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Experiments on Co-Digestion of Cow Dung and Water Hyacinth (*EichhorniaCrassipes*) for Biogas Yield

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Abstract

Water hyacinth (*Eichhorniacrassipes*) is one of the world's worst weeds causing major problems to the global aquatic habitat particularly in the tropics. This paper presents the findings of a research that was carried out to determine the effect of adding cow dung to water hyacinth on the biogas yield. Two drums, 100 litre capacity each were used as digesters in the laboratory experiment. Digester A was loaded with 8kg of water hyacinth and 40kg of water, this gave a ratio of 1:5 and the gas yield was measured daily for 9 weeks. Digester B was loaded with water hyacinth, cow dung and water in the ratio 1:1:10 which gave a ratio of the feedstock to water at 1:5. Results from this study showed that addition of cow dung to water hyacinth increased biogas yield as compared to single substrate feedstock.

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The total volume of gas generated from 8kg of fresh water hyacinth was 7443cm^3, and an increase of 35% in the gas yield was obtained in the digester that contained 50% cow dung. It can thus be concluded that there is an increase in biogas yield when cow dung is added to water hyacinth in the digester. This technology will be useful to peri-urban or rural community people who have problems associated with water hyacinth in their water bodies.

Keywords: Biogas; Anaerobic digestion; Cow dung; Water hyacinth

1.0 Introduction

Water Hyacinth is a floating waterweed with a fibrous root system and dark green rounded leaves up to 5cm in diameter (Fig. 1). The annual production of 200 tons/ha/year might be attainable in eutrophic waters in the tropics. The leaf stalks are swollen into spongy, bulbous structures. Flowers are light purple with a darker blue or purple with yellow centre. The plant propagates itself from tiny root fragments, which break off from the parent plants and quickly develop leaf stalks and broad green leaves. Runners also grow along the water surface from the base of the petioles, resulting in a rapid spread of vegetative reproduction. Under ideal conditions, each plant can produce 248 offspring in 90 days. Water hyacinth roots naturally absorb pollutants, including such toxic chemicals as lead, mercury, and strontium 90 (as well as some organic compounds believed to be carcinogenic) in concentrations 10,000 times that in the surrounding water. In Africa, fresh plants are used as cushions in canoes and to plug holes in charcoal sacks). Not only does it destroy native habitats, but it also seriously depletes water bodies of oxygen, increases water loss and provides a breeding ground for mosquitoes and other disease carrying organisms [1].

Global depletion of energy supply due to the continuing over-utilization is a major problem of the present and future world communities. It is estimated that the fossil fuels will be running out by the next few decades [2]. Therefore, attention has currently been focused on the conversion of biomass into fuel. This provides several advantages. Firstly the utilization of the abundant and inexpensive renewable resources, secondly, the reduction in greenhouse gas emissions and toxic substances and thirdly there will be the microeconomic benefits for rural and peri-urban communities with sustainability component. Biogas production from manures, from sewage sludges and agricultural wastes has been studied very well [3, 4]. Much attention is now being focused on the potentials and constraints of using water hyacinth for the production of biogas. The possibility of converting water hyacinth to biogas or biofuel ethanol is currently established in a number of developing countries, mainly in India [5]. Water hyacinth has increasingly been recognized as a potential target for production of ethanol and methane. Hydrolysis of water hyacinth by dilute acid yields mixture of sugars with xylose as a major component (about 60%), which can be a feedstock for bioethanol [5].

Water Hyacinth has limited beneficial uses. It cannot be used as exclusive livestock feed because it contains too much silica, calcium oxalate, potassium and too little protein.

Fig. 1. Infestation of water hyacinth on Awba dam lake, University of Ibadan

It cannot be directly used as a blanket fertilizer because its C:N ratio is too high (about 30) necessitating addition of supplemental nitrogen depending on the crop [6]. Rampant growth of water hyacinth can destroy native wetlands and waterways, killing native fish and other wildlife. Water hyacinth can form dense mats that spread out across water surfaces eventually choking the entire water body. Propagation can be so rapid that an infestation may double in size every week under ideal conditions. In view of these features, converting the weed into biogas will be a good choice to provide low cost bioenergy for the communities who are threatened by this prolific aquatic weed. This paper gives some of the results obtained on co-conversion of water hyacinth and cow dung mixtures on a pilot scale.

2.0 Materials and methods

2.1 The bioreactors

Two anaerobic digesters were designed, fabricated and set up as shown in Fig. 2 and Fig. 3.

Fig. 2. The se up of the digesters for the experiment

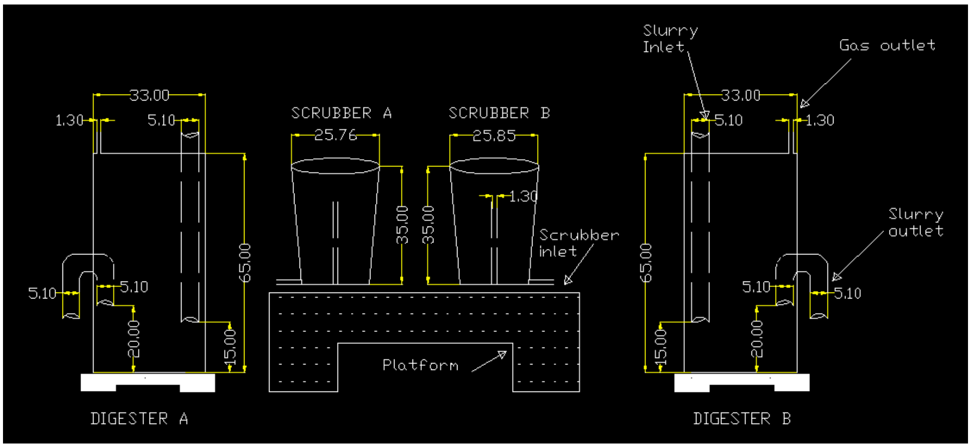

Fig. 3. Designs of the biogas digesters set up showing front elevation

2.2 Preparation of water hyacinth feedstock

The collected fresh water hyacinth from Awbadam lake in the University of Ibadan campus was thoroughly washed several times with tap water to remove adhering dirt and particles, it was later chopped into pieces (size 1-2cm). The pieces were later pounded in a mortar to produce homogenous slurry (Fig. 4). This pretreatment is good for better degradation as the feedstock will have larger surface area for the growth and activities of methanogenic bacteria in the digester.

2.3 Loading the digester

The water hyacinth feedstock weighing 8kg, was introduced into digester A (green colour), then 40litres of water was added, which makes water hyacinth to water ratio of 1:5. Then 1kg of fresh cow dung was added to the digester to activate the methanogenic activities. For digester B, 4kg of water hyacinth was weighed and added to 4kg of fresh cow dung and fed into the digester. Then, 40kg of water was poured into the digester to put water hyacinth, cow dung and water in the ratio 1:1:10. This is equivalent to a ratio 1:5 if the mass of water hyacinth is added to the mass of the fresh Cow dung. The bioreactor was allowed to mature for about 3 weeks. The experiment was run for 63 days. The biogas produced was collected by allowing it to flow into an inverted tube filled with water. As the gas collects, the water gets displaced such that the volume of liquid displaced is equal to the volume of gas collected. This phenomenon is known as downward displacement of water.

3.0 Results and discussion

3.1 Composition of feedstock

The chemical composition of cow dung and water hyacinth are given in Table 1. These materials by virtue of their carbon to nitrogen ratio are found feasible in the generation of biogas. The composition also indicates that they contain low or acceptable levels of minerals and heavy metals.

Fig. 4. A= Fresh plant; B= Chopped plants; C= Pounding of plants; D= The feedstock ready for use

Table 1. Chemical composition of material

Parameter	Cow Dung	Water Hyacinth
Organic carbon, mg/Kg	190.715±.021	300.0±.01
Total Kjeldahl Nitrogen, mg/Kg	20.045±.007	10.44±.01
Total Phosphorus, mg/Kg	30.800±.014	10.92±.01
Potassium, K, mg/Kg	70.335±.007	70.27±.02
Mn (mg/kg)	-	234.65±.07
Zn (mg/kg)	7.085±.007	45.70±.14
Fe (mg/kg)	-	76.30±.00
Pb (mg/kg)	12.150±.071	0.48±.02
Cu (mg/kg)	0.420±.014	11.57±.01
Cr (mg/kg)	-	23.74±.01
Cd (mg/kg)	1.185±.007	0.05±.01
Ni (mg/kg)	12.850±.071	46.85±.07

3.2 Digester environment and biogas yield

The ambient temperature in the laboratory ranged from 24°C to 35°C with a mean temperature of 30°C over the 63 days experimental period. The experiment started on Tuesday 19th April 2011 and ended on Monday 20th June 2011, the volume of biogas produced during the whole experimental cycle was measured by downward displacement of water and recorded. The line diagram for the daily volume of gas produced during the entire experimental period is given in Fig. 5. Increased biogas production of water lettuce (*Pistiastratiotes*) was similarly reported at mesophilic temperatures of 30°C [7]. A low mean temperature could affect the level of biogas production since temperature profoundly influences the growth and performance of methanogenic bacteria and the rate of hydrolysis [8, 9]. The mixing ratio of 1:5 of water hyacinth and water could also affect the rate of biogas production. Aliyu in 1996 [10] noticed an increase in biogas production when the ratio of pigeon droppings with water was increased from 1:3 to 1:4.

Digester A started producing gas from the third day. The gas added up to 367cm^3 within the first seven days of the experiment. It is important to note that the gas produced within this period is low in methane content but high in $CO_2$and therefore the gas did not combust. The volume of the gas produced increased to 669cm^3 in the second week and to a maximum of 1,474cm^3 at the end of the fifth week after which the biogas generation decreased for the next four weeks to 289cm^3 before the experiment was terminated. The cumulative volume of gas produced at the end of the nine weeks of the experimental period was 7443cm^3.

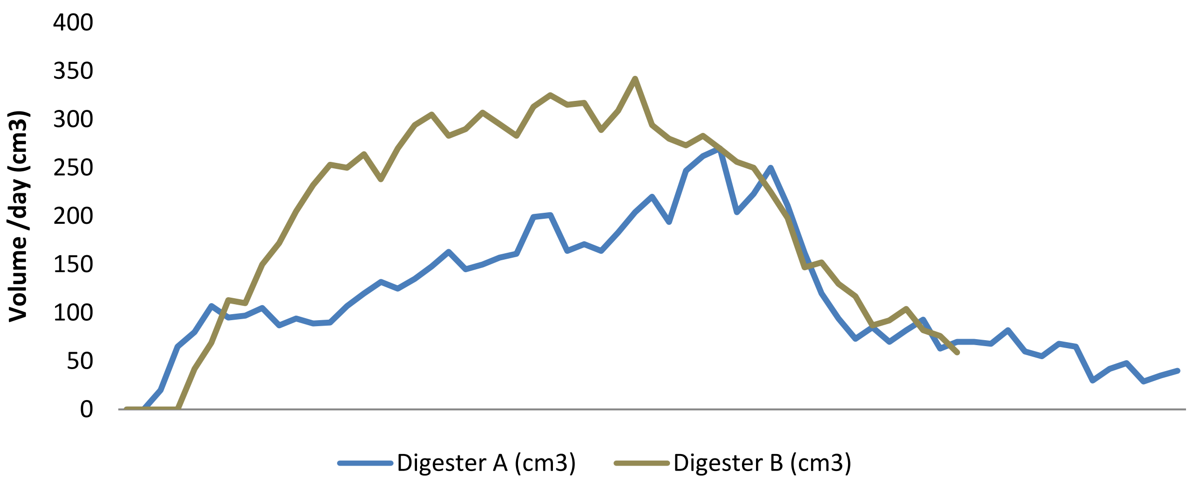

Fig. 5. Line diagram of the daily yield of biogas in the digesters A and B

For digester B, the total volume of gas produced within the first seven days of the experiment was 224cm^3. There was a rapid increase in the volume of gas yield from the second week of the experiment as shown in Fig 6. The maximum yield of 2155cm^3 was recorded in the fourth week of the experiment after which the yield started decreasing for the next four weeks. This made the total number of weeks for gas production in digester B to be eight weeks and the total volume of gas produced equals 10070cm^3

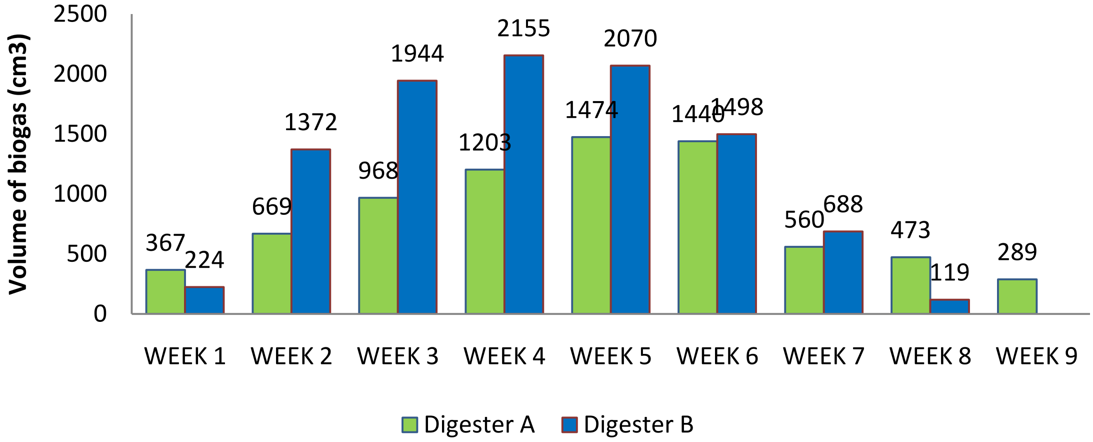

Fig. 6. Comparison of the cumulative volume of biogas yield (cm^3)

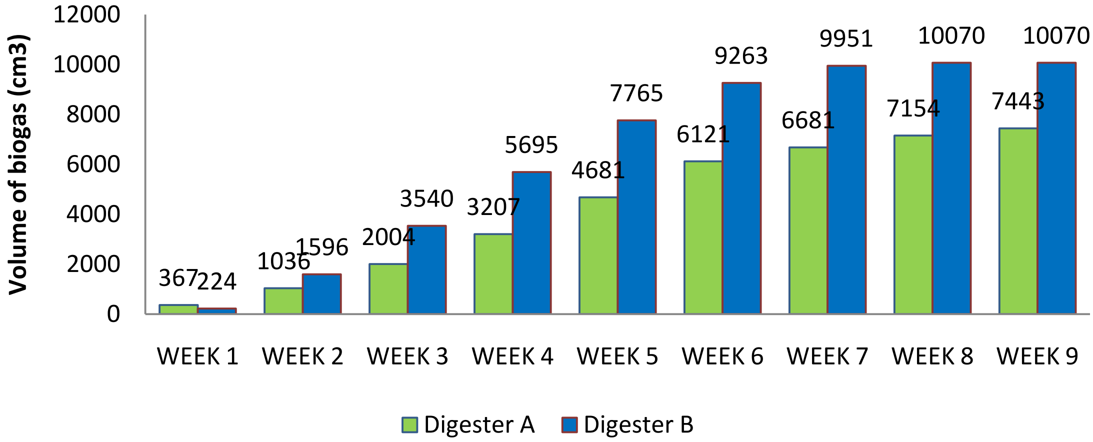

Fig. 7. Comparison of the cumulative volume of biogas yield (cm^3)

3.3 Projections of biogas generation from the study

The projections made from this study are based on the assumption that there exist a linear relationship between the mass of feedstock (water hyacinth) that was fed into the digester and the quantity of gas produced from the anaerobic digestion.

A) Projection 1

If 8Kg of water hyacinth produced 7443cm^3 of biogas

1Kg of water hyacinth will produce 970.38cm^3 of biogas

1 Metric ton of water hyacinth will produce 1,000 x 930cm^3

1 Metric ton of water hyacinth will yield 0.930m^3 of biogas.

B) Projection 2

From the Literature, 1m^3 of biogas is equivalent to 0.46Kg of Liquified Petroleum Gas (LPG)

One standard cylinder of LPG weighs 12.5Kg

By calculations, 26m^3 of biogas is equivalent to one standard cylinder of LPG

As 1 ton of Water Hyacinth yields 0.930cm^3 of biogas from this study, 27.95 tons of water hyacinth is equivalent to 1 standard cylinder of LPG.

That means a standard cylinder of LPG (12.5kg) can cook 3 meals for a family of 5 for 30days.

4.0 Conclusion

The experiments suggest that an appropriate technology (Anaerobic Digestion) can be used for the bioconversion of water hyacinth to biogas. Co-composting mixtures of cow dung and water hyacinth at a household level is economically viable as most of the Nigerian communities near aquatic bodies have continuous supply of the weed and most of these communities also rear animals to supplement their food needs. Other livestock wastes may also be supplemented in place of cow dung as evident from earlier studies conducted by the authors.

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