Sudan University of Science and Technology

College of Animal Production Science and Technology

BIOGAS PRODUCTION FROM POULTRY MANURE

انتاج الغاز الحيوي من زرق الدواجن

A desertion Submitted in Partial Fulfillment of the Requirement for the Degree of Bachelor of Science (Honours) In Animal production science and technology

Submitted by:

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Dedication

To our parents,

Supervisor,

Teachers,

Families,

Friends and all gave help,

We dedicate this work.

Acknowledgment

First almost grateful thanks to Allah for all He has giving us to complete this work. We wish to express our special appreciation and gratitude to our supervisor Dr. Daoud Elzober   for his suggestions, guidance and good supervision during this work .

Our thanks are extended to our families for their encouragement during the study and special thanks are due to our colleagues.

Finally we thank all people who help us throughout our study.

Abstract

The study was conducted at College of Animal Production Science and Technology, Sudan University of Science and Technology. The objective of this research was to design and construct a simple digester for production of biogas in rural area using poultry manure and other animal and plant byproduct. A plastic digester of 50 L was used in this study using poultry manure and plant byproduct as main component for the production of biogas, the ratio of carbon and nitrogen source was 3:1. The PH was 7.0 at the start of the experiment and 7.5 at the end of experiment. The total biogas produced was 260ml. the study concluded that poultry manure is good byproduct for production of biogas.

المستخلص

أجريت هذه التجربة بكلية عوم وتكنلوجيا الإنتاج الحيواني. جامعة السودان للعلوم والتكنلوجيا. وكان الهدف من هذه الدراسة هو تصميم مخمر بسيط لإنتاج الغاز الحيوي في المناطق الريفية باستخدام زرق الدواجن والمخلفات النباتية والحيوانية الاخرى. تم استخدام برميل بلاستيكي سعة 50 لتر كمخمر لاهوائي وباستخدام زرق الدواجن ومخلفات نباتية لإنتاج الغاز الحيوي. وكانت نسبة مصدر الكربون والنيتروجين الى 1:3 وكان قيمة الاس الهيدروجيني PH 7.0 في بداية التجربة و 7.5 في اخر يوم من التجربة. وكانت الكمية الكلية المنتجة 260 ميلتر. خلصت هذه الدراسة الى ان زرق الدواجن مادة جيدة لإنتاج الغاز الحيوي.

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Chapter one

1. Introduction

The lack of energy sources in the world stimulates the researchers to look an alternative energy sources. In recent years, studies on the waste recovery and alternative energy sources have been popular in the scientific Feld. Many studies argue about biogas production from different sours of organic wastes. Until 19th century wood (the traditional biomass) was the only primary energy source used for cooking and heating. This ended when it was replaced by charcoal, an epoch which lasted 75 years and followed in 1950 by a continuously increased use of petroleum and natural gas. However, with all fossil resources, the quantity of oil is limited and will not last forever. For sure there will be a time when all existing accessible oil fields will have been exploited. This makes renewable energies showing biggest potential for securing the availability of energy in the future.

Biogas is a clean and renewable energy that may be substituted to the natural gas. Biogas is a by-product of the decomposition of organic waste by anaerobic bacteria. (Rumana Rashid et al 2010)

In some area in Sudan, water pollution and access to energy resources present challenges to human health, environmental pollution and economic development. Less than 10% of the population of 21 sub-Saharan African countries have access to electricity [Mshandete and Parawira 2009]. The need for alternative renewable energy sources from locally available resources cannot be over emphasized. Besides, the alarming population explosion in Africa and its concomitant effect on natural resources due to increased wood charcoal fuel production and consumption [UNDP 2015] is not sustainable in the long term. Therefore, any reduction in wood fuel consumption as a result of biogas production might be expected to have favorable effect on reduction in deforestation [FAO 2015]. The production of biogas from manure (poultry manure) is very suitable to produce clean energy and protect the environment from deforestation and desertification.

Objectives:

The specific research objectives are:

1. to evaluate the production of biogas from poultry manure.

2. To produce biogas in rural areas from available plant and animal waste.

3. To design and construct a simple digester for produce of biogas in rural areas.

Chapter two

2. Literature review

2.1 **poultry manure produced in Khartoum state:**

The last survey of poultry farms in Khartoum State revealed that there were about 612 farms with 8.2 million broiler chicken and 1.3 million layers. These large numbers of growing chicks implies large amount of poultry wastes. The quantity of manure excreted from chicken depends on feed intake and diet digestibility. (Elemam (2011)) stated that Poultry litter commonly collected after each production period in plastic sacks and sold as fertilizer (land application). No medicinal or metabolic additives were used except for coccidiostat. The total litter produced in Khartoum state was 95097.58 ton/year based on information of poultry farm producer's [Elemam (2011)].

Omdurman area secured the largest statistics of broiler, broiler growers, chicks and parents in comparison to the other two areas in Khartoum state, and therefore there is a large quantity of litter produced about 68.42% of total litter produced in Khartoum state. Most of poultry litter produced (87.1%) in Khartoum state was used as fertilizer and only 0.71% was used in animal feed (Elemam (2011)

2.2 **Factors Effecting Anaerobic Digestion**

2.2.1**Temperature: -**

Temperature has pronounced impacts on anaerobic digestion. It has three main temperature ranges: from 10 - 25°C (psychrophilic conditions), from 30 - 37°C (mesophilic conditions) and from 48 - 55°C (thermophilic conditions) (Hasib *et al* 2007).Since Psychrophilic digestion process is very slow, only mesophilic and thermophilic digestion processes are used in practice. At very low or high temperature the activities of bacteria population is almost stopped consequently the digestion process becomes very long, hence the production of biogas is reduced and the methane content becomes very low. As a result the optimal temperature for mesophilic growth is situated near (40°C). The digestion process takes place at mesophilic (35 – 42 °C) or thermophilic (45 –60 °C) temperature conditions. It is important to keep a constant temperature during the digestion process, as temperature changes or fluctuations will effect the biogas production negatively. In most instances, methanogenic diversity is lower in plants operating at thermophilic temperatures (Karakashev. *et al* (2005)). Therefore, thermophilic processes are more sensitive to temperature fluctuations and require longer time to adapt to a new temperature. Mesophilic bacteria tolerate temperature fluctuations of +/−3 °C without significant reductions in methane production. The growth rate of methanogenic bacteria is higher at thermophilic process temperatures making the process faster and more efficient (Leven *et al*(2007)).

2.2.2 **pH Value :-**

The pH of the digester is a function of the concentration of volatile fatty acids produced, bicarbonate alkalinity of the system, and the amount of carbon dioxide produced. The optimum range of pH for biogas production is between 7.0 and 7.2 (Wadud et al(2010)). But the substantial biogas can be produced for the pH range of 6.6 to 7.6. Biogas production reduces many fold for the pH value of less than 5 as the bacteria population decrease significantly under the circumstances. The generally accepted pH range for optimum operation of an anaerobic digestion system is between 6.8 and 7.6. Methanogenic bacteria are significantly inhibited below pH 6.2 (Metcalf and Eddy (1991)). pH also affects parameters such as ammonia (NH3) concentration. In turn pH is affected by levels of alkalinity and volatile fatty acids present in the system.

The optimum pH interval for mesophilic digestion is between 6.5 and 8.0 and the process is severely inhibited if the pH value decreases below 6.0 or rises above 8.3. The solubility of carbon dioxide in water decreases at increasing temperature. The pH value in thermophilic digesters is therefore higher than in mesophilic ones, as dissolved carbon dioxide forms carbonic acid by reaction with water (Teodorita *et al*(2008)).

Anaerobic bacteria, especially the methanogens, are sensitive to the acid concentration within the digester and their growth can be inhibited by acidic conditions. It has been determined that an optimum pH value for anaerobic treatment lies between 5.5 and 8.5 (Verma (2002))

2.2.3 **Carbon / Nitrogen Content**

The amount of carbon is important element in anaerobic digestion process and nitrogen present in the organic materials, which is represented by the carbon to nitrogen (C/N) ratio (Verma (2002)). Unlike, for example, the lignocellulosic crop residues with low nitrogen content and high (C/N) ratio ranging from 60 to 90, animal manure has a low (C/N) ratio ranging from 10 - 20 (20 for cow manure). A high (C/N) ratio is an indication of rapid consumption of nitrogen by methanogens and results in lower biogas production. The optimal range of (C/N) ratio for anaerobic digestion is reported to be in the range of 25 to 35(Santosh et al (2004)). Carbon and nitrogen are the two components that anaerobic bacteria require for survival (Igoni et al (2007)). For optimum degradation a (C/N) ratio of 20-30 is often recommended Nitrogen present in the feedstock has two benefits (Steffen et al (1998): it provides an essential element for synthesis of amino acids, proteins and nucleic acids . it is converted to ammonia which, as a strong base, neutralizes the volatile acids produced by fermentative bacteria, and thus helps maintain neutral pH conditions essential for cell growth.

2.3 Biogas Technology Researches in Africa

Sudan is an agricultural country with plenty of water resources, livestock, forestry resources, and agricultural residues besides municipal and industrial wastes. The supply of agriculture was estimated at 44.5 x 106 kg, animal dung was 900 x 106 kg and bagasse 840 x 106 kg in 2005. (Omer A.M. (2005)). However, it is an energy importing country and the energy requirements are supplied through imports that cause financial problems. The oil import bill consumes more than 50% of the income earnings of the country. In Sudan there were 200 installed biogas units for family, community or industrial uses in 2005 and the main sources of feedstock were agricultural and animal wastes. (Omer A.M. (2005)).

There is need for research on the potential to utilize the large quantities of biomass for biogas production and improve the biogas yield.Typically different variants of anaerobic digesters need to be used to treat each different feedstock optimally. There have been some efforts to research on the potential to utilize water hyacinth as a feedstock for biogas technolog (Dirar and El Amin (1988)). Water hyacinth biomass is abundant in White Nile and 2400 tons of fresh biomass were estimated to pass to some towns every day and increasing to 5 000 tons daily in summer. These researchers optimized the anaerobic digestion of water hyacinth focusing on the effect of solids concentration, temperature, and retention time and inoculum source in batch experiments.

There are some cases of successful biogas intervention in Africa, which demonstrate the effectiveness of the technology and its relevance for the region. The lessons learned from biogas experiences in Africa suggest that

having a realistic and modest initial introductory phase for Biogas intervention; taking into account the convenience factors in terms of plant operation and functionality; identifying the optimum plant size and subsidy level; and; having provision for design adaptation are key factors for successful biogas implementation in Africa (Taleghan and kia (2005)).

Some significant research has been done on reactor design by some Nigerian scientists that would lead to process optimisation in the development of anaerobic digesters. For instance, the Usman Danfodiyo University, Sokoto, designed a simple biogas plant (with additional gas storage system) that could produce 425 L of biogas per day which could be sufficient to cook meals for one person (Dangogo and Fernando 1986).

concerning the design of a high performance anaerobic digester designed and constructed a plastic bio-digester and used it to produce biogas from spent grains and rice husk mixed together. The digestion of the slurries was undertaken in a batch operation and good biogas production was reported [Igoni et al (2008)].

Chapter Three

3. Materials and Methods

3.1 Experiment Location

This study was carried out at the college of Animal Production Science and Technology, Sudan University of Science and Technology, at the plant laboring.

3.2materials

3.2.1 Poultry manure

Poultry manure was obtained from poultry farms of college of animal production Science and Technology. Hilat kuku.

3.2.2 plastic 50-liter digester

The experimental digester system consists of a tank. Its capacity is approximately 50 liters, and made of a density polyethylene material.

3.2.3 Cylinder 0f 1 litter:

A cylinder of one-liter capacity was used for storage of biogas.

3.2.4 drip plastic tube

A drip plastic tube was used to connect between the digester and storage tube to transfer gas.

3.3 Methods

3.3.1 Experimental digester

Polyethylene digester with a capacity of approximately 50 liters was used. A drip plastic tube was used to connect between the digester and storage tube to transfer gas.

3.3.2 Experimental model set up

The total weight of the feedstock was 40 Kg (poultry manure 10 kg and vegetable and molasses 30 Kg) at the ratio of 1:3 (nitrogen source: carbon source). Biogas generation started after 30 days from charging the digester. The average temperature ranged from 30 to 37°C (mesophilic conditions).

The substrates was mixed, stirred and cleaned from stones and other unnecessary materials. After the container was filled with the mixture, the input slot was closed well to prevent gas leakage and secure the success of the anaerobic fermentation process. The Retention time was 60 days for the experiment digester.

3.3.3 Measurement of pH

The pH of the substrate was measured with pH papers in the beginning of the experiment and it was 7.0 and in the end of experiment it was 7.50.

3.3.4 Gas volume Measurement

A plastic cylinder of1 litters was used as water tank and 1000 ml measuring cylinder as water collector, also a drip hose (5/16 mm) was connected between the digester and water tank to transport the gas produced from digester to water tank. The water displaced was measured using a measuring cylinder. The volume of biogas produced equal to the volume of water displaced within the period.

Chapter Four

4. Results

4.1 Gas volume:

The amount of biogas produced was presented in table 1.

Table (1) : Gas produced in the laboratory digesters (ml)

Days	Displacement (ml)
0	0
1	50
4	100
14	100
16	10
total	260

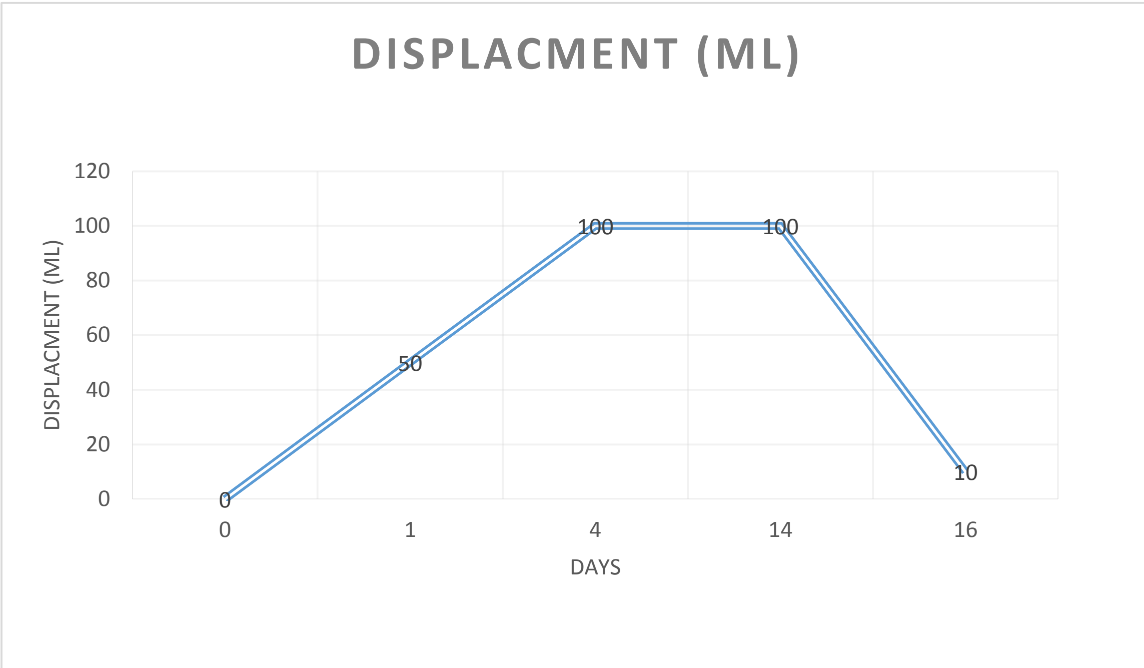

Fig: (1) water displacement graph

4.2 pH value:

At the start of experiment was 7.0

At the end of experiment was 7.5

Chapter five

5. discussion

5.1 amount of biogas produced:

The amount of biogas reported in this study was 260 ml. this volume of biogas in present study was higher than that posted by (Rashid et. al (2010) as 26 ml.

5.2 PH value:

The PH value in this study was range from 7.0 – 7.5. which was similar to that reported by (waddud (2010)) as rang between 7.0 – 7.2.

(Metcalf (1991)) reported PH value as 6.2 which was lower than the result of this experiment.

The PH value in the present study was higher than that reported by (Verma (2002)) as range 5.5 – 7.5. this difference might be due to difference in materials used and the environmental temperature

5.3 Temperature:

The average temperature in this study was ranged between 30- 37 □ c which was similar to (Hasib. et al (2007). reported that the mesophilic temperature was ranged between 30- 37 □ c. and that of (Karakashev. *et al* (2005)) which reported that the mesophilic condition is ranged between 35-40 □ c.

Conclusion and Recommendation

1. This study concluded that the poultry manure is good source for production of bio gas, total biogas production from digester were 260 ml, from the mixed ratio 3:1 carbon to nitrogen.
2. Study should conduct using different agriculture and animal byproduct to generate biogas especially in village and rural area.
3. Production of biogas will reduce the environmental pollution produced by animal and plant waste.

References

- Dangogo SM, Fernando CEC (1986). A simple biogas plant with additional gas storage system. Nigerian J. Solar Energ. 5: 138-141
- Dirar HA, El Amin HB (1988). Methane fermentation of water hyacinth: effect of solids concentration and inoculum. Appl. Microb. Biotechnol. 4: 299-312.
- Elemam MB (2011). Use of deep stacked poultry litter in sheep rations. Ph.D thesis, Department of Animal Nutrition, University of Khartoum, Sudan.
- FAO. Food and Agriculture Organization (FAO), Rome, Italy. http://faostat.fao.org/site/626/DesktopDefault.aspx?PageID=626#ancor. Accessed on 1 March 2015.
- Igoni AH, Ayotamuno MJ, Eze CL, Ogaji SOT, Probert SD (2008). Designs of anaerobic of digesters for producing biogas from municipal solid-waste. Appl. Energ. 85: 430-438
- Igoni, H., Ayotamuno, M. J., Eze, C. L., Ogaji., S. O. T., Probert., S. D. (2007) designs of anaerobic digesters for producing biogas from municipal solid waste. Applied Energy, vol. 85 : 430-438.
- Karakashev D., Bastone D. and Angelidaki I (2005) Influence of environmental conditions on methanogenic compositions in anaerobic biogas reactors. Appl Environ Microbiol 71:331–338
- Leven L., Eriksson ARB., and Schnürer A (2007) Effect of process temperature on bacterial and archael communities in two methanogenic bioreactors treating organic household waste. 683–693
- Metcalf AND Eddy (1991). Wastewater Engineering. McGrawHill, New York, USA, 425 – 426
- Hasib, J. Hossain, S. Biswas, A. Islam,(2007), “Bio-Diesel from Mustard Oil: A Renewable Alternative Fuel for Small Diesel Engines,” Modern Mechanical Engineering, Vol. 1, No. 2, pp. 77 83,.
- Mshandete A.M., and Parawira W.(2009) Biogas technology research in selected sub-saharan africa. Afr. J. Biotech. 2009;8(2):116-125

- Omer A.M (2005). Biomass energy potential and future prospect in Sudan. Renew. Sustain. Energ. Rev. 9: 1-27..
- Rumana Rashid ,Biological Treatment of Organic Waste for Poultry Farm in Hot Climate Volume 1, No. 1 (2010). 11-14.
- Santosh, Y., Sreekrishnan, T.R., Kohli, S. and Rana, V. (2004) Enhancement of Biogas Production from Solid Sub- strates Using Different Techniques—A Review. Bioresource Technology, 95, 1-10.
- Steffen, R., Szolar O., Braun R., (1998). Feed stock for anaerobic digestion. Making energy and solving modern waste problem.
- Taleghani G, Kia AS. 2005. Technical–economical analysis of the Saveh biogas power plant. Renewable Energy. 30:441–6.).
- Teodorita Al Seadi, D. Rutz, H. Prassl, M. Köttner, T and .Finsterwalder.(2008) ,Biogashandbook , Published by University of Southern Denmark Esbjerg, p26- 42
- UNDP. Human development report,UN Development Programme, New Yor. Available: http: //hdr.undp.org /en/reports /global/ chapters/.. Accessed on 23 February 2015.
- Verma, S. (2002) Anaerobic Digestion of Biodegradable Organics in Municipal Solid Wastes. Master’s Thesis, Ap- plied Science Columbia University, New York.
- Wadud, D, J,Graham, R. B. and Noland, “Gasoline Demand with Heterogeneity in Household Responses,” The Energy Journal, Vol. 31, No.1, pp 47–73, 2010.