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STUDIES ON BIOGAS PRODUCTION FROM FRUITS AND VEGETABLE WASTE

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ABSTRACT
Organic compounds decompose under anaerobic condition to yield biogas. This work presents results of the study on biogas production from fruits and vegetables waste materials and their effect on plants when used as fertilizer (Using digested and undigested sludge). It has been observed that the highest weekly individual production rate is recorded for the cow dung (control) slurry with average production of 1554 cm^3, followed by pineapple waste which had 965 cm^3 of biogas, then by orange waste which had 612cm^3 of biogas, lastly, pumpkin and spinach wastes had 373 cm^3 and 269 cm^3 respectively. The results obtained shows that difference in the production of biogas to a large extent depends on the nature of the substrate. All the substrates used appeared to be good materials for biogas production and their spent slurries can be used as a source of plant nutrients.

Key words: Biogas, Anaerobic digestion, Substrate, Vegetable waste, Cow dung

INTRODUCTION

The techniques used for the conversion of organic materials to biogas have been in existence for many years. Methane generation has been applied to meeting the energy needs in rural areas. In the England, India, Taiwan, for example, methane generating units as well as plants using cow manure and municipal waste have been in operation for years. In United States there has been considerable interest in the process of anaerobic digestion as an approach to generating a safe clear fuel as well as source of fertilizer (Garba and Sambo, 1995). The use of rural wastes for biogas generation, rather than directly used as fuel or fertilizer, offers several benefits such as, the production of energy resource that can be stored and used more efficiently, the production of stabilized residue (sludge) that retains the fertilizer value of original material and the saving of energy required to produce equivalent amount of nitrogen-containing fertilizer by synthetic process. Indirect benefits of biogas generation include the potential for partial sterilization of waste during formation with consequent reduction of the public health hazard of faecal pathogens and reduction of fungal and other plant pathogens from one year's crop residue to the next.

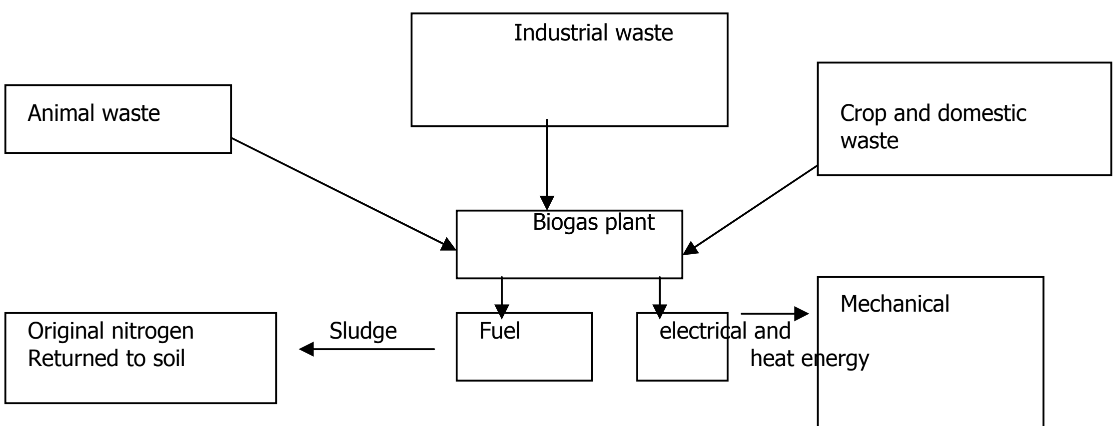

Figure 1: Schematic diagram of biogas generation and uses

Biogas is a flammable gas produced when organic materials are fermented under anaerobic condition. It contains methane and carbon (IV) oxide with traces of hydrogen sulphide and water vapour. It burns with pale blue flame and has a calorific value of between 25.9-30J/m^3 depending on the percentage of methane in the gas. The gas is called by several other names, such as: dung gas, marsh gas, gobar gas, sewage gas and swamp gas (Dangoggo and Fernando, 1986).

Biogas production involves the fermentation of organic materials such as agricultural waste, manure and industrial effluents in an anaerobic environment to produce methane (CH_4), carbon (IV) oxide (CO_2), and hydrogen sulphide (H_2S).
Anaerobic digestion is a three stage process.

The first stage consists of micro organisms attacking the organic matter where complex organic compounds such as cellulose and starch are converted to less complex soluble organic compounds. Polymers are transformed into soluble monomers through enzymatic hydrolysis

$$n(C_6H_{10}O_5) + nH_2O \xrightarrow{\text{hydrolysis}} n(C_6H_{12}O_6) \quad (1)$$

These monomers become substrates for the microorganisms in the second stage where they are converted into organic acids by a group of bacteria.

$$n(C_6H_{12}O_6) \xrightarrow{\text{acid forming bacteria}} 3n\,CH_3COOH \quad (2)$$

These organic acids primarily acetic acid form the substrate for the third-stage.

$$CH_3COOH \xrightarrow{\text{methane forming bacteria}} CH_4+CO_2 \quad (3)$$

In the third step, methanogenic bacteria generate methane by two routes, by fermenting acetic acid to methane (CH_4) and CO_2 and by reducing CO_2 via hydrogen gas or formate generated by other bacterial species.

$$CO_2+4H_2 \xrightarrow{\text{reduction}} CH_4+2H_2O \quad (4)$$

Similarly CO_2 can be hydrolysed to carbonic acid and to methane as in equations5 and 6

$$CO_2+H_2O \xrightarrow{\text{Hydrolysis}} H_2CO_3 \quad (5)$$

$$4H_2+H_2CO_3 \xrightarrow{\text{reduction}} CH_4+3H_2O \quad (6)$$

The carbon dioxide and hydrogen sulphide in the biogas are undesirable. They are removed for optimum performance of biogas as fuel.
Carbon dioxide is removed by passing the gas into lime water which turns milky due to formation of calcium carbonate.

$$Ca(OH)_{2(aq)}+CO_{2(g)} \longrightarrow CaCO_3+H_2O \quad (7)$$

H_2S is removed by passing the gas through a lead acetate solution.

$$(CH_3COO)_2Pb(aq)+H_2S_{(g)} \longrightarrow 2CH_3COOH_{(aq)}+PbS_{(s)} \quad (8)$$

In addition to temperature other parameters are controlled to ensure proper operation.
Microorganisms are sensitive to pH changes. Buffering is necessary for pH.
The rate of biogas production depends: the nature of the substrate, temperature, pH, loading rate, toxicity, stirring, nutrients, slurry concentration, digester construction and size, carbon to nitrogen ratio, retention time, alkalinity, initial feeding, total volatile acids, chemical oxygen demand (COD), total solid (Ts), volatile liquids etc.
The concentration of water-soluble substances such as sugar, amino acid, proteins and minerals decrease with age of plants (Anderson*,* 1979) because, non-water soluble substances such as lignin, cellulose, hemi cellulose and polyamides increase in content with the age of the plant. This means that vegetable matter from younger plants produce more biogas compared to those from the older plants. For waste products from animals, the type and age of animal, its feeding and living conditions, the age and storage of the waste product are factors affecting the quality and quantity of the gas produced. In general finely ground waste products produce more biogas due to large surface area of contact with bacteria. (Maarshishwari and Vasidevan, 1981)
This paper presents results of the study on biogas production from fruits and vegetable wastes aimed and at comparing the quantity of biogas produced from the substrates.

MATERIALS AND METHODS

The materials used in this investigation as substrates were cow dung (control) and waste residue from fruits such as: orange, pineapple and vegetables such: spinach, pumpkin, all of which were agricultural waste materials.

Sampling and Sample Treatment

The waste materials were collected fresh from various locations around Kano and Kano metropolis, were sun dried for twenty days then oven dried at 110°C for 10hrs before use.

The fruits waste were collected from Naibawa market along Kaduna-Zaria Express way, while the vegetables waste were collected from Yankaba market along Hadejia road and the cow dung was collected from Wudil cattle market. The dried samples were grounded using wooden pestle and mortar. By using sieving machine in order to obtain powdered samples which were then stored in a separate black polyethylene bags.

***Fabrication of Digesters*: -** Five portable digesters were fabricated using three-litre empty plastic gallons, bicycle valves, strip of rubber and polyvinylchloride (PVC) tube of 0.8 cm diameter. A hole was bored on the cover and the valves were inserted into the hole. Then, the (PVC) tube also inserted to cover the outlet of the valves. The tube was tightened using a strip of rubber. This was used as digester.

***Preparation of Slurry*:-** From the dried samples, different slurries were prepared and used for the investigations.
200g of each substrate was taken and mixed with 1.5 litre of water and each transferred into a separate digester. The biogas produced, from the digester was connected to a separate inverted 1000cm3 measuring cylinder. The volume of biogas produced from each digester was recorded separately.

RESULTS AND DISCUSSION

The results of the investigation are presented in the Figures below:

The biogas production process was investigated for each of the substrate under investigation and was observed that the highest individual production rate is recorded for the cow dung slurry (control) with average production of 1554 cm^3, followed by pineapple waste which had 965 cm^3 of biogas, then by orange waste which had 612cm^3, pumpkin and spinach wastes had 373 cm^3 and 269 cm^3 respectively. Therefore, the difference in the production of biogas to a large extent depends on the nature of the substrate.

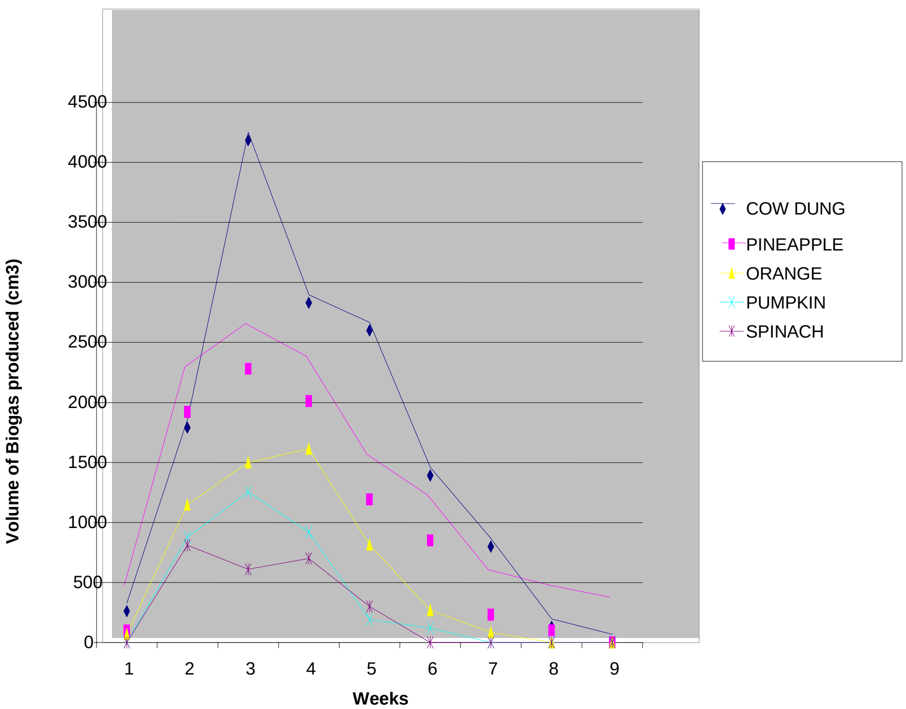

Figure1: Comparative Biogas Production from Fruits and Vegetable Waste

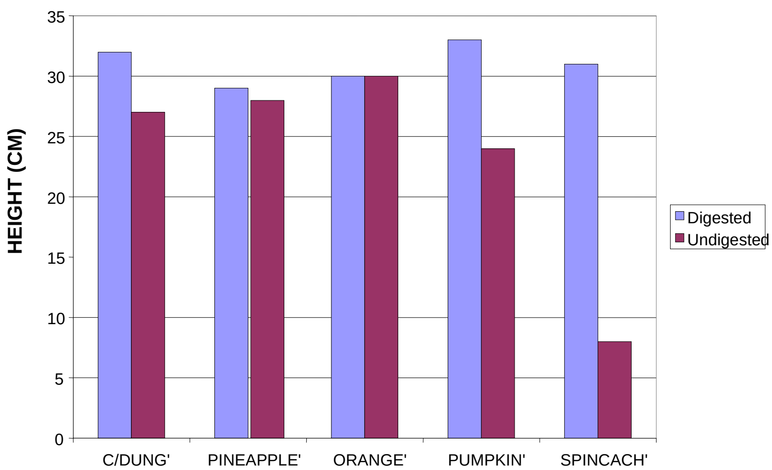

Figure 2: COMPARATIVE GROWTH FOR PLANTS OF DIGESTED ANDUNDISGESTED MANURE

Field Test Analysis

Germination Period:- The germination period of the seeds planted using digested and undigested manure were recorded below:

Table 1: The Weight of the Sludge Before and After Digestion.

	Cow dung	Pineapple	Orange	Pumpkin	Spinach
Weight Before Digestion (g)	200	200	200	200	200
Weight After Digestion (g)	168.8	172.3	150	180	145

Table 2: Effect of type of manure on seed germination

Days	Cow dung	Pineapple	Orange	Pumpkin	Spinach
Seed germination period using digested manure	2-days	3-days	3-days	3-days	3-days
Seed germination period using undigested manure	4-days	3-days	3-days	4-days	4-days

From Table 2 above, it was observed that using digested manure, the seeds germination period for digested cow dung manure takes two days and the seeds of digested pineapple, orange, pumpkin and spinach manure take three days, while seeds for the undigested manure for cow dung, pumpkin and spinach take four days, pineapple and orange manure take three days.

Conclusively, there is effect on rate of germination in digested and undigested manure for seeds planted with cow dung, pumpkin and spinach, while for pineapple and orange manure remain ineffective.

CONCLUSION

Comparative studies on biogas production from different waste of fruits and vegetables using cow dung as control was carried out.

It was evident from the result that, all the five substrates used in this investigation are good materials (substrate) for biogas production. However, the volume produce by the same feed stock concentration is dependent of the waste material so also the time taken to start production. This is an indication that fruits and vegetable waste which dominate our biodegradable domestic waste can be converted to fuel for domestic and industrial applications.

It has also been confirmed from our findings that by-products (spent slurry) of this process could also be used as fertilizer / improved organic manure for agricultural production.

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