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Production Analysis of Biogas from Animal Dungs and Biodiesel from Neem and Jatropha Seed Oils

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Abstract: Biogas and biodiesel as renewable fuels were produced in this study from different substances. Comparative production of biogas from selected slurries was done to determine the production efficiencies and the effectiveness of different feeds. The production potential of a feed with respect to digester size, distance travelled by the gas and temperature variation on the efficiency of biogas production were also investigated. The results showed that cow dung (190 cm^3), one meter (3573 cm^3), outside (4180 cm^3), and two liter (5020 cm^3) setups produced more total biogas than their counterparts. Biodiesel was produced from neem and jatropha seed oils which were extracted by simple mechanical devices and then pretreated using esterification or neutralization process to reduce FFA to < 1 (which gives high quality) before being trans-esterified using methanol with KOH as catalyst to biodiesel. The FFA of both oils decreased on esterification and neutralization which account for their essence in biodiesel production. Esterification is more economical than neutralization based on the time required. It was observed that the biodiesel should be produced as soon as the oil is extracted because the longer oil stays, the higher the FFA, which requires multiple esterification and neutralization.

Keywords: biogas; biodiesel; animal dung; seed oil; free fatty acid

1. Introduction

Biogas is an environmental friendly, economic and an alternative means to fossil fuel, (Merlin *et al*, 2014). Biogas typically refers to a mixture of different gases produced by the breakdown of organic matter by microorganisms in the absence of oxygen. Biogas can be produced from raw materials such as agricultural waste, manure, municipal waste, plant material, sewage, green waste or food waste. It is a renewable energy source and in many cases exerts a very small carbon footprint (Hassan et al., 2015).

Like any chemical reaction biomethanization could be influenced by factors that usually affect the rate of chemical reaction such as temperature, concentration, surface area and catalyst (Bagudo et al., 2010). In the presence of oxygen, the organic material "composts" (undergoes aerobic decomposition) and when decomposition occurs in the absence of oxygen (anaerobic condition), methane gas is produced, and the liquid remaining is rich in nitrogen and other nutrients (Hassan et al., 2015).

The concept of the utilization of vegetable oil as a fuel dates back to 1895 when Dr. Rudolf Diesel invented the first diesel engine which runs on vegetable oil. He stated that the use of vegetable oil for engine fuels may be insignificant today, but such oil may become a source in time as important as petroleum and coal tar products of the present time (Rekam et al., 2018).

Biodiesel, the most promising alternative diesel fuel, has received considerable attention in recent years due to its following merits: biodegradable, renewable, non-toxic, less emission of gaseous and particulate pollutants with higher cetane number than normal diesel. In addition, it meets the currently increasing demands of world energy that, in a large degree, is dependent on petroleum based fuel resources, which will be depleted in the foreseeable future if the present pattern of energy consumption continues (Xiaohu et al., 2011).

Biodiesel is derived from vegetable oils or animal fats through transesterification (Fukuda et al., 2001). Transesterification is also called alcoholysis, which uses alcohols in the presence of catalyst (e.g., base, acid or enzyme depending on the free fatty acid content of the raw material) that chemically breaks the molecules of triglycerides into alkyl esters as biodiesel fuels and glycerol as aby-product. The commonly used alcohols for the transesterification include methanol, ethanol, propanol, butanol, and amyl alcohol. Methanol and ethanol are adopted most frequently, particularly the former due to its low cost (Xiaohu et al., 2011).

Recently, homogeneous transesterification with NaOH and KOH catalysts is major technology involved in production of biodiesel (Lee et al., 2015)

Currently, the demand for edible oils such as soybean, corn, and palm oil for biodiesel is growing fast and their prices are rising. Rising food prices as a result of growing demand is a concern for global food security. Development of non-edible oil-based biodiesel production can decrease the risk of food security. Jatropha (*Jatropha curcas*) is one of such non-edible vegetable oils, which has great

production potential; it can be grown in very poor soils or idle lands and it has seeds with 30%to 40% approximate oil content (Harumi et al., 2009). Neem seed oil is another type of such oils.

Among such research works on biodiesel include Goering et al., 1981, on 11 different bio-oils to study the characteristic properties. It was done to know which of these oils were best suited for use as an alternative fuel. Of all the bio-oils it was found that sesame, corn, rapeseed, soybean, and cottonseed oils had the better and favorable fuel properties. Auld et al., 1982 conducted research on diesel engine filled with rapeseed oil and studied the effect on the performance of the engine. Use of rapeseed oil gave similar performance as that of diesel fuel used the engine. The results were conducted for short-term. The long-term test was needed for further investigations. Royan et al., 2006 studied the enzymatic production of biodiesel by methanol analysis of cotton oil by using immobilized candida Antarctica lipase catalyst in an at-butanol solvent. He concluded that the concentration of t-butanol for optimum conversion is not high and consequently energy expense needed for its recovery can be taken and it is needed in all cases to take off the excess amount of methanol during the process. Xiaohu et al., 2011 studied parameters affecting transesterification process of cottonseed oil by response surface methodology with SAS and PSI plot programs. The experimental results based on Ride Max analysis and RSM showed the optimal conditions are methanol/oil molar ratio of 7.9, time of 45 min, the temperature of 53°C, the catalyst concentration of 1% and rate of mixing is 268 rpm.

In this study, anaerobic digestion was carried out to produce biogas from some selected animal dungs and the effect of some production parameters on biogas yield was investigated. Biodiesel was also produced from neem and jatropha seed oils respectively. The aim was to use esterification or neutralization process to reduce acid values of these oils and produce biodiesel of high quality via transesterification of the oils with methanol in the presence of potassium hydroxide.

2. Materials and Methods

2.1. Biogas Production

2.1.1. Comparative Production of Biogas from Selected Slurries

Dry animal dung of cow, donkey and camel were grinded separately using mortar and pestle. 200g of each of the animal dung was measured using a weighing balance and then transferred into three separate digesters respectively. $1200cm^3$ of water was added to each digester containing different dung. The digesters were shaken in order to form slurries. A measuring cylinder of $1000cm^3$ capacity was filled with water and inverted into a plastic basin of water; it was then clamped on a retort stand. A rubber hose for the digester was passed into the measuring cylinder. Biogases produced from the digesters were noted (from water displacement by the gas in the cylinder) after twenty four hours every day. Before readings are taken every day, the digesters were shaken in order to mix the slurries which enable the release of gas into their respective

gas collectors (i.e. measuring cylinder). The setup for the experiment is shown in Figure 1 below.

Figure 1: Experimental setups for the comparative production of biogas from selected slurries

2.1.2. Effect of Distance Traveled by the Gas on the Efficiency of Biogas Production

Using a weighing balance, 150 g each of goat dung was weighed and poured into two separate digesters respectively. 750 cm^3 of water was added to both digesters and corked immediately. Both digesters containing the goat dung were agitated gently to ensure proper homogenous mixture. Two plastic basins were used as water basins and two (1000 cm^3) measuring cylinders were inverted into the water trough. One of the digesters is placed at distance of three meter and the other was placed at a meter distance, then both were connected to their respective gas collectors by the use of three meter and one meter rubber hoses respectively. Observation and recording of gas produced from both digesters is taken after twenty four hours (24hrs) at 12:35 every day. Before readings are taken every day, the digesters were hand shaken in order to mix the slurries and release gas into their respective gas collectors (measuring cylinders), such that when all the volume of water in the cylinder is displaced by the gas, the measuring cylinders are then refilled with water and inverted again for the process to continue. The setup for the experiment is shown in Figure 2 below.

Figure 2: Experimental setups for the effect of distance traveled by the gas on the efficiency of biogas production

2.1.3. Effect of Temperature Variation on the Efficiency of Biogas Production

200g of chicken droppings are weighed with the aid of a weighing balance and then transferred into two separate digesters respectively. 750 cm^3 of water was added to both digesters respectively and were corked immediately. The digesters were hand shaken to ensure proper homogenous mixture and two plastic basins were used as water basins, and then two measuring cylinders were separately inverted into the water in each basin. One of the digesters was placed outside the laboratory while the other was kept inside to prevent it from direct sunlight, and the digesters were connected to their respective gas collectors with the aid of rubber hoses. Observation and recording of gas produced from the digesters is taken after twenty four hours (24hrs) at 12:35 every day. Before readings are taken every day, the digesters were agitated to mix the slurries and ease the release of gas into their respective gas collectors. When all the volume of water in the cylinder is displaced by the gas, the measuring cylinders are then refilled with water and inverted again for the process to continue. The setup for the experiment is shown in Figure 3 below.

Figure 3: Experimental setups for the effect of temperature variation on the efficiency of biogas production

2.1.4. Effect of Digester Size on Biogas Production

150g each of chicken droppings are weighed using a weighing balance and then transferred into three separate digesters. 750 cm^3 of water was added to the digesters respectively and were corked immediately. The digesters were hand shaken gently to ensure proper homogenous mixture of the slurries and three plastic basins were used as water basins. Three measuring cylinders were inverted into the water trough. The digesters were connected to their respective gas collectors with the aid of rubber hoses. Observation and recording of gas produced from each size of digesters is taken after twenty four hours (24hrs) at 12:35 every day. Before readings are taken every day, the digesters were hand shaken in order to mix the slurries and ease the release of gas from the digesters. When all the volume of water in the cylinder is displaced by the gas, the measuring cylinders are then refilled with water and inverted again for the process to continue. The setup for the experiment is shown in Figure 4 below.

Figure 4: Experimental setups for the effect of digester size on biogas production

2.2. Biodiesel Production

2.2.1. Sample Preparation

The neem and jatropha seeds were harvested, deshelled, and dried. The seeds were compressed using mechanical pressing machine to extract oil from the seeds. The extracted oil was filtered. 0.1M solution of potassium hydroxide was prepared by dissolving 1.4g of KOH in deionized water and made to the mark of 250 mL volumetric flask.

2.2.2. Acid Value Determination

The acid value of the oil was determined by dissolving 2g of oil sample in 25mL of propanol. The solution was titrated against 0.1M KOH using phenolphthalein as indicator. The titration was carried out until faint pink colour appears (end point). Acid value was calculated using the formula as shown below:

$$Acid\ Value = \frac{(titre\ value) x\ (molar\ mass\ of\ KOH) x\ (molarity\ of\ KOH)}{weight\ of\ oil}$$

$$Free\ Fatty\ Acid\ (FFA) = \frac{acid\ value}{2}$$

2.2.3. Esterification Process

In this step, free fatty acids were first converted to esters in a pretreatment process with methanol using an acid catalyst (H_2SO_4). A reactor is filled with certain mass (g) of seed oil. The catalyst, sulfuric acid (99 %), is dissolved in methanol and then added to the reactor at a reaction temperature of 70 ℃. Next is constant agitation, allowing to stand for some hours and separation (Harumi et al., 2009).

So for this study, 75g oil sample is weighed and transferred in to round bottom flask. 23.194mL of methanol and 0.515mL of H_2SO_4 were measured and mixed in a conical flask. The methanol-acid mixture and the 75g oil sample are placed on heating mantle at temperature of 60ºC. A magnetic stirrer was then added to the mixture, the stirrer was set at 400rpm. When the temperature of mixture reaches 60ºC, at this point timing started and after 60 minute the reaction stops. The mixture is poured into a separating funnel for separation. The mixture separates into two layers, the lower layer is removed. Washing is optional at this stage. The mixture is then titrated against 0.1M KOH to determine the new acid value. The aim of the esterification is to reduce the acid value to less than 1 so that trans-esterification process for biodiesel will occur; otherwise the process can be repeated until the acid value is less than 1.

The volume of methanol in the procedure above was calculated using the formula:

$$Vol. of\ Methonal = \frac{2.25\ x\ FFA\ x\ weight\ of\ oil}{100}$$

Similarly, the volume of H_2SO_4 as used in the procedure above was calculated using the formula:

$$Vol. of\ H_2SO_4 = \frac{0.05\ x\ FFA\ x\ weight\ of\ oil}{100}$$

2.2.4. Neutralization Process

Degumming of neem and jatropha seed oils to reduce some impurities is done by using de-ionized water at ratio of 4:1 i.e. 200mL of neem or jatropha oil to 800mL of de-ionized water stirred for 40 minutes at 65ºC. Neutralization of the degummed oil using 0.1M NaOH (4:2 oil to NaOH) at a temperature of 85 ºC and 400rpm with constant stirring for 40 minutes. The mixture is then poured into a separating funnel and allowed to stand for 12 hrs, two layers separates and the lower layer is removed. The acid value of the upper layer is determined as in 2.2.2 above. The neutralization process has similar aim as in the esterification process above. The free fatty acids are being neutralized by the base thereby reducing the acid value of the oil sample.

2.2.5. Alkaline Trans-esterification

After the esterification or neutralization pretreatment process, the oil is taken in a conical flask and heated up to 60 ºC.1% of KOH catalyst (calculated as 1/75g oil x 100 = 1.33g KOH) is dissolved in methanol. The reaction was carried out using 100% excess methanol, i.e., the molar ratio of methanol to oil is 6:1. The dissolved solution is poured into the flask containing the oil gotten from the upper layer of either the esterification or neutralization process. The mixture is heated and stirred for 1hr.On completion of reaction, the mixture is poured into separating funnel and allowed to stand for 12 hr. The

glycerol and impurities are settled in lower layer and it's discarded. The impure biodiesel remain in upper layer. It contains some traces of catalyst (KOH), glycerol and methanol. Since the remaining unreacted methanol in the biodiesel has safety risks and can corrode engine components, residual catalyst (sodium hydroxide) can damage engine components, and soap in the biodiesel can reduce fuel lubricity and cause injector coking and other deposits (Ryan, 2004), the methyl ester layer (biodiesel) was washed with hot distilled water (about 60 °C).The washing process can be done 3 or 4 times with hot distilled water added to the methyl ester(biodiesel) and gently stirred. When the water reacts with catalyst, soap formation is observed and gets separated from the esters. When the distilled water is added to the esters for the removal of the catalyst, there is a chance of water molecules retained in the methyl esters. To remove the water molecules trapped, the esters are further heated above the 100°C till the water molecules get evaporated. The process is referred to the drying process. Finally, at the end of process glycerin is produced as a byproduct(Rekam et al., 2018). The essence of drying after removing the unreacted methanol, the remaining catalyst, and soap is to minimize the undesired biological growth. The upper layer is pure biodiesel and lower layer is drawn off.

2.2.6. Determination of Density

Density measurements were carried out in similar way according to the method by Harumi et al., 2009, using a density/specific gravity meter at 25°C.

The figure below (figure 5) is a flowchart which shows the steps involved in the biodiesel production.
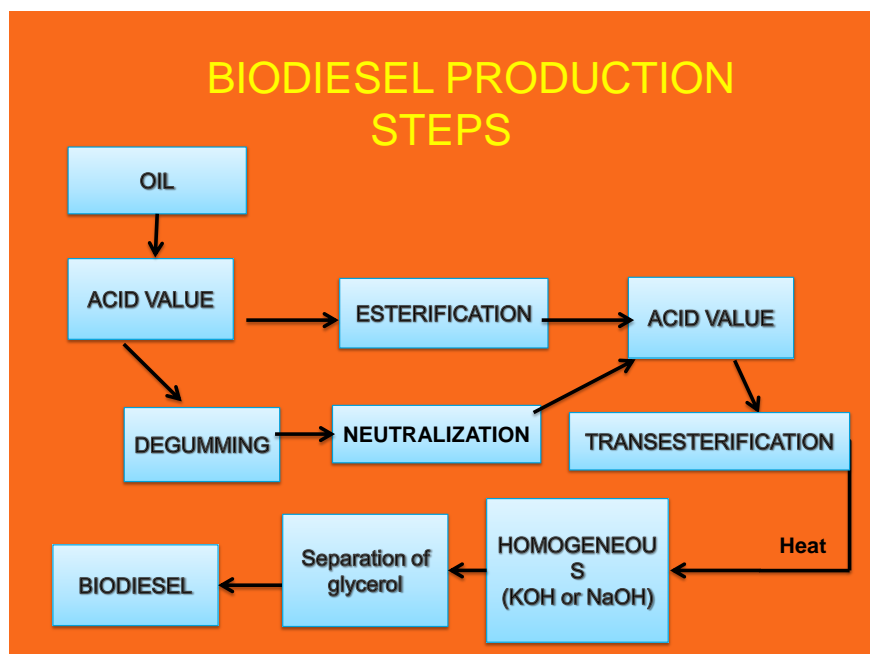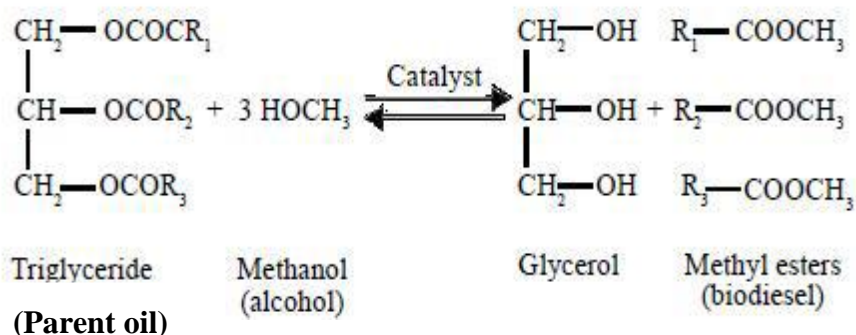

Figure 5: The biodiesel production steps

The figure below (Figure 6) shows the chemical reaction for the transesterification reaction in the biodiesel production.

Transesterification:

Figure 6: Chemical reaction for biodiesel production

3. Results and Discussion

In table 1, it can be seen that during the first and second day of the experiment, there was no any change in each set up. But in the third day, it has been observed that the amount of water from each measuring cylinder (i.e. gas collector) started reducing as shown in the table followed by the following days, which indicated that biogas has been produced from the three digesters and diffused in to the gas collectors. The amount of water from the measuring cylinder (i.e. gas collector) from the setup of cow dung has reduce more than that of the camel and donkey dung set ups, which implies that cow dung produced more gas than camel and donkey dungs.

Table 1. Results of the comparative production of biogas from the selected slurries for one week

Day	Biogas produced by donkey dung (cm^3)	Biogas produced by camel dung (cm^3)	Biogas produced by cow dung (cm^3)
1	Stagnant	Stagnant	Stagnant
2	Stagnant	Stagnant	Stagnant
3	20	40	50
4	40	70	90
5	70	110	130
6	80	140	170
7	100	175	190

In table 2, the results of the effect of the distance traveled by the gas between 1 meter and 3 meter digesters show that the 1 meter digester produced a total of 3573 cm^3 of biogas in 3 weeks 4 days more than that of 3 meter with 3290cm^3 total biogas production through the same period. The decreased biogas volume observed with the digester which was placed at a 3 meter distance from the measuring cylinder setup could be attributed to the longer distance the gas has to travel through before reaching the gas collector.

Table 2. Results of effect of distance traveled by the gas on the efficiency of biogas production for three (3) weeks and four (4) days

Distance of digester from gas collector	1 METER	3 METER
Commencement of biogas production lag time(day)	2nd	3rd
volume of gas produced (cm^3)	**110**	**160**
Average weekly production (cm^3)	**510.42**	**470.00**
Average daily production(cm^3)	**142.92**	**131.60**
Total gas produced in 3weeks 4 days (cm^3)	**3573**	**3290**

In table 3, the results of the effect of temperature variation on biogas production between the experimental setup placed inside the laboratory and that placed outside the laboratory show that the setup outside the laboratory produced a total of 4180 cm^3 of biogas in 2 weeks 4 days more than that from the setup inside the laboratory with 1040 cm^3 total biogas production through the same period. Thus, temperature of the environment also affects the amount of biogas production.

Table 3. Results of effect of temperature variation on the efficiency of biogas production for two (2) weeks four (4) days

Digester location	INSIDE	OUTSIDE
Commencement of biogas production lag time (day)	2nd	2nd
Volume of gas produced (cm^3)	**50**	**440**
Average weekly production (cm^3)	**148.57**	**597.14**
Average daily production(cm^3)	**57.78**	**232.22**
Total gas produced in 2weeks 4 days (cm^3)	**1040**	**4180**

In table 4, the results of effect of digester size on the efficiency of biogas production is shown. It can be seen from the table that the three digesters of different sizes all started biogas production on the second day of the experiment. The 2 liter digester produced a total volume of 5020 cm^3 of biogas more than the other two digesters. The 1 liter digester produced a total of 2260 cm^{3}of biogas which is less than 2500 cm^3 produced by the 5 liter digester, both of which are less than the 5020cm^3 biogas produced by the 2 liter digester. This outcome could indicate that for any three different digesters of sizes in the ratio of 1: 2: 5 that of 2 may give more biogas than the others. An example is for 10, 20, and 50 liter digesters, that of 20 liter could produce more gas than the other 10 and 50 liter digesters.

Table 4. Results of effect of digester size on the efficiency of biogas production

Digester size	1 liter	2 liter	5 liter
Commencement of biogas production lag time(day)	2nd	2nd	2nd
volume of gas produce (cm^3)	50	260	70
Average weekly production (cm^3)	322.85	717.14	357.14
Average daily production(cm^3)	90.40	200.80	100.00
total gas produced (cm^3)	2260	5020	2500

In table 5, the value of FFA for neem oil using the esterification process reduced after the first esterification process from 13.74 (before esterification) to 1.4025 (after first esterification). After the second esterification process, the value further reduced from 1.4025to 0.70125.Since higher amount of free fatty acids (FFA) (>1% w/w)in the feedstock can directly react with the alkaline catalyst to form soaps, which are subject to form stable emulsions and thus prevent separation of the biodiesel from the glycerol fraction and decrease the yield (Demirbaş, 2003), it is better to select reactant oils with low FFA content or to remove FFA from the oil to an acceptable level before the reaction (Xiaohu et al., 2011).

Table 5. Determination of FFA (free fatty acid) for Neem oil using Esterification

Before esterification	First esterification	Second esterification
13.74	1.4025	0.70125

In table 6, the value of FFA for neem oil using the neutralization process reduced after the first neutralization process from 13.745 (before neutralization) to 2.10 (after first neutralization). After the second neutralization process, the value further reduced from 2.10to 0.561. The neutralization process

has similar aim as in the esterification process. That is to reduce the acid value to less than 1 so that trans-esterification process for biodiesel will occur; otherwise the process can be repeated until the acid value is less than 1.So, the free fatty acids are being neutralized by the base thereby reducing the acid value of the oil sample so as to produce biodiesel of high quality. Thus, after the neutralization process, the value of FFA is reduced to less than 1 and so is ideal for high quality biodiesel.

Table 6. Determination of FFA for Neem oil using Neutralization

Before neutralization	First neutralization	Second neutralization
13.745	2.10	0.561

In table 7, the value of FFA for jatropha oil using the esterification process reduced after the esterification process from 1.222 (before esterification) to 1.02 (after esterification).The aim of both the esterification or neutralization step is to reduce the acid value to less than 1 so that trans-esterification process for biodiesel will occur; otherwise the process can be repeated until the acid value is less than 1.If this happens, then high quality biodiesel can be produced from the oil sample. That is, if the FFA value falls below 1, high quality biodiesel can be obtained. However, in the table (table 7), the FFA value is not less than 1 but has reduced from 1.222 (before esterification) to 1.02 (after esterification). This however, will give a better quality biodiesel than when the oil sample is having the initial FFA value of 1.222. If for example, the esterified jatropha oil had been esterified for the second time after the first one, the value would have decreased more than 1.02 to less than 1 which will give a high quality biodiesel than would the sample having 1.02.

Table 7. Determination of FFA for Jatropha oil using Esterification

Before esterification	After esterification
1.222	1.02

In table 8, the value of FFA for jatropha oil using the neutralization process reduced after the neutralization process from 1.222 (before neutralization) to 0.81345 (after neutralization). The aim of the neutralization step is similar to that of the esterification step; that is, to reduce the acid value to less than 1 so that trans-esterification process for biodiesel will occur; otherwise the process can be repeated until the acid value is less than 1. Generally, low FFA oils, give high quality biodiesel.

Table 8. Determination of FFA for jatropha oil using Neutralization

Before Neutralization	After neutralization
1.222	0.81345

In table 9, the value of density for neem oil is 0.9073 g.cm^{-3} while for neem biodiesel is 0.8232 g.cm^{-3} which shows that the biodiesel obtained from neem oil is less dense compared to the neem oil. This can be due to the decrease in the free fatty acid content in the biodiesel of seed oil than the seed oil itself or rather can be attributed to the molar mass differences. However, if the density of an oil sample does not change after the biodiesel production step via transesterification, it means the oil has not been trans-esterified since the density has not changed before and after the process. Since the methyl esters (biodiesel) is different from the triglyceride (parent oil) from which it is produced, it is expected that their densities should be different.

Table 9. Determination of density of Neem oil and Density of Neem biodiesel at 25°C

Density of Neem oil (g.cm^{-3})	Density of Neem biodiesel(g.cm^{-3})
0.9073	0.8232

In table 10, the value of density for jatropha oil is 0.9104 g.cm^{-3}while for jatropha biodiesel is 0.8730 g.cm^{-3}which shows that the biodiesel obtained from jatropha oil is less dense compared to the jatropha oil. This can be due to the decrease in the free fatty acid content in the biodiesel of seed oil than the seed oil itself or rather can be attributed to the molar mass differences. The relationship between the density of the jatropha oil and its biodiesel is similar to the above discussion for neem oil and its biodiesel. Density however, is related to temperature. The work of Harumi *et al*., 2009, on density of *Jatropha curcas* Seed Oil and its Methyl Esters indicated the different values of density for *Jatropha curcas* Seed Oil and it's Methyl Esters (biodiesel).

Table 10. Determination of density of Jatropha oil and Density of Jatropha biodiesel at 25°C

Density of Jatropha oil(g.cm^{-3})	Density of Jatropha biodiesel(g.cm^{-3})
0.9104	0.8730

In table 11, the value of FFA for the esterified neem biodiesel is 0.695 higher than that of the neutralized neem biodiesel (i.e. 0.560). The esterified neem biodiesel is the biodiesel that is produced from neem seed oil after passing through the esterification process to reduce the FFA value for better quality biodiesel. Similarly, the neutralized neem biodiesel is the biodiesel that is produced from neem seed oil after passing through the neutralization process to reduce the FFA value for better quality biodiesel. Thus, the neutralized neem biodiesel has low FFA value than the esterified neem biodiesel.

Table 11. Determination of FFA for Neem biodiesel for both Esterification and Neutralization processes

Esterified Neem biodiesel	Neutralized Neem biodiesel
0.695	0.560

In table 12, the time taken for both oils to be esterified is 12 hours while that of neutralization is 36 hours. Hence, esterifying both oils to reduce the acid value before biodiesel production via transesterification is faster than the neutralization path. Thus, the esterification is more economical than the neutralization process. This has to do with the time requirement for both processes. A process which is faster will be preferred especially if it is fast, cost effective (or cheap) and gives high yield. If however, the fast process gives low yield than the slow process, then a decision has to be made each time between time and yield depending on the objective of such production. If quantity or yield is not the target goal, then the fast process is preferred if speed is the goal, while if time is not an issue, then the slow method is preferred if yield is the goal.

Table 12. Time variation for esterifying and neutralizing neem and jatropha oils

Oil Type	Esterification of oil	Neutralization of oil
Time	12 hours	36 hours

4. Conclusions

The different types of dung used in this research for biogas production shows that a wide range of substrate can be utilized as long as they are biodegradable. In the four experiments conducted, the cow dung, one meter, outside, and the two liter setups produced more biogas than their counterparts. This research shows that the FFA for both oils decreased on esterification and neutralization which account for the essence of esterification and neutralization in biodiesel production. For high quality and to reduce the cost of production of biodiesel from neem and jatropha seed oils, the FFA of the oil was reduced to less than one. Esterification is more economical than neutralization based on the time required. Also the amount of feed stock lost during esterification is about 5% while that of neutralization is about 20%. It is also observed that the biodiesel should be produced as soon as the oil is extracted because the longer oil stays, the higher the FFA, which requires multiple esterification and neutralization.

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