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Utilization of Banana Peels for Biogas Productions

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Abstract
Anaerobic degradation of banana peels was carried out using yeast to generate biogas at room temperature (33°C). The slurry was prepared by mixing 2.0 g of banana peels with 1.0 g yeast and 50 cm^3 of distilled water into a digester coupled with a mechanical agitator to ensure a homogeneous mixture and monitored for 31 days. The amount of yeast and volume of water were varied and the volumes of biogas generated were measured. It was observed that there was no biogas production in the first three days; however the results showed a non- linear production of gas during the retention periods of 31days, with corresponding increase in cumulative volume of biogas. It was also found that when the amount of substrate was doubled, the average cumulative volume of biogas production increased, implying that kinetically the degradation is of the first order. The banana peels have good potential as a biogas producer. The technology is a good option for the management of household wastes and production of alternative energy from cheaper and available biodegradable sources.

Keywords: Banana peels, Degradation, yeast, biogas, biofuels.

Introduction

The rapid increase in loading of obnoxious gases, CO_2, N_2O, CFCs etc. in the atmosphere as a result of burning of fossil fuels and other anthropogenic factors have led to increase in global warming resulting into climatic change with probable consequences of flooding, desertification, drought etc. The occurrences have necessitated the dare need and quest for alternative sources of fuels; 'green fuels' produced from biomass. These fuels are clean burning and result in no net increase in the proportion of greenhouse gases in the atmosphere (Garba *et al*., 1996, Adeyemo & Adeyanju, 2008). In evaluating national development and the standard of living of a nation, the supply and consumption of energy are very important (Ukpai & Nnabuchi, 2012). Human energy consumption has been moderate before the industrial revolution in the 17th century, when man used to rely on the energy from animals strength to do work. Recently man had acquired control over coal, electricity, crude oil, natural gas etc. Sustainable resource management of wastes generated and the development of alternative energy sources are the present challenges due to economic growth. The society today is confronted with dwindling sources of fossil fuels and chemical feedstock and the proliferation of wastes generated by municipal and agricultural industries. This has arose great interest in the use of agricultural wastes as substitutes for fossil fuels. The conversion of renewable sources or wastes to chemicals and fuels by microbial fermentation through a biogas reactor represents a challenge in the present day and more so in the nearest future (Adeyemo & Adeyanju, 2008). Anaerobic degradation can convert energy stored in organic matter present in the lignocellulosic wastes into biogas. Energy supplied from fossil fuels is not easily recycled and takes a long time to form, hence it's exhaustible and not renewable. Renewable energy remained one of the best alternatives for sustainable energy development, since the grid electricity has become too expensive. Sources of renewable energy are wind, hydro, ocean waves, geothermal energy resources and solar electricity (Ukpai *et al*., 2012, Adrian *et al*., 2012).

Biogas is another source of renewable energy produced when biomass is subjected to biological gasification and methane rich gases are produced from the anaerobic digestion/degradation of organic materials. Solving the problem of shortage and scarcity of fossil fuels and also environmental problems that the world is facing today requires long term potential actions for sustainable development. In this respect, renewable energy resources appear to be one of the most efficient and effective solutions (Ofoefule *et al*., 2010). Biomass is the biological organic materials that are renewable and can be recycled to produce biogas (Haboy *et al*., 2010). Liquid fuels from biomass are already in commercial markets in many countries of the World especially as blends with gasoline and diesel (Padma *et al*., 2005). A huge amount of wastes is generated daily from the various processing industries in Nigeria. The wastes are usually disposed off either into the sea, river or on the land as solid materials, which causes support for breeding of flies and constitute health hazards to people living around the area (Dalen *et al*., 2017). The things that are considered as wastes many years ago have in recent times become useful, such that it can be inferred in life, ‘nothing is a waste’.

In the production of biogas, biomass wastes are held in a digester or reactor, the gas is produced in a three phase process namely; hydrolysis, acid forming and methane forming phases using environmentally sensitive micro-organisms. The biogas composed of 50-70% methane, 20-40% carbon(iv) oxide, 1-10% hydrogen, 1-3% nitrogen, 0.1% oxygen and carbon monoxide with trace amount of hydrogen sulphide (Ofoefule *et al*., 2009, Elijah *et al*., 2009, Haboya *et al*., 2010 & Nitin *et al*., 2012). Biogas is a waste management technique because the anaerobic treatment process eliminates the harmful micro-organisms. It is cheap because feed stock are waste materials. The technology ensures energy independence as a unit can meet the need of a family or community. The digester slurry is a good source of fertilizer. Biogas when refined burn as well as liquefied gas but does not add to global warming like liquefied gas (Chonkor, 1983, Ukpai & Nnabuchi, 2012,). Biogas technology has in recent time been viewed as a very good source of sustainable waste management/treatment as disposal of waste has become a major problem especially to the third world countries. The effluent from this process is a residue rich in essential inorganic elements like nitrogen and phosphorus needed for the healthy growth of plants known as bio fertilizer which when applied to the soil enriches it with no detrimental effect to the environment. The aim of this study is to investigate the biogas potential of banana peels.

Materials and Methods

Sample collection and treatment

Banana peels were collected from Farin gada Market of Jos North Local government of Plateau state Nigeria. The banana peels were washed and rinsed with distilled water. The peels were chopped into small chippings and sun dried for 14 days (2 weeks). It was then ground into powder and served as digester feed. A set of improvised 250 cm^3 cylindrical container were washed and cleansed thoroughly and used as digesters. A hole was made on top of each digester lid and polyvinylchloride (PVC) or rubber tubing of 3 mm in diameter and 20 cm^3 long was inserted into each lid and glued.

Methodology

The slurry used was prepared by mixing 2.0 g of banana peels with 1.0 g yeast. This was moistened with varying volumes of pre warmed water. To each digester, 50 cm^3 of distilled water was added. Each digester was thoroughly stirred by mechanical shaking to ensure the formation of homogeneous mixture. The PVC tube from the digester was drained into an inverted 100cm^3 measuring cylinder, filled with brine in a water trough, such that the outlet is directed upward in the cylinder. Fermentation/degradation was carried out at room temperature with fluctuation between 28 and 33^{o}C for thirty one days. Digesters were stirred by shaking and swirling twice in a day. The volume of biogas yield was determined as equivalent of the volume of water displaced from the cylinder. The measuring cylinder was refilled as soon as there was complete displacement. The acidified brine was used in order to prevent the dissociation of biogas in the water. The medium pH was found to be between 6.6 and 7.8. Three different sets of slurries were made; 4.0, 6.0 and 8.0 g of the banana peels with 1.0g yeast and 50 cm^3 of distilled water was added to each sample in duplicates and monitored for 31days. After 31days , a new set of four digesters labelled; A, B, C, D were charged with 100 cm^3 of distilled water and 2.0g of yeast in each case and 2.0, 4.0, 6.0 and 8.0 g of banana peels were added in that order and monitored for another 31 days. The experiment was repeated for each set of digesters.

Results and Discussion

The results on Figs.1 and 2, show non-linear production of biogas during the retention period of 31 days. On the first day, there was no production of biogas, suggesting that the micro-organism responsible for the anaerobic biochemical reaction for the conversion of the substrate using yeast as catalyst was not activated thus fermentation could not start (Adeyemo *et al*., 2008). The slurry temperature of 30^{o}C was maintained during the process of fermentation, Ukpai and Nnabuchi (2012) reported that ambient temperature affects the rate of digestion due to the outside walls of the digester surface make direct contact with the atmosphere hence the digester walls absorb or lose heat depending on the temperature gradient between the digester and its immediate environment. This implies that seasons affect the rate of heat loss or gain from the digester which in turn affects the microbial activities in the slurry at each stage. The bacterial involved may not play its role completely as ambient temperature fluctuates due to climatic conditions.

Biogas production from organic substrate is a microbial process that involves the combined action of four groups of bacteria in four stages (Khandelwa &Mahdi, 1986). The first stage is the degradation of higher molecular weight substrate like starch, cellulose, fats, proteins, oils etc. presence in organic materials into low molecular weight compounds like fructose, glucose etc. that are able to pass through bacterial membrane by a group of hydrolytic bacteria. Thus polymers are transformed into monomers by enzymatic hydrolysis (Isaacs, 1984).

$$n(C_6H_{12}O_5)_{(S)} + nH_2O \rightarrow nC_6H_{12}O_6 \qquad (1)$$

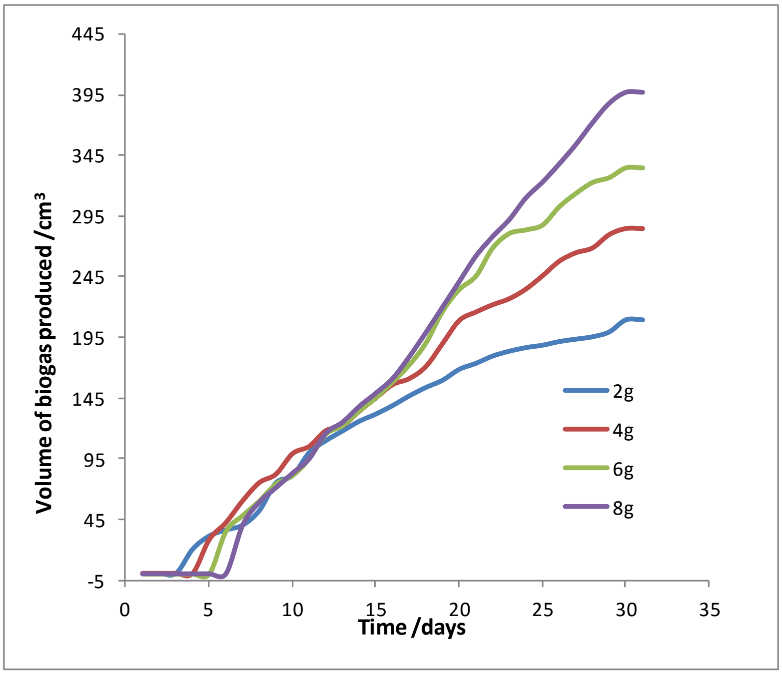

Figure. 1: Variation of cumulative biogas yield with time of degradation and mass of banana peels with 1 g yeasts, 50 cm^3 water.

The product of the first stage is converted into organic acids and by-products like CO_2, H_2O, H_2, NH_3 etc. by a group of bacteria known as acetogens, which are collectively called ‘acid formers’.

$$n(C_6H_{12}O_6)_{(aq)} \rightarrow 3nCH_3COOH_{(aq)} \qquad (2)$$

The third stage is the conversion of hydrogen and simple carbon compounds produced in the second stage into ethanoic acid by a group of bacteria called homoacetogens.

$$4H_{2(g)} + 2CO_{2(g)} \rightarrow CH_3COOH_{(aq)} + 2H_2O_{(l)} \qquad (3)$$

The fourth stage is the conversion of ethanoic acid and some compounds like CO_2 and H_2 into methane (CH_4) by a group of bacteria known as methanogens.

$$CH_3COOH_{(aq)} \rightarrow CO_{2(g)} + CH_{4(g)} \qquad (4)$$

$$CO_{2(g)} + 4H_{2(g)} \rightarrow CH_{4(g)} + 2H_2O_{(l)} \qquad (5)$$

Bioliquid (maltenes and asphatenes) which is usually heavier than biogas is produced simultaneously with the biogas in the fermentation pit during fermentation. Usually in the biogas/bioliquid digestion unit, all four stages are occurring simultaneously and if any one stage gets out of hand the production of CH_4 and the bio liquid will be affected (Isaacs, 1984). At peak production, the micro-organisms were acting on the maximum amount of organic matter possible. Gas production begins to drop after this point because all the excess substrate is converted to methane and there is steady decline in the amount of substrate available to the bacteria to act on. There is also a decrease in either carbon or nitrogen available for use. The decline continues until the gas comes to a stop. As fermentation approaches the end, the burning characteristics of the biogas improves (Sang *et al.*, 2006).

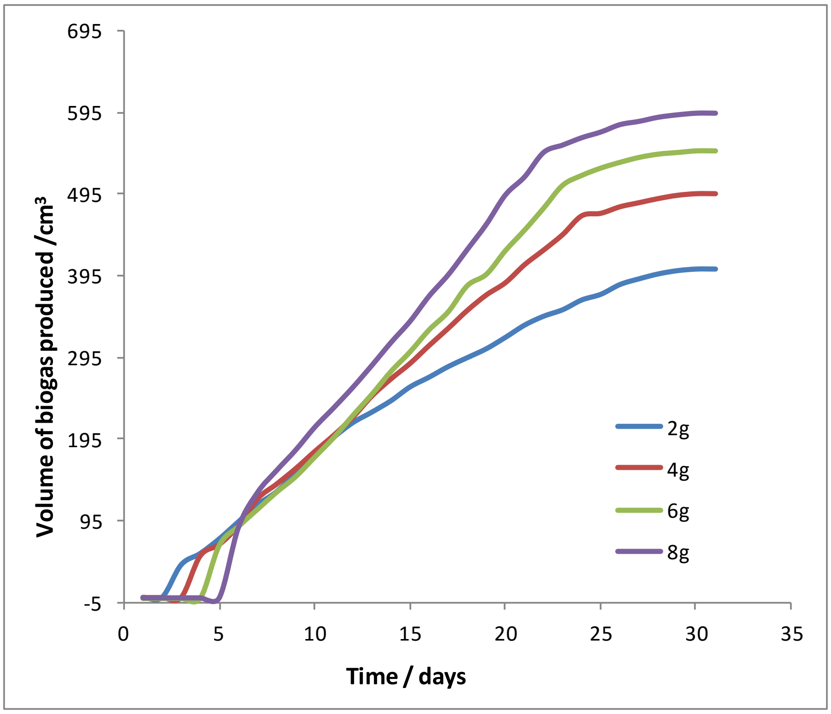

Figure. 2: Variation of cumulative biogas yield with time of degradation and mass of banana peels with 2 g yeasts, 100 cm^3 water.

The cumulative yield for the four digesters in the first set up (Fig.1) are 210, 285,334 and 397 cm^3 for the 2.0, 4.0, 6.0 and 8.0 g of banana peels respectively with 1.0 g of yeast as additive in 50 ml of distilled water. There is a progressive increase in the volume of biogas produced as mass of substrate increased providing more substrate for biodegradation. Also when the concentration of the yeast was increased from 1.0 to 2.0g (Fig.2) with the same amount of banana peels (substrate) with 100 ml water, there was massive increases in the volumes of biogas produced indicating that the substrates were exhaustively degraded by the enzymes (yeast). The increase in the volume of water also improved the penetration of the substrate by the yeast as the amount biogas produced is influenced by total solid of the slurry and microbial activities (Elijah *et al*., 2009).

The break or stoppage (non-linearity with days) during the 31 days retention period may be due to unfavourable ambient conditions due to temperature fluctuations which influenced methane producing bacteria. Ofoefule and Uzodinma (2009) posited that the low biogas yield and slow onset of gas production and flammability of digested cassava peels can be enhanced significantly when combined with animal wastes. Ubwa *et al* (2013) reported that when plant materials were blended with cow dung and poultry droppings, they gave fastest on set of gas flammability while that with some dung had the highest cumulative volume of gas production. Banana peels have soft tissues, rich in fibre content and low lignin content making it a potential substrate for biogas production.

Conclusion

Based on the findings made in this work, it is established that banana peels in combination with yeast is a potential source of biogas and could also form enhanced manure for farm application. The use of this technology to generate biogas and bio fertilizers should be encouraged in larger production in order to reduce environmental pollution and health hazards. It is possible that if this technology is enhanced, it would help to harness other benefits such as creating a stabilized resource that retains its fertilizer value of original material and reducing unwanted pathogens, improved public health, monetary returns which come from saving on fossil fuel, cleaner cooking and better hygiene. Biogas production is a means of converting waste materials into valuable products and also serves as a powerful tool to sanitize the environment.

References

Adeyemo S.B and Adeyanju A.A (2008). Improving biogas yield using media material. *Journal of Engineering and Applied Sciences* **3(2)**: 207-210.

Adrian E.C, Ioana I, Dumitrel G.A and Francis P (2012). Comparative study on factors affecting anaerobic digestion of agricultural vegetable residues. *Biotechnology for Biofuels.* **5:39** doi: 10.118611754-6834-5-39.

Chonkor P.K (1983). Microbial ecology during anaerobic fermentation of cellulose waste materials in S.K. Vyas, Grewal, N.S (Ed). BiogasTechnology USG Publisher, Luthiana, India. pp 21-26.

Dalen, M. B, Mador, S. D and Oyewola J.S (2017).Utilization of plastic wastes in asphalt design for road construction; *British Journal of Applied Science & Technology* **19 (3)**: 1-7

Elijah T.I, Ibifuro A.M and Yahaya S.M(2009).The study of cow dung as co-substrate with rice husk in biogas production. *Journal of Scientific Research and Essays.* **4(9)**: 861-866.

Isaacs, S. H. (1984) Ethanol Production by Enzymatic Hydrolysis Parametric Analysis of a Base-Case

Process. Solar Energy Research Institute. 1617 Cole Boulevard Golden, Colorado 80401

Nitin A.W, Thakre S.B, Dhote A.V and Whankhade P.S (2012). Enhancement of biogas from abattoir cow liquor waste with some agro-industrial wastes, *International Journal of Engineering Research and Applications* **2(5)**: 1383-1388.

Ofoefule A.U, Nwankwo J.I and Ibeto C.N (2010). Biogas production from paper wastes and its blends with cow dung. *Advances in Applied Science Research* **1(2)**: 1-8 ISSN: 0976-8610

Ofoefule A.U and Uzodinma E.O (2009). Biogas production from blends of cassava peels with some animal wastes. *International Journal of Physical Sciences* **4(7)**: 398-402.

Sang L, Li L and Zheng F (2006). Study on the comprehensive utilization of banana by-products. *Heilongjang Agricultural Science* **4**:96-98.

Ukpai P.A and Nnabuchi M.N (2012). Comparative study of biogas production from cow dung, cow peas and cassava peeling using 45 litres biogas digester. *Advances in Applied Science Research.* **3(3)**: 1864-1869.

Uzodinma E.O, Ofoefule A.U, Eze J.I, Mbaeyi I and Onwuka N.D (2008). Effect of some organic wastes on the biogas yield from carbonated soft dry sludge. *Scientific Research and Essays*. **3(9)**: 401-405.

Angelidaki I, Ellegard L and Ahing B.K (1999). A comparative model of anaerobic bio-conversion of complex substrate to biogas. *Biotechnology Bioengineering* **63**: 363-372.

Khandelwa K.C and Mahdi S.S (1986). Biogas Technology. A practical Handbook Mettill Publishing Company Ltd. New Delhi India 2-5.

Zhang C.L.J, Liu X, Wang J, Li S and Zhang L (2013). Alkaline Pretreatment for enhancement of biogas production from banana stem and swine manure anaerobic codigestion. *Bioresource Technology* **149**: 353-358.