Advances in Science and Technology, Vol. 2, No.2, September/October 2008, pp97-101.

Physico-Chemical Considerations in the Anaerobic Digestion of Palm Oil Mill Effluents (Pome)

S.M.O. Akhionbare*, C.C. Uche, C.J. Eke and O.B. Dunkwu
Department of Environmental Technology, Federal University of Technology, Owerri.
(Submitted: April 15, 2008; Accepted: August 6, 2008)

Abstract

A sample of palm oil mill effluent (POME) was digested in a batch operation. Two parameters necessary for gas production (retention time and temperature) were monitored. Results showed that gas production started on the 10th day with a volume of 12 cm^3 at a temperature of 25^{o}C. Analysis of the data using correlation analysis, regression analysis and product-moment coefficient of correlation established a linear model strongly relating gas yield and the process parameters giving an indication that thermophilic digestion is effective in treating POME. Anaerobic digestion of POME could be a viable alternative energy source in local communities involved in palm oil processing as well as serve as a pollution abatement initiative.

Keywords: palm oil mill effluent (POME), biodigestion, thermophilic, retention time.

1.0 Introduction

There is currently a worldwide awareness on environment friendly production processes which aim at defining standards for the ecosystem (Lim 1988). These production processes include zero waste concept, integrated waste management, waste reduction at source, etc. These stress the need for: minimization of emissions and utilization of nutrients, as well as, utilization of renewable energy sources. Processing of palm fruits generates liquid effluents that have high biochemical oxygen demand (BOD) and chemical oxygen demand (COD) values (Gopal and Ma 1986). In Nigerian rural communities, these effluents are simply drained into streams, rivers, creeks, or discharged indiscriminately into the environment because farmers lack the skill and knowledge in palm oil mill effluent management (Ajuyah 1998). This causes significant impacts on coastal areas and resources. They therefore waste potential fertilizer, energy resource and livestock feed. This in turn affects the socio-economy of the inhabitants (Quah 1982). Valuable marine resources and underground water are also threatened (Chua and Gian 1986).

Anaerobic digestion of organic waste such as POME has been an important development in rural sanitation during the last few decades (Ni and Nyns 1993), and is basically an extension of the anaerobic process of sludge digestion used in municipal sewage treatment. The use of anaerobic digesters in homes and agro-based industries helps to reduce such unpleasant effects as odour, river and stream pollution, aesthetic degradation while generating energy for cooking and heating purposes (Speece 1985). Biodigesters can provide a sustainable substitute for kerosene, firewood and propane for families needs (Fulford 1988). It provides for sanitary treatment of organic waste, satisfactory control of fly breeding, efficient and economic recovery of the waste carbon as methane and retention of humus waste and nutrient for use as fertilizer (Fulford 1988).

Various chemical and microbiological reactions take place in the digester (Ni and Nyns 1993; BSR 1984). Ma and Ong (1982) stated that the digester must be loaded with effluents on regular basis to ensure a regular supply of food for the anaerobic bacteria to thrive. Sustainable performance of anaerobic digester depends on the proper management of the chemical and physical environment within the digester as stated by (Meynell 1976).

This study examines the effect of two physico-chemical parameters on the effective performance (in terms of gas yield) of a prototype biodigester fabricated for micro-community and household use.

* Corresponding author's e-mail address: smoakhionbare2007@yahoo.com

2.0 Materials and Methods

2.1 Biodigester Design and Construction

A schematics of a typical Biodigester is shown in Figures 1a and 1b

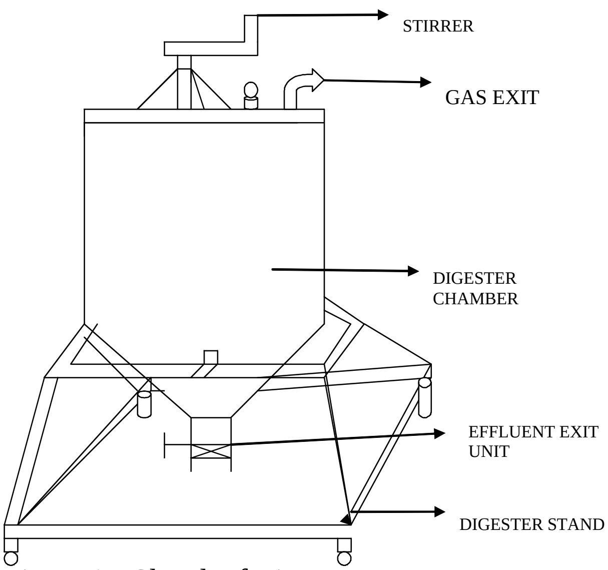

Figure 1a: Sketch of Digester

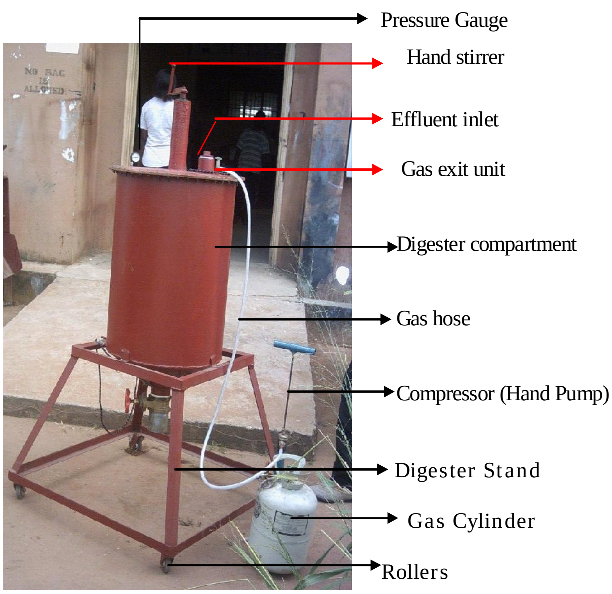

Figure 1b: The Anaerobic Digester (A Prototype)

2.2 The Chamber/Stand

2mm iron sheet of gauge 14 was cut and folded into a cylindrical form by welding the two ends together. The base was folded and joined to form a cone with an opening for the attachment of the gate valve (outlet). Systems of baffles (four at each position and six different positions) were welded to a shaft for proper stirring of the digester contents. A stand was constructed using the 1½" angle iron and four rollers fixed to the base of the stand for easy mobility.

2.3 The Cover

The cover was cut out and constructed to have a flange with about 34 holes. This was done to obtain a proper guarding using studs and nuts. A gasket (made of cellophane material) was cut and fixed on this flange to create an air-tight condition. The cover was incorporated with gas exit unit for withdrawal of the issuing gas. A sensitive pressure gauge calibrated in pounds per square inch (PSI) for checking the pressure of the digester and a gate valve serving as inlet for effluent were also installed (see Figure 1b). The inlet was sealed off with tapes to prevent gas leakage.

2.4 The Heater

A thermostat fitted to the equipment regulates the operating temperature. Two 1-kilowatt-heating elements were placed in parallel below the base and plugged to a 30 amps 220Volts electrical socket. Two holes, drilled close to the base and brazed with copper tubes sealed at one end, which make contact with the digester content, serve for measuring the temperature of the digester content.

2.5 The Finishing

The equipment was sand-papered and coated three times with red oxide paint to discourage corrosion. It was mounted on the stand and held in position using studs and nuts.

2.6 The Charging

Fifty (50) litres of POME was properly stirred and fed into the equipment. A thread tape was used to seal up the inlet and the content was allowed to ferment anaerobically. It was occasionally stirred. The temperature of the slurry and ambient temperature were observed and recorded daily. The pressure of the gas produced was recorded daily.

2.7 The Process Operations/Monitoring

The POME was gradually heated electrically from

0 to 20°C without any observed gas production. The variation of gas production was monitored as the temperature increased until it reached 40°C when there was high quantity of gas production. Two parameters (temperature and retention time) of the process were recorded. The pressure of the gas generated was used to measure the rate of gas generation; increase in gas production increases the pressure of the system. Gas production readings were taken for 25 days. The total volume of waste (POME) to be processed is a function of digester size and retention time. Total capacity of the prototype digester was 150 litres. The digester required supplementary heating to achieve the temperature required for efficient digestion to occur within a short period of time.

3.0 Data Analysis

Correlation analysis was employed to measure the degree of relationship between temperature, retention time and gas yield. Scatter diagram and product-moment coefficient of correlation were used for measuring the degree of correlation existing between them. Regression analysis was used as a forecasting tool to estimate the gas yield as a function of temperature and retention time (Nworuh 2001).

4.0 Results and Discussion

Figures 2 to 5 show the variation of gas yield with temperature and retention time respectively. Seven (7) days were observed as the average production lag time (number of days required for biogas production to start) for the digester. At 20°C, there was no observable reaction until the temperature increased to 25°C when gas production was noticed. As retention time increased, gas production also increased. It was obvious that in 5 days, the micro-organisms were not yet established in their new environment (Thy et al, 2003). There was also the presence of oxygen which does not support anaerobic digestion (Ma and Ong, 1982); hence gas production was not observed. Thus, on utilizing the oxygen present in the system, anaerobic fermentation set in producing a linear relationship between retention time and biogas yield.

The increase in gas yield as temperature progressed from 40 to 55°C indicates that thermophilic temperature range produces higher gas yield than mesophilic temperatures (Wiegant, 1986). Hence thermophilic temperature is an efficient method of treating POME.

The results of correlation analysis and product-moment coefficient confirm that the strength of relationship between biogas yield and process parameters (retention time and temperature of the digester) because both had a linear relationship with a positive slope (Figures 2 and 3). A strong positive correlation (0.993) was established between retention time and biogas yield; and also between temperature and biogas yield (0.992). Also the product-moment coefficient showed that there exist a very strong positive correlation between biogas yield and the duo of retention time and temperature of the digester. Regression analysis predicted the gas yield at various conditions of temperature and retention times. The relationship confirmed the yield of biogas. The regression analysis result showed that retention time is related to biogas yield by the

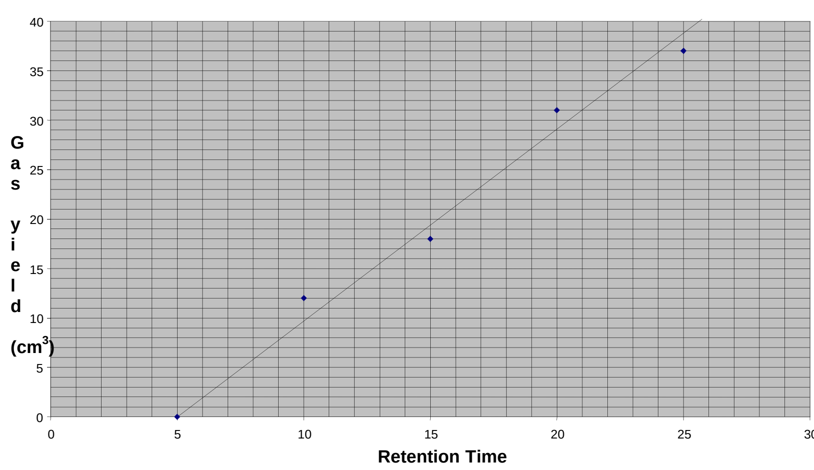

Figure 2: Retention Time and Gas Yield Relationship

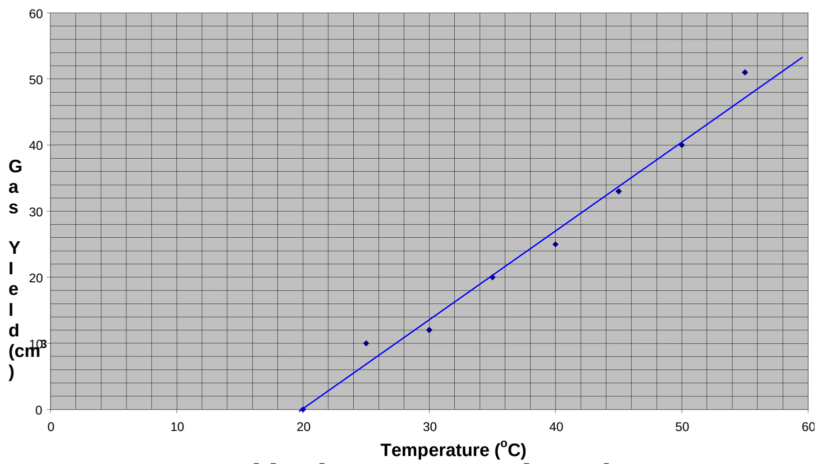

Figure 3: Gas Yield and Temperature Relationship

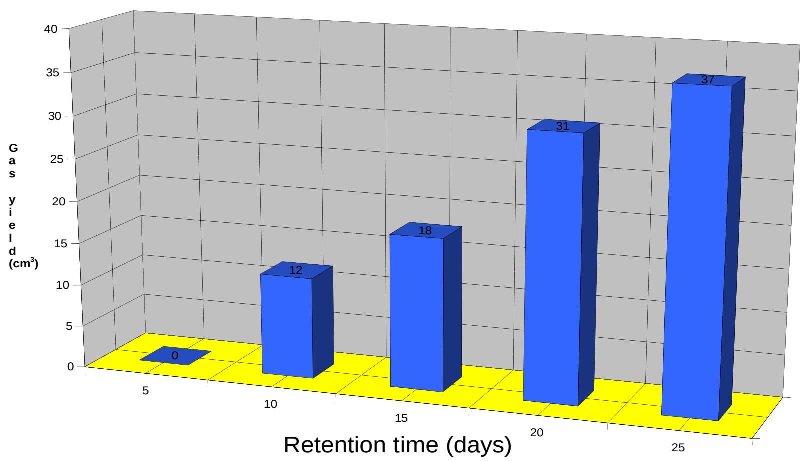

Figure 4: Gas yield with retention time relationship in a prototype biodigester for POME

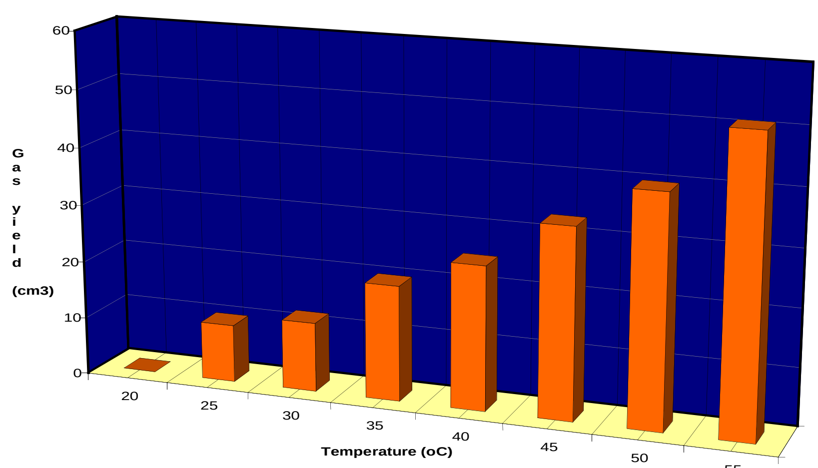

Figure 5: Gas yield relationship with temperature in a prototype biodigester for POME

model Y = 1.86X – 8.3; and temperature relationship with gas yield is Y = 1.369X – 18.74. These relations were used to predict the gas yield at a given temperature and retention time if all conditions are kept normal. Scatter diagrams showed that the points clustered together indicating a linear relationship between the parameters and gas yield. This justifies the suitability of anaerobic digestion in treating palm oil mill effluents.

5.0 Conclusion

The strong linear relationship between temperature, retention time and biogas yield is an indication that thermophilic digestion is effective in treating POME. A biodigester can play a vital role in integrated farming system by contributing to the control of pollution while producing energy for other uses. The search for alternative energy sources such as biogas should be intensified so that ecological disasters such as water pollution, soil and land degradation, eutrophication, etc can be arrested. In view of this, anaerobic digestion is an efficient treatment method for treating palm oil mill effluents, thus ensuring environmental equity and sustainable development, especially in rural communities involved in palm fruit processing activities.

References

Ajuyah, A.O. 1998, "The Potential of Integrated Bio-systems In Small Pacific Island Countries", International Conference on Integrated Biosystems, pp 67-80, http://www.naturalfuel.com.ace/

Bioenergy System Report 1984, "Innovations in Biogas System and Technology", Bioenergy systems and Technology Project, http://www.usaid.org

Chua, N.S. and Gian, A.L. 1986, "Biogas Production and Utilization, Keck Sengs Experience", A Paper presented at the National Workshop on Recent Developments in Palm Oil Milling Technology and Pollution Control, Kuala Lumpar, pp 11-63.

Fulford, D. 1998, Running a Biogas Programme, ITP, New York pp 98-103.

Gopal, J. and Ma, A.N. 1986, "The Comparative Economics of Palm Oil Mill Effluent Treatment and Resource Recovery Systems", A Paper Presented At The National Workshop on Recent Developments in Palm Oil Milling Technology and Pollution Control, Kuala Lumpur Malaysia, Palm Oil Research Institute of Malaysia Paper No 14.

Lim, K.H. 1988, "Integrated Systems for Treating and Utilizing Plantation Effluents", I*n* Anaerobic Digestion, Hall, E.R. and Hobson, P.N. (ed), Pergamon Press, Oxford, pp 303 – 313.

Ma, A.N. and Ong, A.S.A. 1982, "Anaerobic Digestion of Palm Oil Mill Effluents", Palm Oil Research Institute of Malaysia (PORIM) Bulletin, **4**(24).

Meynell, P.J. 1976, Methane; Planning a Digester, The Gresham Press, Surrey, pp180

Ni, J.Q. and Nyns, E.J. 1993, Biomethanization: A Developing Technology in Latin America, Catholic University of Louvain, Belgium pp 67-68

Nworuh, G.E. 2001, Fundamentals of Applied Quantitative Techniques for Management Decisions, Adyudo Press, Owerri, pp138-155.

Quah, S.K. and Gillies, D. 1982, "Practical Experience in Production and Use of Biogas", Proceedings of National Workshop on Oil Palm By-products Utilization, Kuala Lumpur Malaysia pp 119 – 125.

Speece, R.E. 1985, "Anaerobic Digestion", Proceedings of the 4th International Symposium on Biogas Technology, Guangzhou China, pp 515 – 528.

Thy, S. Preston, T.R. and Ly, J. 2003, "Effects of Retention Time on Gas Production and Fertilizer Value of Biodigester Effluents", M. Sc. Thesis, University of Tropical Agriculture, http://www.mekarn.org/msc2001-03/santhyexp1apr26.htm.

Wiegant, W.M. 1986, "Thermophilic Anaerobic Wastewater Treatment, Anaerobic Treatment: A Grown-up Technology", Conference paper, Schiedam Industrial Presentation, pp115-127.