Preliminary Investigations into the Operating Parameters for the Generation of Quality Biogas from Piggery Waste

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ABSTRACT
An investigation was carried out to determine the necessary parameters and the required information for the operation of a 42m³ biogas digester constructed at Ojokoro for Ojokoro Cooperative Agricultural Multipurpose Society (OCAMS) by the Federal Institute of Industrial Research Oshodi (FIIRO). The total solids and volatile solids were 14.02% and 3.7% respectively. A mixing ratio of 1.4 kg of piggery wastes to 1.0 litre of water was found to be optimal with a retention time of 15 days. Quantity of biogas produced per day was 65.68 m³ with methane content of 45.68 m³.

Key words: Digester, biogas, total solids, volatile solids, piggery waste

INTRODUCTION
Biogas is created as a result of microbial degradation of lignocellulosic material under anaerobic conditions in a liquid medium, the main active component being the gas produced; methane (CH₄), also known as marsh gas (Abubakar, 1992; Ojosu, 1995). The degradation process takes place in three stages, in which different organisms are engaged.

Facultative bacteria (ie, bacteria that can live in the presence of or without oxygen) break down polymers such as fats, proteins and cellulose (Abubakar, 1992 and Odeyemi, 1998). Apart from producing simpler soluble compounds, these bacteria remove the oxygen from the closed environment, an important step for the subsequent methanization process. Acid forming bacteria turn the compound formed into organic acids such as acetic, propionic and lactic acids. Methanogenic bacteria act on acetic acid to form methane (CH₄). In the presence of hydrogen they can also reduce carbon dioxide (CO₂) to CH₄ (Odeyemi, 1998). Animal manure, such as pig waste, cow dung, and poultry droppings give quicker and better results in biogas production than crop residues (Lawal, et al, 1995). Apart from carbon/ nitrogen ratio, animal wastes that have undergone partial degradation are more readily digested (Odeyemi, 1998). Since biogas production is not totally exothermic, insulation of the system is desirable, hence sinking of the pit underground to maintain an even mesophilic condition is optimal (Forwek, 1994). This explains why, in temperate and colder climates, biogas is less attractive because of lower output, unless special measures are taken. Biogas cannot stand any oxygen change and fluctuations in temperature, it is also sensitive to changes in pH (optimum 6.80 – 7.2) (Adewunmi, 1995). Soluble sulphide such as nickel, copper, zinc and detergents act as inhibitors. If any of these are present in the system, the plant performance is reduced (Onyekwelu, 1991; Garba and Sambo, 1992; Odeyemi, 1995).
Biogas is a flammable gas produced by anaerobic fermentation of organic waste materials. It is composed of methane (55-70%), carbon dioxide (30-40%) and traces of other gases, such as nitrogen, hydrogen, water and hydrogen sulphide (Abubakar, 1992). The production of biogas from animal waste has existed for more than 100 years and it is an undisputable fact that in many countries of the developing world, including Nigeria, most of the energy for domestic use comes from fuel wood. This poses a great danger for wildlife and desert encroachment, as well as soil erosion, particularly for locations close to the desert. These ecologically harmful practices can be checked by adopting the use of biogas technology which produces gas for use in cooking and lighting, as well as fuel for running small thermal engines (Forwek, 1994).

A detailed review of biogas production had earlier been reported (Lawal et al, 1995). Preliminary investigations as to the quantity of pig waste feed stock available at Ojokoro Cooperative Agricultural Multipurpose Society; a piggery farm in Lagos, has been assessed (Lawal et al, 1995). However, the generation of parameters on laboratory scale for the production of quality biogas from piggery waste is yet to be done. This paper, therefore, is a research on the appropriate water to piggery waste mixing ratios, the suitable materials to be added to increase the carbon content, and the monitoring of all necessary parameters required in biogas experiments, including the simple burning test in order to obtain good quality biogas. The data generated will be used for the successful running of the 42m³ digester designed and constructed by FIIRO.

**Preparation of Feed Stocks:** This is as shown below, taking into consideration the objectives of the research.

**Experiment No. 1**

To determine the appropriate mixing ratio:

i. 1.2 kg : 1 litre(fresh piggery waste to water)

ii. 1.5 kg : 1 litre(fresh piggery waste to water)

**Experiment No. 2**

To increase the carbon content of the feed stock

i. 2.0 kg of piggery waste + 1.0 kg of cassava leaves.

ii. 2.0 kg of piggery waste + 1.0 kg of grass.

iii. 4.2 kg of piggery waste blended with 1.64 litre of corn steep liquor.

**Experiment No 3**

Another experiment was performed on one-week old piggery waste using a ratio of 1.4 kg:1 litre (piggery waste to water). The gas produced was later passed through 10%(w/v) potassium hydroxide and 10 grams of anhydrous calcium chloride to remove carbon dioxide and water vapour respectively.

In the above experiments, the following items were monitored:


ii. Volatile solids(as stated in A.O.A.C. 1980 method)

iii. pH: carried out on daily basis

iv. Temperature: taken twice daily(morning and later in the afternoon)

vii. Gas produced, monitored daily

viii. Gas analysis, done on a weekly basis

ix. Stirring, done on a daily basis

x. Quality of gas by simple burning test using a glowing splint

**MATERIALS AND METHODS**

**Sample collection:** Fresh piggery waste material was collected at the dumping site of OCAMS, located in the suburb of Agege in Lagos metropolis.

**Digester Design:** Laboratory type digesters fabricated at the Federal Institute of Industrial Research, Oshodi(FIIRO) were used for the experiments, carried out in the different digesters. The digester is 30cm high with two outlet connections, one for gas and the other for the introduction and taking out of slurry samples. A glowing splint was used to test for quick burning.
RESULTS AND DISCUSSION

Physiochemical assessment and quality of biogas monitored for the various experiments revealed that the pH was within the range required for biogas production, but good quality biogas was not yet obtained as evident from the quick burning test that gave poor result as shown in table 1.

Table 2 also showed similar results, as the expected biogas yield could not support combustion.

Table 1. Physicochemical assessment and quality of biogas using mixing ratio of 1.2 kg:1.0 litre (Piggery waste: water)

<table>
<thead>
<tr>
<th>Weeks</th>
<th>Average PH</th>
<th>Average Temp°C</th>
<th>Vol of gas produced (m³)</th>
<th>Analysis of biogas CO₂:CH₄</th>
<th>Quick burning test for gas</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>6.9</td>
<td>32</td>
<td>0</td>
<td>High:low</td>
<td>NB</td>
</tr>
<tr>
<td>1</td>
<td>6.6</td>
<td>40</td>
<td>0.8</td>
<td>High:low</td>
<td>NB</td>
</tr>
<tr>
<td>2</td>
<td>6.3</td>
<td>32.5</td>
<td>0.6</td>
<td>High:low</td>
<td>NB</td>
</tr>
<tr>
<td>3</td>
<td>6.8</td>
<td>32</td>
<td>1</td>
<td>High:low</td>
<td>NB</td>
</tr>
<tr>
<td>4</td>
<td>6.4</td>
<td>33</td>
<td>2</td>
<td>High:low</td>
<td>NB</td>
</tr>
<tr>
<td>5</td>
<td>6.4</td>
<td>32</td>
<td>1.2</td>
<td>High:low</td>
<td>NB</td>
</tr>
</tbody>
</table>

Total solids: 19.76%, volatile solids = 5.6%, NB: Not burning

The results of experiment 3 is as shown in table 3, which showed good quality combustible biogas yield.

Experiment no. 3 was therefore adopted and used in formulating the likely expectations from the 42m³ OCAMS biogas digester. Adoption of results from experiment 3, has achieved the following:

The appropriate mixing ratio of the slurry, the total solid (TS) and the volatile matter of the slurry, the quantity of pig manure to be fed in per day, the temperature of the digester, the retention time (RT), the expected gas yield per day, and the quantity and quality of biogas to be produced.

The retention time was 12 days, and at this stage, the biogas produced was scrubbed by passing it through 10% KOH and 10% calcium chloride. As earlier stated from the result, the following deductions were made.

i. The mixing ratio helped to enhance the stability of the pH.
ii. The KOH helped to remove the non-combustible carbon(iv)oxide and ammonia.
iii. Calcium chloride helped to remove water vapour
iv. Combustible blue flame obtained for quite some time with 2-3 hours build-up from the digester.

The following were expected from the OCAMS biogas digester: total solids of 14.02%, volatile solids of 3.7%, the biogas reactor size is 42m³, the volume of
manure to be pumped in per day after the initial start up of the digester was 2.4m³, the retention time (RT) was between 12-15 days, the appropriate mixing ratio was 1.4kg-1 litre (piggery waste to water). The volume of spent material after digestion was 2.4m³, the temperature inside the digester in the morning was 35°C, and in the afternoon: 42°C, bulk density of the material after digestion was 0.83kg/m³. From the various calculations made, quantity of biogas expected per day was 65.68m³, the methane gas expected after scrubbing was 45.68m³ per day. The volume of potassium hydroxide was 204 kg in 25 litres of water and quantity of anhydrous calcium chloride was 3.0 kg.

Conclusion

Studies have shown that piggery waste can be a good source of natural raw material for biogas generation. An appropriate mixing ratio and other optimal conditions, as highlighted from the study, will help to ensure that adequate and good quality biogas is produced. The data generated can be used to successfully operate the 42m³ biogas digester plant.

REFERENCES


