ABUAD Journal of Engineering Research and Development (AJERD) ISSN: 2645-2685
Volume 1, Issue 2, 143-148

Empirical Study of Energy Prospect of Cassava Peels, Cow Dung and Saw Dust

Olawale Olaniyi Emmanuel AJIBOLA*, Ebun E. OGUNTIBEJU

Department of Systems Engineering, University of Lagos, Lagos, Nigeria
oajibola@unilag.edu.ng/ebunoguntibeju@yahoo.com

Corresponding Author: oajibola@unilag.edu.ng

Date of First Submission: 10/02/2018
Date Accepted: 01/06/2018

Abstract: *Biomass, especially those of cow dung (CD), cassava peels (CP) and saw dust (SD) have been discovered to contain high Carbon to Nitrogen (C:N) ratios. To this end, efforts towards achieving self-sufficiency in energy production have led to the co-digestion of CD, CP and SD under anaerobic conditions. In this project, cow dung, sawdust, cassava peels and water were mixed in ratio 1:0:1:4, 1:1:0:4 and 1:0:0:2 respectively. The slurries obtained were digested anaerobically under mesophilic condition. A retention period of 20 days was set for gas production. Comparative study of the biogas yields was conducted to determine the most ideal waste combination for optimum energy production. The overall result shows that a blend of saw dust and cow dung with a total yield of 80,238mL is the most viable waste combination for biogas production over and above those of cassava-peels/cow-dung, and cow-dung with total yields of 77.712mL and 60.842mL respectively. The significance of this study is to reduce the environmental and health hazards associated with inadequate waste management systems in Nigeria by turning waste to wealth. The by-product of the anaerobic process is also useful as manure to grow agricultural produce.*

Keywords: *Saw dust, cow dung, cassava peels, anaerobic digestion, biogas.*

1. INTRODUCTION

Energy is one of the most fundamental inputs for the achievement of many millennium development goals. Energy exists in various forms such as potential, kinetic, solar, thermal, electrical, chemical, and nuclear. Based on the law of conservation of energy; energy can neither be created nor destroyed, but can be transformed from one form to another [1]. Burning gasoline in car engines converts (chemical energy) stored in the atomic bonds of the constituent atoms of gasoline into heat energy that then drives a piston, which moves the automobile [2]. The wide range of energy use can be broadly divided into three main economic sectors, Residential use (heating and cooling homes, lighting office buildings), Transportation (driving automobiles and moving machines) and Commercial use. The sources of energy can be broadly classified into two categories: the non-renewable and the renewable forms of energy [3]. The use of biomass as one of the renewable resources to generate energy and power has positive environmental implications and creates a great potential to contributing considerably more to the renewable energy sector, particularly when converted to modern energy carriers such as electricity, liquid and gaseous fuels [4]. Biomass is available in a variety of forms and is generally classified according to its source (animal or plant) or according to its phase (solid, liquid or gaseous) [4, 5]. In order to generate electricity, biomass can be combusted, gasified, biologically digested or fermented, or converted to liquid fuels for propelling a generator [6]. Several research institutions, international agencies and programmes such as the ESMAP programme administered by the World Bank rate biomass as one of the cheapest available renewable energy resource for power generation [7 – 9].

The use of biomass has two main advantages: first, is its nearly unlimited availability and second is the fact that it can be used without essential damage to the environment. In addition, biomass is a storable resource, inexpensive and has favourable energy efficiency. Biomass resources that are available in the country include agricultural crops and crop residues, fuel wood and forestry residues, waste paper, sawdust and wood shavings, residues from food industries, energy crops, animal dung/poultry droppings and industrial effluent/municipal solid waste [10 – 14]. This study highlights the energy potential of selected organic wastes with the ultimate aim of attracting research interests towards the use of biomass from agricultural produce and other readily available organic wastes to produce methane, as is a cost-effective and eco-friendly alternative energy. This work proposes the utility of sawdust and cassava peels, co-digested with cow dung as a means of generating biogas, and an eco-friendly method of disposing of organic wastes.

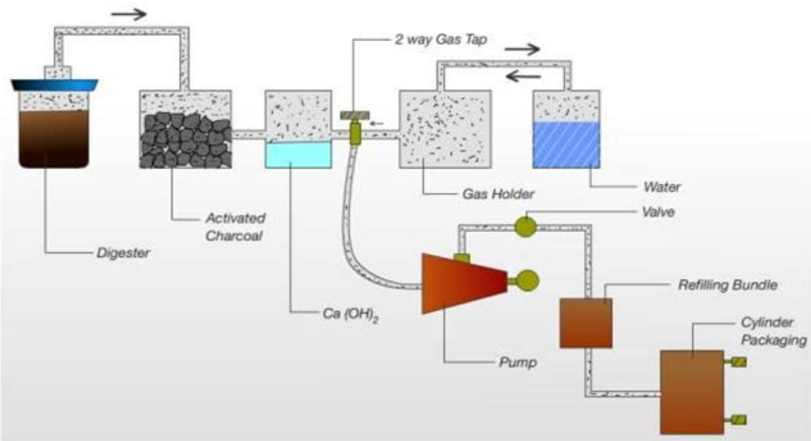
2. MATERIALS AND METHOD

2.1 Materials

The materials used in setting up the digester are: activated charcoal, calcium hydroxide Ca(OH), gas holder tubes; water, adhesives (Abro 2000 Silicon Sealant, Epoxy Hardener and Super Glue), 50kg Portable Weighing Scale, 3 units of 20 litre white kegs, 3 units of 250mL laboratory beaker, 3 units each of 16-inch tri-cycle tubes, 6 units of 8mm industrial gas tap, 3 units of 8mm T- connector, 42 feet rubber hose, digital thermometer, PH meter, Bunsen burner and tripod stand. The afore-stated materials were arranged in the form contained in Figure 1. All perforations were properly sealed and the whole system was air tight.

2.2 Preparation of Co-substrate

In this project, the methodology is purely empirical. The slurry obtained from Cow Dung (CD), Sawdust (SD), Cassava Peels (CP), and water (W) were anaerobically digested in batch digesters A, B and C in ratio 1:0:1:4, 1:1:0:4 and 1:0:0:2 respectively under mesophilic conditions. Various mixes of substrates were tested during the course of the experiment but the aforementioned ratios gave optimum yield of biogas. The results obtained were analysed to determine the slurry with the highest biogas yield. Biogas production was monitored daily by water displacement method. Figure 2 shows the initial setup of the experiment:



Source: Ajibola and Suley, 2012

Figure 1: Schematic of the anaerobic digestion process

2.3 Loading of Digesters

The different substrates were weighed and mixed thoroughly in a water container. The mixtures were loaded into the 25-litres fabricated batch digesters. The waste was loaded to ¾ of the digester volume, leaving ¼ head space for gas collection. The digesters were airtight with the tightening lid locked to exclude air.

Figure 2: Final experimental setup

2.4 Determination of Quantity of Biogas Produced

The quantity of biogas produced daily in millilitres was determined by downward displacement of water by the biogas on daily basis using a 25ml laboratory beaker. The amount of water displaced into the beaker corresponds to the volume of gas produced. The digestion process was carried out for 20days. The final experimental setup is as contained in Figure 2.

2.5 Combustion of Biogas

The combustibility of the biogas produced was determined using the Bunsen burner. The Bunsen burner was connected to the digester's valve (tap); with a pipe hose, the valve was then opened to allow the flow of gas through the hose to the gas burner. The biogas produced blue flame

3. RESULTS

The summary of the composite in Digester A, Digester B and Digester C, the total weight of the respective slurry formed, the days of commencement of biogas production by each composite and the total volume of biogas produced from each slurry in the various digesters are as contained in Table 1:

Table 1: Mixing ratio of organic waste in digesters A, B and C

Digester	**A**	**B**	**C**
Mix Ratio (CD:SD: CP: W)	2:0:1:6	1:1:0:4	1:0:0:2
(Waste: Water)	1:2	1:2	1:2
Cow Dung	4kg	3kg	6kg
Saw Dust	0	3kg	0
Cassava Peels	2kg	0	0
Water	12kg	12kg	12kg
Total weight of slurry	18kg	18kg	18kg
Gas Production (days)	4th day	2nd day	2nd day
Volume of gas produced in 20 days (mL)	**60842 mL**	**80238 mL**	**77712 mL**

Figure 3 compares energy potential in saw-dust/cow-dung as co-substrate (Digester A) with that of the slurry of cow dung (digester C). Table 2 is the comprehensive appraisal of the quantitative parameters of the experiment. It shows the retention period for the entire experiment, the average daily temperature of the immediate environment of the experimental setup, the daily volume of biogas from Digester A, Digester B and Digester C in millilitres, and the cumulative volume of the biogas produced by each of the aforementioned digesters.

Table 2: Cumulative Volume of gas produced in digesters A, B and C

Retention Period	**Av. Daily Temp (°C)**	**Daily Volume (mL)**			**Cumulative Volume (mL)**		
		A	**B**	**C**	**A**	**B**	**C**
1	26.3	0	0	0	0	0	0
2	28.2	0	0	0	0	0	0
3	28.7	0	55	115	0	55	115
4	30.4	85	124	327	85	179	442
5	31.2	192	295	432	277	474	874
6	32.8	420	407	594	697	881	1468
7	28.2	408	645	425	1105	1526	1893
8	28.4	452	593	440	1557	2119	2333
9	33.5	530	670	590	2087	2789	2923
10	31.7	506	667	614	2593	3456	3537
11	30.6	515	640	657	3108	4096	4194
12	29.1	490	625	608	3598	4721	4802
13	33.7	542	765	625	4140	5486	5427
14	28.7	453	650	614	4593	6136	6041
15	26.5	508	603	535	5101	6739	6576
16	27.9	522	506	354	5623	7245	6930
17	29.5	452	568	325	6075	7813	7255
18	28.7	348	540	215	6423	8353	7470
19	28.2	305	485	186	6728	8838	7656
20	27.1	324	494	120	7052	9332	7776
Total					**60842**	**80238**	**77712**

The study revealed a dramatic overturn in the production of energy as the cumulative biogas production of Digester B containing the slurry of cow dung and sawdust as co-substrates surpassed that of Digester C containing cow dung as the sole substrate. This took place after the 13th day of the experiment even though it had surpassed Digester C production on daily biogas production by the 7th day of the experiment. Biogas production from the composite of Digester A consisting of cassava peel and cow dung has been on the low ebb except on the 6th day of the experiment when

 ISSN: 2645-2685

its production level surpassed that of cow-dung/saw-dust slurry sparingly.

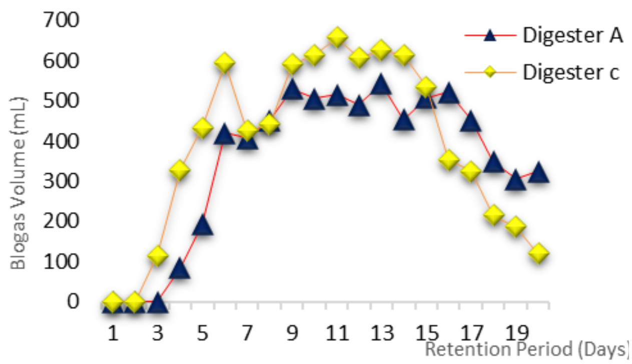


Figure 3: Comparative analysis of biogas production in Digesters A and C

In Figure 4, we have considered the comparative analysis of the yield of biogas in digesters A and B while Figure 5 relates the biogas yield from digesters B and C respectively in details.

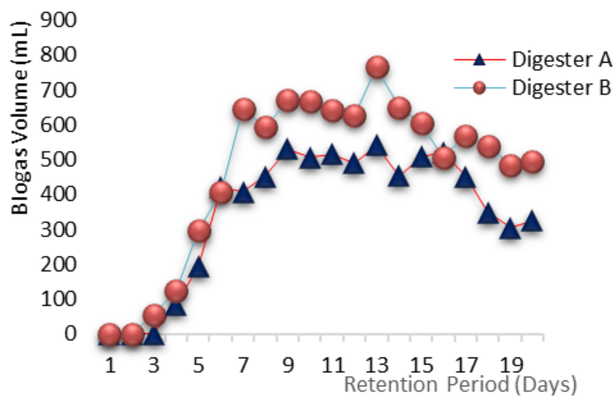


Figure 4: Comparative analysis of biogas production in Digesters A and B.

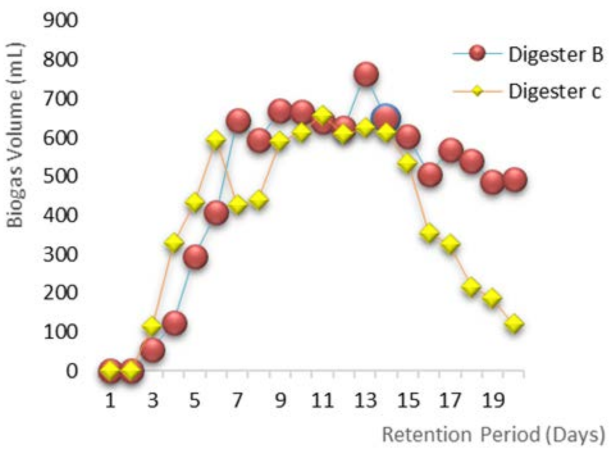


Figure 5: Comparative analysis of biogas production in Digesters B and C

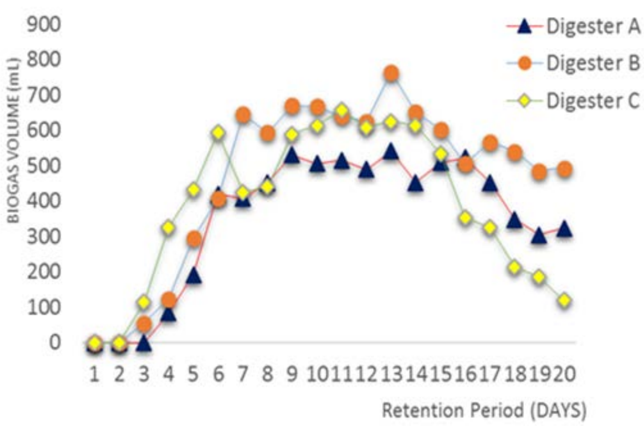


Figure 6: Comparing biogas production in Digesters A, B and C

Figure 6 is the comprehensive graphical comparative analyses of the outcomes of the experiment in concise form. It enumerates the digesters A, B and C in precise term.

4. DISCUSSION

Fresh cow dung was obtained in abattoirs where cattle are slaughtered for human consumption. The dung is obtained after the evacuation of the dung from the intestine of the cow. Moreover, it exists in two types; the intestinal dung and the excrement (excreted) dung from cows: The intestinal dung is the type removed from the intestine of cows slaughtered in the abattoirs for human consumption. The intestinal cow dung consists of the undigested residues of consumed matters. They are very fresh and contains the normal microbial floral as found in the rumen of cow. Excreted dung is the dung excreted by cow species, which are herbivores. It consists of digested residues of consumed matter, which has passed through the cow's gastrointestinal system [15]. For the purpose of this study, fresh intestinal cow dung were obtained from the Semi Mechanised Abbatoir, Bariga, Lagos State, and Oko-Oba Farm, Agege, Lagos. The graphical plot of Figure 3 shows a steep slope with an early production of biogas production in digester C containing the slurry of cow dung. This could be attributed to the microbial population and the surface area of cow dung that provides a medium for maximum activities of the extracellular enzymes and mass transfer of the anaerobes within the digester [16].

Digester C started producing biogas from the 2nd day, and it attained a local maximum on the 6th day before experiencing a sharp decline. This could be attributed to the temperature drop between the 6th and 7th day. Digester B (cassava peels and cow dung) however, started producing biogas on the 3rd day and attained a local maximum on the 6th day. It maintained a steady rise before reaching a global maximum on the 13th day, while in digester C reached its local maximum on the 11th day. The shallow slope after the 14th day in digester C indicates a sharp decline in the daily amount of biogas produced, digester A however only experienced a gradual decline after the 16th day implying better stability. The gradual decline in digester B compared with the sharp decline in digester C, can be attributed to the decrease in the microbial population of the cow dung. Digester B containing cassava peels shows a potential rise between the 19th and 20th day due to unused energy still present in the cassava peels. This implies that over a longer retention time, cassava peels and cow dung might be more reliable. The cow-dung was co-digested with cassava peels, to increase biogas-production by lowering the C:N ratio, since cassava peels alone gives very poor results due to its lignocellulosic properties (high value of organic carbon and very low value of total nitrogen) [17]. The added cow dung (animal manure) lowered the C:N ratio of the peels to value between 20/1 and 30/1 ideal for anaerobic digestion [18 – 20].

Result obtained from figure 4 which compares biogas yield between digester B (CD: SD) and digester C (cow dung only). Both digesters started producing gas on the 2nd day, however, digester C (cow dung only), recorded a higher initial yield with 155ml of gas on the 2nd day compared with 55ml from digester B. This could be attributed to the less microbial population and high fat and fibre content of saw dust [16], therefore degradation of the waste takes longer time. Figure 5, compares digester A (CD:CP) with B (CD:SD). Digester B (cow dung only) started producing biogas from the 2nd day, and its reached a local maximum on the 7th day. Digester A (cassava peels and cow dung) didn't start producing biogas until the 4th day and reached a local maximum on the 6th day. It maintained a steady rise before reaching a global maximum on the 13th day, while digester B reached its local maximum on the 7th day. Digest A which contained cassava peels and cow dung recorded the lowest yield. This could be due to traces of cyanide in the cassava peels, which underscores the unreliability of the soaking method in reducing the acidic content of cassava. The mixing ratio of 1:1 was used because it was noticed that biogas production decreased with increasing mixing ratio. The reason for this is that the higher the quantity of peels in the mixture, the higher the cyanide content and the lower the volume of biogas produced due to the reduction in digestion activities. Digester B containing saw dust and cow dung, therefore is a better mixing ratio for biogas production if there is no urgent need for biogas utilization. However, digester C containing only cow dung would be preferred if the biogas is required urgently.

According to Figure 6, it is clear that the co-substrate of cow-dung and sawdust as contained in digester B has a better prospect of all the three asides its flourishing production level within the retention period. The slurry of cow-dung in digester C flourish over and above the content of digester B only for the first six days and that of A for fifteen days. However, the slurries in digesters A and B both show upward trend after nineteen days revealing rewarding prospect for future biogas production. To this end, it becomes imperative to expend resources more on the composites of cow dung rather than the monolithic slurry of cow dung. This research is in agreement with the work of [3] and other such studies [21 – 26].

5. CONCLUSIONS

In this work, we have charted a course along which a dependable solution to the incessant power supply could be proffered and provided a sure springboard for researchers in the field of renewable energy upon which a veritable knowledge base could be built. From the result obtained in this project work, cow dung, sawdust and cassava peel have been established as excellent co-substrates. However, ratio 1:1 of CD:SD has been shown by empirical evidence to be the best mixing ratio if there is no urgent need for biogas. The equal quantity of the cow dung and saw dust in the digester, provided just sufficient bacteria that aided digestion of the wastes. The time lag and the cumulative biogas yield shows that the sawdust and cow dung is a better substrate mixture over cassava peels and cow dung on one hand, and cow dung on the other. Since the raw materials are available in abundance within the country, Saw-dust/Cow-dung mix could as well solve the energy for rural communities. Based on the enormous amount of saw dust produced daily at sawmills, and with over 1,500 cattle slaughtered on daily basis in Lagos metropolitan alone, the availability of raw material is assured. While the degraded waste can also be used as biofertilizers. It is our hope that if results from this research effort is implemented, problems associated with power supply in Nigeria is solvable.

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