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Research Article

# EVALUATION OF THE BIOGAS PRODUCTION POTENTIAL OF ANAEROBIC CO-DIGESTION USING CATTLE DUNG, POULTRY DROPPINGS AND CORNCOB

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## ABSTRACT

The production of biogas through anaerobic digestion process is a function of nature of substrates (biomass) loaded into the digester. Therefore, this project principal aim was to evaluate the biogas production potential of anaerobic co-digestion using cattle dung, poultry droppings and corncob. The research was carried out in 6 constantly agitated 500ml batch digesters at room temperature for a period of 62 days with the cattle dung, poultry droppings concentration held constant and varying corncob concentration. The volume of biogas produced during this period was evaluated using water displacement method. At the end of the experiment, it was observed that corncob concentration of about 44-50% which corresponds to about 6.67- 7.4% of total solids in 250ml water gave rise to most efficient biogas production mixture. The maximum biogas yield or efficiencies being 0.013litres/TS (g) fed, 0.045litres/VS (g) fed, 0.2litres/TS (g) destroyed and 0.225litres/VS (g) destroyed. The digester with 0% corncob and that with 71.43% did not produce any biogas throughout this period. It was also suggested that, for an efficient co-digestion of cattle dung, poultry droppings and corn cob, the substrate has to be mixed in approximate ratio 1:1:2 respectively and a cylindrical digester size of 22m$^3$ volume will be good enough for an efficient co-digestion of cattle dung (5kg), poultry droppings (5kg) and corncob (10kg) in 250kg (250m$^3$) of water.

# INTRODUCTION

Production of waste materials is an undeniable part of human society, particularly as the population is on geometric increase. The wastes are produced by several sectors including industries, forestry, agriculture and municipalities. The accumulation of waste and the "throw-away philosophy" result in several environmental problems, health issues and safety hazards, and prevent sustainable development in terms of resource recovery and recycling of waste materials. A perspective aimed at promoting greater sustainable development and resource recovery has influenced solid waste management practices, and is gradually becoming implemented through policy guidelines at national levels in a number of industrialized and even developing countries. Guidelines and directives to reduce waste generation and promote waste recovery are laid down according to the "waste management hierarchy", in which waste prevention, reuse, recycling and energy recovery are designed to minimize the amount of waste left for final, safe disposal (Isa and others, 2004).

The increasing population and the development demands in the Third world have caused an increasing demand on traditional fuels. The fast rate of forest destruction and low rate of aforestation has simultaneously reduced the availability of firewood. To arrest the environmental and agricultural deterioration, it is imperative to introduce other sources of energy such as hydro-power, wind and solar energy and biogas. Biogas is considered as one of the cheapest renewable energies in rural areas in developing countries. Production of biogas would not only save firewood but also be beneficial for integrated farming systems by converting manure to an improved fertilizer for crops or ponds for fish and water plants. Other benefits of biodigestion include the reduction of manure smell, elimination of smoke when cooking and the alleviation of pathogens and thereby improving hygiene on farms (Bui, 2002).

# AIMS AND OBJECTIVES OF STUDY

To attempt at bringing out useful/usable products from environmental waste material (corncob) and while generating wealth from waste and control of environmental pollution is achieved. Also creation of an alternative source of power (energy) for the future at a relatively affordable rate. And as a by-product, good and reliable soil manure is generated.

# LITERATURE REVIEW

Biogas is a renewable, high quality fuel, which can be utilized for various energy services such as heat, combined heat and power or a vehicle fuel. This would reduce the use of fossil-fuel-generated energy and lessen environmental impact, including global warming and pollution, improve cleanliness, reduce demand for wood and charcoal for cooking and provide a high quality organic fertilizer (Parawira, 2004).

According to Daniel (2000), biogas can also be produced naturally at the bottom of ponds and marshes which gives rise to marsh gas or methane gas. He stated further that, there are two man-made technologies for obtaining biogas; the first (which is more wide spread) is the fermentation of human and/or animal waste in specially designed digesters. The second is a more lately developed technology for capturing methane from municipal waste landfill sites. The scale of simple biogas plants can vary from a small household system to a large commercial plant of several thousand cubic meters (Daniel, 2010).

## METHODOLOGY

**(a) SAMPLE COLLECTION:**Poultry droppings were collected from a poultry farm situated in Choba community in Rivers State. The Poultry uses the battery cage system, hence, the droppings from the farm was void of other particles such as sawdust typical of the deep litter system. About 1kg of the droppings was collected once from the farm in a plastic container with covering. Also, Cattle dung was obtained from an abattoir situated in Choba community, Obi-akpor Local Government Area of River State. Approximately 1kg of the cattle dung was collected once from the abattoir in a plastic container as well. Corncobs were collected from the streets of Choba community as well as from the University campus (Choba and Abuja). A total of twenty pieces of the corncobs were gathered for the research purpose.

**(b) PRE-TREATMENT OF SAMPLES COLLECTED:**The poultry droppings and the cattle dung were sun dried for about 10 days, after which they were crushed mechanically using a grinding mill. Note that these two samples were treated separately. The purpose of crushing them was to ensure homogeneity in their structure. In the same vein, the corncob were first sun dried for two weeks, thereafter, oven dried at 70°C for two hours and then crushed using grinding mill also to attain homogeneous structure of particles.

**(c) EXPERIMENTAL MATERIALS:**The under listed materials were employed in setting up the experiment. Buchner 500ml, Conical flask 250ml ,Measuring Cylinder 100ml,Corks,Connecting tubes/ Delivery tubes, Flat bottom flask, Funnels, Filter papers, Weighing Crucibles, Chess cloth, pH meter, Muffle furnace, Thermometer, Grinding mill

**(d) DIGESTER PREPARATION:**A set of six 500ml Buchner flask were used as digesters. Each of the digesters contained fixed quantity of cattle dung and poultry droppings, but an increasing quantity of corncob. The digesters were labeled 1, 2, 3, 4, 5 and 6 respectively. The table 1 shows the composition of the digesters used in this experiment

The wastes in each of the digester were mixed with 250ml of distilled water and then corked so as to create anaerobic environment. The experimental set up were allowed to run for a period of 62 days and agitated once daily and records also taken daily. Ambient temperature measurement was also determined during the period of the experiment. pH was determined before the commencement of the experiment and also at the end of the experiment.

## PRESENTATION OF RESULT

**(A) PARAMETERS MEASURED:**

i. Ambient temperature determination

ii. Determination of total solids

iii. Determination of volatile solids

iv. Measurement of biogas

**(B) COLLECTION OF DATA:**The results of pH Values Before and After Experiment total and solids determination of digesters content before and after experiment are as presented in the table 1 .

| Digesters | PH Values (before experiment | PH Values (After experiment | Cattle dung (g)(B) | Poultry Droppings (g)(B) | Corncob (g)(B) | Total Solids (g)(B) | Total Solids % in 250ml $H_2O$ (B) | Corncob % of Total solids(B) | Total Solids (g)(A) |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 6.77 | 6.10 | 5 | 5 | 0 | 10 | 3.85 | 0.00 | 5.725 |
| 2 | 6.76 | 7.49 | 5 | 5 | 5 | 15 | 5.66 | 33.33 | 10.95 |
| 3 | 6.68 | 7.38 | 5 | 5 | 10 | 20 | 7.41 | 50.00 | 15.82 |
| 4 | 6.56 | 7.35 | 5 | 5 | 15 | 25 | 9.09 | 60.00 | 18.325 |
| 5 | 6.42 | 7.30 | 5 | 5 | 20 | 30 | 10.71 | 66.67 | 24.69 |
| 6 | 6.37 | 7.27 | 5 | 5 | 25 | 35 | 12.28 | 71.43 | 28.112 |

**Table 1:** Total Solids of Digesters Content Before and After Experiment

Note: (A) Represents after experiments while (B) represents before experiment

Results of Volatile Solids Determination

a) The volatile Solids content of the three substrates namely; Cattle dung, Poultry droppings and Corncob were determined before the commencement of the experiment and is as shown in the table 2.

| **Sample** | **Volatile solids(% of total solids)** |
|---|---|
| Cattle dung | 74 |
| Poultry droppings | 77 |
| Corncob | 82 |

**Table 2:** Volatile Solid Contents of Respective Substrate Before Commencement

b) Results of volatile solids determination of digesters content before and after experiment are presented in Table 3

| Digester | Volatile solids(g)(B) | Volatile solids in 250ml of $H_2O$(%)(B) | Volatile solids(% of total solids)(A) | Volatile solids(g)(A) |
|---|---|---|---|---|
| 1 | 7.55 | 2.9315 | 81.034 | 4.6392 |
| 2 | 11.715 | 4.4762 | 71.7169 | 8.7290 |
| 3 | 15.88 | 76.6435 | 12.125 | 12.125 |
| 4 | 20.045 | 76.4802 | 14.015 | 14.016. |
| 5 | 24.210 | 74.5281 | 18.401 | 18.401 |
| 6 | 28.375 | 79.8591 | 22.45 | 22.45 |

**Table 3:** Volatile Solids of Digesters Content Before And After Experiment**.**

Note: (A) Represents after experiments while (B) represents before experiment

**(C) ANALYSIS OF DATA:**

**Biogas Production Analysi**s:The analysis carried out on the biogas produced is that of the variance study which is to ascertain whether the corncob had any significant or appreciable impact on biogas production or not in each of the digesters having varying amount of corncob.

Let the Null hypothesis ($H_o$) = There is no significant difference in the mean biogas produced by the 6 digesters.

$$X_A = X_B = X_C = X_D = X_E = X_F$$

Let the alternate hypothesis ($H_a$) = there is a significant difference in the mean biogas produced by the 6 digesters.

$$X_A \neq X_B \neq X_C \neq X_D \neq X_E \neq X_F$$

$X_A$ = mean biogas produced in Digester 1.

**Analysis of Total Solids and Volatile Solids Destroyed:** The table 4 shows the total solids and volatile solids destroyed before and after the experiment.

| Digester | Total solids destroyed(g) | Volatile solids destroyed(g) |
|---|---|---|
| A | 4.275 | 2.9108 |
| B | 4.05 | 2.9860 |
| C | 4.18 | 3.755 |
| D | 6.675 | 6.03 |
| E | 5.31 | 5.809 |
| F | 6.888 | 5.925 |

**Table 4:** Total Solids and Volatile Solids Destroyed at the end of Experiment

**Analysis of Biogas Production Rate:** The Average rate of biogas production is the biogas production rate at the end of 62 days

| Digester | Average biogas production rate (biogas (l)/digester vol/day) |
|---|---|
| 1 | 0.00000 |
| 2 | 0.01196 |
| 3 | 0.02282 |
| 4 | 0.01917 |
| 5 | 0.01501 |
| 6 | 0.00000 |

**Table 5:** Average Biogas Production of Digesters

## RESULT AND DISCUSSION

The data obtained before and after the experimental set up were quite different in their initially determined values. The pH values of the slurry before and after the experiment shows a significant difference, with the pH values of the slurry before the experiment lower than that of the slurry after the experiment. This is in consonance with the work of Shoeb and Singh (2000, 2002). It was also observed that the total solids and volatile solids concentration changed over time and this is to show that the micro-organisms (bacteria) responsible for anaerobic digestion of waste were active during the experimental period.

In the course of the experiment, two of the digesters failed to produce biogas. Interestingly, the two digesters are the ones with extreme compositions, namely digester 1(zero % corncob) and digester 6(71.43% corncob). As a result of this, the results obtained from the other four digesters, 2, 3, 4, and 5 were used in the graphical plots and discussion. The failure of digester 1 to produce biogas was probably due to the high concentration of acidogenic bacteria. These bacteria are facultative anaerobic and can grow under acidic conditions. They use the oxygen dissolved in the solution or bounded-oxygen, thereby, creating an anaerobic condition which is essential for the methane producing microorganisms. Therefore, methane- and acid-producing bacteria act in a symbiotically way. Hence excessive acid-producing bacteria lead to toxic situation and consequent low or no yield of biogas. It also explains the drop in pH value at the end of the experiment in this digester. This is consistent with the work in Biogas digest, volume 1, page 9-10.

In the other hand, the inability of digester 6 to produce biogas can be attributed to high carbon-nitrogen ratio caused by the excessive corncob in that digester. According to biogas digest, vol. 1, the C/N ratio of cattle dung is 19.9, poultry droppings 9.65 and that of corncob is 49.9 and the metabolic activities of methanogenic bacteria can be optimized at a C/N ratio of approximately 8-20. Therefore, digester 6 which has a mixture containing 71.43% corncob will definitely has a high C/N ratio thereby inhibiting the process of methane formation.A higher ratio will leave carbon still available after the nitrogen has been consumed, starving some of the bacteria of this element. These will in turn die, returning nitrogen to the mixture, but slowing the process and eventually terminating the digestion (Santhosh and Revathi, 2014). Also, Lutz (2008), explained that as a result of the presence of inhibitory substances, bacterial growth can be negatively affected resulting in a decrease of the rate of methane gas production or may even cause anaerobic digester upset.

It is noteworthy also that the pH value of the different digesters (excluding digester 1) seems to lie close to the optimum pH requirement (6.6-7.6), and this helped to provide a similar working environment in the digesters. The temperature within the period varied between a 2-day average minimum of 26.5°C; and 2-day average maximum of 30°C. Also, an average temperature of 28.6°C was recorded within this period.

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