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DAILY AND CUMULATIVE YEILD OF BIOGAS PRODUCTION FROM THREE DIFFERENT ANIMAL MANURE

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ABSTRACT

This study investigated daily and cumulative production of biogas from three different manure; poultry dropping, pig dung and cow dung. 3kg of each of the dried dungs was mixed simultaneously with 16 litres of water in three 20 litre biogas digesters constructed for the experiment simultaneously to give a 0.19kg/litre slurry volume of biomass each. The biogas yield was measured for 30 days on daily basis using water displacement method at ambient temperature variation of between 28^0C and 32^0C. It was observed that the production of biogas did not start for all the three manure until the 4^{th} day. After which, it increased and got to the peak on the 13^{th} day for poultry manure, 14^{th} day for pig manure and 12^{th} day for cow dung. From the comparative analysis of the biogas production from the three manure, results obtained indicated that manure from poultry, pig and cow, gave average daily yield of 38.67ml, 34.17ml and 26.00ml respectively while a cumulative value of 1160.00ml, 1025ml and 780ml respectively were also recorded for 30 days' retention period. These results show that the three manure used are excellent biomass materials.

KEYWORDS: Biogas, biomass, biological waste, animal manure, biogas production, inoculating starter.

1.0 INTRODUCTION

In the past, animal waste was used as fertilizer while the left over was either left in an open to decompose or dumped in the lagoon, sea or river thus posing a significant environmental hazard. However, introduction of environmental control measures on odour and water pollution gave incentives for biomass –to-energy conversion such that air pollutants emitted from biological wastes which include methane, nitrous oxide, ammonia, hydrogen sulfide, volatile organic compound and particulate matter which could have caused serious environmental and health hazard are converted to useful biogas. (Salman 2018, Ukpai and Nnabuchi 2012).

Manures and biological "left over" which were considered waste in time past are now useful materials, such that it can be stated that nothing is a waste". The term waste can only apply to a material when it lacks useful technology for its application or transformation (Elijah et.al, 2009, Ilaboya et.al, 2010 and Ofoefule et.al 2009). Biogas is the source of renewable energy produced when biomass material is subjected to gasification in order to generate a mixture of methane-rich gas by the breakdown of organic matter in the absence of oxygen, a process called anaerobic digestion (Ofoefule et.al, 2010).

Anaerobic digestion can convert stored energy in animal manure or any other biomass material into biogas. Anaerobic digestion of animal manure is gaining popularity as a means to protect the environment and to recycle materials efficiently into agriculture. Energy from fossil fuel resources is exhaustible and non-renewable. Development of bio-energy (renewable energy) is therefore critical for national economic development. The dwindling sources of fossil fuels and chemical feedback and proliferation of waste generated by municipalities and agricultural industries have yielded interest in the use of agricultural waste as a substitute for fossil fuels. Hence the conversion of biomass (waste) to chemicals and gas by microbial fermentation through a biogas reactor will remain a challenge of the present age (Adeyemi and Ade Yanju, 2008). Since biogas and other renewable energy like wind, hydro, waves, solar and geothermal energy have thermal energy that can be converted to thermal and electrical use, biogas and its application will remain attractive for along time. (Ojolo et. al, 2011and Ukpai et. al, 2012).

Many researchers have used different types of biomass materials for production of biogas. These include wastes and residues of agro and food industries, crop harvests and animal wastes. The more recent trend is the development of a system that will reduce over-dependence on crops in production of bio-fuels. The use of edible crops as biomass materials have potential of causing food insecurity. In view of this, the following are commonly use: pig manure, cattle manure, chicken dung; slaughter-house waste, spent grains, leaf litter, water hyacinth, aquatic weed, distillery slurry and municipal waste water (Guruswamy et.al 2003; Lucas and Bamgboye 1998) machido et.al 1996, Maishanu and Sambo, 1991 and Abbasi et.al 1990).

In a laboratory scale experiment the investigation on production of biogas from animal wastes by Obiakwu and Nwafor (2016) revealed that biogas produced contained 65% methane at the temperature of 310k. Zhang et.al (2013) also in their study on production potential of different mixtures of unscreened diary manure and food waste show that methane yield from fine screened manure is higher. Abubakar and Ismali (2012) in their investigation for biogas production discovered that the average cumulative biogas yield 0.15L/kgvs and 47% methane content was generated.

Imam et.al (2013) in their investigation on fermentable materials using dung, poultry waste and water hyacinth discovered that the percentage of methane content in biogas produced for different materials is not significantly different. Owamah et.al (2014) investigated the optimization of biogas production using chicken dropping with cymbopogon citralus as anaerobic co-digester. The result obtained show that 1.8L/kg/day of biogas was produced. Borowski et.al (2014) experiment on anaerobic digestion of municipal sewage sludge with swine manure and poultry manure indicated that addition of swine manure to the sewage sludge significantly increase the biogas by 40%.

Isa and Demirer (2007) study on anaerobic treatability and methane generation potential of three different cotton wastes namely cotton stalks, cotton seed hull and cotton oil cake revealed that approximately 65, 86 and 78ml of methane were generated respectively. Also, Okeh et.al 2014 in a laboratory scale study on biogas production from rice husks generated from different mill using cow rumen fluid as a sources of inoculum. Feed stock to water dilution ratio of 1:6 w/v at initial P.H 7 gave maximum biogas yield range of 357ml/day. Study has revealed that paper and other biodegradable materials can be blend with animal waste as inoculum to produce biogas (Ofoefule et.al 2010). Also, Ubwa et.al (2013) in their work on preparation of biogas from plants and animal waste concluded that plants materials (Stems and leaves) rich in fiber content and low in lignin content with soft tissues in combination with animal's waste are potential sources of biogas.

The merits of biogas are endless: these include the fact that it is a waste management techniques in which micro-organism are eliminated during the anaerobic process. It is a clean source of energy security because its feed stocks are obtained from waste materials. The technology for biogas production is design in a way that ensure energy independent. Consequently, a unit can be design to cater for a community or a family. The digested substrate when dried and condition is believed to give a high yield effect on crop as an organic fertilizer. Biogas when used as domestic cooking industrial heating and combined heat and power (CHP) operation produce positive effect on the environment as there is no build up of carbon monoxide to the reduction of green house emission thereby reducing global warming. (Ukpai and Nnabuchi, 2012, Chonkor, 1983; Tabascum et.al, 1990; Salman, 2018 and Recebli et.al, 2015).

The major considerations for effective production of biogas from livestock manure according to (Elijah et. al, 2009, Salman, 2018 and Recebli et.al 2015) among others are PH and temperature of feed stock. Usually biogas system operates optimally at neutral PH and mesophilic temperature of around 35^0C. The carbon-nitrogen ratio range of 20:1 to 30:1 is also an important factor for maximum gas production. It worth nothing that animal manure carbon-nitrogen ratio of 25.1 falls within this range. Other important factors include solid concentration in feed materials, pretreatments, ease of mixing and handling and hydraulic retention time (HRT) which determines the value of digester.

2.0 MATERIALS AND METHODS

The poultry dropping and pig dung were used for the experiment collected from Adeniran Ogunsanya College of Education, Otto/Ijanikin, Lagos Experimental farms while the cow dung was collected from Otto/Ijanikin cow slaughter slab adjacent to the College. The three samples of dung were sundried for seven days. Each sample was then milled into particles using laboratory material grading sieve of 2.00mm (Ojolo et.al 2011 and Ofoefule et.al 2009). Three kilograms of each grades of animal manures were obtained for the experiment and already digesting dung of the three animals to be used as inoculators were also obtained.

2.1 Experimental Set Up

A set of three 20 litre biogas digesters to cater for the digestion of the three animal waste simultaneously were constructed in the workshop using steel. Each of the digesters was connected to a gas collector by a plastic hose. A control valve is positioned at the end of the hose to keep the digester air-tight as much as possible when closed thereby creating the much desired anaerobic environment to enhance the activities of the anaerobic bacteria and quicken the production of the desired biogas. Each control value was opened periodically to allow the flow of the biogas into the gas collector.

A thermometer was installed on the top of each of the digesters to monitor the temperatures inside the digesters. Each digester also had an opening on the top for the loading of the substrate (animal waste) which must be firmly locked with a threaded lid. After constructing the digesters, a leakage test carried out to ensure that they were free of any kind of leakage or else, the digesters would not function.

Each of the digesters was connected to the gas measuring apparatus. The apparatus is a one-litre measuring cylinder filled with water and inverted into acidified saline solution (5g of table salt in 2litres of water in a trough). This permits collection of biogas by downward displacement of water in the measuring cylinder. (Ojolo et.al 2011, Uzodinma et.al 2018, Ukpai and Nnabuchi 2012).

2.2 Experimental Procedure

Each sample of the pulverized animal dungs was loaded into the digester and thoroughly mixed with a quantity of water to form slurry. In this experiment, 3kg of the three different dry pulverized dung each was mixed with 16litres of water to give a 0.19kg/litre slurry. Submerging of the substrate in water was to expel air (Oygen) in the substrate so that the anaerobic bacteria could start their activities for the biogas generation. It worth noting that already digesting animal dung was also added as inoculating starter to quicken the microbial action and the biogas generation.

As the experiment continued, the digester was shaken periodically to allow for even spread of micro-organisms in the digesters which led to complete digestion of the substrate. Shaking of the digesters also got rid of artificial barrier for biogas generation created over the surface of the substrate. (Ojolo et.al 2011, Uzodinma et.al 2018, Ukpai and Nnabuchi 2012). The volume of biogas yield was measured and recorded on daily basis. During this period, daily ambient temperature varied between 28^{o}C to 32^{o}C were observed.

3.0 RESULTS AND DISCUSSION

3.1 Results

Table 1: Biogas yield from the animal manure (ml).

	Poultry	Pig	Cow
Total biogas yield (ml)	1160.00	1025.00	780.00
Average yield/day (ml)	38.67	34.17	26.0
Biogas yield/kg (ml)	386.67	341.67	260.00

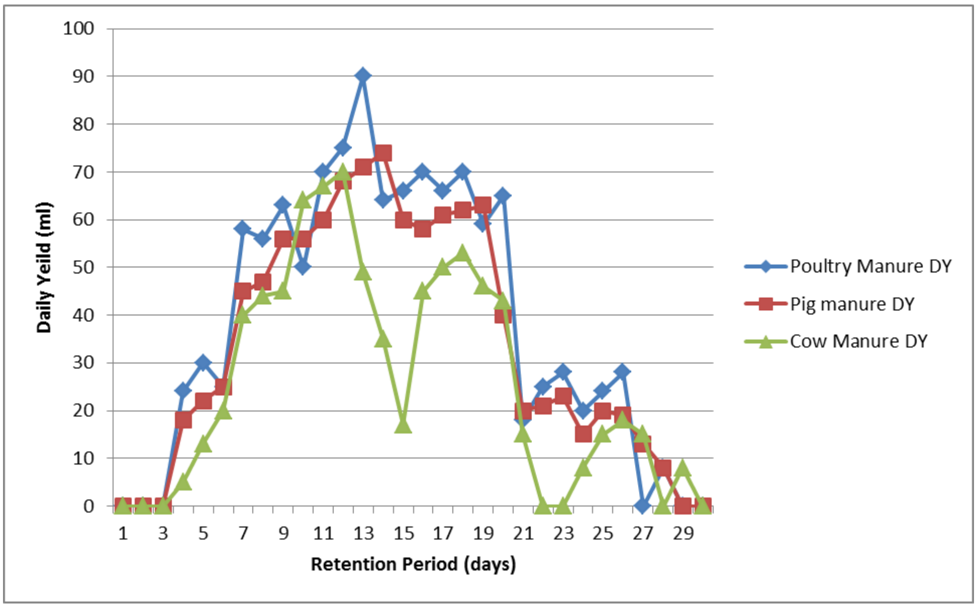

Fig. 1: Daily production of biogas from three different animal dungs.

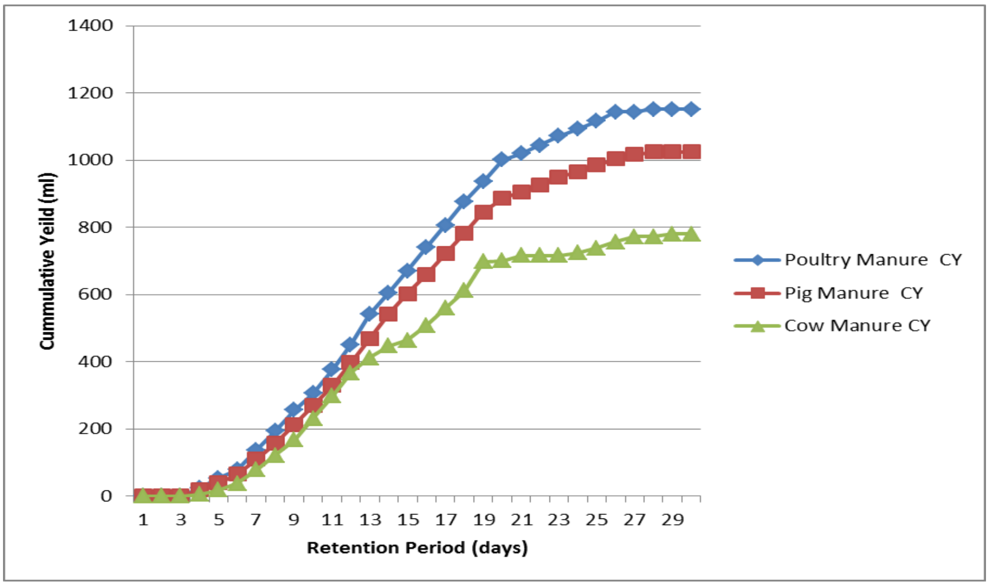

Fig. 2: Cumulative biogas yield from three different animal dungs.

3.2 DISCUSSION

The results in Fig. I above shows nonlinear production of gas during the retention period of 30 days. On the first three days there was no production of biogas for the three manure used thus suggesting the fermentation has not started (Adeyemo, et. al 2008, Salman 2018 and Recebli et. al 2015). The samples low moisture content account for increase in the cumulative volume of gas produced as the generation of biogas depends on several factors such as PH, temperature, total solid concentration in feed materials and microbial activities (Elijah et.al 2009, Salman, 2018 and Recabli et.al 2015).

It was also observed that the production of biogas did not start for all the three manure until the 4th day. It increased and got to the peak on the 13th day for poultry manure, 14th day for pig manure and 12th day for cow dung. After the peak, the production fell sharply until 16th day, (and 18th day and 19th days respectively for poultry manure, pig manure and cow manure. The production then declined again and went up again at 23rd day for both poultry manure and pig manure while another peak was observed for cow dung at the 26th day. After this retention period the biogas production fell sharply again and declined gradually till the 30th day (Fig 1).

The breaks or nonlinearity of gas production within the 30 days' retention period is due to unfavourable ambient condition and temperature fluctuation which influenced methane producing bacteria (Ofoefule and Ugodinma, 2009).

From the comparative analysis of the biogas production from the three manure, the following result were obtained. The result in Fig 2 and Table 1 shows that manure from poultry, pig and cow, gave average daily yield of 38.67ml, 34.17ml and 26.00ml respectively while a cumulative value of 1160.00ml, 1025ml and 780ml respectively were recorded for 30 days' retention period. These results show that the three manure used are excellent biogas materials (Guruswamy et. al 2003, Lucas and Bamgboye1998, Machido et. al 1996 Maishanu and Sambo, 1991 and Abbasi et. al 1990).

4.0 CONCLUSION

The poultry dropping produced the highest volume of biogas, followed by pig dung and then cow dung. This could be attributed to greater amount of nutrients and nitrogen in the poultry dropping. It can also be inferred that waste from smaller animals produced more biogas than bigger animals. The lag time for all the three animal waste was four days this may be due to the drying and grading pre-treatment given to all the three manure. The three animal wastes can be termed good sources of biogas and as such could also form potential inoculating starter for plant material and other biological waste. The use of this technology in combining plants and other wastes to generate biogas and bio-fertilizers should be encouraged in larger scale production in order to harness other benefits such as creating a stabilised resource that retains the fertilizer value of original material and reducing unwanted pathogens, improved environment and public health through, cleaner cooking and better hygiene.

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