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Gas Evacuation Effect on the Quantity of Gas Production in a Biogas Digester

E.C. Okoroigwe and S.N. Agbo
National Centre for Energy Research and Development,
University of Nigeria, Nsukka, Nigeria

Abstract: A 1200 L plastic biodigester developed at the National Centre for Energy Research and Development, University of Nigeria, Nsukka was used to investigate the effect of gas evacuation at different rates on total gas yield of three animal wastes: fresh cow dung, dry hog and poultry wastes. The daily gas yield from the anaerobic digestion of fresh cow dung and poultry droppings for single and multiple draw is presented. The daily gas yield profile from the digestion of hog waste for single draw is also presented. The overall gas yield was higher in multiple draw system in both cow dung and poultry wastes, as against the single gas draw.

Key words: Biogas, yield, gas evacuation, single draw, multiple draw, anaerobic digestion

INTRODUCTION

Biogas production in the world has taken diverse dimensions over the years. It has moved from laboratory demonstrations of various digestion processes to pilot plants and even more to life applications at homes and small industries. In some countries of the world, biogas production has been integrated into their national, (DESA, 1999), domestic (www.solarengineering.co.za/plasticbiogas; Marchaim, 1992) and industrial (Carl and Lamb, 2002), energy mix. Its use for the production of cooking gas and for electricity generation cannot be overemphasized especially for developing nations like Nigeria where insufficiency of energy supply has been the bane of the socio-economic and technological development.

Biodigesters are simple or complex devices, which under anaerobic conditions, breakdown complex wastes to simpler forms with the release of biogas (a mixture of Methane, CO₂ and some trace gases such as hydrogen sulphide). The performance of a good biodigester is measured in terms of the quantity (either by mass or volume) of biogas produced per period of digestion. Since the process of digestion is a complex process involving activities of microbes, some factors/conditions ought to be maintained to ensure optimum gas production. This process is a versatile biotechnology (Okoroigwe, 2005; FAO, 1997), capable of converting almost all types of polymeric materials to methane and carbon dioxide under anaerobic conditions. The organisms are classified according to their major activities such as the acidogens-primarily concerned with fermentation; acetogens, which produce hydrogen and acetate; and methanogens, which complete the activities by producing methane. Special bacteria found in the stomach of ruminant animals, lakes, manure pits, sewage and some organized sludge, carry out the process of biomaterials fermentation. Methane-producing bacteria can also be found in some higher plants.

During non-methane producing stages, fermenting bacteria secrete exoenzymes, hydrolyzing organisms whose variety and amount vary with variety and quantity of the organics involved. They are classified into cellulose splitting, fat splitting and protein splitting. At this instance,

Corresponding Author: E.C. Okoroigwe, National Centre for Energy Research and Development, University of Nigeria, Nsukka Tel: +234-8030983646

polysaccharides are hydrolysed into monosaccharides while protein is hydrolysed into peptides or amino acids and fats into glycerol and fatty acids. The long chain fatty acids and aromatic amino acids are further acted upon by acetogenic bacteria e.g., *acetobacterium xylinum*, *clostridium* etc to produce hydrogen, acetic acid and carbon dioxide. During methane producing stage, methanogenic bacteria utilize the simple compounds (acetic acid, hydrogen, formic acid and carbon dioxide) to form methane, carbon dioxide and some trace gases such as hydrogen sulphide.

Several works have been done in the area of biogas generation from organic wastes (Eze, 2003; Okoroigwe, 2005; Dioha *et al.*, 2003; Itodo *et al.*, 1992; Garba and Uba, 2002). Some factors such as PH of the fermenting medium, total solids, volatile solids, environmental and slurry temperatures, nature of waste, manure loading rate, residence time in the digester and animal rations have been identified to affect the rate of waste digestion and biogas production (Carl and Lamb, 2002; Eze, 2003; Anonymous, 1994; Ezeonu *et al.*, 2005; Dioha *et al.*, 2005; Garba and Sambo, 1992). In this study, the effect of the rate of gas evacuation on total gas yield was investigated experimentally using a 1200 L biogas digester installed at the National Centre for Energy Research and Development (NCERD), University of Nigeria, Nsukka.

MATERIALS AND METHODS

A 1200 L capacity plastic biodigester (Fig. 1) developed and installed at the NCERD, University of Nigeria, Nsukka (Latitude 6.8°N longitude 7.29°E) was used to experimentally evaluate the effect of the rate of gas evacuation from the digester on the overall gas yield using fresh cow dung, dry piggery and poultry wastes. The cow dung was collected at Nsukka Abattoir while hog waste was collected at the Faculty of Veterinary Medicine Animal Farm, University of Nigeria, Nsukka (UNN). The poultry droppings were collected from the UNN Animal Science Department farm where the birds



Fig. 1: Experimental biodigester set up

were intensively reared. The wastes were separately mixed with water at 1: 2 (waste: water) ratio and then fed into the plastic biodigester and sealed for anaerobic digestion. This was done for each of the waste as given above. A total of 270 kg of each solid waste was mixed with 540 kg water. Both piggery and poultry droppings were pulverized before mixing. Gas production was monitored, measured and recorded at specified time interval. The volume of biogas produced was measured by downward displacement of water in a 22 L calibrated container. On release of gas, the quantity of water displaced by gas was taken to be approximately the volume of gas produced. The volume of gas generated by cow dung and poultry wastes were differently collected thrice daily (multiple draw) and summed to obtain the total daily gas yield. These setups were also monitored for daily gas yield for single draw for the purpose of comparison. In the case of hog waste, the measurement was taken once a day for the entire period of digestion.

RESULTS AND DISCUSSION

Figure 2 shows the comparison in gas yield for single and multiple gas draw using cow dung. It indicates that the overall gas yield increased sharply and more significantly with multiple draw when compared with single draw. A similar pattern is also observed with poultry waste (Fig. 3). This indicates that the gas production within the digester is enhanced as the generated gas is evacuated. A maximum daily gas yield of 185 L was generated from cow dung in a multiple draw and 76 L in single draw. For poultry waste, a maximum daily yield of 130 and 70 L were, respectively obtained for multiple and single draws. A similar yield pattern has been reported (Ofoefule and Uzodinma, 2005; Ezeonu *et al.*, 2005) for both cow dung and poultry wastes. This increased gas yield in multiple draw can be attributed to the pressure differential between the slurry and the vacuum on top of slurry created by the gas evacuation. Hence, to maintain equilibrium in the system the microbes were activated to produce more gas thereby increasing the total gas yield. If the gas is not removed the increased pressure above slurry would inhibit gas release from slurry. Hence, constant evacuation of gas would activate the microbes to generate more gas.

Figure 4 shows the gas collection profile for a single draw using hog waste. It further shows a very low yield when compared with yields from multiple draw as earlier mentioned for poultry and cow dung wastes. Generally, the results for all the wastes show that the gas yield decreases over time since the active microbes are used up during the methanogenic process.

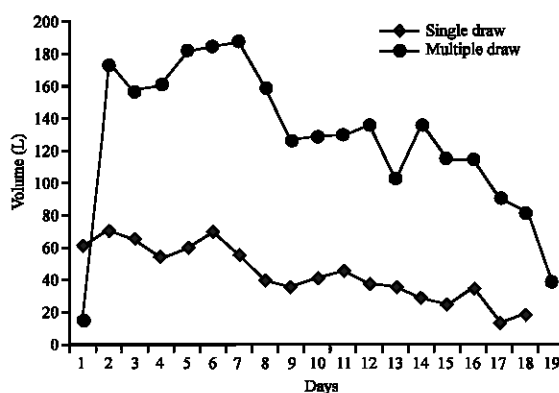


Fig. 2: Gas production from cow dung at different collection rates

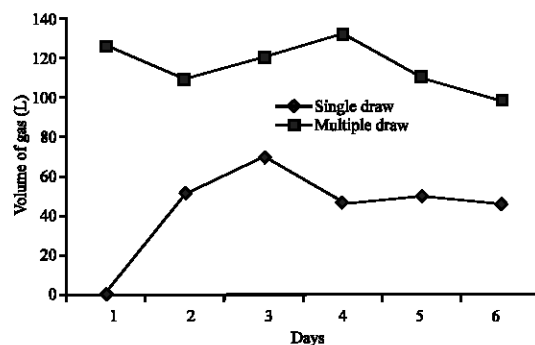


Fig. 3: Gas production of poultry waste at different collection rate

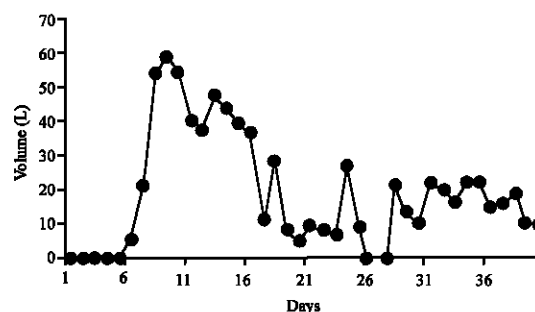


Fig. 4: Gas production of hog waste

CONCLUSIONS

The rate of gas evacuation from a biogas digester is an important parameter that also determines the volume of gas produced. Gas yield is higher for multiple evacuations per day than in single evacuation. This is attributed to the activities of the active microbes, which are enhanced as the biogas is removed from the digester.

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