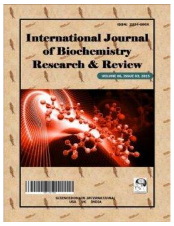

International Journal of Biochemistry Research & Review

20(4): 1-5, 2017; Article no.IJBCRR.38656
ISSN: 2231-086X, NLM ID: 101654445

Generation and Analysis of Biogas from Some Animal and Vegetable Wastes

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Authors' contributions

This work was carried out in collaboration between all authors. Author EASO designed the study, wrote the protocol. Author BOO designed the analytical procedure for the determination of the gases and wrote the first draft of the manuscript and author GSS managed the literature searches and the analyses of the study. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/IJBCRR/2017/38656
Editor(s):
(1) Richard A. Manderville, Professor, Departments of Chemistry and Toxicology, University of Guelph, Canada.
Reviewers:
(1) Yuwalee Unpaprom, Maejo University, Thailand.
(2) Kabiru Mu'azu, National Research Institute for Chemical technology, Nigeria.
(3) Denise Aparecida Chiconato, Sao Paulo State University, Brazil.
(4) Ahmed Karmaoui, Morocco.
(5) Nahid Akhtar, india.
Complete Peer review History: http://www.sciencedomain.org/review-history/23310

Original Research Article

Received 25th November 2017
Accepted 15th February 2018
Published 23rd February 2018

ABSTRACT

The world relies heavily on fossil fuels for both domestic and commercial energy needs but there is an environmental effect of these fossil fuels and as the energy consumption is becoming very significant as there is depletion of the fossil fuels. Research has to be in the development of alternative energy sources. One of the alternative sources of energy is bio-energy. The common fuels obtainable from biomass are bio-ethanol and biogas. This study aims at the production of biogas from biologically degradable wastes by co-digestion system and analyzing the percentage composition of CH_4 and CO_2 in biogas produced. It involves using fruit (peels and seeds of orange, tomato, cucumber) and vegetable (efo shoko-leafy vegetable) wastes mixed with pig manure in an anaerobic digester. Thus giving an alternative energy source and making the environment cleaner by reducing the green energy gases and wastes. The gas content, therefore, is analysed. The composition of CO_2 and CH_4 content in biogas generated were CO_2 28.1% and CH_4 68.9%.
Phytochemical screening, proximate analysis of the fruit waste, vegetable waste and the pig waste

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were carried out. The proximate analyses were carried out for carbohydrates using Anthrone method, Total Lipids Using Bligh & Dyer Method; Crude Fibre, moisture content, total ash, and crude protein method as described by AOAC (1995); The high content of the methane obtained is a high indication that the waste materials used are a good source of biogas generation and can be used to provide a cleaner environment.

Keywords: Biogas; waste products; methane; biomass.

1. INTRODUCTION

There are various sources of energy, but the ones mostly used are from fossil fuels. The by products of fossil fuels are harmful to the environment because of pollution. Alternative sources of energy are needed now and this is found in bioenergy [1]. Biogas can be generated when organic matter is fermented with the assistance of micro organisms in the absence of air or oxygen [2]. The production of biogas plays an important role in reducing greenhouse gases emissions and facilitates a sustainable development of energy supply. The process of production only uses energy from renewable energy sources. Hence, no net carbon dioxide is added to the atmosphere, making it environmentally benign energy source.

Biogas is a combustible mixture of gases consisting mainly of methane (CH_4) and carbon dioxide (CO_2.) The gases formed are the waste products of the respiration of the decomposer microorganisms and the composition of the gases depends on the biomass and the various compositions that are being decomposed. If the material consists of mainly carbohydrates, such as glucose and other simple sugars and high-molecular compounds (polymers) such as cellulose and hemicellulose, the methane production is low. However, if the fat content is high, the methane production is likewise going to be high [2]. The generation of biogas is a form of renewable energy, because it is generated from organic wastes by anaerobic fermentation. Anaerobic digestion of agricultural wastes is of increasing interest in order to reduce the greenhouse gas emissions and production of biogas provides a versatile carrier of renewable energy, as methane can be used for replacement of fossil fuels in both heat and power generation and as a vehicle fuel. The residue from anaerobic fermentation is a valuable fertilizer due to the increased availability of nitrogen. Anaerobic treatment minimizes the survival of pathogens which is important for using the digested residue as fertilizer.

Biogas-generating technology is a favorable dual-purpose technology at present: the biogas generated can be used to meet energy requirements while the organic residue is a useful fertilizer. This in turn will give a cleaner environment. The production of methane during the anaerobic digestion of biologically degradable organic matter depends on the amount and kind of the material added to the system. In India and China alone, there are more than one million small, simple plants, each treating waste (sewage, animal manure, crop residues, etc.) from a single household. The biogas is used in the housekeeping for cooking and the digested biomass used as a fertilizer.

2. MATERIALS AND METHODS

2.1 Substrate Collection

Fruit and vegetable wastes were collected from an Ikorodu market and mixed with pig manure collected from a pig farm in Ogun state is used as substrates for biogas production.

2.2 Fabrication of Anaerobic Digester

The anaerobic biogas generation digester of fruit and vegetable wastes mixed with pig manure was fabricated using two (20L) plastic container, two ½ inch plastic valve, glue, bicycle tube and gas hose ½ inch diameter × 40cm length. An opening was made on the cover of the two plastic containers just about the size of the plastic valve, the valves were inserted into opening made on the cover while glue and clay was added around the sides of the valve to make it air tight and firm. Then, gas hose ½ inch diameter× 40 cm were firmly inserted into the valves and channeled into a bicycle tube which will serve as storage for the gas generated.

2.3 Sample Preparation

The mixture of biodegradable waste - peels and seeds of orange, tomato, cucumber, efo shokor (leafy vegetable) were chopped into smaller size, slurry obtained by mixing fresh pig manure and tap water. The mixture of the waste was: pig manure 3 kg, the others 0.5 kg each so the ratio was 3:2 in the first digester. The mixture of the waste in the second digester was: pig manure 10 kg, the others 2 kg each so the ratio was 5:4.

5 kg of the substrate was fed into the first digester while 17 kg of substrate was fed to the second digester before the mouth was properly sealed. The two digesters were fed once and placed in an open space. The temperature was between 25 and 30°C at atmospheric pressure for twenty two days [3,4,5,6].

Fig. 1. The fabricated digesters

2.4 Data Collection and Analysis

Proximate analysis (carbohydrates, crude fibre, moisture content, crude ash, protein and crude fat) was carried out on wastes materials used.

The CO_2 and CH_4 composition of biogas was also determined using absorption method.

$Ca(OH)_2$ was prepared to absorb CO_2 from biogas (purifying the gas) while the percentage of CO_2 absorbed is calculated using

(1) % of CO_2 = $\frac{M1-M2}{M1} * 100$. 1M NH_3 = M1V1 = M2V2

Where M_1 = mass of biogas before removal of CO_2

M_2 = mass of methane and other gases after removal of CO_2

(2) % of CH_4 = 100% - (CO_2 + 3% (H_2S and other gases)

The 3% average is given to (H_2S and other gases) because they range between 1-5% in biogas composition.

To validate, the amount of CO_2 in $CaCO_3$ formed is determined by Standardization of EDTA with $CaCO_3$

Reagents used and Preparation

i. EDTA
ii. $ZnSO_4$ to standardize EDTA
iii. Ammonia buffer solution
iv. Eriochrome black T indicator.
v. $Ca(OH)_2$

3. RESULTS AND DISCUSSION

3.1 Effect of Moisture

The moisture content of the materials used range from 61% to 87.35%. Pig manure had the highest moisture content, the moisture content are high for the agricultural wastes used. This will help the relative methanogenic activity to increase and the rate of methane production will function with optimum at pH 6.41. High moisture content provides greater activity of water as soluble enzymes and coenzymes needed for metabolic activities will help the growth of microorganisms [7].

3.2 Effect of Minerals

The ash content values which range from 1.08% to 4.50% confirms presence of essential minerals like calcium, sodium, potassium but when in high quantity could be used to retard growth of certain microorganisms due to presence of toxic elements. These values are not too high.

Table 1. Proximate analysis of the vegetables, fruits and the pig dung

Parameters	CHO %	Protein %	Crude fat %	Moisture %	ASH %	Crude fibre %
Leafy Vegetable	8.89	1.20	0.195	65.5	4.50	3.62
Cucumber	4.77	2.02	0.08	72.28	3.32	0.54
Orange	7.45	1.11	0.16	80.7	1.08	1.90
Tomato	15.17	7.00	6.17	61.0	2.30	8.91
Pig Dung with pH 6.41		1.60	0.14	87.35	2.60	0.04

3.3 Effect of Crude Fiber

The values for crude fiber ranged from 0.04% - 8.91%, these values are fairly low. Lee et al. 2003 in their paper stated that crude fiber is an important component of methane production. He also stated that methane production decreases as the content of crude fiber increases, this confirms that substrate with the lowest crude fiber have the highest methane production. The low content is an advantage to the waste materials content used in this research.

3.4 Effect of Crude Fat

The crude fat ranged from 0.08% to 6.17% the proportion of carbohydrate, protein, and lipid in a feedstock will influence biogas yield and composition with lipid yielding higher volumes of biogas per gram of feed material than both carbohydrate and protein [8], (Heaven et al., 2011,).

3.5 Effect of Carbohydrate

The carbohydrate content ranged from 4.77% - 15.17% which is fairly low. However, if material that is been decomposed consists mainly of carbohydrate methane production will be low due to the fact that microbes involved in digesting carbohydrate rich diet are different, they would produce propionate which will remove hydrogen from methane production.

3.6 Effect of Crude Protein

The crude protein values ranged from 1.11% to 7.00%, this is fairly low. Crude protein measures all sources of nitrogen in feedstock, high protein feedstock could modulate bacteria fermentation in the digester.

The presence of these and in the various compositions is able to help in the methane content.

3.7 Biogas Production

Biogas generation in one of the digesters constructed was evident as pressure build-up was noted after 14 days of startup shown in Fig. 2.

3.8 Biogas Composition

Percentage of methane and carbon dioxide in biogas varies with the maturities of feedstock, temperature, water content, a loading rate of raw material and bacterial actions.

Fig. 2. Second fabricated digester with pressure built up of biogas

Table 2. The percentage composition of the CH_4 and CO_2

Biogas composition	CH_4	CO_2
	68.9 %	28.1 %

4. CONCLUSION

This investigation shows that biogas can be successfully produced from co-digestion of manure with fruits and vegetable wastes without any chemical added to the system. The quality of methane composition in biogas and quantity of biogas produced depends on the composition of materials fed to the digester, fat and moisture content is important in methane yield. Through anaerobic digestion of fruit and vegetable wastes we can avoid the emission of harmful greenhouse gases and make a positive contribution to a cleaner environment. Production of biogas from fruit and vegetable waste and pig dung is a major step toward harnessing the least utilized renewable energy resource. From this work, methane gas has been produced. The CO_2 generated in the mixture can be removed. The methane content is high, no additional energy was used as the microorganisms were used in anaerobic condition, in the generation of the biogas.

ACKNOWLEDGEMENT

We wish to acknowledge Dr. Sobamowo of the Faculty of Engineering, University of Lagos, who guided us in the design of the digesters.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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Peer-review history:
The peer review history for this paper can be accessed here:
http://www.sciencedomain.org/review-history/23310