

Production of Methane and Carbon Dioxide from Slaughter Waste

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ABSTRACT: All over the world Energy is the dynamic force for the development. The various sources of waste generated can also be used for producing clean energy in the form of biogas using certain biochemical process like anaerobic digestion. Anaerobic digester is feeded with the waste generated from the slaughter house (SH). There is number of Slaughter house (SH), where huge amount of waste is generated every day. But no measures have been taken to treat the waste for energy recuperation. This research work intends to advance the use of biogas. This research work also brings about the feasibility of biogas production from Slaughter House (SH). Analysis of the samples was done in the laboratory to find out the pH, Total Solid (TS), Volatile Solid (VS) and Carbon Nitrogen (C:N) ratio and the values were 7.3, 23.5%, 76.5% and 23.9 respectively. Mini digester of 20 liter capacity was used to carry out the anaerobic digestion process. The study was conducted in a batch reactor, for a period of 60 days, with daily average temperature varying between 28^oC to 35^oC. The origin of the anaerobic digestion process plays the main role in varying the composition of biogas. The compound such as methane (CH₄), carbon dioxide (CO₂), nitrogen (N), hydrogen (H₂), hydrogen sulfide (H₂S), oxygen (O₂) is evolved during the digestion process. The residue, called activated sludge, can be dried and used as fertilizer.

KEYWORDS: Slaughter waste, biogas, methane.

I. INTRODUCTION

In absence of air (or oxygen) certain microorganisms helps in decomposition of biodegradable organic matters to produce biogas. Biogas is a flammable mixture of various gases. Anaerobic digestion of certain biological wastes such as cattle dung, vegetable wastes, sheep and poultry droppings, municipal solid waste, industrial wastewater, landfill, etc helps in the production of biogas. Biogas and slurry are the important products of anaerobic digestion process. There are different components of gases in biogas production, the majority of them being methane, 50-70 % and Carbon dioxide, 30-40 % with traces of Sulphur Dioxide and Hydrogen gas (Lazor *et al.*, 2010). The important objective of this research work is to examine the potential for producing biogas from residues of slaughter houses within ukkadam.

Following are the precise objective of this research work.

- To recognize the sources and individuality of slaughterhouse waste for biogas production.
- To find out the total solid, volatile solid, organic carbon and nitrogen contents of the feedstock.
- To conduct the quantity of daily production of biogas in lab scale.
- To trace the pH, temperature and analyze the methane content of the gas.

II. EXPERIMENTAL PROCEDURES

2.1 Pasture Investigation

Sample from slaughter houses were collected from the major market area in ukkadam which is 1% of the total slaughter houses.

2.2 Waste categorization and Quantification

The weight of the waste generated from the individual animal executed was noted and the weight of animal before execution was noted and after final grounding of meat for selling. The variation between the initial and final weight gave the weight of the total amount of anaerobically digestible and non digestible waste (Amrit *et al.*, 2009). Later the anaerobically digestible and non digestible waste was separated and it was weighed individually. Quantification of waste in a day was carried out by multiplying the average amount of waste produced from individual animal by total numbers of animals executed in a day.

2.3 Laboratory examination

To analyze the biodegradability of Slaughter House Waste some parameters are required: pH, total solids (TS), volatile solids (VS), organic carbon content (C) and organic Nitrogen content (N) were determined. After the completion of the digestion process NPK value of the digested slurry was also tested.

2.4 Determination of quantity of substrates

The samples are feeded into the mini digester in different proportion by diluting the substrates i.e. slaughter house waste to 7% TS.

Table 2.1: Ratio of Dilution of slaughter house waste (SHW)

Sample	Mass in (kg)	Water in (litres)	Innoculum in (kg)	Total TS in (kg)	Total mass of slurry (kg)
SHW	4.0	10.0	1.00	1.60	15.00

2.5 Trial investigation

The study was carried out based on the principle of batch feeding into the digester. This experiment was carried out in a small digester of 20 liter capacity water jar (Figure 2.1). The substrate composition mentioned in Table 2.1 is the content added in the digester.

Following chronological steps were taken for scheming the digester. On the top of the digester a hole was made with a drill. The diameter of the hole was half inch. Then the Gas flow pipe was fixed to the hole. The gas flow pipe was connected to the regulating valve, to control the flow of gas (Guillermo *et al.*, 1999). Another hole of about 1/3 height of the digester at the lateral side was made, for slurry outlet. M-seal was used at all the joints to make the joints completely air tight.

Inlet: A cork is used to seal the inlet opening. Since this is a batch type digester, daily substrate addition is not needed. The substrate is added only once at the beginning and the digester is sealed.

Gas line: The gas from the digester is carried by a pipe attached to the top of the digester. The flow from the digester is controlled by providing regulating valve connected to the pipe line. The gas was collected in a pipe line and deliberated by means of water displacement method.

Outlet: At 1/3rd the height of digester the outlet pipe was connected. The function of the outlet pipe was to take the

slurry out of the digester. The sample is taken out daily to check the pH value of the slurry.

Water seal: The gas from the digester is carried by a pipe which is connected to water seal, with trough of water. This pipe was fixed to the graduated beaker at the bottom, the graduated beaker was filled with water and kept upside down (Janet, 2013). The mini digester was feeded with samples i.e. slaughterhouse waste, which were diluted to 7% TS. Laboratory study was then carried out in a batch type biodigester of 20L capacity. 14 kg of slaughterhouse waste slurry was filled in a reactor. From operating biogas plant 1 kg of slurry was added to each digester as innoculum. The study was carried out for a period of 60 days. Daily measurement was taken for temperature, pH and the volume of gas produced was carried out.

Batch experiment setup:

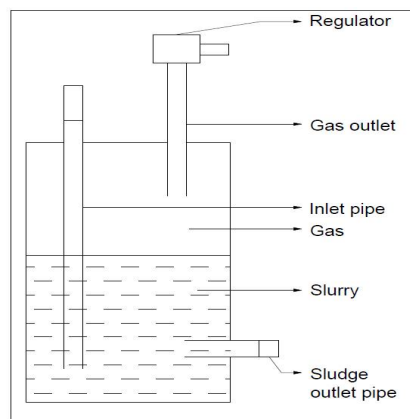


Figure 2.1: Schematic diagram of bio digester

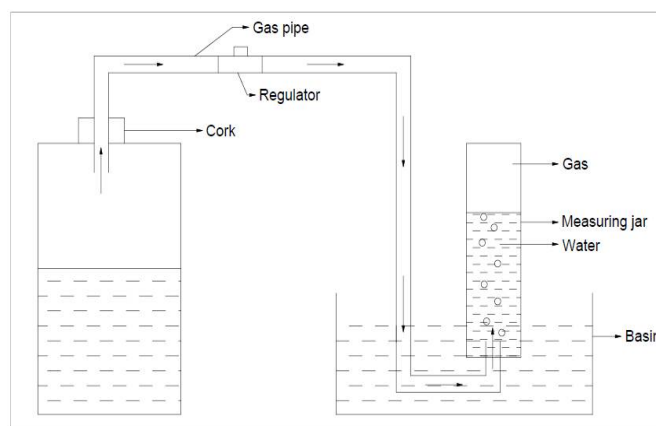


Figure 2.2: Schematic diagram of batch type biogas plant for laboratory study

2.6 Properties of the substrates

The biochemical analysis of slaughterhouse waste and cow dung was carried out to determine the properties of these substrates.

Table 2.2: Biochemical analysis of slaughterhouse waste

Parameters	Slaughter house Waste
pH	7.3
Total Solid (TS) %	23.5
Volatile Solid (VS)%	76.5
Nitrogen (% dry mass)	1.9
Carbon (% dry mass)	45.41
C:N	23.9

III. DISCREPANCY OF INFLUENCING FACTORS

3.1 pH

The pH value gives a rough indication on the circumstances of the fermentation process. The most favorable pH value for anaerobic digestion process is in hiatus of 6.5 to 7.5. The pH value of the digestion slurry may have the tendency to decrease depending upon some of the feeding materials. In such a case calculated amount of lime (CaCO₃) can be added to adjust the pH value (Ajay *et al.*, 2012). Nitrogen is liberated in the form of ammonium hydroxide during the process of methane formation, when nitrogenous materials are used for feeding. This causes an augment in pH value of the media.

Due to the increase in VFAs production the pH decreased promptly by acidogenic bacteria as well as carbonic acid due to high concentration of carbon dioxide gas at initial stage. The simply digestible portion of organic matter was hydrolyzed and converted to fatty acids quickly. As the Volatile Fatty Acids (VFA) was consumed by methanogens to generate methane the pH value began to increase progressively (Solmaz *et al.*, 2011). It was experimentally observed that there was constant pH after 4th week. Due to proper alkalinity, the substrate was able to safeguard itself and prevented the acidification occurrence during digestion. The result is reliable with the previous research.

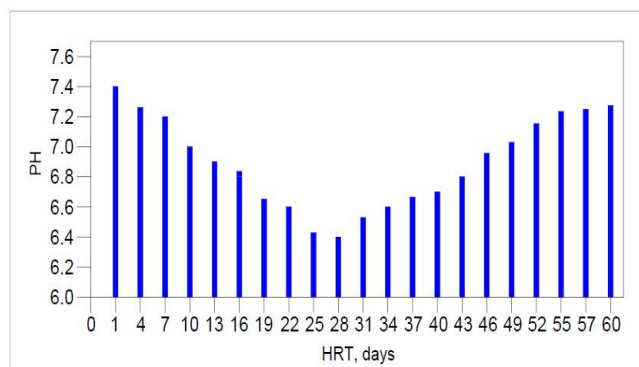


Figure 3.1: Variation in pH of SHW during the experiment, the pH value of SHW varied from 6.4 to 7.5.

3.2 Temperature

The temperature deviation during the experimentation has been shown in the figure 3.2. The temperature of the system deiced within the mesophilic temperature range ie. 28–35^oC. Therefore, for most favorable gas production, the temperature of digester can be increased by 7-10^oC (budiyono *et al.*, 2011), since most favorable temperature at mesophilic condition is 30–35^oC.

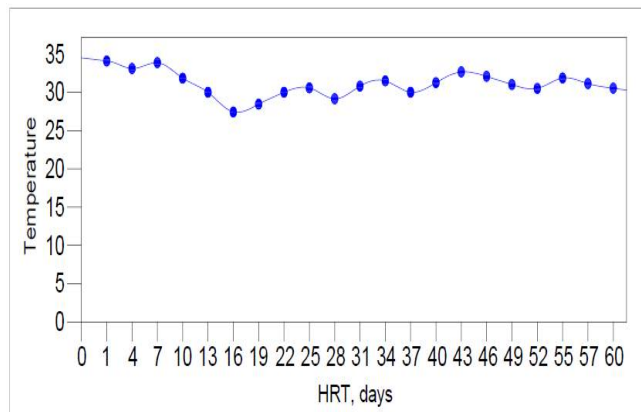


Figure 3.2: Daily average temperature variation of sample

3.3 Biogas production

On the fifth week, the daily biogas yield for SHW digestion hits the highest point. This could be mainly due to the composition of paunch manure, which is mainly fibrous material, rich in lignocelluloses (Recebli *et al.*, 2015). Since the content and distribution of lignin is responsible for the restricted enzymatic dilapidation of lignocelluloses, by restricting the ease of access of enzymes, the putrefaction of these fibrous matters takes longer time by microorganisms. In the commencement and at the end of the digestion the biogas yield generally seems to be lesser. This general drift is recognized to biogas production rate in batch condition which openly corresponds to specific growth rate of methanogenic bacteria in the biodigester. The plot of the biogas collective yield is shown in figure 3.3. After 10 days of observation, biogas is started generating and continued until the end of 60 days of detention period for biodigester containing SHW.

The study was carried out for a period of 60 days. In the commencement and at the end of the digestion the biogas yield generally seems to be lesser. Daily production of temperature, pH and the volume of gas was measured continuously. Gas analyzer is used for testing the biogas for its chemical composition.

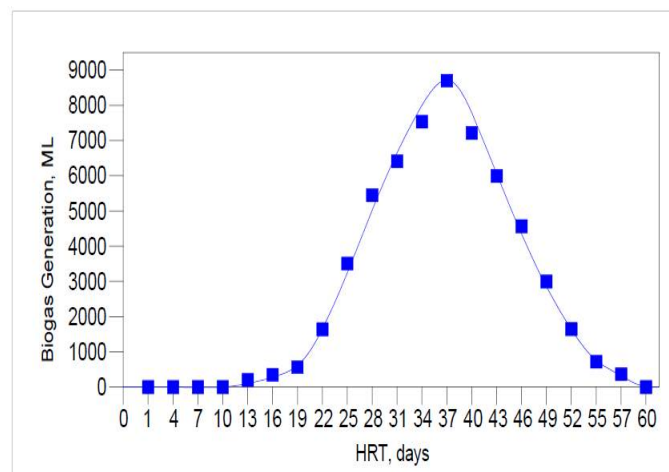


Figure 3.3: Biogas production from SHW.

3.4 Methane yield

Due to the dilapidation of organic matter in the substrates and presence of methanogens from the inoculum, the initial biogas was produced. Due to the occurrence of hydrolysis stage and acid forming stage, fermentative and acid forming bacteria were predominant in these periods the low methane content was the result. Because of the growth of methanogenic bacteria, the biogas yield was then increased, which utilized end products from the acid forming bacteria to produce methane (Ann, 2005). Methanogenic bacteria were predominant at this stage.

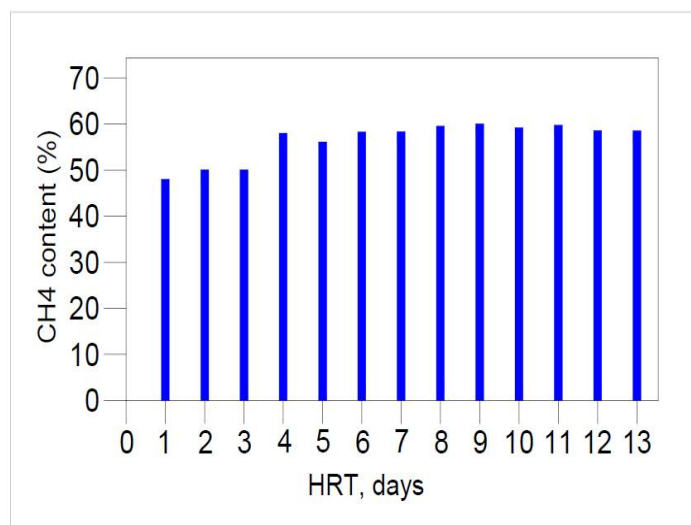


Figure 3.4: Methane gas generated from SHW.

The daily biogas yield for SHW, peak value of biogas yield was 12 L with 56.6% methane content on the 21st day. Methane content was measured after one week of gas formation for SHW in the digester.

3.5 Potential of biogas energy from SHW in ukkadam

The net feed of the slaughter waste obtained from SH present in ukkadam is estimated to be 2560 kg/day (anaerobically digestible waste) (pratima *et al.*, 2015). The total amount of gas production from the slaughter house waste of ukkadam slaughter house is found to be 90.2 m³/day, which is adequate to provide 2 times meal per day for 440 people saving about 67 LPG cylinders per month. About 646 kg fertilizer can be produced daily from the accessible waste.

3.6 Design deliberation of Bio Gas Plant

From the use of Bio gas Calculation tool version 3.1, the volume of biogas plant is calculated to be 694.9 m³ for hydraulic retention time of 60 days. The concept of decentralizing of bio gas plant is made, Since the volume of digester is very soaring and such soaring volume digester are not installed till today and cost of haulage per day for carrying of feeder (slaughter house waste) to plant is assumed to be higher due to the locations of Slaughter house (Sulema *et al.*, 2015). For the decentralization, 694.9 m³ of digester is broken down into 6 small bio gas plants with capacity of 101 m³ of digester each. From each of those bio gas plants fertilizer and biogas shall be sold out.

For 101 m³ digester: After decentralization, from each biogas plant of 101m³, 12.9 m³ of biogas can be produced per day, which can provide 2 meals a day to 59 people in that area. It can replace 9.5 LPG cylinders per month and the quantity of fertilizer produced is 85 kg per day.

IV. CONCLUSIONS AND RECOMMENDATIONS

4.1 Conclusions

The study concluded to the following:

- ❖ The amount of biogas produced from SHW is higher. Slaughter House Waste can be used as a feeder for the production of biogas.
- ❖ The values of pH, Total Solids (TS), Volatile Solids (VS) and C:N ratio obtained from laboratory analysis were 7.3, 23.5%, 76.5% and 23.9 respectively.
- ❖ The favorable pH range for biogas generation, during the anaerobic digestion process lies in between 6.4 to 7.5.
- ❖ The specific gas production from SHW was estimated to be 0.199 m³/kg VS.
- ❖ The methane content of produced gas from SHW lies between 47.5 to 59.9% which is within the range of conventional biogas generation.
- ❖ The amount of biogas produced from slaughter house waste present in ukkadam is 90.2 m³ per day.

4.2 Recommendations

- ❖ A good feeder for the production of Bio Gas is the Slaughter House waste, hence complete study could be carried out on slaughter house waste.
- ❖ The study has to be carried out in larger digester, before going for actual implementation phase, understand the operation in real practice, under continuous / semi continuous feeding system.
- ❖ It is further suggested to carry out investigation using other advanced equipment like mass flow meter, volumetric gas flow meter compatible in low gas pressure, as this test has been carried out in inadequate time frame with restricted resources.
- ❖ There should be obligatory requirement to establish biogas plants in each slaughter house (if more land area is available) or at suitable locations, both from energy enlargement as well as environmental protection point of view.
- ❖ Special targets of the government should be on the large scale biogas plants as in developed countries. This is useful because a considerable amount of currency will be saved for the government in importing fossil fuels.
- ❖ A clean look towards the on hand industrial generation aspect is to be explored creating proper policy, subsidies and incentives. Research work on energy generation from slaughter house waste should be carried out.
- ❖ Additional study could be done on making of biogas from codigestion of slaughter house waste and wastewater.
- ❖ Projection on fertilizer/composting techniques from the effluent of the biogas plant should be deliberated.
- ❖ Outlook of producing electricity from the wastes should be analyzed.

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