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Effect On Biogas Generation in Thermophilic & Mesophilic Condition by Using Cow Dung - A Comparative Analysis

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Abstract: *Today, our energy need is fulfilled by burning oil and only a very small percentage is generated by nuclear power plants. The increasing cost of petroleum products is a big problem facing most developing countries of the world including India. There are many sources of energy but biogas is different from other renewable energy, because of its favorable controlling, collecting and characteristics. The present work was based on to generate biogas form waste and effectiveness of the cow dung in different operating conditions (thermophilic and mesophilic) in 20 liter capacity tank. First experiment was performed for cow dung in thermophilic condition. Biogas yield from this experiment was 29050 ml over the study period of 19 days. Similarly the second experiment was performed to check the gas production from the cow dung in mesophilic condition. The total gas production of 25693ml was recorded from this experiment and the study period for this was 25 days. The overall results from these experiments were compared. Daily biogas production was measured by using water displacement method. This project work shows the effect of uncontrolled operating conditions on biogas generation.*

Keywords: *Biogas generation, thermophilic, mesophilic, anaerobic digestion, energy.*

1. INTRODUCTION

As we know that a very big problem in developing countries like India is deforestation and a large of the part depends on following fuels like charcoal and fuel-wood for fuel supply which requires deforestation. Also soil erosion is the major problem. Use of firewood as energy is also harmful for the health due to the smoke arising from them which causing air pollution. The increasing cost of petroleum products is a big problem and facing most of the countries of the world including India. There are many sources of energy but biogas if different from other renewable energy because of its favorable controlling, collecting and characteristics.

Biogas contains approximately 55-65% (CH_4) of methane and 30-40% of carbon dioxide (CO_2**)** (H S Sorathia, Dr. P Rathod and A S Sorathiya et al, 2012). The calorific value of biogas is appreciably high **(**S.Ashok Kumar, C.Marimuthu, E.P.Balaji and S.Shakeel Riswan et al, 2012**)**. Kitchen waste is organic material having the high calorific value that's why efficiency of methane production can be increased by several orders of magnitude. Also in most of cities and places, kitchen waste is discarded in open which causes the public health hazards and diseases. Due to Imperfect management of kitchen wastes like uncontrolled dumping causes several adverse effects. Unfavorable dumping causes land pollution also a big problem which causes flies of mosquitoes.

2. BIOGAS

The Biogas is a renewable energy source. Mainly biogas is a mixture of different gases such as CH_4, CO_2 and small amount of other gases produced by organic matter breakdown in the absence of oxygen (O_2). Also biogas can be produced from

food waste, municipal waste, animal manure and agricultural waste.

The gases like methane, hydrogen and carbon monoxide can be oxidized with oxygen and this energy release allows biogas to be used as a good fuel. It can be used for heating purpose such as cooking.

3. COMPOSITION OF BIOGAS

The composition of biogas may vary because it depends on origin of anaerobic digestion process. Generally biogas contains major part of methane and CO_2 and very small amount of other gasses as given below-

Table 3.1: Composition of biogas

Compound	%	Formula
Methane	50-75	CH_4
Carbon dioxide	25-50	CO_2
Nitrogen	0-10	N_2
Hydrogen sulfide	0-3	H_2S
Hydrogen	0-1	H_2
Oxygen	0-0.5	O_2

4. CHARACTERISTICS OF BIO-GAS

Biogas is produced from the anaerobic digestion in an air tight vessel called biogas digester and generally the biogas composition depends on feeding substrates. As compare to the air the lightness of biogas lies between 19 -22 percent and this gas is colorless and burns with blue flame similar to LPG. Also its calorific value is about 20 Mega Joule/m^3 and ignition temperature varies between 640 to 760^0.

5. ANAEROBIC DIGESTION PROCESS

Anaerobic digestion is a biochemical process in which decomposition of organic matter is occurred by microorganisms and this happens in presence of oxygen or in other words it is called as bio-methanization process which takes place in the absence of oxygen. If in a anaerobic digester the homogenous mixture of different organic waste is digested then the digestion is called as co-digestion.

5.1. Hydrolysis

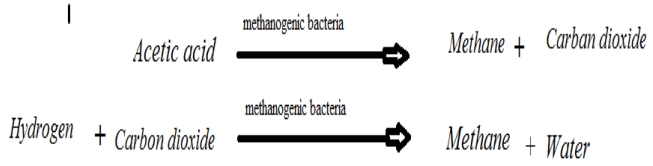
Hydrolysis is the first stage which occurs in anaerobic digestion process .Firstly proteins carbohydrates and lipids has to disintegrates into monomer and polymer .during hydrolysis process carbohydrates takes small time or few minutes to disintegrate while proteins and lipids takes few days .complex compound like lignin and cellulose takes more time to disintegrate.

5.2. Acetogenesis & Acidogenesis

Acetogenesis process also known as fermentation process in which fatty acid and sugar are again further degrades into short organic compounds. During this process significant amount of CO_2 and H_2 are generates. Acetic acid is the final product of this process. During fermentation process acid forming bacteria grows continuously, which are responsible for the generation of methane micro-organisms and creates anaerobic condition in digester tank (Suyog Vij *et al.*, 2011).

5.3. Methanogenesis

In the digester tank methanogenesis is the third and final stage of anaerobic digestion process ,in which methanogenic bacteria increases in significant amount ,this micro organisms generates CH_4(methane) by consuming hydrogen as shown below-



During this process 70 % of methane generated from acetate and remaining 30 % formed due to conversion of hydrogen(H) and carbon dioxide (CO_2) (Hand book of biogas

:Teodorita Al Seadi, Dominik Rutz, Heinz Prassl, Michael Köttner, Tobias Finsterwalder, Silke Volk anf Rainer Janssen *et al.*, 2011).

6. MATERIAL AND METHOD OF CONSTRUCTION

6.1. Material

For the fabrication of biogas digester different components were used. The description of each component with image is given below.

(a) Digester tank: I used 20 liter capacity plastic tank. The function of this tank is to digest the feed material in anaerobic condition.

(b) Pipe: 1.5 inch diameter pipe was used for slurry inlet and outlet respectively.

(c) Caps: 1.5 inch diameter caps with inlet and outlet pipes were used in order to maintain anaerobic condition inside the digester tank.

(d) Flexible tube: It was used for measurement and storage purpose.

(e) Gas regulating valve: This valve was used for the storage with tube and for measurement with water displacement setup.

(f) M-seal: M-seal was used to join all the pipe joints to prevent the leakage of gas.

(g) Instant adhesive glue: It was used with M-seal for two purposes, first to avoid the leakage of air inside the digester and second to prevent the leakage of gas from the digester.

(h) Graduated beaker: a graduated beaker also was used to calculate the amount of gas generated. As the gas from the gas regulating valve is released, it displaces water. The amount of water displaced by the gas is measured in ml.

(i) Digital thermometer: A digital thermometer was used to take inside and outside temperature readings of the digester.

(j) T-joint: A T-shaped joint also was used to which three pipelines were attached. Out of these three, one for gas storage in rubber tube, second for gas burning and third one for gas outlet from the digester.

6.2. Method of Construction

- To make experimental setup a 20 liter capacity bottle was used.
- For slurry outlet and inlet two holes was drilled at two sides, one at the top of the digester head and other in the wall of the digester.
- 1.5 inch diameter pipes were inserted in these holes for slurry inlet and outlet respectively.
- A small hole was made in the cape of the digester in order to insert gas pipe of 0.5 cm diameter.
- One and of the gas pipe was inserted into the digester and other end of the pipe is connected to the gas regulating valve.
- Two regulating valves were used in order to perform multiple tasks i.e. for gas storage and gas measurement.
- A tube of 2-wheeler vehicle was used to collect the produced gas from the digester.
- A funnel was used to fill the slurry inside the digester.
- All the connections were joined by using glue and M-seal.

7. PLAN OF EXPERIMENTAL SETUP FOR UP-SCALED DIGESTER

The plan of experimental setup is shown in figure.

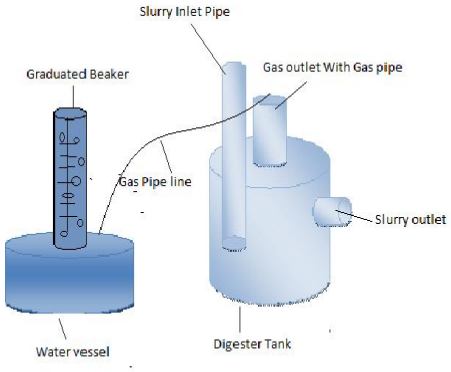


Figure 7.1 Plan of up-scaled experimental setup

8. EXPERIMENTAL WORK & RESULTS

8.1. Experiment -1 (Up-scaled Digester)

Objective: - Generation of biogas from cow dung in thermophilic condition**.**

Procedure: -

(a) A 20 liter plastic jar as digester was used for generation of biogas.

(b) 18 liters Slurry was prepared from Cow dung and water in ratio of 1:1 in a plastic bucket.

(c) Prepared slurry was filled into the digester by using a small funnel.

(d) The level of slurry inside the digester was maintained above the slurry outlet pipe in order to avoid gas loss from the digester.

(e) The outlet and inlet slurry pipes were capped in order to maintained anaerobic digestion condition inside the digester.

(f) Also a gas pipe was used to collect biogas. One end of the pipe was fixed to the digester at the top and sealed by M-seal while other end was connected to the rubber tube through the gas regulating valve.

(g) The digester was left in atmospheric condition.

(h) The temperature readings were taken daily five times in a day.

(i) The pH values were taken two times i.e. first day before feeding into the digester and last day of experiment.

(j) The biogas production was measured on the daily basis by using water displacement method.

Calculation of pH

The value of pH was 6 measured in the beginning of the experiment before feed in to the digester. After the final reading of gas production again it is measured and that was 9.

Calculation of Temperature

The temperature readings were taken by using digital thermometer. Five readings were noted per day between 9 AM-6PM. Temperatures of slurry inside the digester were also noted daily by inserting temperature sensor inside the digester through the inlet of slurry pipe. An average reading of this temperature was noted per day.

Flame Detection Test

Flammability of gas was observed on 8^{th} day of the experiment. The gas from the digester was stored in a tube for flame detection test. The gas was burnt with blue flame as shown in figure 1.8.1.

Figure 8.1.1: Gas detection test

Calculation of Biogas Yield

The calculation of biogas yields were taken on the daily basis from the third day of experiment at 5 PM. To calculate biogas yield water displacement method was used. A graduated inverted glass beaker of 500 ml capacity was used for the measurement. The beaker was filled completely by water. The gas entered into this inverted beaker as the gas valve opened and it displaced water which indicates the reading on graduated scale.

Results:-

I completed this experiment in the duration of 21 days. The following readings were taken during the experiment which is given in the table 5.2.1 below. The complete experiment was carried out in a batch type biogas reactor in thermophilic conditions i.e. Between 37^0 C - 44^0 C.

It is clear from the result of experiment that the generation of biogas in the first and second day was low as compared to third day reading that was 680 ml gas production. Farther the rate of decomposition was slow up to days. The performance of the digester with cow dung was high between 8^{th} to 14^{th} days of the experiment because of due to methanogenis bacteria growth. Also it is clearly shown in the table that the temperature readings were between 40-44 ^{0}C from 8^{th} to 14^{th} day. After 15^{th} day the generation of biogas was gone decreasing because of due to decomposition of material and lower microbial growth. The maximum gas production were recorded on 12^{th} day of the experiment, also the temperature of 44 ^{0}C was measured. Also the shaking of digester was done thrice a day because it does not settle the molecules at lower surface. Farther the gas particle below the level of slurry moves in upward direction which gives actual production of gas inside the digester. Again shaking of digester avoids the non-uniform distribution of nutrients.

8.2. Experiment -2 (Up-scaled Digester)

Objective: - Generation of biogas from cow dung in mesophilic condition.

Procedure: - The digester used in previous experiment again was used i.e. 20 liter capacity plastic tank as a digester and same procedure is applied.

Calculation:-Calculations of pH, temperature and biogas yield are calculated as before.

Result:-

I completed 3^{rd} experiment in the duration of 25 days. The following readings were taken during the 3^{rd} experiment which is given in the table 5.3.1. The complete experimental work was performed in a batch type biogas reactor. All the readings from this experiment are shown in the table 5.3.1 and it is clear that the decomposition of matter was slow in 1^{st} to 7^{th} day. On 10^{th} day of experiment, the generation of gas was batter and continued to 15^{th} day. Again we can see that the values of biogas were lower after 15^{th} day. On 20 & 21^{st} day of experiment it noticed that the volume of gas was 940 and 960 ml respectively, but next day it was 1110 ml and average temperature observed as 25 ^{0}Cwhich was due to humid climate. The total gas production from the experiment was 25690 ml in 25 days of observation. The average temperatures reading were recorded between 30-34 ^{0}C up to 15^{th} day but temperature was lower after up to the end of experiment which was between 24-30 ^{0}C.

9. COMPARATIVE ANALYSIS AND DISCUSSION

From overall reading we can see that the gas production was low up to 3-4 days in both the cases, but the biogas from thermophilic production the was comparatively more from mesophilic production. This happened due to slow microbial growth in mesophilic condition. The production of gas from 8^{th} to 14^{th} days of experiment in case of thermophilic study was more compared to mesophilic condition because the fermentation of material was faster due to high temperature i.e. between 40 -44 ^{0} C .the maximum gas yield in thermophilic condition was 3000 ml were recorded and average temperature were marked as 43^{0} C. Between 10^{th} to 15^{th} day the gas production was good and the highest gas yield of 2160 ml was noted for mesophilic arrangement. Total biogas yield in 20 liter digester tank in the study period of 19th days was 29050 ml recorded for thermophilic condition. On the other hand total gas yield in case of mesophilic condition were 25690 ml in study period of 25 days. From the result of above mentioned values, we can say that the fermentation period is more in the case of mesophilic condition. Also from the obtained result HRT for 20 liter capacity digester can be find out. The HRT should be between 14 to 15 days for thermophilic condition while for mesophilic condition HRT should be 17-19 days according to recorded values.

Table 9.1: Comparison of Biogas production with respect to temperature in thermophilic and mesophilic conditions for cow dung

Day	Avg.temp. in (^{o}C)	Gas prodn. In (ml)	Avg.temp. in (^{o}C)	Gas prodn. In (ml)
	Thermophilic Condition		Mesoophilic Condition	
3	37	680	34	350
4	38	960	33	640
5	38	1130	34	890
6	40	1370	29	550
7	41	1720	33	860
8	41	2230	34	1020
9	43	2460	32	1110
10	44	2320	32	1240
11	44	2890	32	1100
12	44	3000	34	1730
13	43	2650	33	2160
14	40	2110	31	7090
15	39	1560	30	1510
16	38	1300	30	1330
17	39	1020	30	1200
18	38	930	28	1130
19	37	720	29	1250
20	-	-	26	940
21	-	-	25	960
22	-	-	25	1110
23	-	-	24	960
24	-	-	29	820
25	-	-	31	640

10. CONCLUSION

The present work was based on to check the effectiveness of biogas production in uncontrolled conditions of pH, temperature and atmospheric conditions. Also the effect of co-digestion on the gas generation was evaluated. The complete study was done in the duration of 45 days in batch system. The total biogas generation from the 20 liter capacity digester was 29050 ml for thermophilic condition and 25690 ml for mesophilic condition. From the results it can be said that the anaerobic digestion of cow dung in thermophilic condition generates more gas as compare to mesophilic condition. We can see that the reading of temperatures were higher for thermophilic as compare to the mesophilic condition and due to which the rate of decomposition in case of thermophilic was faster. This result shows that the temperature affects the digestion rate or biogas generation.

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