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Anaerobic Co–Digestion of Turkey Droppings with Coconut Oil Cake under Mesophilic Condition

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Abstract — Anaerobic digestion of animal waste has a high potential in the generation of bio gas at mesophilic conditions. In this paper we experimentally investigated the biogas production potential of turkey faeces using fixed and floating type digesters in batches. The gas outputs from the digesters showed that using the floating type resulted in a gas production of 5.38 litres on the 12th day, which is a10% increase in gas production when compared to the fixed type digester. To enhance biogas production coconut oil cake was used as an additive. The addition of an additive resulted in a biogas production of 6.36 litres on the 12th day, a 12% increase.

Keywords — Biogas, Floating dome digester, Fixed dome digester, Turkey droppings etc.,

I. INTRODUCTION

Anaerobic digestion for biogas production has become very popular among several countries, since it is an environmental friendly source of energy[1].Anaerobic digestion of organic matter to methane is a viable method of waste treatment and resource recovery. The process is carried out by action of various groups of anaerobic bacteria. Biogas is an alternate source of energy with low pollution levels[2] in comparison to fossil fuels which are produced by the anaerobic digestion of biodegradable materials such as manure, sewage, municipal waste, green waste, plant material and crops.

Biogas technology provides further benefits such as reduction of municipal wastes, sewages etc., which will keep the environment clean [7].Lack of process stability, slow processing, decrease in gas generation during winter and high cost of the system are some of the limitations of biogas technology [4].Nevertheless, biogas production can be improved by various techniques such as optimization of the various operational parameters and addition of additives and slurry to the digester [6].

II. ANAEROBIC DIGESTION

The process of conversion of organic matter into methane in the absence of oxygen is called as anaerobic digestion. Anaerobic digestion is a natural process in which bacteria converts organic materials into biogas [5]. The process occurs in an anaerobic environment through the activities of acid and methane forming bacteria that breakdown organic matter and produce methane (CH_4) and carbon di oxide (CO_2) in a gaseous form known as biogas.

$$\text{ORGANIC MATTER} + H_2O \rightarrow CH_4 + CO_2 + H_2S$$

Four basic types of bacteria are involved in the production of biogas from the feedstock. They are, Hydrolytic bacteria, which will break down complex organic waste into simple organic compounds such as sugar and amino acids [3]. Fermentative bacteria then convert those products into organic acids. Acidogenic bacteria convert the acids into hydrogen, carbon dioxide and acetate. The methanogenic bacteria produce biogas from acetic acid, hydrogen and carbon di oxide [4].

III. FACTORS AFFECTING BIOGAS PRODUCTION

Various factors such as biogas potential of feedstock, design of digester, inoculum, nature of substrate, pH, temperature, loading rate, hydraulic retention time (HRT) etc., influence the biogas production. Temperature inside the digester has a major effect on the biogas production. The bacterial action will be very active in the mesophilic and thermophilic range [10]. Maintenance of the system pH in the proper range is required for efficient anaerobic digestion. The suitable pH value for biogas production ranges between 6.4 and 7.2 [11]. The organic loading rate is defined as the influent mass rate of chemical oxygen demandper unit volume. Methane yield was found to increase when the organic loading rate decreases [12].

The Hydraulic retention time (HRT) is the time taken for complete digestion of the substrates in Digester. Hydraulic retention time is the ratio of volume of the digester to the influent flow rate [13].At mesophilic and thermophilic temperature ranges, it is possible to carryout anaerobic digestion at low hydraulic retention time [10].Inoculum is the bacterial substance which will be used for start-up of anaerobic digestion in digesters.With the addition of inoculum, it is possible to increase gas yield and reduce retention period [3].

IV. COMPOSITION OF BIOGAS

Table 4.1 - Composition of biogas [4]

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Compound	**Molecular formula**	**Percentage %**
Methane	CH_4	50–75
Carbon dioxide	CO_2	25–50
Nitrogen	N_2	0–10
Hydrogen	H_2	0–1
Hydrogen sulphide	H_2S	0–3
Oxygen	O_2	0–0

The composition of biogas varies depending upon the origin of the anaerobic digestion process. Landfill gas typically has methane concentrations around 50%. Advanced waste treatment technologies can produce biogas with 55–75% methane. Biogas also contains water vapour. The fractional volume of water vapour is a function of biogas temperature [8].

V. MATERIAL AND METHODOLOGY

The pilot model floating dome digester was fabricated with a capacity of 20 litres. The turkey droppings were collected from farms, dried and pre-processed by mixing the turkey droppings and water in a 1:2 ratio. The digester is completely closed in order to prevent the entry of oxygen into it. Subsequently, anaerobic digestion takes place inside the digester and biogas and digested slurry are produced as an end result. The gas samples are stored in a bladder and are taken for further chromatographic analyses.

A. Design of digester

Table 5.1 - Design of digester

Digester type	**Floating dome batch type digester**
Digester capacity	20 liters
Volume	$0.021m^3$
Height	38cm
Diameter	22cm
Stirring method	Manual
Insulation	Water jacket

The floating digester is made by using stainless steel with 20 litres capacity. The height and diameter of the digester is 38cm and 22cm respectively. The temperature of the digester is maintained using water jacket.

Figure 5.1 - Digester setup

Above figure 5.1 shows the pilot model floating dome digester kept in the field for biogas production.

B. Selection Of Potential Feedstock

There are various kind of feedstock available for biogas production. Most of the biogas plants uses dung of cow, poultry, swine and turkey etc., for biogas production. Animal dung will produce large amount of biogas because of its high nutrient content. Turkey droppings are used here, as the turkey are fed with grass. This infers that the nutrient content will be high in turkey droppings, which enhances the rate of biogas production.

C. Selection Of Additives

The additives are the substances which are used for enhancing the biogas rate. Additives are of many types and are used according to the nutrient content present. Coconut oil cake is used in this work, as the coconut oil cake is rich in amino acid so the biogas production rate will increase proportionately.

D. Preprocessing of feed stock

Turkey droppings were collected from the turkey farms and then filtered from dust and waste. Turkey droppings were dried, powdered to make sure that turkey droppings is mixed with water completely for better digestion to take place. Turkey droppings are then fed into the digesters in batch wise with different feed properties in two different digesters. The batch wise feedstock preparation were given below.

E. Batch 1&2

Turkey droppings are mixed with water in the ratio of 1:2 and stirred well in order to mix them properly and are then fed into the floating dome digester and fixed dome digesters in equal proportions.

F. Batch 3&4

Turkey droppings are mixed well with water in the ratio of 1:2. The coconut oil cake is powdered well and then mixed with feed and water mixture by 5% and fed into the floating dome digester and fixed dome digester. Stirring is done in order to make the oil cake mix well with the feed.

G.Gas Production

Biogas production is obtained by anaerobic digestion process and the volume of the gas is measured by gas flow meter. After the gas sample is taken at the peak period, the gas sample was analysed to find the gas composition (i.e.) methane, carbon-di-oxide and hydrogen sulphide content.

H.Measuring Parameters

The parameters which have been measured in this work are pH, temperature, volume, hydraulic retention time.

The pH of the feed is measured by litmus test using litmus paper. The pH of the feed is found by dipping the litmus paper in the feed and the colour of the litmus paper will change according to its pH value. By using the litmus colour scale, pH of the feed was determined. The temperature is measured by using thermometer. The volume of the gas is measured by using positive displacement type gas flow meter. The hydraulic retention time is noted from the day the feed is fed into the biogas digester. The maximum retention time for the process to be completed in this case is 18 days.

VI. RESULTS AND DISCUSSION

The results of the batch experiments under different feedstock conditions are elucidated in the table. These tables indicate the volume of biogas generated at various instances of temperature and pH for the retention period of 18 days. The batch experiments namely

- **Batch 1:** Feed in floating dome digester without additive.
- **Batch 2:** Feed in fixed dome digester without additive.
- **Batch 3:** Feed in floating dome digester with coconut oil cake as additive.
- **Batch 4:** Feed in fixed dome digester with coconut oil cake as additive.

Table 6.1 - Feed in floating dome digester without additive

Day	**pH**	**Temperature °C**	**Volume of Bio-gas Generated in liters**
3	6.8	28.5	1.79
6	7.0	30	2.82
9	6.9	31.6	4.45
12	7.0	32	5.34
15	6.8	30.5	4.85
18	6.7	29.5	4.53

The sample biogas is taken for analysing the composition of biogas and readings are tabulated as follows.

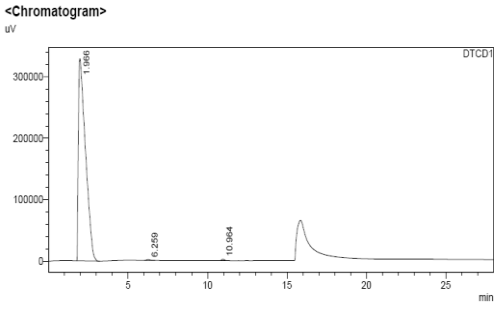

Figure 6.1 - Chromatogram 1

Table 6.2 - Composition of feed without additive in floating dome digester.

Retention time	**Ph**	**Temperature**	**Composition**	
			CH_4	**CO_2**
12^{th}day	7.0	32	0.171%	0.191%

At the retention period of 12^{th} day, the biogas sample was analysed and the methane composition in the sample is 0.171% and CO_2 composition is 0.191%.

Table 6.3 - Feed in fixed dome digester without additive

Day	**pH**	**Temperature °C**	**Volume of Bio-gas Generated in liters**
3	6.7	30.5	1.34
6	6.9	31.8	2.27
9	7.0	32.3	3.94
12	7.0	33	4.86
15	6.8	31.5	4.52
18	6.6	29.5	4.32

Table 6.4 - Feed in floating dome digester with coconut oil cake as additive

Day	**pH**	**Temperature °C**	**Volume of Bio-gas Generated in liters**
3	6.9	30.5	2.35
6	6.8	31.8	3.41
9	7.0	32.3	5.82
12	6.9	33	6.36
15	6.7	31.5	6.12
18	6.6	29.5	5.42

The sample is analysed to find the composition of biogas produced. The result is as follows

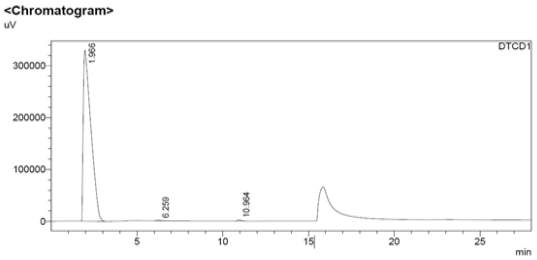

Figure 6.2 - Chromatogram 3

Table 6.5 - Composition of feed without additive in fixed dome digester.

Retention time	**pH**	**Temperature**	**Composition**	
			CH_4	**CO_2**
12^{th} day	6.9	33	1.981%	29.215%

Table 6.6 - Feed in fixed dome digester with coconut oil cake as additive

Day	**pH**	**Temperature °C**	**Volume of Bio-gas Generated in liters**
3	6.8	30.5	1.95
6	7.0	31.8	3.15
9	7.0	32.3	5.03
12	6.8	33	5.68
15	6.9	31.5	5.24
18	6.7	29.5	4.92

VII. GRAPHICAL REPRESENTATION

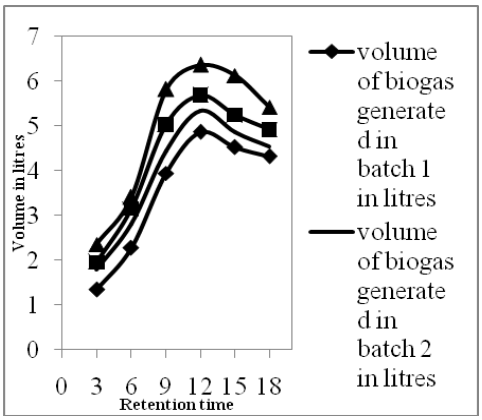

Fig 7.1 - Volume of the gas (vs) retention time

From figure 6.1, the biogas production rate for the retention period of 18 days is shown. The volume of the biogas is moderate after the 6^{th} day and at the peak period of 12^{th} day the gas production rate is high. After the peak period the volume slightly decreases.

VIII. CONCLUSION

Biogas was produced from turkey droppings under batch type processing in fixed and floating dome type digesters. To enhance the production of biogas, coconut oil cakes were used as an additive. Experiments were conducted for four samples of turkey droppings along withan additive and results are obtained. It was observed that by adding additive the anaerobic digestion was advanced and the activity of the microbes are quick by reducing hydraulic retention time and producing better yield.

In floating dome digester, biogas production rate is found to be maximum in the absence of additive with 5.34 litres and in the presence of additive with 6.36 litres at the 12^{th} day of retention period.

In fixed dome digester, biogas production rate is found to be maximum in the absence of additive with 4.86 litres and in the presence of additive with 5.68 litres at the 12^{th} day of retention period.

The methane yield is found to be enhanced by adding additive.

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