EXAMINATION OF EFFECTIVENESS OF BIOGAS PRODUCTION FROM ANIMAL WASTE WITH BLENDS OF ENERGY CROPS (*ZEA MAYS INDURATA AND PANNICUM MAXIMUM*)

Samuel C. Ilabor
Department of Chemistry,
Federal College of Education (Technical), Asaba,
Delta State.

And

Knowledge Atikueke
Department of Chemistry,
Federal College of Education (Technical), Asaba,
Delta State.

Abstract

The quest for alternative energy source as against the usual fossil source is a well known global issue. Fuels obtained from plant and animal origin whether living or delayed are to know as biofuels. E.g. fuels from Cassava tuber, cane sugar, jatropha, etc. The choice of a particular plant depends on its availability, intended problem to be solved and cost. Waste of plant and animal originated from poultries have become another major environmental challenge even as the nation craves for food security agenda (ie. Production of more food, more waste generated). The concept of "waste to wealth" has been well acknowledged globally. Its relevance as an alternative energy source of domestics and laboratory use cannot be overemphasized. Thus, in this paper, wastes from animal energy crop were subjected to the process of biogas production. The result showed significant yield in the gas produced. It applicability in integrated farms was also discussed.

Keywords: Biodigester, Biogas, Biodegradable, Biotechnology.

There has never been a time other than our present times where conscious emphasis and effort is placed on the environmental implication of the combustion of fossil fuel, effects of particulate matter and other forms of environmental threats such as green house effect, crude oil spills, acid rain, ozone layer depletion, etc. associated with the various anthropogenic activities most especially the prevalent conventional forms of energy generation. This is why the Federal Government of Nigeria has given a mandate to oil companies to stop gas flaring by the end of 2012 (Punch, 2013). The modern concept of the scientific revolution that is fast graining grounds now is the conversion of waste to wealth with a firsthand interest in keeping up with environmental hygiene from national to a global scale (Hills and Roberts, 1980).

Biogas contains methane, carbohydrate and other gases. It is a gas produced from the biological degradation of organic matter such as cow dung, poultry droppings, rabbit dung, sewage, swine dung, energy crops, etc. This type of biofuel is produced when anaerobic bacteria decomposes the biomass anaerobicallys. The use and poor disposal methods of animal wastes and agricultural plant remains is one of the major sanitation problems faced by most developing countries. (Chao, 2003). Currently, in most parts of Nigeria, people traditionally use animal wastes as fertilizers on farms to boost agricultural production. This practice has been intensified as a result of high cost of fertilizer that has slowed down the pace of farming in Nigeria. Apart from the fact that dried or semi-dried animal wastes sprayed on farms as fertilizers are a potential health hazards to both grazing animal, the leaching effect into ground and surface water poses a great danger to humans in the area of ground water supply.

The quest for the availability of energy has led to the huge consumption of fossil fuel on a very large scale. Fossil fuel is a non-renewable energy resource (depletable resource) and upon combustion produces a lot of toxic substances which contributes significantly to green house effect, ozone layer depletion, formation of acid rain, particulate matter pollution, global warming, etc. because, fossil fuel id depletable, its availability will continue to decrease and cost will continue to increase. Since, the world might run out of oil and natural gas in 2050 and 2068 (http/:Petrostrategies, Inc.. .2013) typically, the capital and running costs of a biogas electricity generating plant is $3,700 t 7,000/kwh (₦4584, 600.00) respectively. The total capital costs of anaerobic digester plants are high and may range from a few hundred of thousands to a few million dollars (*http://www.agric.gov.ab/...2013*)

Biogas is a mixture of methane^{-}(CH_4), the active gas (50-70%., carbon dioxide (Co_2) (30-40%); hydrogen (H_2) (5-10%); Nitrogen (N_2) (1-2%) and other traces of carbon monoxide, ammonia, hydrogen sulphide and water vapour. The levels of these gases depend on the nature of the waste, also, some nutrient polymers such as carbohydrates, proteins and lipids required for the reaction to take place. They are broken down anaerobically into three stages as pointed out by Uzodinma and Ofoefule (2008).

Stage 1: Hydrolysis

Hydrolytic decomposition of plant and animal matter. This stage breaks down the organic matter to usable sized molecules such as sugar.

$(C_6H_{10}O_5)n + nH_2O$ --------------> $n(C_6H_{12}O_6)$

Stage 2: Andogenesis/Acetogenesis

This is the conversion decomposed organic matter to organic acid

$n(C_6H_{12}O_6)$ ------------> nCH_3COOH

Stage 3: Methanogenesis (Methane Formation)

Finally, the acids are converted to methane gas.

$3nCH_3COOH$ -----------> $nCH_4 + CO_2$

Biogas has a flame temperature up to 800^{o}C and a calorific value of 5650Kcal per cubic meter of gas (Anon, 2003). According to Uzodinma and Ofoefule (2006) a biogas system becomes flammable when its methane content is at least 45%. The use of biogas can be traced back to the ancient persons who observed that rotten vegetables produce flammable gas (San, 2003). In 1859, Indians built the first sewage plant in Bombay. Marco polo mentioned the use of covered sewage tanks in China. This dates back to 2000 years ago in ancient China. The idea for the manufacturing of gas was brought to the United Kingdom in 1895 producing wood gas from wood and later coal. The resulting gas used in lighting street and homes (San, 2003). With small locally fabricated biogas unit as shown in this research work, the gas is channeled with air tight valves. The by-products are also useful fertilizers and soil improvers or compost if the feed is not contaminated (Anon, 1995). According to Hills and Roberts (1980), anaerobic digestion generally perceived as a waste treatment technology is basically a simple process carried out in a number of steps that can use almost any organic waste material as a substance. It occurs in digestive systems, marches, rubbish, dumps, septic tanks, etc.

The representative data or reactions in a biogas digester and their constituent energy under standard and typical conditions are given by Hill and Roberts (1980) in table 1.0.

Table 1.0: Biogas Digester and their Constituent Energy

Representative Reaction	Products	AG^+	AG
Glucose + $3H_2O$	$3CH_3 + 3HCO^-_3 + 3H^+$	-403.6	-399.1
Glucose + $4H_2O$	$2CH_3OO^- + 4H^+ + 4H_2$	-2063	-318.5
$CH_3COO^- + H_2O$	$CH_3 + HCO_3^- + H^+$	-31.0	-24.5
$4H_2 + HCO^- + H+$	$CH_4 + 3H_2O$	-135.5	-31.6
Butyril + $2H_2O$	$2CH_3COOH + 3H_2$	+48.1	-17.4
Propanoate + $3H_2O$	$2CH_3COO^-H + H^+ + 3H_2$	+748.1	-17.4
Butanoic acid + $7H_2O$	$3CH_3COOO^- + HCO_3^- + 3H^+ + 3H_2$	+89.7	-15.7
$2HCO_3 + H^+$	$CH_3COO^- + 2H_2O$	-104.6	-7.0

Statistical data showing the potential biogas production from different feedstock and crops is given by Agbogu and Mbaey (2006) as shown in table 2:0

Table 2.0: Potential Biogas Production from Different Feedstock

Feedback	Availability (Animal^{-1}d^{-1})	(cm^{3}kg^{-1})
Cattle Waste	10	0.56
Buffalo Waste	15	0.54
Piggery Waste	2.25	0.18
Chicken Waste	0.18	0.011
Human Waste	0.4	0.028

However, the Federal Government of Nigeria has in 2001 established the National Biotechnological Development Agency (NABDA) and given the mandate to develop conversion strategies to promote sustainable utilization of Nigeria's huge biological resources and to facilitate the speedy evaluation and utilization of the process and products of biotechnology while ensuring environmental stewardship (Ofoefule and Uzodinma).

In Ibadan, "Habitat Watch"; an NGO and a community based organization has joined with technology innovators from Thailand and the sustainable Ibadan project, Nigeria (UN-HABITAT PROGRAMME) to install biogas plants that will run abattoir's effluents to create a source of domestic energy, abate pollution and mitigate green house effect. The biogas plant is expected to return a profit on the initial investment within three years and will have a production life span of fifteen years (GNEEDER, 2006).

In the developing economies, the major challenge in the energy sector has been how to ensure cheap and alternative source of energy for all categories of cooking in large/medium, farms/poultries and families, how to guarantee effective and efficient source of energy in schools, colleges and laboratories.

The purpose to this research is focused on how to convert the readily available biodigestable resources such as poultry droppings and energy crops such as pannicum, maximum and zea mays indurata to alternative energy source using a simple low cost locally fabricated anaerobic digester.

This research highlights the processes based on a waste to wealth concept that sees rubbish (garbage, debris or wastes, differently) not as tiresome waste of space but as where there are economic opportunities. This research confirms the combustibility of methane gas obtained from poultry droppings and energy plant remains as a way of enlighten the populace on the importance of bioconversion of wastes into useful energy where these wastes are in abundance and constituting pollution problem and disrupting environmental aesthetics.

Materials and Methods

Locally Fabricated Digester Materials

200 litre capacity steel drum, one piece of 90cm length ½ GL pope (galvanized), one piece of ½ ball gauge, one piece of bent GL, two pieces of ball valves, one tin of putty, a four yard length of 1 inch diameter gas line, two screws, a bursen burner, screw driver, a top pan weighing scale and two pieces of nipple GL.

Digester Input Materials

The Digester Input are given on table 3.0

Table 3.0: Digester Input Materials from Three (3) Different Farms

S/N	Name of Poultry Farm	Quantity of Dropping (kg)	Nature of Dropping
1	Consummate Foods ltd, Asaba	27.5	Wet
2	Dele Poultry/farm ltd, Asaba	16.0	Wet
3	Obiora Farms ltd, Asaba	156.5	Wet

Total quantity of dropping is 27.5 + 16.0 + 156.5 = 200kg

Hence, total quantity of wet poultry droppings obtained from the three farms weighs 200kg.

Plat Materials Used

Table 4: Nature of Energy Crops Used

Name of Energy Crop	Quantity (kg)	Nature
Pannicum Maximum	5.0	Fresh
Zea Mays Indurata	15.0	Semi dried

Total quantity of plant materials used weighed 20kg and about 80 litres of waste was used.

Slurry Mixture

Total quantity of slurry = Total quantity of poultry + Total quantity of plants remains + about 80 litres of waste water.

The slurry was properly mixed and manually fed into the biodigester and the experiment was carried out under daily ambient temperature range of between 25^{o}C to 31^{o}C throughout the period of the experiment.

Precautions Taken Before, During Slurry Mixture and After Slurry Transfer

1. It was ensured that all fabricated parts were properly welded, sealed air tight to avoid leakages.

2. Proper care was taken when transporting the biodigester from the fabricating workshop to avoid fracture of welded parts.
3. There was use of laboratory aprons, hand gloves and nose masks during slurry handling.
4. The tap at the base of the biodigester was opened to enable outflow of excess waste water during slurry transfer into the digester unit.
5. It was ensured that all parts of the biodigester unit were properly connected.

Finally, it was ensured that the unit and its whole content were closely monitored to avoid unnecessary opening of the unit's taps before and after all flammability tests were conducted.

Results and Discussion

Table 5.0 shows the date, period, t me allowed and the flammability test result for the experiment.

Table 5: Flammability Test Result

Date	Time Elapsed (days)	Order of Test	Date of Test	Flammability Result
5/10/2010	10	First	15/10/2010	No flame
15/10/2010	10	Second	25/10/2010	Flammable with shorter retention
25/10/2010	15	Third	9/11/2010	Flammable with longer retention time

The result obtained from the table 5.0 shows that anaerobic digestion of animal waste and blends of energy crops yielded biogas that is clean, efficient and environmentally friendly for cooking under a total period of 35 days. The production of flammable gas took place after a 20 days period but shorter retention may be because energy crops have high carbon and fibre which indicates that it contains a lot of cellulose, semi cellulose, pectin, lignin, and plant wax (Uzodinma and Ofoefule, 2008). Lignin and plant wax are very difficult to biodegrade and can be a major rate determining step in anaerobic digestion process

Poultry waste used in biogas production has longer onset of gas flammability and shorter retention time. This could be attributed to the production of excess ammonia as a result of high levels of protein and nitrogen in poultry waste which tends to intoxicate the system (Ofoefule and Uzodinma, 2006).

Earlier work done by Tinsley and Nowakawski in 1959 submitted that application of poultry droppings to waste slurry brought an abundant and vigorous micro-flora immediately into contact with feed substrate. They further explained that as uric acid was decomposed, ammonia was produced which diffused rapidly so that the cellulose composing organisms were well supplied with nitrogen from an early stage.

Therefore, blending poultry dropping with energy crops may have aided the onset of gas flammability for a poultry waste and field grass blend even though poultry is not a ruminant animal. Digested sludge does not only increase crop yield but also improves the soil and its fertility, a number of field works has proven (Garba, 1994).

Conclusion

The flammability results obtained from this investigation shows that biogas can be a suitable substitute to fossil fuel energy resource. Also, blending poultry droppings with energy crops, also, increase the gas yield and retention time of biogas. The problem associated with anaerobic digester technology is that it seems complicated and expensive, but it can really be very cheap as compared to the cost of kerosene, petrol, diesel, cooking gas and synthetic fertilizer.

Nearly all small and medium scale farm holdings or individuals could afford the estimated cost of ten thousand naira for the construction of a locally made biodigester as shown in this work. This investigation equally shows that it takes between 25 and 35 days to generate your own biogas ready for cooking if the biodigester is well constructed, temperature conditions met and precautionary measures taken to ensure safety and longevity of your biodigester. It is well reported that all Songhai-farm projects in Nigeria and other West-African countries rely on biogas-waste-recycled-mechanism for their daily energy use.

The adoption of biogas technology is a very good alternative solution to local energy needs, provides significant benefit to humans and the ecosystem. Individuals can fund and run successfully this kind of low cost biotechnology to reduce their expenditures on highly expensive depletable energy. Larger farm holdings and diary operations need appropriately scaled down treatments for the mountains of dung and wastes from their livestock, birds and plant wastes. There should be an immediate shift in government policies to favour the adoption and popularization of biotechnology and other sources of renewable energies in Nigeria.

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