Assessment of biogas construction potential from sensitive and administered agricultural wastelands

Vivian Lotisa, Utian Junta, Mike Embouma, Ibrina Browndi
Department of Urban and Regional Planning, Rivers State University, Port Harcourt, Nigeria

ABSTRACT
In this study, the evaluation of biogas production potential from 5 raw and processed agricultural wastes: soybean residues, papaya peels, sugarcane bagasses, rice straws and greater galangals were investigated. The experimental study was carried out into 2 parts. Firstly, the batch experiment was conducted in mesophilic conditions (30°C), at five different hydraulic retention times (HRT): 15 days, 20 days 25 days 30 days and 35 days. The results revealed that soybean residue generated the highest biogas yield of 560.47 ml. at the HRT of 25 days. Papaya peels produced the highest biogas yield of 404.24 ml. at the HRT of 15 days. Bagasse generated the highest biogas yield of 263.04 ml. at the HRT of 25 days. Straw and greater galangal showed a very low biogas yield under the studied conditions. Secondly, the continuous experiment was carried out under an optimal HRT of each feedstock using a digester of 200 liters between 60 days. The average biogas production rate of soybean residue, papaya peel, bagasse, straw and greater galangal was 63.01, 54.63, 16.28, 13.94 and 0.68 L/days, respectively. Finally, the methane yield of biogas produced from different feedstocks was analyzed using a gas chromatography. The results shown that biogas from soybean residue, papaya peel, bagasse, straw and greater galangal precedes the methane yield of 57.14%, 53.70%, 49.12%, 56.25% and 73.50%, respectively

KEYWORDS: Predictive Analysis, Urban Planning, Innovation Adoption, Machine Learning

1.0 INTRODUCTION

Progressive depletion of world fossil resources, combined to increasing energy consumption as well as the negative environmental impacts of fossil fuel use, led to a shift toward alternative renewable resources of energy. Biogas could be a potential renewable source for heat and electricity as well as motor fuel for the foreseeable future, contributing significantly to sustainable development in terms of socioeconomic and environmental concerns [1-9]. Biogas is a mixture of different gases produced by the biological decomposition of organic matter in the absence of oxygen, called an anaerobic digestion process. It mainly consists of methane (CH4), carbon dioxide (CO2) and a trace amount of other gases such as hydrogen sulphide (H2S), ammonia (NH3), hydrogen (H2), nitrogen (N2) and carbon monoxide (CO). Biogas can be produced by anaerobically digesting several organic matters such as agricultural wastes, municipal wastes and industrial wastes. Regarding agricultural crop wastes and residues, they are usually disposed into the land [10-19]. Although their advantages as soil fertilizers and harvesting nutrients in feed crops, the accumulation of large amounts of agricultural wastes causes greenhouse gas and toxic gas emissions, leading to environmental impacts and public health problems. Therefore, the utilization of agricultural wastes as a bio-fuel source has become crucial in order to overcome the crisis energy problems as well as environmental damages. However, the main problem with anaerobic digestion of crop residues is that the most of the agricultural wastes are lignocelluloses with low nitrogen content [20-29]. To improve the digestibility of these materials, several researches and technologies were recently investigated such as co-digestion with other manure wastes and different pre-treatment methods. However, these technologies cannot be applied to convert agricultural wastes into biogas for small scale productions, especially households and small farms since their cost ineffective and their complication. To overcome this problem, the suitability between agricultural waste type and bio-fuel type are basically required in order to efficiently use the renewable source [30-39]. In this work, the evaluation of biogas production potential of raw and processed agricultural wastes was investigated, allowing suitable and effective utilization renewable sources of energy as well as sustainable application for households and small scale users. Experimental investigations were carried out in both laboratory scale and pilot scale [1-7]. For the laboratory scale study, the effect of hydraulic retention time on the rate of biogas production was investigated in a batch

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digester system of 500 ml of capacity. For the pilot scale study, the stability of biogas production rate was studied in a continuous digester system of 200 L of capacity [8-15]. Finally, the biogas composition was analysed for assuring the possibility of utilization of raw and processed agricultural wastes studied in this work as an alternative renewable source of energy [1-17].

2.0 METHODOLOGY

Five raw and processed agricultural wastes: soybean residues, papaya peels, sugarcane bagasses, rice straw and greater galangal were used in this studied. Soybean residues, papaya peels and sugarcane bagasses were daily collected from soybean milk shop, fruit shop and juice shop, respectively, located in the area of Pa-payom district of Phattalung, Thailand. Rice straws and greater galangals were obtained from a rural area of Songkhla, Thailand. The collected agricultural residue samples were chopped and then ground into small particles less than 5 mm in size. Fresh caw manure was collected from the caw farm of faculty of technology and community development, Thaksin University, Phattalung campus, Thailand. Such manure was chosen as it was well adapted to the types of wastes considered in this study. The inoculum was prepared by mixing caw manure and distilled water at the ratio of 1:1 (v/v) [18-26]. In this work, the evaluation of biogas production potential of raw and processed agricultural wastes was investigated using batch digestion and continuous digestion processes. For the batch experiment, the effect of hydraulic retention times (HRT) on the biogas production rate was investigated. Five different HRT: 15, 20, 25, 30 and 35 days were carried out under mesophilic conditions (34 - 37°C). The digestion system consists of 500 ml digester flask and 300 ml gas storage flask. To start the experiment of each agricultural residue, 250 ml of inoculums were introduced in the anaerobic digester [21-34]. Such an inoculum was anaerobically digested until it released all gas production. Then, an amount of agricultural wastes (Q) was calculated using equation (1). The calculated feedstock flowrate was a mixture of 50% of agricultural waste and 50% of distillate water. The amount of feedstock and the quantity of agriculture wastes loaded in digesters that corresponds to different HRT was shown in Table 1 [31-39].

$$Q = \frac{V_{working}}{HRT} \quad (1)$$

With HRT : Hydraulic retention time (day)
V : Working volume of the digester (ml)
Q : Feedstock flowrate (ml/day) or organic loading rate (OLR)

Table 1 Experimental design of different raw and processed agricultural wastes studied in this work.

Hydraulic retention times (HRT) / Day	Feedstock flowrate (Q) / ml/day	Quantity of agricultural waste / ml
15	16.66	8.33
20	12.50	6.25
25	10.00	5.00
30	8.33	4.17
35	7.14	3.57

The feedstock was prepared and then loaded into the digester, as can be seen in the Figure 1. The digestion system was mixed for maintaining an intimate contact between microorganisms and the substrate. It was finally sealed by a paraffin film. Daily gas production was measured using water displacement method and corrected for standard temperature and pressure. A quantity of biogas production was daily recorded until no biogas produced. Each experimental HRT was repeated 3 times to minimize an experimental uncertainty. The average of the recorded quantity of biogas production for different HRT was reported here.

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Fig. 1 Batch digestion experiment at different hydraulic retention time studied in this work.

For the continuous experiment, the stability of biogas production from raw and processed agricultural wastes was investigated between 60 days. The anaerobic digestion system consists of 200 L digester tank and 150 L of storage tank, as shown in Figure 2. 100 L of inoculums were loaded into the digester. For each agricultural waste, The HRT of digestion which corresponded to the highest biogas production rate of the batch experiment was used as the appropriated HRT for the continuous experiment. A daily feedstock flow rate was calculated using, one again, the equation (1). The ambient temperature and pressure were used. Daily biogas production was measured using water displacement method, corrected for standard temperature and pressure and then recorded. Finally, to assuring the potential of raw and processed agricultural wastes studied in this work, the biogas composition was analyzed using a mobile gas chromatography.

Fig. 2 Continuous digestion experiment at the pilot scale.

4.0 DISCUSSION

In this work, the evaluation of biogas production potential from 5 raw and processed agricultural wastes: soybean residues, papaya peels, sugarcane bagasses, rice straws and greater galangals were investigated using both the batch digestion and continuous digestion processes. Firstly, the batch experiment was conducted at five different hydraulic retention times (HRT): 15, 20, 25, 30 and 35 days, under in mesophilic conditions (34 - 37°C). The average quantity of biogas production at different HRT was presented in Table 2.

Table 2 Quantity of biogas production (ml) and its standard uncertainties at different hydraulic retention times (day) produced from different raw and processed agricultural wastes studied in this work using the batch digestion process.

Agricultural wastes	Hydraulic retention times (Day)				
	15	20	25	30	35
Soybean residues	442.16 ± 0.23	477.92 ± 0.48	560.47 ± 0.56	409.17 ± 0.31	322.16 ± 0.29
Papaya peels	404.24 ± 0.68	282.60 ± 0.71	219.80 ± 0.90	182.12 ± 0.50	189.20 ± 0.23
Sugarcane bagasses	206.94 ± 0.55	203.04 ± 0.21	263.20 ± 0.74	211.20 ± 0.48	179.68± 0.66
Rice straws	3.26 ± 0.12	3.62 ± 0.23	3.09 ± 0.21	4.26 ± 0.03	3.56 ± 0.07
Greater galangals	22.51 ± 0.25	41.66 ± 0.32	45.83 ± 0.45	19.16 ± 0.33	21.16 ± 0.41

The highest biogas generation from soybean residues, papaya peels, sugarcane bagasses, rice straws and greater galangals was observed at the HRT of 25, 15, 25, 20, and 25 days which correspond

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to the volume of 560.47 ml, 404.24 ml, 263.20 ml, 3.62 ml and 45.83 ml, respectively. More substrate conversion into biogas was achieved with longer HRT and lower OLR for all agricultural waste excepted papaya peels. The experimental results obtained in this work agree well with those reported by N. Aramrueang et al. who studied effects of hydraulic retention time and organic loading rate on performance and stability of anaerobic digestion of Spirulina platensis [1-9]. The HRT of anaerobic digestion and the volume of biogas produced strongly depend on the composition of raw agricultural wastes. Soybean residues provided the highest biogas production rate whereas rice straws generated the lowest biogas production. Soybean seeds contain 40% of proteins, 20% of lipid, 35% of carbohydrate and 5% of other components such as phospholipids, vitamins and minerals which are easily biodegradable compounds [10-19]. On the other hand, the composition of the rice straw includes 31.57% of cellulose, 22.38% of hemicelluloses, 19.17% of lignin and 26.88% of other components which are classed as difficultly biodegradable compounds. Then, the appropriated HRT obtained from the batch experimental study was used to calculate the feedstock flowrate for the continuous digestion [20-29]. The continuous experiment was carried out during 60 days. The daily biogas production from different raw and processed agricultural residue was represented in Figure 3. For papaya peels and soybean residue, biogas production rate continuously increased during the first 30 days and the stabilization of biogas production rate was achieved after 30 days of anaerobic digestion. For galangal, the biogas production rate was unstable during 60 days of anaerobic digestion [30-39]. For sugarcane bagasse and rice straw, the biogas production rate was stable but very small quantity. The average biogas production rate of soybean residue, papaya peel, bagasse, straw and greater galangal was 63.01, 54.63, 16.28, 13.94 and 0.68 L/days, respectively.

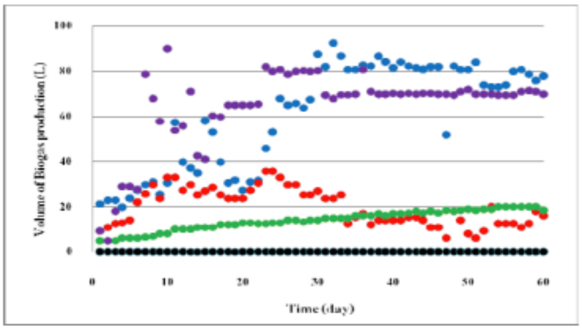

Fig. 3 Daily biogas production from different agricultural wastes studied in this work: (•): papaya peels, (•): soybean residue, (•): galangal, (•): sugarcane bagasse and (•) rice straw.

Finally, the composition of biogas produced from different agricultural residues was analyzed using the mobile gas chromatography. Table 3 presented the percentage of methane, the percentage of carbon dioxin and traces of hydrogen sulfide contained in biogas produced from different agricultural wastes studied in this work. For rice straw, a good agreement between the composition of biogas obtained in this work and that reported by M. Narra et al. but slightly higher than that reported by Z. Yong. Such a difference may come from the different conditions used in the anaerobic digestion. For papaya peels, the percentage of methane found in our study perfectly agree with that of the investigation of S.O. Dahunsi whereas the percentage of carbon dioxide found in our study was 2 times higher. Moreover, the methane yield biogas produced from greater galangal was highest compared to other studied materials. However, there is no investigation in the literature which could confirm these results since we reported the biogas production potential from greater galangal for the first time in this study

Table 3 Composition of biogas produced from different raw and processed agricultural wastes studied in this work using the continuous digestion process.

Agricultural wastes	**Biogas compositions**		
	CH_4 (%)	CO_2 (%)	H_2S (ppm)
Soybean residues	57.14 ± 1.05	22.77 ± 0.45	< 0.001
Papaya peels	54.00 ± 1.32	40.40 ± 0.78	0.009
Sugarcane bagasses	49.12 ± 1.28	29.98 ± 0.48	< 0.001
Rice straws	56.25 ± 2.51	21.58 ± 1,02	< 0.001
Greater galangals	73.50 ± 2.24	24.80 ± 0.56	0.002

We could suggest, here, that for the small scale production of biogas such as households, papaya peels were a promising feedstock owning to its low HRT, its high biogas production rate and its

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composition. However, for rice straw, sugarcane bagasse and greater galangal, it is batter to convert them into other alternative renewable energy such as charcoal or briquette charcoal.

4.0 CONCLUSION

The evaluation of biogas production potential from 5 raw and processed agricultural wastes: soybean residues, papaya peels, sugarcane bagasses, rice straws and greater galangals were investigated using both the batch digestion and continuous digestion processes. The batch experiment was conducted at five different hydraulic retention times (HRT): 15, 20, 25, 30 and 35 days, under in mesophilic conditions (34 - 37°C). The highest biogas generation from soybean residues, papaya peels, sugarcane bagasses, rice straws and greater galangals was observed at the HRT of 25, 15, 25, 20, and 25 days which correspond to the volume of 560.47 ml, 404.24 ml, 363.20 ml, 3.62 ml and 45.83 ml, respectively. The HRT of anaerobic digestion and the volume of biogas produced strongly depend on the composition of raw agricultural wastes. Then, the appropriated HRT obtained from the batch experimental study was used to calculate the feedstock flowrate for the continuous digestion. The continuous experiment was carried out during 60 days. The average biogas production rate of soybean residue, papaya peel, bagasse, straw and greater galangal was 63.01, 54.63, 16.28, 13.94 and 0.68 L/days, respectively. Finally, the composition of biogas produced from different agricultural residues was analyzed using the mobile gas chromatography. The experimental results obtained in this work agree well with literature investigations. For conclude, papaya peels was a promising feedstock owning to its low HRT, its high biogas production rate and its composition. However, for the small scale production, it is better to convert other lignocellulosic materials such as rice straw, sugarcane bagasse and greater galangal into other alternative renewable energy.

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