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Organization Study of Anaerobic Processing of Organic Waste to Biogas Using an Integrated Bioreactor

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Abstract
Optimization studies of anaerobic waste matter digestion using integrated Bioreactor system was carried out using curve fitting software programs such as MATLAB7.9 and EXCELL2007. The substrate material was municipal organic waste. The integrated bioreactor system comprised a standard up flow anaerobic sludge bed (UASB) (Module I), vessel bioreactor (Module II). The simultaneous batch process showed that chemical CSTR to 97% for the UASB. Observed cumulative methane yields at three OLRS for the tree reactor system shown from further analysis and observation that the vessel bioreactorhad the highest efficiency of 17.941 $(CH_4/STP)k^{g-1}$ *of substrate material the optimization was characterized by short hydraulic retention time (HRT) especially for the module II and greatly improved stability which result in high COD reduction. Application of Gompertz Models to cumulative methane yield revealed that the methane yield is a family of power series functions of the type;* $y = 8.4x10^{x7}–4.5 \times 10^{-3} x^{6} + 0.1x^5- 1.1x^4 + 7.5x^3+ 29x^2 +72x + 0.35R^2 = 0.9987$ *where y = values of methane yield and theoretical Gompertz construct. Application of a combined Chen-Hasimoto logistics models and Fenton's multiple lump mineralization principle permitted explicit solution by MATLAB/EXCEL software to the model* $COD_{(1)} = fxCOD^0xexp\ (k_it) + (l-f)\ x\ COD_0xexp\ (-kt)$*. The following values of kinetic constants for module I, II and II were obtained* $8.4x10^{-2}$, $3.17x10^{-2}$, $4.37x10^{-1}$*for OLRI module I-III, respectively. The trend is the same for OLR 3. The* R^2 *values showed that there was very close arrangement between observed values and theoretical curve fitting models as described by the conceptual equations.*

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I. Introduction

Nowadays, energy crisis, environmental quality enhancement and climate change are key issues in utilization of energy. According to current research and future predictions, crude oil reserve cannot last for more than 100 years and natural gas reserve will run out in another 50 years. (Cowtney and Dormain 2003). This means that severe energy shortage as a result of depletion of hydrocarbon fossil fuel will begin to occur in another 50 years (Sen 2009). Global average temperature is predicted to increase from 1. To 5.8^{oc} per year by 2100 and this increase in temperature will continue to riselong after 2100 (Dow and Dowing 2009). This phenomenon is directly linked to introduction of carbon dioxide to the atmosphere from fossil fuel use (Sen 2009). In order to encourage the move from energy generation based largely on petroleum resources, various protocols are designed to give assistance to the energy generation methods which do not directly depend on the petroleum and gas (Wayman et al., 1990). The idea technique is anaerobic treatment process for the bioconversion waste to biogas. In comparism with aerobic process, the system does not require aeration (Ergudertal 2001). Kinetic model which is used in the design of bioreactor describes the performances of biological activities and the growth relates to nutrients and organic sources of that in the environment. The kinetic models are divided into structured and unstructured models. The intracellular products are multi-components which are followed by structured model. The exracellular product act in enzyme and individually enhance the biochemical reactions may follow the unstructured model (Najafour 2007).

The purpose of the present research was to investigate the performance of integrated reactors for the conversion of waste to biogas. Kinetic model were analyzed to determine the suitability of the models for the bioconversion of waste to biogas.

II. Materials And Methods

Municipal solid organic waste (MSOW) was obtained by carefully segregating waste from central market in Owerri, Imo State, Nigeria. The following reactors were removed from 500kg of waste heap-bottle and glass, plastic and rubber, metal and metalloids, stones and cloths. Portions comprising vegetable matter, waste fruits, and food remains were segregated and dried in a vacuum oven at 70^oC for a total of 24hrs.

Table 1: shows the characteristics of municipal solid.

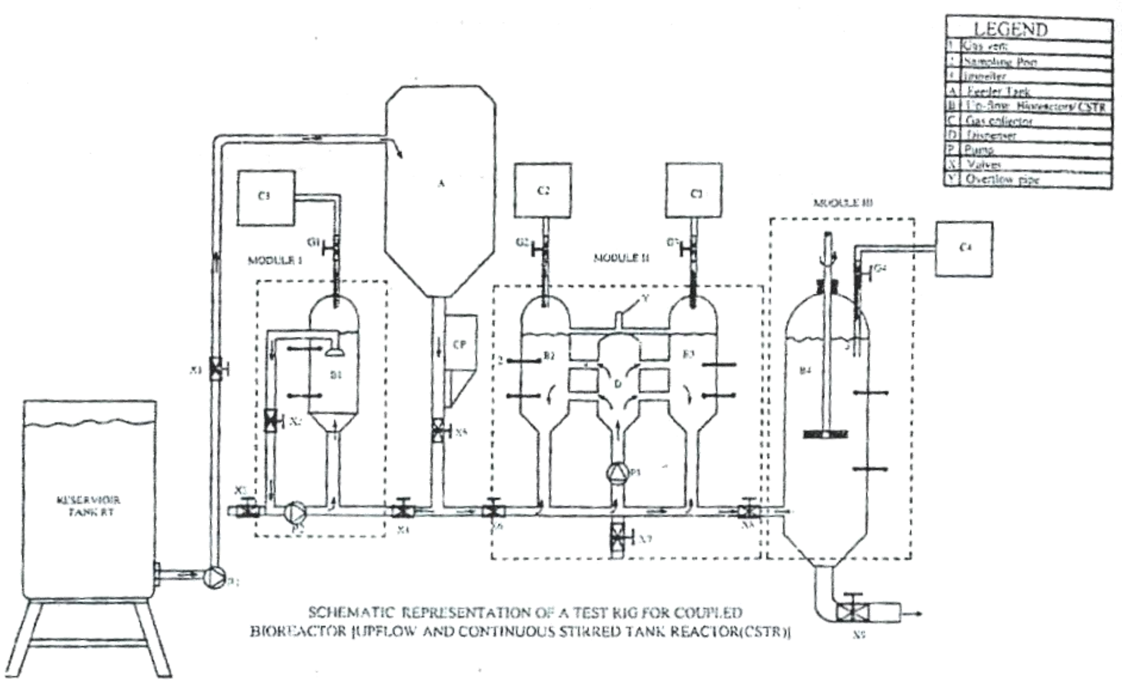
Components	Percentage weight
Plastic	2.3
Stones	1.4
Paper	5.6
Organic fraction (vegetable, wood remains)	58
Straw and woody substance	3.0
Glass	2.0

The table 1 gives the general characteristic of the solid waste before segregation. The organic fraction including straw and woody fibers were isolated and treated as described below.The vacuum dried organic waste was ground in stage using a hammer mill endocottesoctogendigital (2000). 50kg of the mill was sieved with a sieve shaker BS 410, ISO3310 fisher and portion which cross.
The 500µm size was selected. 10kg of the 500µm size was packed in air tight polyethylene bags and seated for subsequent treatment.

Preparation of feed slurry

The slurry or a given ORL was prepared by mixing a given amount of 500µm mesh MSOW in 250L of water in a reservoir tank. The catalysts of freshly slaughtered cow rumen content was prepared by mixing 2kg of the content in 5L of de-ionized water. The mixture was stirred with a hand-held electric stirred and quickly filtered through a nylon cloth.3-5 liters of the filtrate was mixed feed slurry in the reservoir tank and stirred with hand-held stirrer for 30mins. The mixture was transferred to the overhead tank for distribution.

Experimental setup



The integrated bioreactor rig construction and fitting were performed at a workshop complex of Project Development Institution (PRODA) Enugu. The PRODA Workshop space provided the equipment and the expertise for the fabrication work. The rig comprises of three coupled bioreactors. One up flow (UASB) identified as BI, a twin vessel reactor with central dispensing unit identified as B2 and B3, and a continuous stirred tank reactor (CSTR) as B4. All the reactor vessels including the central dispenser, have cylindrical configuration. There is an overhead feeder tank identified as A. the overhead tank is fed with substrate slurry from a surface tank reservoir identified as Rt where the organic substrate slurry is prepared. Figure 1 below presented the schematic of the integrated bioreactor.

An electric pump delivers the slurry from the reservoir to the feed tank. Thereafter, the substrate slurry is fed to all bioreactors by gravity while opening valves X4, X5, X6 and X8. The closure of valve X3, X4, X6, X7, X8 and X9 configures the rig into three experimental modules I, II and III each of which is capable of independent operation and observation. Each module of the bioreactor rig has a sampling port, a vent gas and provisions for attachment of sensors for temperature and gas pressure monitoring devices. Module I and II bioreactor each have additional meter pump for recirculation.

III. Result And Discussion

The up flow (UASB) was independently operated at a first instance. The methane yield along with COD was collected at intervals of one day. Initial runs attempting an hourly harvesting of gas yield failed due to the fact that the rate of production was faster than the arrangement of monitoring and collection. In all cases, an HRT of between 13 and 15 days was observed to be limited for any further breakdown of organic matter. The graph of observed methane yield against HRT for ORLI module 1-3 is shown below as fig 1-3.

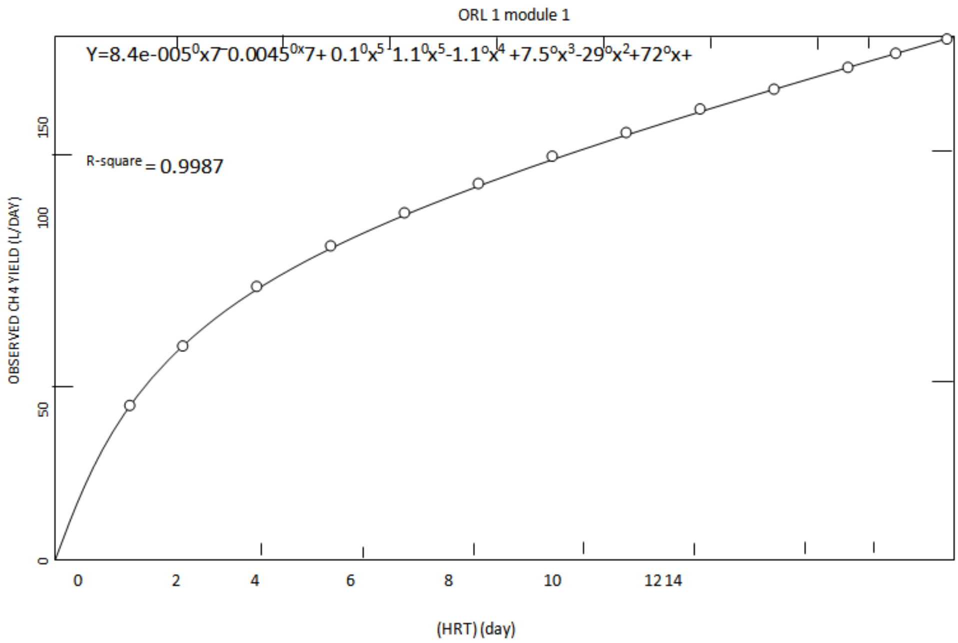


Fig 1: Graph of observed Methane Yield Against HRT OLR 1 Module 1

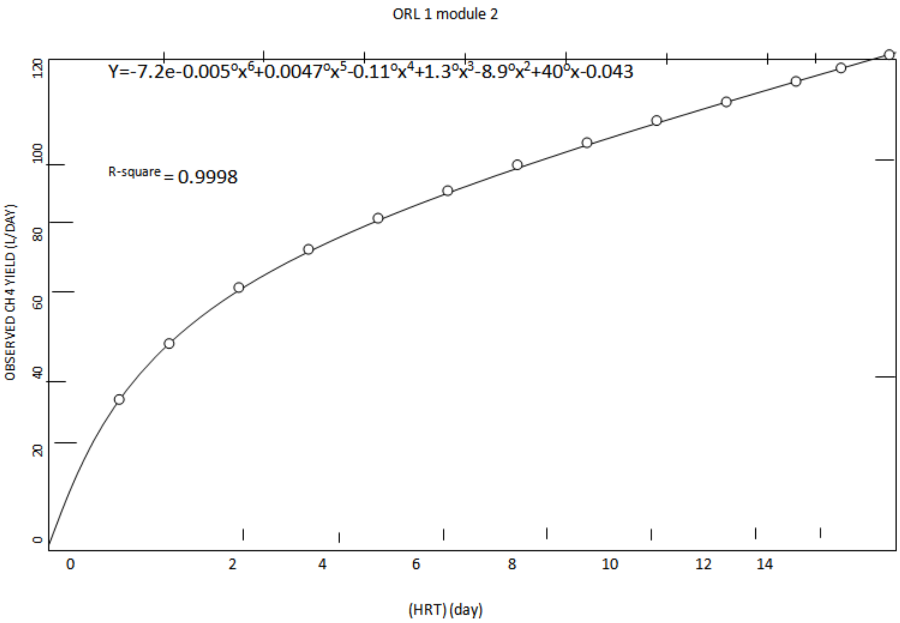


Fig 2: Graph of observed Methane Yield Against HRT OLR 1 Module 2

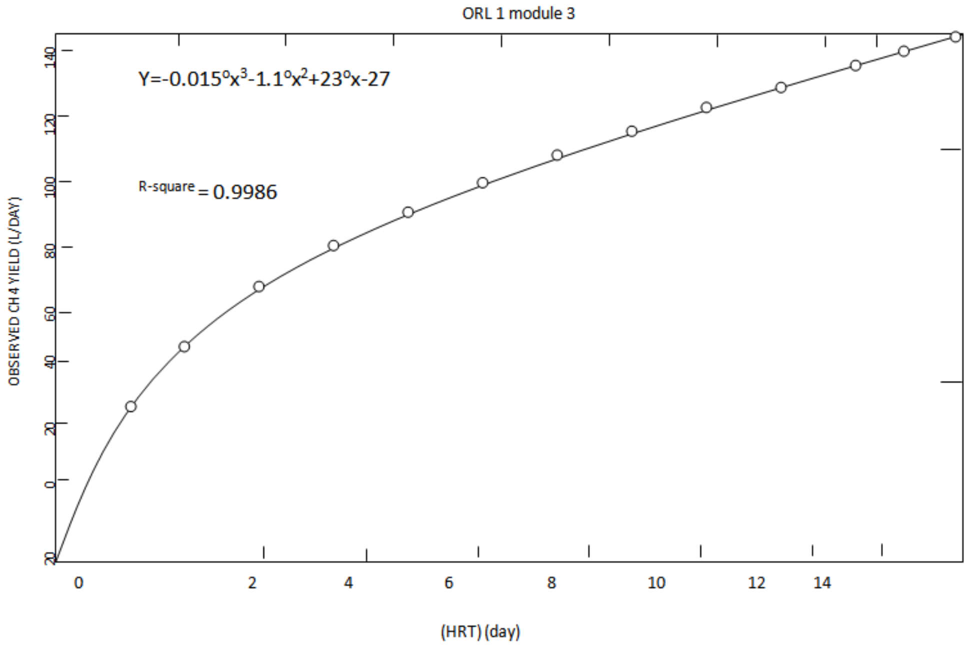


Fig 3: Graph of observed Methane Yield Against HRT OLR 1 Module 3

The graphs were plotted using met lab version 7.9. The yield of methane was expressed as a power series. The values are represented as table 2.

Table 2: Methane Yield as a Power function of seventh order

Organic loading rate (OLR 1)	Module	Functional equations
	I	$Y=8.4e\text{-}005^{0}x7^{-}0.0045^{0x}7+0.1^{0}x^{5\,-}1.1^{0}x^{5}-1.1^{o}x^{4}+7.5^{o}x^{3}-29^{o}x^{2}+72^{o}x+$ $R^{2}=0.9987$
	II	$Y=-7.2e\text{-}0.005^{o}x^{6}+0.0047^{o}x^{5}-0.11^{o}x^{4}+1.3^{o}x^{3}-8.9^{o}x^{2}+40^{o}x-0.043$ 0.9998
	III	$Y=-7.2e\text{-}0.005^{o}x^{6}+0.0047^{o}x^{5}-0.11^{o}x^{4}+1.3^{o}x^{3}-8.9^{o}x^{2}+40^{o}x-0.043$ 0.9986

The R2 values indicated agreement between observed experimental points and fitted theoretical constructs. The models represented by OLRI module III fit into a group whose power series order is below five (5). However, there is tendency for lower R2 values which means a higher disparity between experiments and theoretical construct of the plotter function. In general, the graphs of ORLI modules I and II shows smooth and steady increase until steady state condition is achieved, maintained and eventually depletion of reactant biomass becomes the limit of the reaction.

The application of the modified Gompertz equation
$M = Px.\exp\{-\exp[(^{Rm}_{p}\exp\{\gamma - t\} + 1)]\}$
On data represented by graphs in figure 1-3 shows the ORL 1 module II had the highest predicted methane production potential 34727mL/stp followed by ORL module I with 29079mL/stp while ORL 1 module III had 23550mL/stp. The comparatively higher methane has generated by module II was probably due to the integrated flow and scale of mixing patterns. This is supported by the experimental observations in which pumping module in module II did not permit partial separation of substrate particles. Instead, more homogenous.
Slurry was recycled in reactor vessels in a flow regime characterized by substrate up flow considering its substrate working volume of 62.8L against 75L for module I and II.

IV. Conclusion

Experimental studies on anaerobic digestion of organic municipal waste was carried out simultaneously with the bioreactor module I and II on a batch at 370^{o}c. The performance of the bioreactor was based on accumulative biogas yield. The high R-value obtained by the curve fitting software employed show a close agreement between observed and theoretical postulate. It is therefore concluded that although the module II system is fractionally slow but with higher cumulative yield of methane, it is an entire new concept in reactor design and processing, having never been described in available literature finally, the work using state of arts methods such as particle image velocimetry and computational fluid dynamic software in order to characterize module II twins bioreactor.

Abbreviations and nomenclature

OLR - Organic Loading Rate (mg/L)
HRT: - Hydraulic Retention Time (t)
UASB: - Up flow Anaerobic Sludge
CSTR: - Continuous Stirred Tank Reactor
MSOW: - Municipal Solid Organic Waste
PRODA: - Project Development Institute
M: - cumulative Methane Production (e)
P: - Methane Production Potential (e)
Rm: - Maximum Methane Production rate (ed^{-1})
Exp: - Exponential
COD: - Chemical Oxygen Demand (mgk)

References

[1]. Courtney, B.B. (2003). Worldwide Fossil Fuel Chemistry Department of Louisiana State University.
[2]. Dow and Downing (2006). The Atlas of Climate Change: Mapping the world's greatest challenges. Lost Angeles: University of California Press.
[3]. Erguder, T.H., Tezel, U.,Guven, E. andDemirer, G.N. (2001). Anaerobic biotransformation and methane generation potential of chees whey in batch UASB reactor. Waste Manag. 21;643-650
[4]. Najafpour, G.O. Zinatizadeh A.A.,L. Mohammed, A;Rlsa, M.H. and NastrollahZadeh, H. (2007). High anaerobic digestion palm oil mill effluent in an up flow anaerobic sludge-fixed film bioreactor, process Biochemistry 44 pp 370-379.
[5]. Sen, Z, (2009) Global Warning threat on water Resource and Environment; a review of Environment Geology. 587. Pp 321-329.
[6]. Wayman, M. and Pareh, S.R. (1990). Biotechnology of Biomas conversion. Fuel and Chemical from renewable resources edition, Open University Press-milton Keynes pp 235.

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