence of the hydrogen gas. Generally three main reactions occur during the entire process of the anaerobic digestion to methane [13] i.e. hydrolysis, acetogenesis and methanogenesis.

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II. MATERIALS AND METHODOLOGY

2.1. Collection of Food waste:

The food waste was collected from the mess of SDMCET, Dharwad; which was mixed food containing rice, curd, pulses, curry, chapattis etc. The food was initially collected in container as usual and amount necessary was taken from it.

2.2. Size reduction:

The sample was ground in the kitchen mixer grinder to reduce size to make in form of paste.

2.3. Moisture content:

Sample was taken and kept at the temperature of 105° C in an oven overnight and moisture content was determined using following equation (1).

$$\text{Moisture content} = \frac{w_2 - w_3}{w_2 - W_1} \times 100 \qquad (1)$$

where ,W_1-weight of empty crucible , w_2-weight of crucible + sample before drying

w_3- weight of crucible + sample after drying

2.4. Total solids content:

It is the amount of solid present in the sample after the water present in it is vaporized. The total solid can be calculated by using either of the equation.

$$\text{Total solids content} = 100 - \text{Moisture content} \qquad (2)$$

$$\text{Total solids content} = \frac{w_3 - w_1}{w_2 - W_1} \times 100 \qquad (3)$$

2.5. Volatile solids (VS %)

Dried residue from total solids analysis was kept in the furnace at 500°C for 2 hours and the weight of the crucible along with ash was taken. The volatile solids are all the organics solids present in the sample. The volatile solid can be calculated using the following formula.

$$\text{Volatile solids} = \frac{w_3 - w_4}{w_3 - w_1} \times 100 \qquad (4)$$

Where, w_4-weight of crucible + ash after furnace

2.6. Study of parameters:

Parameters like loading rate, pH and total solids content were studied that effect the generation of the gas.

2.6.1. Loading rate:

It is the quantity of kitchen waste, cow dung and water that should be fed to the digester to get maximum output. Loading rate in this was necessary to determine the volume of the digester.

2.6.1.1. Ratio of cow dung to kitchen waste:
To study the maximum amount of gas generation with respect to amount of kitchen waste and cow dung, nine different samples were prepared containing different amount of kitchen waste and cow dung like 1:1, 1:2, 1:3 etc. The combination was used in nine different water bottles of 2L capacity with the arrangement of downward displacement of water to measure the gas generated. The amount of gas generated was determined by measuring the level of water. The gas generated was measured on daily basis until the generation completely stopped.

2.6.2. Quantity of water
The minimum quantity of water required for the maximum generation of the gas was needed to determine the loading rate. For this six different samples were prepared with constant amount of the cow dung and kitchen waste but varying amount of water quantity from 250 ml to 1600 ml in same arrangement of 2L water bottle.

2.6.3. pH:
The pH was measured on daily basis using pH meter. Later, the sample for which maximum amount of gas was generated for the above loading rate determination was taken. pH between 6.5 to 7 was maintained by addition of NaOH.

2.6.4. Total solids content:

Above sample was taken for the measurement of the total solids content.

2.6.5. FTIR analysis:

The small amount of ground kitchen waste was dried and taken for FTIR analysis. The slurry from the one of the bottle was also dried and taken for FTIR analysis. The FTIR analysis was done mainly to see the composition of the kitchen waste.

2.6.6. Composition of the gas:

The composition of the gas was determined by using flue gas analyzer.

2.6.7. Calorific value of gas (CV):

After knowing the composition, the calorific value of gas can be calculated. The equation for calculation is given below

$$\text{CV(MJ/kg)} = \frac{a \times x + b \times y + c \times z}{a + b + c} \quad (5)$$

Where, a, b and c are the weight of gas and, x, y and z are calorific value of pure a, b and c

2.7. Determination of volume of gas generated:

For the determination of the volume of gas per day from the given sample two 20 L tanks were used. As we have already determined the ratios at which cow dung, kitchen waste and water should be fed, the same ratio was maintained. Tank1 was given the feed of the cow dung, kitchen waste and water as above. And tank 2, the first day feed was same as the tank 1 but from the second day only kitchen waste and water was fed maintaining same solids content. The system was so adjusted that with continuous feed for 4 days there was flow of slurry. The following were the feed given daily to the both tanks for 14 days.

2.8. Amount of gas generated
The amount of the gas generated was measured. The measurement was done by downward displacement of water. The measurement was started from 4th day till 14th day.

2.9. Volatile fatty acids
Volatile fatty acids (VFA's) are fatty acids with carbon chain of six carbons or fewer. They can be created through fermentation. Following method was used to determine VFA's.
100 ml of sample was taken in the beaker. It was filtered. pH of filtrate was checked. 20 ml of the filtrate was taken and to which 0.1M HCl was added until pH reached 4. Heating was done using the hot plate for 3 minutes. After cooling it was titrated against 0.01M NaOH to make pH from 4 to 7. Amount of HCl & NaOH were recorded.
Total VFA content in mg/l acetic acid = (Volume of NaOH titrated) * 87.5 (6)

III. Results and Discussions

3.1. Kitchen waste composition

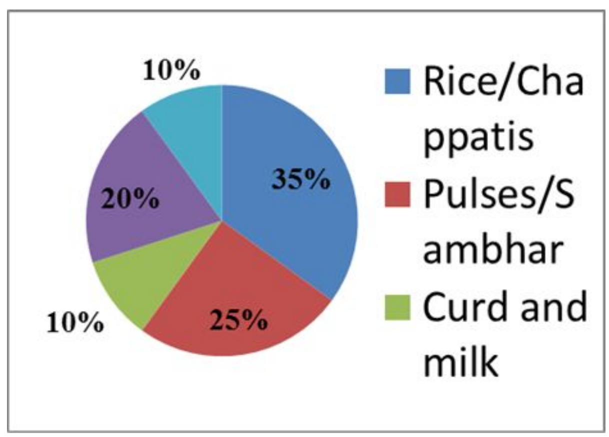

Figure 1: Pie chart showing different contents of kitchen waste.

The moisture content was 73.062%. It shows high moisture content which makes kitchen waste suitable for anaerobic digestion. The total solids content was 26.93%. Volatile solids content was 95.21%. It showed kitchen contains high organic content.

3.2. Ratio of cow dung to kitchen waste.

The gas generated was studied at room temperature. The generation of gas was found till 4th day and stopped. From this we can infer that the digestion of kitchen waste will not take more than 4 days.

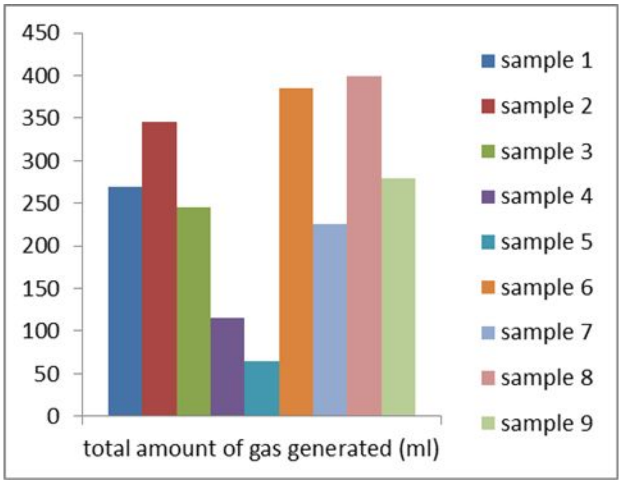

Figure 2: Bar graph showing the amount gas generated by different samples.

From the above data the data it is clear that the maximum gas was generated in sample 8 which was 400 ml. The sample 8 contains 25 g of kitchen waste and 25 g of cow dung. Therefore the cow dung and kitchen waste should be in the ratio of 1:1. Further the average gas generated per day in sample 8 was 80 ml per day.

3.3. Quantity of water

It is clear the maximum quantity of gas generated was 415 ml. This amount of gas was generated from the sample which contains 25 g of both kitchen waste and cow dung and 250 ml of water which is sample 1.

3.4. pH and Total solids %

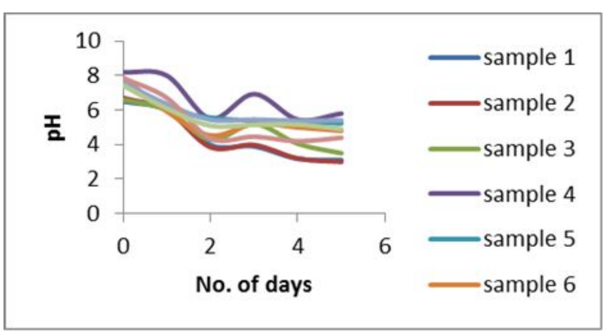

Figure 3: No. of days vs. pH for different samples.

The pH of samples was measured on the daily basis. The pH of sample containing the kitchen was comparatively low as compared to sample containing only cow dung only. This was because there was more conversion of organic matter into acid and the organic content of the sample with kitchen waste was more. Comparing the results with that of gas generation, we can conclude that when there was more acidic condition prevailing within the system, there was low gas generation. Even total solids percentage was measured. It was found that the solids content of every sample was reducing every day. This shows that some amount of the solids was getting converting into gas.

The graphical representation of above samples is shown below. It was found that more the acidic condition more time was there for digestion of kitchen waste. So there is a need of maintaining pH of the system in the range of 6 to 7. The sample 8 which contains equal weight of cow dung and kitchen waste was taken and NaOH was added. The results are show in the graph.

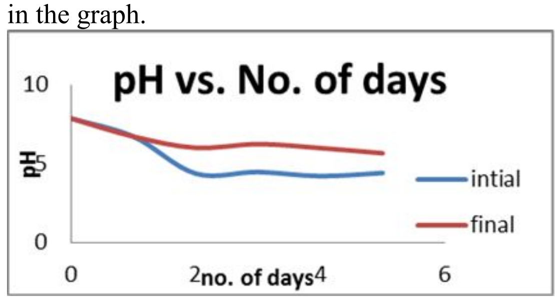

Figure 4: Comparison of pH.

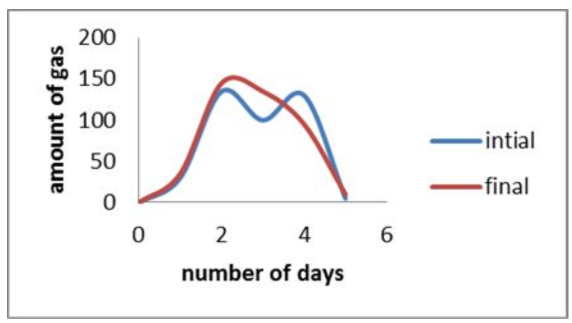

Figure 5: Gas generated comparison.

It is clear from the graph that pH was maintained between 6 and 7 by addition of NaOH. Due to this maintenance of pH, the gas production was 420 ml which is around 1.2% increment. Also from the second graph, we can conclude that there was continuous generation of gas as compared to initial condition. By addition of the NaOH, fluctuations in gas generations were eliminated.

3.5. FTIR analysis

In first result of the FTIR, it was clear that all the above functional groups are present, which shows enough of organic materials are present and also the nitrogen required for the growth of the bacteria is also present.

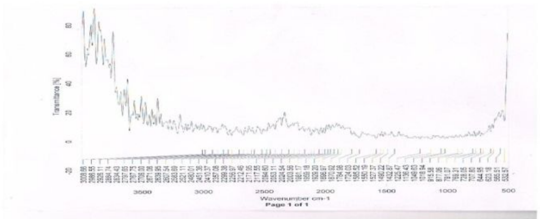

Figure 6: FTIR of Kitchen waste before digestion.

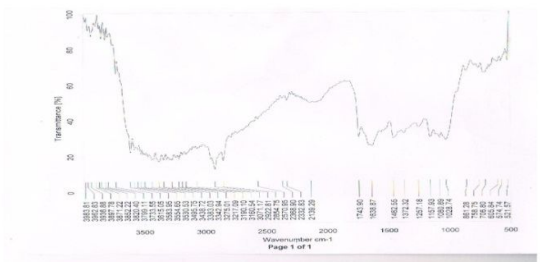

Figure 7: FTIR of Kitchen waste after digestion.

In the second FTIR result, the peaks of the most of the organic materials are reduced. Hence we can say that, some parts of the organic materials were consumed. And the peaks around 3300-3350 cm^{-1} were still sharp, so there is still some nitrogenous element present which makes it as potential fertilizer.

3.6 Composition of the gas

The composition of the gas found using flue gas analyzer is tabulated below.

Sl. No.	Composition	% by volume
1	Carbon dioxide	8.1
2	Methane	69.8
3	Air	22.1

Table 1: Composition of biogas.

Using equation 5 calorific value is found to be 31.085 MJ/kg (i.e. 10.36 kwh/m^3).

CONCLUSION

From the above study it is clear that kitchen waste has the great potential and can replace the current energy consumption. With little investment such plants can be constructed, which can be operated with a very little care and can save a lot of money that is currently invested in buying. Not only biogas has potential save cost and energy, it can also protect environment by management of such domestic waste in a scientific method.

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