BIOGAS PRODUCTION FROM COW DUNG VIA FIXED DOME BIOGAS DIGESTER: A PILOT DEVELOPMENTAL PROJECT IN IGUOVBIOBO COMMUNITY OF EDO STATE, NIGERIA

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ABSTRACT

Biogas is an energy produced from renewable sources like manure from livestock, poultry, human beings and any other biological materials like grass and straw. Biogas is very cheap to produce and finds application in lighting and heating. The construction of the digester with dimension of 3,200 mm in diameter and 2,400 mm deep at Iguovbiobo, in Uhumwonde Local Government Area of Edo state involved the following components: excavation work, basement work, digester wall casting, dome vault construction, concrete placement and discharging tank Other important aspects of the fixed dome biogas digester are the installation of gas cleaner, burner, gas lamp/bulb and piping work. The cow dung is the initial raw material used as the initial fermentable material used for biogas production. About 12,600kg of the cow dung was collected with 762 mm of water added and used as slurry. It was observed that the gas holder was filled with gas and the gas cleaner reading was at maximum of 10 kilo paschal (kpa). When the gas burner was ignited, it produced blue and odourless flame. Biogas production from animal waste especially cow dung is cheap and environmental friendly.

Keywords: Biogas, Fixed Dome, Cow dung, Digester, Developmental project

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INTRODUCTION

Biogas is an energy produced from renewable sources like manure from livestock, poultry, human beings and any other biological materials like grass and straw. Biogas is very cheap to produce and finds application in lighting and heating. The main constituents of biogas are methane (CH_4) and carbon (IV) oxide (Hurtas *et al*.,2015). Kerosene is a fossil fuel that is widely used in many developing countries for cooking and lighting. It is expensive and often needs to be imported. In areas where biogas is being utilized the use of kerosene would drop considerably (Gautana *et al*, 2009).

Advantages of biogas production in Nigeria include but not limited to favorable climate and biomass resources. To construct the biogas digester, the following factors should be put into consideration viz; Site location, availability of materials for construction and nearness to availability of renewable resources like manure from livestock (Sammer, 2015; Balsam, 2006).

The digester should not be located on a site where ground water level is high or in loose sandy soil. The digester is often built adjacent or connected to an animal pen or a toilet to allow the passage of waste directly into the digester. The digester should be away from growing trees to avoid roots penetration and should be away from path and highway for safety of the foundation. It is advisable to be built close to orchards or vegetable garden for easy usage of the waste fluid as manure. The digester should be less than 25,000 mm away from the kitchen or where biogas is used to reduce the pipeline cost. Materials required for biogas digester construction are cement, sand, gravel, PVC pipe, steel pipe, and one-way valve (Virenda *et al*., 2006). Biogas is a cheap source of energy; it reduces deforestation and also serves as cheap source of fertilizer. Also, spraying of the biogas fluid on plant leaves prevents plant diseases and pests. Environmentally, biogas is considered as clean fuel and it does not produce smoke or soot. (Gautana *et al*., 2009).

The main objective of this project was to demonstrate alternative cheap source of energy from cow dung via fixed dome biogas digester for cooking and lighting at Iguovbiobo community which is a rural settlement in Uhumwonde Local Government Area of Edo state in the rural areas.

MATERIALS AND METHODS

Location of the construction: This biogas digester was constructed at Iguovbiobo community in Uhumwonde Local Government Area, Edo state and the project was financed by the West Africa Agricultural Productivity Programme (WAAPP) in conjunction with the Rubber Research Institute of Nigeria, Benin City.

Construction of Digester: Construction of the digester featuring; excavation work, basement work, digester wall casting, and dome fault construction.

Digging or Excavation Work: After completion of the layout work, land excavation started with the availability of the following tools; spade, shovel, basket, crow bar and picks. The digging was done per dimension fixed during layout. The base was leveled and rammed such that the earth was untouched. It was ensured that excavation soil was deposited at least 2,000 mm away from the pit in each side to ease the construction. The dimension of the digester is 3,200 mm in diameter and 2,400 mm deep. The displacement or compensation tank is 1,200 mm wide, 1,200 mm width, and 2,400 mm deep (Fiesinger *et al*., 2006).

Basement Work: After proper ramming and leveling, the concrete was poured on the basement reinforced with 12.70 mm metal rod. The concrete was 150 mm thick steep slope towards the displacement tank by 130 mm. The sand used for preparation of concrete mixture is cleaned and does not contained soil or other materials and the gravel used is neither big nor small (about 15 mm or ¼ of thickness of the concrete layer).The basement was connected to the digester wall through anchor joint made from 12.70 mm metal rod.

Figure 1: Excavation work

Digester Wall Metal Work or Mould Setting: Metal mould was used and this was made up of a galvanized metal plate measuring 2,438 mm by 1,219 mm and 1 mm thickness. The metal plate was placed behind a semicircular 25.40 mm iron rod supported by 38.10mm rod that connects all the semicircular iron rods together. A round (digester) wall casting of 152 mm thickness was made from the mixture of cement, sand, gravel and water. The cylindrical wall or digester wall is 1,219 mm from the finished floor. The materials used are comparable to standards and it has no moving parts or any metal parts that can rust.(Sasse, 1988).

Dome Vault/Construction of Gas Holder Form Work: A wood of 305 mm in diameter and 1,854 mm high was formed into mushroom shape by nailing 305 mm length of 2 by 2 planks round the top of the wood. The prepared wood was placed at the centre of the digester; legs (plank) that were about 165 mm shorter than the height of the digester wall were positioned round the digester and connected together. Series of 2 by 2 inches (50.8 x 50.8 mm^2) planks were used to connect the mushroom head to the legs. The planks were properly braced and connected together for rigidity. A PVC pipe of 1,092 mm long, 25.4 mm thick and 350 mm diameter was erected directly opposite the passage door from the digester to the displacement or compensation tank. The PVC pipe was positioned such that it eases the charging of the waste into the digester. The PVC is 600 mm from the finished floor of the digester and about 76.2 mm below the upper part of the passage door. Ply wood was then placed on top of the form work and loaded with red soil smoothened and kept moist. The top soil was later covered with the plywood to achieve a smooth surface on the casting.

Concrete Placement: After the placement of plywood on top of the soil, a concrete mixture (sand, gravel, cement and water) was poured on the form work to cast dome vault or gas holder. The concrete is about 102 mm in thickness, gas pipe was erected into the concrete before curing. After curing the gas holder was plastered and smoothened outside to prevent gas leakages. The surface was covered with the soil after 24 hours.

Figure 2: Surface finishing

Figure 3: Positioning of gas pipe

Figure 4 : Inlet/Charging pipe

Figure 5: Digester covered with the soil

Compensation or Displacement or Discharging Tank: A compensation tank is connected to the digester through a passage of 915 mm wide and 710 mm high. As the name implies, the tank is used to discharge the sludge, inspect the digester water level and even gas formation. Compensation tank was raised with 152 mm block and plastered twice (with addition of water seal cement) after which it was painted with raw cement.

Piping Work/Leakage Test: Biogas special design hose was used for the connection, the hose is connected to the gas pipe on the gas holder and connected to the compressor. Along the line (mid-way between the gas pipe and the compressor), a T-junction was installed that connects non-return valve. Water level was maintained above the valve to detect leakage in the system. The digester was air tight by blocking all the openings in the structure. The non-returned valve was locked, air was supplied to the system/digester by the compressor for 10 minutes and stopped. Line to the compressor was blocked and the non–returned valve was opened to allow passage of air to push up the water level if there is no leakage and a drop in the water level if there is leakage.

Installation of Gas Cleaner/Filter, Burner, and Lamp or Bulb: Gas cleaner/filter is a unit that cleans and filtered unwanted gases or materials such as water vapor, hydrogen sulphide, hydrogen and sulphur from the biogas. Gas cleaner installed has maximum storage capacity of 10 Kpa. The inlet and outlet nozzle or plugs were properlly installed to avoid gas leakages (Figure 6a). At about 1 m distance from outlet plug/nozzle a T-junction was placed to supply gas to the burner and gas lamp conrol valve.

Gas Burner: is a unit that uses the biogas generated for cooking. It comprises of burner, automated igniter, and the frame. The frame accommodates double burner, it has a knob used to allow the passage of gas into the system and also used to initiate spark that ignite the gas (Figure 6b).

Gas Lamp or Bulb: This unit is made up of control valve, switch, filament and glass shade. Metal frame accommodates the filament, tungsten net, igniter, and the glass shade. Flow of gas to the gas lamp is regulated by control valve for proper glowing and the switch initiate spark that glows the filament (Figure 6c).


Figure 6a


Figure 6b


Figure 6c

Figure 6a: Installtion of Gas Filter.
Figure 6b: Installation of Gas Burner/Cooker.
Figure 6c: Installation of Gas Lamp

Preparation of Waste (Cow Dung): Cow dung is a raw material used as initial fermentable material for the biogas digester constructed. About 12,600 kg of the cow dung was collected and used as slurry. The cow dung was charged into the digester after it was properlly cured (digester wall) through the inlet pipe up to a height of 1,220 mm of the digester. Water was added to the dung and water level was maitained at 762 mm from the top of the displacement tank. The gas cleaner was left opened for 12 hours for the air and water vapour to escape after which it was then left for 3 days for the gas to build up.The first discharge and refill should be done 20-30 days after starting the operation. Discharge slurry fluid remains 3-5% of the total content and refills the digester with the same volume of raw materials. After that the discharge was made and refilled every 5-10 days. The daily volume of gas produced was measured to be 1 m^3 .

RESULTS AND DISCUSSION

Perfomance Evaluation of the Constructed Biogas Plant

One million metric tons of waste produces an average 5.6 million m^3 / year or 15,400 m^3 / day of gas as reported by Tom Fiesinger *et al*., (2006). About 12,600 kg of the cow dung was collected and used as slurry thereby producing 10 Kpa of gas daily. After cleaning and drying of the complete system, the gas cleaner was locked and allowed the gas to build inside the digester for 3 days. On the third day, the following were observed:

- The gas holder was filled up by the gas. This was confirmed by increase in water level in the displacement tank.

Data on biomass use is often hard to access and difficult to evaluate because of the diversity in consumption patterns, differences in units of measurement, the lack of regular surveys and the variation in heat content of the different types of biomass.

- Gas cleaner reading was at maximum point of 10 Kilo paschal (Kpa)
- Gas burner was ignited; it produced blue and odourless flame (Figure 7). The burner was used to boil eggs at a time period of 8½ minutes.
- The beneficiary of the project at Iguovbiobo community used the system continuously for 4 hours before the team of scientists left the site.
- Also, gas lamp was tested (Figure 8) and glowed with very little inflow of gas to the system. This unit is left functioning on because it consumes little gas compare to the gas burner.

Figure 7:Testing of gas burner

Figure 8: Testing of gas lamp

There are several other types of small biogas plant design but the fixed dome model is the most commonly used. It has advantages of being cheap to build and has no moving parts or any metal parts that can rust. This will make the biogas digesters last for a long time, typically over 20 years. It is constructed underground which saves space and makes it less sensitive to seasonal temperature change (Sasse, 1988). It also generates local job. As a contrast, the pyrolysis gasifier biogas plants are more expensive to build and maintain. The more complex technology gives rise to many problems. Household biogas plants commonly use kitchen toilet waste and cattle manure. Using the digested biogas slurry as a fertilizer is a great way of bringing back nutrients to the soil and is very important in reducing soil degradation. It also helps to reduce environmental pollution and reduce modern urban and rural waste problems (Klingler, 2000). The fact that digested manure actually has more nutrients than fresh manure makes this very worthwhile. This can also have an effect of reducing deforestation due to agricultural expansion.

CONCLUSION AND RECOMMENDATION

- Biogas production from cow dung is cheap and environmentally friendly.
- The Iguovbiobo pilot developmental project produces about 10 Kpa gas daily.
- It is easier and simple to maintain and due to low pressure characteristics of the biogas, the risk of leakages and explosion is minimal.
- Therefore, it is hereby recommended that people should adopt the use of biogas domestically in order to reduce pressure on natural gas and the risks involved.

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REFERENCES

Balsam, J. 2006. Anaerobic Digestion of Animal Wastes Factors to Consider.pdf. ATTRA - National Sustainable Agriculture Information Service.

Ferm, R., Elena, J., Elsabet, G., Jasme, C., Anna, A., Marianne, H., Frances, B, Lius, C, Cristina R, Gemma G, Eusebi R and Nuria V. 2015. Energy Recovery from Landfills Biogas by the use of Microturbines and Biological Removal of Hydrogen Sulhpide and Siloxanes. from www.microphilox.com .

Gautana, R., Baraib, S., Heart, S. 2009. Biogas as sustainable energy source in Nepal:Present status and future challenges. *Renewable and sustainable energy reviews,* 13:248-252.

Hurtas, J.I., Giraldo, N. and Izquerdo, S. 2015. Removal of H_2S and CO_2 from Biogas by Amine Absorption. Mass transfer in chemical engineering proceses, Dr. Jozef MarkoAj (Ed) ISBN 9789533076195 Intech, available from: http//www.intechopen.com/books/masstransfer-in-chemical-engineering-proceses.

Klingler, B. 2000. Environmental Aspects of Biogas Technology. in: AD-Nett (ed): AD: Making energy and solving modern waste problems, Ortenblad H Herning municipal utilities, Denmark, pp.53-65.

Sammer, M. 2015. Biogas Construction. Cairo University, Faculty of Agriculture, Department of Agricultural Engineering Egypt: www.intechopen.com (Retrieved on May, 2015).

Sasse L. 1988. Biogas plants. A publication of Deutsches Zentrum fur Entwicklungstechnologien Gate in Deutsche Gesellschaft fur Technische zusammenarbeit (GTZ) Gmbh-1988).

Fiesinger, T., Bruce. D. Roloson, Nbranan .R. Scott, Kimberly Bothi, Kelly Saikonean, Steven Zacari (2006); Biogas Processing. Report submitted to New York State Energy Research and Development Authority, Albary New York.

Virenda, K.V., Ram C., Parchuri, M.V., Subbarao and Shan, S. K. 2006. Biogas Purification and Bottling into CNG cylinders: Producing Bio–CNG from Biomass for

Rural Automotive Applications. Paper Presented at 2nd Joint International Conference on Sustainable Energy and Environment, 21 -23 November, 2006, Bangkok, Thailand.

Zhang, P. 2012. Biogas-Its potential as an energy source in rural households with particular emphasis on China. MSc. Thesis, Department of Noragric, Norwegian University of Life Sciences (http://www.umb.no/noragric). https://brage.bibsys.no/xmlui/bitstream/handle/11250/187822/final%20master%20thesis%20(Ping%20Zhang).pdf?sequence=1