Journal of Physical Sciences and Innovation *Volume 4, September 2012*

www.cenresinpub.org
ISSN 2277-0119

ENERGY PRODUCTION FROM ORGANIC WASTE

[1]Hayatu Abba Ibrahim and [2]Mohammed Maina
Department of Physics, University of Maiduguri, Borno Nigeria
Department of S.L.T., Ramat Polytechnic, Maiduguri, Borno, Nigeria
E-mail: hayatuabbaibrahim@yahoo.com

ABSTRACT

In this research work, organic wastes were used for the production of biogas. The generation of energy, from organic wastes (animal wastes) millet stalks, which is the biomass was used in carrying out the experiment, and also cell lysate and then a digester was used for the fermentation which is a drum type digester. The result shows that, from the digestion of organic wastes (biomass) and the cell lysate, methane gas was obtained as the biogas. The production showed that about 60-70% of methane and 40% of carbondioxide were obtained. Other gases obtained were hydrogen sulphide 0.5%, sulphurdioxide of about 0.4 - 0.6% . The maximum temperature maintained was about 50 – 60 ^{0} F (=28^{0}C) .This research shows that organic wastes could be used as an alternative to energy source.

Keyword: *Biomass, digester and Biogas*

INTRODUCTION

Energy production from organic waste as Biogas is done many times specifically, using animal wastes. The first person to have observed that decaying vegetation produces a combustible gas was Alessandro Volta, 1776. Thirty (30) years later, Volta's gas was proved to be identical with methane gas by William Henry, in early 1800's .Humphray Davy noticed that methane gas was present in farm yard manure. In 1882 – 1884, Trappeiner showed that methane gas was of microbiological origin. India has pioneered small scale anaerobic digestion processes mainly using cow dung rather than agricultural wastes .The first plant for the production of methane utilizing such process was set – up in a leper a selum in 1900 . Another plant was set – up in Indonesia in 1914 in which used strawboard wastes as the source of gas. It was during the Second World War that interest on biogas reached a peak, but the interest later warned because there were cheaper petroleum resources. In 1970 China began the systematic production of biogas in rural area. As a result of the 1972 oil crisis. Brazil launched its national fund programme in 1975 with biomass supplying about 25% of her total energy requirements and France undertook same bio – fuels programmes in Europe, in fact almost all countries enrolled in energy production in the form of biogas, mainly from wood and crop residues as a result of plants producing methane from saw mills and logging wastes. Until 1992, professor .A. S. Sambo in a paper titled 'Renewable Energy Resource in Nigeria' estimated that the biomass resources of the nation stand at about 9x10mJ. Anaerobic digestion provides a means for treating organic wastes. Biogas production by digester has been regarded as an attractive method to deal with the concern of growing wastes disposal showing energy crisis simultaneously (Barker, 1989). Also higher temperature favours the growth of thermophilic bacteria and the fermentation rate is considerably faster (Chittenden et al, 1980).

Lingo celluloses which are the major components of plants residue can be degraded by actinomyceted . This is one of the reasons why compositing is sometimes carried out .It helps in breaking down of the complex structures of the plants to simple ones , which can be easily degraded by animals (Crawfort et al 1997) . In 1997, professor Adeniji of the University of Maiduguri designed and constructed biomass digester utilizing cow dung for the production of methane gas.

SOURCES OF BIOMASS

The biomass resources of Nigeria can be identified as wood, forage grasses and shrubs, animal wastes, waste from forestry, agricultural, municipal and industrial activities. These are generally classified into three categories:

(i) Natural vegetations

The natural vegetation used for biomass are mainly used in the form of wood from trees. Wood is normally 50% cellulose, 25% hemicellulose and 25% lignin. Dried wood has an energy content of 15 x 10^7KJ/metric tonne, (Dort et al., 1978). The wastes from trees cut down for papermaking or timber contains cellulose for direct combustion after drying.

(ii) Energy plantation and Energy crop

Several authorities have estimated the land area needed for energy cultivation in order to provide a country's energy requirement. In 1993, calculations for the estimates shows that at 1% conversion photosynthesis efficiency, 1/10th of the total energy requirements of the nation could be met by about 99% of the land area, (SCEGO et al, 1995). The energy used in producing biogas should be less than the energy obtained in the out put, unless the energy form is not available from any other source. Example of energy crops are Eucalyptus pine, sugar cane, bites, sun flower, palms sweet sorghum e.t.c.

(iii) Organic Wastes

Organic wastes suitable for conversion into biogas include industrial wastes such as paper and pulp, urban gabbage, domestic sewage and agricultural and forestry wastes (stalks, dung, branches, e.t.c.). Other biomass sources are domestic refuse and agricultural wastes. High energy cost experienced presently will lead to a reassessment of the role of such wastes both as sources of energy and fertilizer.

THE PRINCIPLE OF BIOGAS FORMATION

Organic materials and dead plants decays down, which are generally carried out by bacteria. Aerobic bacteria produces the decomposition in the presence of air while anaerobic bacteria affects it in the absence of air , gases escape and the residue is left , which is the manure , when decomposition takes place in the absence of air . Since it is the gas needed, then we involve anaerobic bacteria chemical reaction. During anaerobic process, three gases are evolved – methane, carbondioxide and hydrogen sulphide. Therefore, when organic wastes

are put in the container, no gas will be produced. The oxygen contained in the slurry is consumed in the aerobic bacteria. Once the oxygen is used up, the anaerobic reaction commences. Thus; there is a time lag between feeding the wastes into the digester and the production of gas.

PURIFICATION OF BIOGAS

Biogas is a mixture of carbondioxide, methane gas carbondioxide, Hydrogen, Nitrogen, Hydrogen sulphide and Hydrocarbon gas . The presence of carbondioxide and Hydrogen Sulphide in biogas is undesirable and may be removed if desired.

REMOVAL OF CARBONDIOXIDE

Carbondioxide is colourless and odourless gas .It is heavier than air and does not support combustion nor does it burn itself. Its being removed from biogas by passing the biogas into lime water which turns milky due to the formation of calcium trioxocarbonate (iv)

$$Ca(OH)_{2(aq)} + CO_{2(g)} \rightarrow Ca\,CO_{3(g)} + H_2O_{(L)} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(1)$$

In excess , the water turns clear again due to formation of calcium hydrogen trioxocarbonate (iv) .

$$Ca\,CO_{3(S)} + H_2O_{(L)} + CO_{2(g)} \rightarrow Ca(HCO_3)_{2(sq)} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots..(2)$$

Alternatively , concentrated caustic potash solution could be used to absorb carbondioxide from biogas .

$$2KOH_{(aq)} + CO_{2(g)} \rightarrow K_2\,CO_{3(aq)} + H_2O_{(L)} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots..(3)$$

Since its soluble in caustic soda, it is absorbed as follows:

$$2NaOH + CO_2 \rightarrow Na_2\,CO_3 + H_2\,O \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(4)$$

In excess caustic soda,

$$NaCO_3 + CO_2 + H_2O \rightarrow 2NaHCO_3\,. \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(5)$$

In the absence of these chemicals, the biogas can be passed through water in which case, carbondioxide reacts with water to form carbonic acid , a weak acid .

$$CO_{2(aq)} + H_2\,O_{(L)} \rightarrow 2H_{(aq)} + CO_3 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(6)$$

REMOVAL OF HYDROGEN SULPHIDE

Hydrogen sulphide is colourless , highly poisonous gas , it has a characteristic smell of rotten egg . It is removed from biogas by passing the gas through Lead acetate.

$$CH_3COO_2Pb_{(aq)} + H_2S_{(g)} \rightarrow 2CH_3COOH_{(aq)} + PbS_{(g)} \quad \text{.....(7)}$$

Hydrogen sulphide will precipitate many metallic sulphide when added to solution of metallic salts .When bubbled through solution of Copper (II) Sulphate(IV) , Iron (II) Sulphate (IV) ,Lead (II) Nitrate black precipitate are formed respectively , i.e. :

$$CUSO_{4(aq)} + H_2S_{(g)} \rightarrow CUS_{(g)} + H_2SO_{4(aq)} \quad \text{.....(8)}$$

$$FeSO_4 + H_2S_{(g)} \rightarrow FeS + H_2SO_{4(aq)} \quad \text{.....(9)}$$

$$Pb(NO_3)_2 + H_2S_{(g)} \rightarrow PbS + 2HNO_{3(aq)} \quad \text{.....(10)}$$

After absorbing carbondioxide and hydrogen sulphide, the balance is methane. Methane is colourless, non-poisonous gas, it's much lighter than air, it burns in air with a luminous flame of heat in the process

FACTORS AFFECTING BIOGAS PRODUCTION

To facilitate optimum efficiency of biogas production, the condition in the biogas plants should be favourable to the bacteria involved. A number of factors such as , the nature of the organic wastes , concentration of the slurry , temperature , PH value , degree of mixing , and even seeding with bacteria have been found to affect biogas production (Twiddel and weir ,1990). In an experiment conducted, it was also found that the nature of the feedstock affects biogas production (Weir, 1992). The chemical composition of the feedstock determine the carbon contents, Nitrogen content and PH of the slurry, and all these factors affects gas yield. Manure is found to have variable Nitrogen content and usually consists of faeces , urine and any bedding materiel like straw and corn/millet stalks .Since Nitrogen when excess in animals is excreted in the urine , then the Nitrogen content of the manure depends on the proportion of urine mixed with it .When also , different concentration of slurry are used , the volume of biogas produced increases with increase in concentration , until after a certain limit which it decreases . Stiring also affects the yield of biogas, but its good to stir after feeding, but not continuously and not omitted completely because it could lead to scum formation which may cause a drop in the production of gas. The retention time , which is the time lag between feeding of the slurry into the digester and the time of gas production .Normally , this varies between 8-20 days , with gas production increasing with the number of days . Also, the capacity of the gas collector affects its production. The higher the volume of the gas collector holder, the much gas it can hold at a time, thus enhancing the digester are of batch purpose.

METHOD OF BIOGAS PRODUCTION

Biogas can be produced using digester which ferments the biomass in the absence of air (anaerobically). Basically, there are two methods or types of digester namely: Drum type digester and drumless type digester.

Drum type Anaerobic Digestion

The conventionally plant , originally developed at the Indian Agricultural Research Institute , New Delhi (1935) ,of the drum type consists of masonny digester (i. e. fermentation tank) , with an inlet pipe on one side for feeding the biomass mixed with water. The methane gas is produced by bacteria in either of the methods. The bacteria are anaerobic which operates only in anaerobic environment (i.e. environment that is free from air). Constant temperature in the drum type digester, PH and fresh organic matter promotes maximum methane production. Anaerobic digestion is a two parts process and each part is formed by a specific group of organisms .The first part is the breakdown of complex organic matter into simple organic compounds by bacteria .The served group of micro organisms, the methane formers break down the acid in the methane (Vyas et al, 1989). In a properly functioning digester , the two groups of bacteria must balance so that the methane formers can use just the acids produced by the acid formers .The gas produced in the drum type digester collected in a gas holder or drum-placed over the liquid surface .

Drum less Type Anaerobic Digester

In this type, the pipe for gas flow can be connected directly to the burner or separately .There is no moving part as the whole digester (plant) is an underground well with gas outlet .It is provided with a sloping and smooth inlet on one side and a rectangular outlet on the other side for removal of used slurry. Biogas is also formed in the absence of oxygen and through the fermentation of biomass, which is taken out through a certain pipe fixed to the gas holder or drum.

RESULTS OBTAINED FOR THREE WEEKS DURING THE RESEARCH

Number of days	Gas produced	Quantity of gas (cm^3)	Effects
1— 8	Carbondioxide (co_2)	About 2—3	It does not support combustion
10—12	Carbondioxide (co_2)	About 0.5—1	It does not support combustion
14—16	Methane (CH_4) and hydrogen sulphide (H_2S)	About 0.4—0.9	It has choking smell
18—21	Methane gas only	About 10—15	It burns with pale blue flame

DISCUSSION OF THE RESULT

With reference to the table above, which is after the anaerobic digestion, the gas being produced finally is the methane gas. For the first seventh day, a colourless and odourless gas was produced which shows that fermentation has started occurring. Also on the tenth to twelth day, the gas produced does not support combustion, which is carbondioxide. On the fourteenth day , methane and hydrogen sulphide gas was produced , which has choking smell . Finally, 10—15cm^3 of gas was produced after twenty-first day, which shows that methane gas is present.

GENERAL DISCUSSION

In anaerobic process of biogas production, temperature is considered an important operational parameter. It has been discovered that lower temperature tends to favour the acid forming bacteria and the accumulation of volatile acids which inhibits the methanogens and can even inhibit the process. In the course of the experiment, the millet stalk used were large and were also chopped into smaller pieces. Animal wastes in this case were already broken by the animal digestive track and chewing as the plants are being eaten (Lanman , 1974). Moisture content of the biomass can be contributing factor of gases evolving from the waste. A balance condition has to be maintained for the system to operate effectively. A successful operation of a digestion relies on the correct balance between various groups of bacteria involved in this process (Chittenden et al, 1980).

RESEARCH PROBLEMS AND SUGGESTION

The main problem of this experiment is the fact that it is dependent on the pressure, volume and temperature (PVT) scale of thermodynamics. At a lower temperature , the action of anaerobic bacteria of some kind that are good composer or decomposer are less active and this will definitely affect the gas production capacity of the digester. However, agitation of the digester creates a new pressure in the system, since the system air tight, there is always an increase of the temperature by setting the organic wastes (biomass) and water content as digester in motion. This will increase the total kinetic energy of the system and a rise in temperature is achieved. Another problem encountered in this research work is the problem of linking (escape) of gases, which almost rendered this experimental work fruitless. The main cause of this is rusting which equally did not allow easy screw of the nuts and bolts. To my believe, the rusting is caused by the reaction between the surface of the metal and the water molecule. To solve this problem, grease was applied in most cases to aid loss the nuts and oily maintenance of the relevant arts of the digester. For the linking, araldite was used to glue the linking parts but in order to avoid subsequent linkage, it was mixed with small amount of sand so that force of adhesion is achieved in sealing the linking points. Another serious problem encountered was the blockage of the slurry inlet by the waste when feeding the digester. To avoid this , the millet stalk have to be chopped into smallest pieces before they are pushed down the inlet and not be mixed with water as much of water will be lost in the process of feeding the digester .

CONCLUSION

Almost every organic waste will produce methane gas, but with all things being equal, some are better. Generally, animal wastes produces higher yields of gas over a shorter length of time than vegetable wastes due to the fact that animal waste are partially digested by the animal digestive system. Vegetable wastes especially azadirachta indica although gave out a higher quantity of gas, it takes longer time to be digested in an anaerobic conditions and may not therefore be practically producing higher amount of gas than animal wastes. Methane gas generated from organic waste is used for firing ceramic works , can be used as source of energy in cooking and can easily be constructed . Methane gas can be cheaply produced in this manner with the advent of energy crises and ever rising process of fossil fuels. Instead of collecting and burning the wastes, which pollutes and cause green house effects to the environment, they can be used in digesters where environmental hazard like air pollution and cost of revitalization of environmental damages are going to be reduced. Concerns for energy conservation, environmental pollution and the fact that agricultural organic wastes account for a major portion of our waste materiel has created renewed interest in the processing these wastes for energy recovering of several types of energy capturing process available, anaerobic digestion appears to be the most feasible for the majority of agricultural operations .Anaerobic digestion can stabilize most agricultural wastes while producing biogas or methane gas.

REFERENCE

Abubakar , M. M. (1990) : Biogas General from Animal Wastes ; Nigeria Journal Renewble Energy 1 .

Berkar, H. A (1989): On the Biochemistry of methane Fermentation. Architect microbial pp 404, 405.

Barners, D. (1981): Water and wastewater engineering system p .548

Chittenden, A. E, Head, S W and Reag G. B. (1980): Anaerobic Digestion for small scale vegetable processing. Plants Report on tropical products Institute, p. 139

Dunn, P. D. (1986): Renewable Energies, Sources Conservation. and Application, peter peregrinius Ltd; London, pp274-279.

Dort R. C. (1978): Energy Resources and policy; Addison Wesley company, massachussets, p. 25.

Fernado C. E. C. and Dangogge S. M. (1986): Investigation of some parameter, which affect the performance of Biogas plants, Nigerian Journal Solar Energy, pp 142 – 147.

Garba, B and Sambo, A. S (1992): Effect of operating parameters on Biogas production Rates; Nigerian Journal on Solar Energy, 3; pp 36 – 44

Grierre, M. (1977): A moderri Harball Beyel (Edit) Jonathan Cape Ltd; London p. 287.

Hansen, R. W (1992): Methane Generation from Livestock wastes, pp. 20 – 60.

Hutchmnsion, J. and Datael, J. M. (1963): Flora of West Tropical Africa 2. Hepper F. N. (E. d); Crown Agent for Oversea Government London, p. 61

Maishanu, S. M; Musa, M and Sambo, A. S. (1990): Biogas Technology Development at the Sokoto Energy Research Center, Energy, 3, pp. 36 – 44.

Silverier, C. M. (1986): Microbiology of Biogas Generation ASEAN Course on Biogas Technology and Techniques, pp 35 – 45.