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Recovery of Energy from Waste Generated in Biogas Power Plant

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ABSTRACT

Present investigation deals with recovery from anaerobically digested biomass resources such as cattle dung, agriculture wastes and other organic waste with the addition of various cultures and cascading with other waste such as poultry residue. Biogas production is a clean, low carbon technology, useful for the efficient management and conversion of organic waste into clean renewable biogas and organic manure/fertilizers. It has the potential for leveraging sustainable livelihood development as well as tackling local and global land, air and water pollution. It has been seen that culture like rhizobium, phosphor-culture etc. can be used for re-anaerobic digestion of digested slurry and biogas yield can be increase to 1.3 to 1.5 times than the without use of culture. The biogas quality also gets improved with 48.38% methane and extraction of humic acids becomes easier. Further it has been also seen that NPK content in manure was higher than that without culture. The present work will be worthy for academicians and people dealing with bio-energy, environmental pollution.

Key words- Biogas, anaerobic digestion, culture,

1. INTRODUCTION

In today's energy demanding life style, need for exploring and exploiting new sources of energy which are renewable as well as eco-friendly is a must. In rural areas of developing countries various cellulosic biomass (cattle dung, agricultural residues, etc.) are available in plenty which have a very good potential to cater to the energy demand. Based on the availability of cattle dung alone from about 304 million cattle, there exists an estimated potential of about 18240 million cubic meters (m cu m) of biogas generation annually. The increasing number of poultry farms is another source which can generate biogas of 2173 m cu m annually. In country like India itself there is huge amount of biomass available which is a good renewable source of energy. Biogas comprises of 60-65% methane (CH_4), 35-40% carbon dioxide (CO_2), 0.5-1% hydrogen sulphide (H_2S), and the rest is water vapor etc. it is almost 20% lighter then air. Biogas technology offers a very attractive route to utilize certain categories of biomass for meeting partial energy needs. In fact proper functioning of biogas system can provide multiple benefits to the users and the community resulting in resource conservation and environmental protection.

In our project we will discuss about the use of dig estate or digester output and how to recycle the slurry. Slurry contains a lot of unused resources when it is applied to the field, and some of them end in the environment causing problems when their concentrations rich certain levels, like greenhouse gas emissions (GHG) and eutrophication of ground water. In our project we will investigate the possibility of taking out some of these resources of biogas plant to produce energy. All the changes will be taken in consideration and analyzed in detail for a final evaluation of the viability of this project.

2. PROCESS AND MECHANISM OF BIOMETHANATION

Anaerobic digestion is a biological process that involves the bacteria decomposition of organic compounds in organic waste material to methane, carbon dioxide and simpler organic compounds. This takes place in three main stages-

CELLULOSE + NUTRIENTS

$$(C_6H_{10}O_5)_n + nH_2O \xrightarrow{Hydrolysis} n(C_6H_{12}O_6)$$

Extracellular enzymes.

Step-1 Hydrolysis

SOLUBLE GLUCOSE + NUTRIENTS

$$(C_6H_{12}O_6) \longrightarrow 2CH_3CHOHCOOH$$

Acid producing bacteria

Step-2
Acid-phase

$$(C_6H_{12}O_6) \longrightarrow CH_3CH_2CH_2COOH + 2CO_2 + 2H_2$$

$$(C_6H_{12}O_6) \longrightarrow 2CH_3CH_2OH + 2CO_2$$

BACTERIA CELLS + [VOLATILE FATTY ACIDS] $+CO_2 + H_2$

$$4H_2 + CO_2 \rightarrow CH_4 + 2H_2O$$

Methane producing bacteria

Step-3

$$2CH_3CH_2OH + CO_2 \rightarrow 2CH_3COOH + CH_4$$

Methane fermentation

$$CH_3COOH = CH_4 + CO_2$$

$$CH_3CH_2CH_2COOH + 2H_2O + CO_2 = 4CH_3COOH + CH_4$$

BACTERIA CELLS $+CH_4$ $+CO_2$

FIRST STAGE (HYDROLYSIS)

The first step involves the enzyme-mediated transformation of insoluble organic material and higher molecular mass compounds such as lipids, polysaccharides, proteins, fats, nucleic acids, etc. into soluble organic materials, i.e., to compounds suitable for the use as source of energy and cell carbon such as monosaccharide's, amino acids and other simple organic compounds. This step is called the hydrolysis however if used as additives in biogas plant could improve its performance significantly.

SECOND STAGE (ACIDOGENESIS)

In the second step, acidogenesis, another group of microorganisms ferments the break-down products to acetic acid, hydrogen, carbon dioxide and other lower weight simple volatile organic acids like propionic acid and butyric acid which are in turn converted to acetic acid.

THIRD STAGE (METHANOGENESIS)

In the third step, these acetic acid, hydrogen and carbon dioxide are converted into a mixture of methane and carbon dioxide by the methanogenic bacteria for growth of microbes

3. MATERIALS AND METHODS

List of Instruments Used For Designing of Digester

1] Digester : Three batch type airtight Digester, capacity - 14 liters

2] Biogas container: glass type, capacity - 1 liter

3] Plastic tubes : 0.5 inch, 0 .25 inches.

4] Water displacement meter.

5] Digital pH-electrode meter.

6] Gas analyzer Multiwarn II equipment.

In my experiment, I used different type of additives.Such as poultry waste, cultures for example (rhizobium, phosphoculture), to enhance the biogas production. In this experiment digested slurry of biogas power plant is used.

Three different samples are made such as poultry waste with slurry, digested dung alone, with cultures. Some positive result is achieved. Output of the digester which maximum plants are just lefted at the open space can be used as a seeding. Washed out microbes can be recirculated with some additives to enhance biogas production.

4. BASIC EXPERIMENTAL WORK

Material used

Slurry which is used for the experiment is collected from the pariyat plant. Another additives such as poultry litter, cultures etc are collected. Three digester were used in this experiment and each digester was a simple cylindrical batch feeding digester that has no moving parts. Each digester was loaded with cow dung, water and slurry and then sealed off for the production of biogas to begin for the retention time 2-3 weeks. At the end of the experiment, the digester was off loaded by opening the lid and removing the slurry, this digested slurry is ready for the seeding.. The digested slurry was used in this experiment because it will make fermentation faster.

A set of 3 containers (each of capacity 14 liters) was used as digesters for this experiment, that is, one digester for each sample. Another set of 4 flasks was used. Each contained water and was connected to a particular digester by means of a connecting tube and also, on the other side, connected to a measuring cylinder by means of a connecting tube. The gas collecting apparatus was used to run-off and measure water displaced by the collected gas. The gas was collected by water displacement method. This was carried out by measuring and recording the quantity of water displaced daily using a 100mL measuring cylinder.

Thus, the biogas produced in the digester by the digested slurry (sample) passed through the connecting tube to the flask containing water. The pressure of the biogas produced caused a displacement of the water through a connecting tube on the other side of the flask.

The digester was operated at ambient temperatures. The average temperature was calculated and assumed to be the operating temperature. A digital pH-electrode equipment meter was used to determine the pH of the digested slurry (sample) for the experiment. Gas analyzer Multiwarn II equipment is also used to measure the methane quantity.

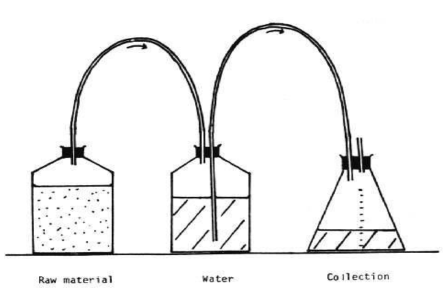


Fig1. Diagram of the experimental digester apparatus

Experimental setup 1

All three digester filled with digested slurry. In First sample, I used slurry and poultry waste mixture. Ratio with water and the whole waste then loaded to about 3/4 of the digester volume. Ratio of water and waste is 1:1.

Experimental setup 2

In second sample, I used mixture of digested slurry and rhizobium culture. About 250 gm of substrate is used**.** Ratio with water and the whole waste then loaded to about 3/4 of the digester volume. Ratio of water and waste is 1:1.

Experimental setup 3

In third sample, I used mixture of digested slurry and phospoculture. About 250 gm of substrate is used**.** Ratio with water and the whole waste then loaded to about 3/4 of the digester volume. Ratio of water and waste is 1:1.

Fig2. Experimental set up of digester

5. RESULTS AND DISCUSSION

Case 1: IN THIS SAMPLE I USED SLURRY + POULTRY WATE MIXTURE. Daily biogas production for first sample is shown in the fig.3. After feeding anaerobic digestion starts and it takes about 15 to 20 days to produce biogas. In this sample gas generation starts from 15th day. Then as the day's progresses biogas generation increases gradually. Maximum gas generation is recorded in 60th day i.e. about (0.45 l/g vs.). After that because of the complete digestion of feed material in the digester takes place the digestion process has stopped.

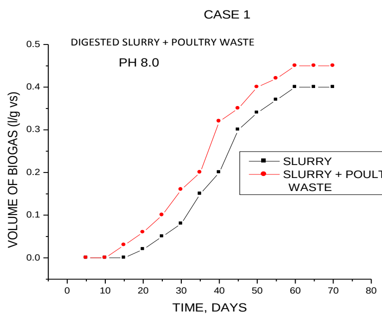


Fig3.

Case 2 : IN THIS SAMPLE I USED SLURRY + RHIZOBIUM CULTURE MIXTURE. daily biogas production for SECOND sample is shown in the fig.4 . After feeding anaerobic digestion starts and it takes about 15 to 20 days to produce biogas. In this sample gas generation starts from 20th day. Then as the day's progresses biogas generation increases gradually. Maximum gas generation is recorded in 55th day i.e. about (0.42 l/g vs.). After that because of the complete digestion of feed material in the digester takes place the digestion process has stopped.

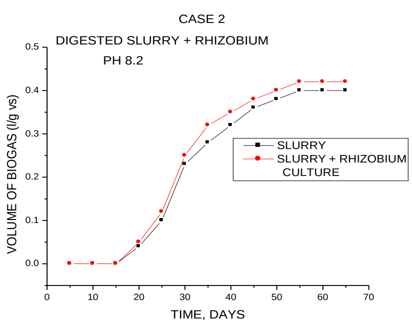


Fig4.

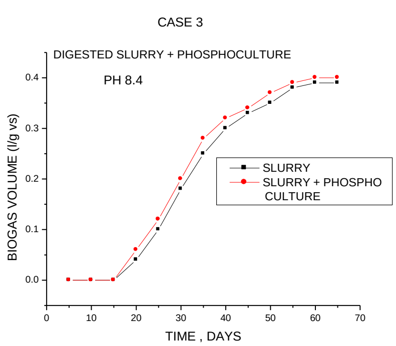


Fig5. Daily biogas production of case-2

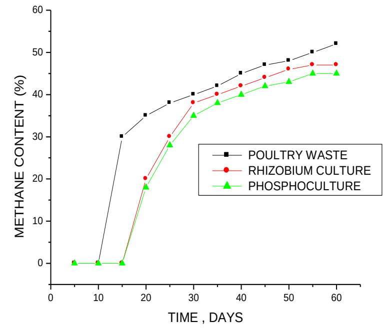
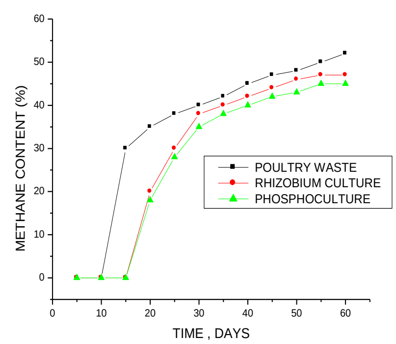


Fig6. Daily biogas production of case-3

Case 3: IN THIS SAMPLE I USED SLURRY + PHOPHO CULTURE MIXTURE. Daily biogas production for THIRD sample is shown in the fig.4. After feeding anaerobic digestion starts and it takes about 15 to 20 days to produce biogas. In this sample gas generation starts from 20th day. Then as the day's progresses biogas generation increases gradually. Maximum gas generation is recorded in between 55th – 60thday i.e. about (0.40 l/g vs.). After that because of the complete digestion of feed material in the digester takes place the digestion process has stopped.

6. COMPARISON BETWEEN THESE THREE SAMPLES ON THE BASIS OF METHANE PERCENTAGE IN THE GAS PRODUCED: FOLLOWING

Figure shows the methane (%) content in the gas produced for the above samples. For analyzing the composition of the biogas, I used Gas analyzer Multiwarn II equipment.



From the above graph we clearly understand that methane contained in sample first is more then that of other two samples. About 50% of total gas is methane.

7. CONCLUSION

In the present investigation it has been found that waste generated in the biogas power plant is harmful not as economic point of view but it is highly polluting and hazardous a for human beings. However this waste can be further anaerobically digested and that will not only eco-friendly but also it will generate biogas as high quality manure. For rapid digestion it has been found that slurry with PW in 60:40 leads high gas yield. Methane content in the generated biogas is also more than 47 % which is sufficient to run gas engines in power plant.

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