THE BIODIESEL PRODUCTION AND EMISSION ANALYSIS FROM KARANJA (PONGAMIA) NON- EDIBLE VEGETABLE OIL

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Abstract-*Biodiesel is an alternative fuel to conventional petroleum diesel fuel and its derived from renewable resources, such as non-edible vegetable oils. The non-edible vegetable oil from seeds such as jatropha and karanja (pongamia) should be converted to a fuel commonly referred to as ''Biodiesel''. Without engine modifications are required to use biodiesel in the place of traditional petroleum based diesel fuel. Biodiesel can be mixed with petroleum diesel fuel in different proportions. This interest based on number of properties of biodiesel including the fact that it is produced from a renewable domestic resources, biodegradability, and it's mainly to reduce the exhaust emissions. The use of biodiesel resulted in lower emissions of unburned hydrocarbons, carbon monoxide, nitrogen monoxide and particulate matter. The karanja are known just crude plant which grow on eroded soils and require a hot climate and hardly any water to survive. The physico-chemical properties of karanja oil were assessed for their potential in biodiesel. And also the properties of karanja biodiesel and petroleum diesel were compared and manipulated. The quality of biodiesel from karanja oil was improved greatly by neutralizing the crude oils.*

Keywords: *Non-edible oil, petroleum diesel fuel, karanja biodiesel, blend, neutralization, Emissions analysis.*

1. INTRODUCTION

Air pollution in India is a serious issues with the major sources being fuel adulteration, vehicular emission, traffic congestion. Many two wheel and four wheel vehicles lacked catalytic convertors. Increases in vehicle emissions were among the highest in the world. Hence one of the solution was reduction of pollution with the help of biodiesel. To minimize the emissions factor such that particularly NO, CO emissions. The refining of oil and supply of fuel was owned, regulated and run by the government, the fuel quality was lax.

In this paper briefly explained characterization and preparation of biodiesel production from karanja non edible vegetable oil. The biodiesel is the mono-alkyl ester of long chain fatty acids produced from vegetable oil and is derived from transesterification process of vegetable oil with ethanol or methanol. Biodiesel should be derived by a number of edible /non edible vegetable oils. The edible oil classified as soyabean oil, palm oil, sunflower oil etc,, and non edible oil classified as jatropha curcas oil, karanja oil, mahua longifolia oil and so on.

Biodiesel an alternative fuel of normal petroleum diesel fuel. Then the biodiesel directly used in its pure form(B_{100}) or can be blended in different proportions along with diesel .For the example of (B_{20},B_{80}) etc. (B_{100}) which means no blended with petroleum diesel fuel, and (B_{20}) its blended with 20% of biodiesel and 80% of petroleum diesel fuel. Hence this project studied only (B_{100}) form. In recent years, several countries mainly United States of America and countries belonging to the European Union have initiated biodiesel production programmes.

Internationally, the biodiesel production programmes in Europe are depends upon sunflower and rapseed oil. The

United States based on soyabean, and the Malaysia based on palm oil. An India's biodiesel production based on jatropha oil, karanja oil. India is already deficient in edible oils and is importing in nature. Then karanja cultivate to the waste lands that are primarily arid lands for biodiesel production.

Then the other plants for biodiesel production process mahua longifolia. The cultivation period of this plant is longer that is three to five years. Also the species is less scarcity has lower yield per hectare.

2. Materials And Methodology :

2.1Materials:

Soxhlet apparatus, Thermometer, Retort stand, Pipette, Measuring cylinder, Separating funnel, Magnetic stirrer, Hot air oven Water bath, Conical flask, Digital weighing balance, Stop watch, Hot plate, Hydrometer, Bomb calorimeter, Ethanol, Karanja oil.

2.2 Methodology:

Initial characterization of the karanja oil sample:

Proximate Analysis Involves In The Following Determination:

2.3 Moisture: About 1 g of vegetable oil is weighed in a crucible. The crucible is placed inside an electric hot air oven maintained at 105-110ºC. The crucible is allowed to remain in oven for 1 hour and then taken out cooled in a desiccator and weighed. Loss in weight is reported as moisture.

$$percentage\ of\ moisture = \frac{loss\ in\ weight}{wgt\ of\ sample\ taken} * 100$$

2.4 Volatile matter: The dried sample left in a crucible (1) is then covered with a lid and placed in an electric furnace maintained 120-135ºC. The crucible taken out of the oven after 7 minutes of heating.

$$\text{Percentage of volatile matter} = \frac{\text{loss in wgt due to removal of volatiile matter}}{\text{wgt of sample taken}} * 100$$

2.5 Ash: The residual sample in the crucible in (2) is then heated without lid in a furnace at 550C for half an hour. The crucible is then taken out cooled first in air then in desiccator and weighed.

$$\text{percentage of ash} = \frac{\text{wgt of ash left}}{\text{wgt of sample taken}}$$

2.6 Other Parameters:

Percentage of other parameters=100-%of (moisture + volatile matter + ash)

2.7 Determination of acid value : **1**g of oil was dissolved in 20 ml of the neutral solvent in 250 ml conical flask, 3 to 4 drops of pheonoptalein indicator was then added and titrated against 0.1N sodium hydroxide. The content was constantly stirred until a pink colour which persisted for fifteen seconds was obtained. The acid value range varies from 0.92 to 6.16 mg NaOH/g.

$$\text{ACID VALUE} = \frac{(\text{v} - \text{b}) * \text{N} * 40}{\text{W}}$$

w – Weight of the oil sample

b – Initial reading of burette

v – Final reading of burette

N – Normality of [NaOH]

2.8 Determination of saponification value: The known quantity of oil was refluxed with an excess amount of alcoholic NaOH after saponification the remaining NaOH was estimated by titrating against a standard acid.

The oil sample was filtered to remove any impurities and last traces of moisture. 1 g of the oil was the weighed into a flask. 5 ml of ethanol and 25 ml of 0.5N alcoholic NaOH was added from burette allowing it to drain for the same duration of time. A reflux condenser was connected to the flasks and allowed to boil gently for one hour. After the flask and condenser get cooled, they were rinsed down the inside of the condenser when a little distilled water and then the condenser was removed. About a ml of indicator was added and titrated against 0.5m HCl until the pink colour was disappeared. The saponification value ranges varies from 102.9 to 209 mg/g.

$$soaponofication\ value = \frac{no\ of\ mg\ of\ \ NaOH\ consumed}{amount\ of\ fat\ taken\ initially}$$

2.9 Determination of molecular weight:

$$Molecular\ weight = \frac{equivalent\ wgt\ of\ NaOH * 1000 * 3}{sv - av}$$

Where

Sv- saponification value

Av-acid value

The molecular weight ranges varies from 800 to 1200 g/mole.

2.10 Determination of specific gravity: Density bottle was used to determine the specific gravity of the oil. A clean dry bottle was weighed and then filled with the oil a stopper was inserted and then reweighed to give. The oil substituted with water after washing and drying and weighed to give as

$$specific\ gravity = \frac{w1 - w0}{w2 - w0}$$

Where

W_0-empty weight of density bottle

W_1-oil weight of density bottle

W_2-weight of water

The specific gravity values ranges from 0.860 to 0.973.

2.11 Determination of iodine value: To find the iodine value of a oil using the method wijs cyclohexane method. Add 2 d melted oil sample in a 200 m1 beaker. Collect 10 ml of cyclohexane and 25 ml of wijs solution. Dark place for 30 min shaking. After leaving 20 ml of 10 g/100ml KI. 100 ml of distilled water. Titrate with 0.1N sodium thiosulphate. Same the titration for blank measurements. The end point was yellow to colourless.

$$Iodine\ number = \frac{(Bl - A) * f * 1.269}{s}$$

Bl - blank titration

A - sample titration

F - factor of 0.1N sodium thiosulphate solution

S – sample volume

The iodine value ranges varies from 0.92 to 11.2 mg of iodine/ g of oil.

2.12 Molar ratio for oil to ethanol :

$$Molar\ ratio = \frac{wgt\ of\ oil}{molecular\ wgt}$$

2.13 Determination of calorific value: To find the calorific value with the help of bomb calorimeter. Calorific value of fuel is the total quality of heat liberated by complete combustion of a unit mass or volume of the fuel. The calorific value of oil ranges varies from 37.83 to 42.05 MJ/kg.

2.14 Determination of peroxide value: A 25 g of oil dissolved in 5 ml of chloroform. Additionally 0.25 ml of KI and 15 ml of distilled water. The mixture was titrated against 0.1N sodium thiosulphate solution. The end point recorded blue to colourless.

$$pv = \frac{(R*B)*molarity\ of\ sodium\ thiosulphate}{wgt\ of\ sample}$$

R- real titrate value

B- blank titrate value

The peroxide values ranges varies from 3.24 to 15.05 meq/ g of oil. Table 1 shows initial characterization of oil.

2.15 Pre-esterification:

i. Reduction of the fatty acid contained in the karanja oil.
ii. Transesterification.

2.15.1 Reduction of free fatty acid:

As obtained in the test carried out on the vegetable oil, it was discovered that the free fatty acid (FFA) contents of oil are high (21.6%). Hence it became necessary to reduce it. The above mentioned process explained in more detail flow diagram.

There are many producers available in this modification to produce a better quality of biodiesel. This can be accomplished in four primary ways, blending of crude oils, micro emulsions, thermal cracking, and transesterification.

2.15.2 Transesterification:

Transesterification process also called as alcoholysis. It is the displacement of alcohol from an ester by another alcohol in a process similar to hydrolysis, except that alcohol is used instead water. This process has been widely used to reduce the triglycerides.

RCOOR'+R"OH→ RCOOR"+R'OH

Transesterification of vegetable oils, a triglycerides reacts with an alcohol in the presence of a strong base, producing a mixture of ethyl esters and glycerol.

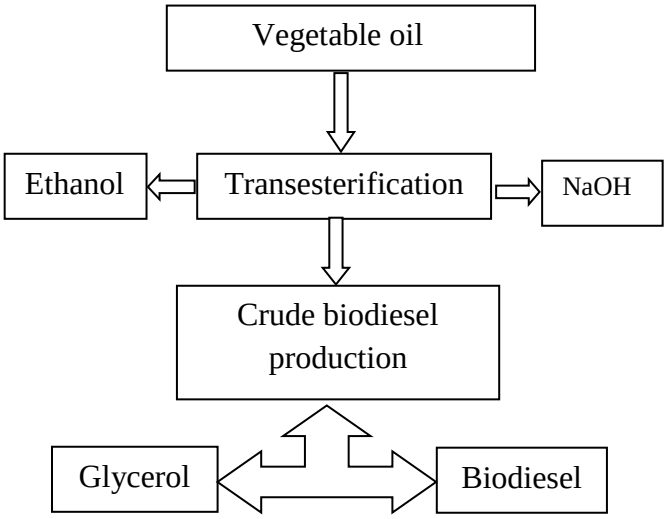

Fig 1. Mechanism of transesterification process.

2.18 Step by Step procedure involved in transesterification:

100 ml of karanja oil was measured and poured into 1000 ml beaker and heated to a temperature of 60 to 75°C.

A quantity of ethanol was poured in a round bottom flask, in a soxhlet apparatus and the heater was turned on. This was done to purify the ethanol.

The sodium hydroxide pellet was taken exactly 1g by using weighing balance.

A solution of sodium ethoxide was prepared in a 250 ml beaker by mixing 1 g of sodium hydroxide pellet and 30 ml of ethanol. The solution was properly stirred until was completely dissolved.

The sodium ethoxide solution wa heated to bring its temperature about 60°C.

Once desired temperature reached, the sodium ethoxide solution was poured in to the warm vegetable oil and stirrer vigorously for 50 minutes by using a magnetic stirrer.

After completion of reaction, the biodiesel mixture was poured into separating funnel and allow to stand for about 24 hours, The lower layer was collected from the bottom of the separating funnel which is mainly comprised of glycerol and soap.

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Fig 2. Separate layer and hot plate

The collected upper layer was washed with warm water to remove any excess glycerol and soap that remain in the biodiesel.

This process was repeated until the clear water was seen, which indicate the biodiesel in the separating funnel is completely free from glycerol and soap.

The washed sample was dried to remove excess water present in the biodiesel.

The quantity of biodiesel collected was measured and recorded.

To study the emission characteristic of our biodiesel. The above procedures were repeated by varying the mole ratio of vegetable oil and ethanol, while keeping catalyst concentration, stirring time, and temperature are remains constant.

Table 1

Initial characterization of the karanja oil

s.no	Tests	Karanja oil
1	Moisture content(%)	6.43
2	Volatile matter(%)	23.10
3	Ash (%)	92.12
4	Other parameters(%)	98.418
5	Density (kg/cm^3)	919.33
6	Specific gravity	0.91933
7	Viscosity(cst@33ºC)	54.3
8	Calorific value(MJ/kg)	38.20
9	Flash point(ºC)	257
10	Fire point(ºC)	264
11	Acid value	25.2
12	Saponification value(mg/g)	88
13	Molecular weight(g/mole)	1910.8
14	Iodine value(mg of iodine/g of oil)	5.12
15	pH	7.02
16	Peroxide value (meq/g of oil)	8.43

3. Main factor affecting the biodiesel:

3.1 Reaction Temperature:

Under conditions simultaneous esterification and transesterification takes place. The maximum yield of esters occurs at temperatures ranging from 60 to 80 ºC at a molar ratio of oil to alcohol 1:6. These studies indicated that given enough time, transesterification can proceed satisfactorily at ambient temperatures in the presence of alkaline catalyst.

3.2 Molar ratio:

The important variable affecting the yield of ester is the molar ratio of vegetable oil to alcohol.

3.3 Mixing intensity:

The transesterification reaction the reactants initially form a two-phase liquid system. As ethyl esters are formed, they act as neutral solvent for the reactants and a single phase system is formed.

3.4 Reactants purity:

The impurities present in the oil is also affect conversion levels. Using crude vegetable oils can be purity obtained 94-97% conversion when using refined oils.

4. **Results and discussions:**

The results of this research work shall be discussed under the following solutions:

i. Characterization of biodiesel
ii. Analysis of the emission test result

4.1 Characterization of biodiesel:

4.1.1 Analysis of Viscosity: Viscosity is the measure of a materials resistance to flow. Viscosity is measured with the help of redwood viscometer. Viscosity is a result of the internal friction of the materials molecules. In the transesterification process to reduction the viscosity of triglycerides (vegetable oil or animal fat). The viscosity of biodiesel ranges varies from 1.9 to 6 cSt at 33ºC.

4.1.2 Flash point: The lowest temperature at which the vapour of a substance momentarily takes fire in the form of a flash point. The flash point of biodiesel ranges from 50 to 240ºC.

4.1.3 Fire point: The lowest point temperature at which the material gets ignited and burns under specified conditions of tests. Fire point of biodiesel ranges from 55 to 320 ºC.

4.1.4 Acid value: To protect engine due to corrosion with using biodiesel, so it's essential to check out the acid value of biodiesel. Table 2 shows karanja biodiesel characterization.

Table 2

Karanja Biodiesel characterizations

S.no	Tests	Karanja biodiesel
1	Calorific value (MJ/kg)	40.3
2	Flash point(ºC)	55
3	Fire point(ºC)	65
4	Acid value(mg NaOH/g)	0.63
5	Density(kg/m³)	890
6	Viscosity (cSt@33 ºC)	4.58

4.2 Analysis of emissions from the karanja biodiesel:

Emission analysis with the help of flue gas analyzer. To check the emissions from the biodiesel exhaust variety of pollutant gases. Such that CO, NO, CO_2, Hydrocarbon etc., the initial stage was biodiesel run in diesel engine thereafter analysis of emission using AVL gas analyser. Hence this paper studied only B_{100} formation of biodiesel only. And also check fuel consumption of 10 cc per seconds due to performance efficiency.

The karanja biodiesel gave higher performance efficiency. The load proceeded about 0, 6, 8.5 kg. If the performance efficiency depends upon the quantity of load. The following tests results are described below.

4.2.1. Fuel consumption or performance efficiency:

For Karanja biodiesel, as the load value increases, fuel consumption value also decreases up to load 6 to 8.5, thereafter the fuel consumption value starts decreasing. Though load value is 0, the initial value of fuel consumption is 53.22. Then the load value gradually increased. Though the load value is 6, the fuel consumption value of 74.06, and also the load value is 8.5, the value of fuel consumption is 70.06. The fuel consumption denoted as 10 cc per seconds.

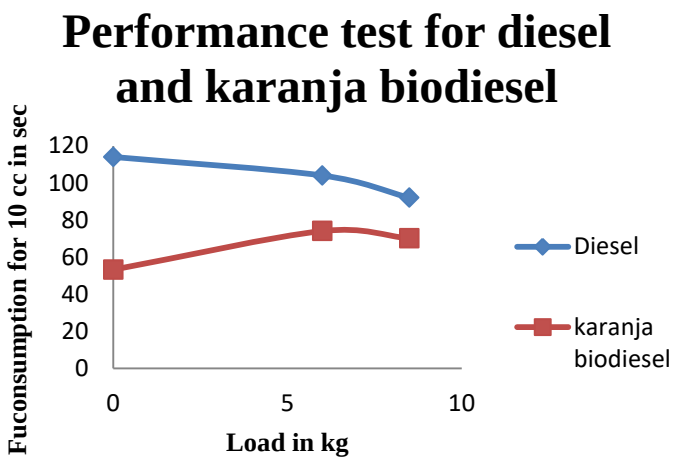

Fig 3. Performance efficiency chart

From fig 3 petroleum diesel, as the load value increases, fuel consumption value also decreases up to load 6 to 8.5, thereafter the fuel consumption value starts decreasing. Though load value is 0, the initial value of fuel consumption is 114. Then the load value gradually increased. Though the load value is 6, the fuel consumption value of 104, and also the load value is 8.5, the value of fuel consumption is 92.The fuel consumption denoted as 10 cc per seconds.

As compared to the petroleum diesel fuel and karanja biodiesel, the karanja biodiesel consumed low level of fuel. So the performance efficiency level get increased in karanja biodiesel.

4.2.2. NO emissions in karanja biodiesel and petroleum diesel fuel:

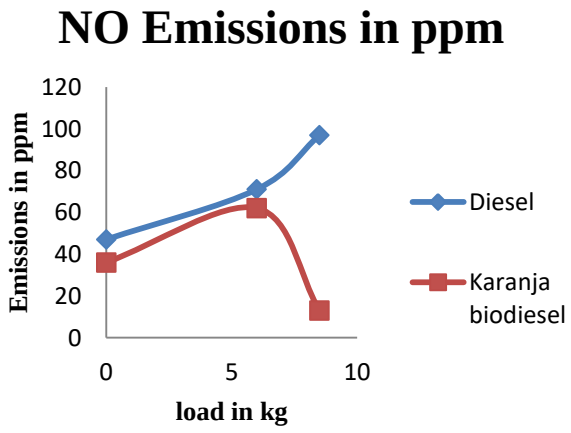

Fig 4. NO Emissions in ppm karanja biodiesel and diesel

From fig 4 Karanja biodiesel, as the load value increases, NO value also slightly increases up to load 6 to 8.5, thereafter the NO value starts increasing. Though load value is 0, the initial value of NO emission is 36 ppm. Then the load value gradually increased. Though the load value is 6, the value of NO emission 62 ppm, and also the load value is 8.5, the value of NO emission is 13 ppm.

For normal diesel, as the load value increases, NO value also slightly increases up to load 6 to 8.5, thereafter the NO value starts increasing. Though load value is 0, the initial value of NO emission is 47 ppm. Then the load value gradually increased. Though the load value is 6, the value of NO emission 71 ppm, and also the load value is 8.5, the value of NO emission is 97 ppm.

The NO emissions were reported with the lowest amount of unsaturated fuel. Biodiesel from more saturated feedstocks, such as fats, yields a smaller NO increase. The NO increases also depends upon the engine technology.

4.2.3. CO emissions in karanja biodiesel and petroleum diesel fuel:

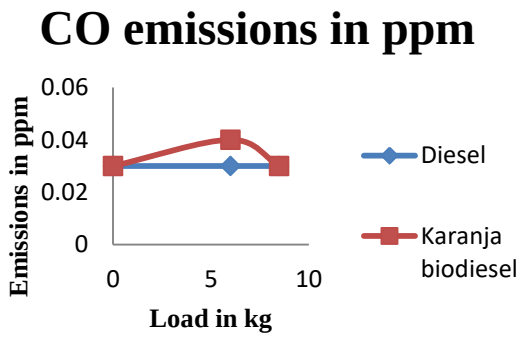

Fig 5. CO Emissions in ppm karanja biodiesel and diesel

From fig 5 Karanja biodiesel, as the load value increases, CO value also slightly decreases up to load 6 to 8.5, thereafter the CO value starts decreasing. Though load value is 0, the initial value of CO emission is 0.03. Then the load value gradually increased. Though the load value is 6, the value of CO emission 0.04, and also the load value is 8.5, the value of CO emission is 0.03.

For normal diesel, as the load value increases, CO value also slightly decreases up to load 6 to 8.5, thereafter the CO value starts decreasing. Though load value is 0, the initial value of CO emission is 0.03. Then the load value gradually increased. Though the load value is 6, the value of CO emission 0.03, and also the load value is 8.5, the value of CO emission is 0.03.

CO emissions is formed mainly due to partial combustion of fuel and also by insufficient supply of air during combustion.

5. Conclusions

In this study the following useful conclusions are derived based on experimental work and also from test report.

The test report, the emission of NO from the vehicular emissions get reduced and the molar ratio 1:6 optimum yield is obtained.

Improves engine and performance efficiency 36% than compared to the petroleum diesel fuel.

The NO emission reduced more than 31% compared to the traditional diesel fuel.

The level of hydrocarbon is higher than the biodiesel compared to the diesel fuel. Level of hydrocarbon in diesel 6 ppm and karanja biodiesel 14.66 ppm.

The flash point of karanja biodiesel 56ºC and fire point 65ºC and viscosity 4.58 cst at 33ºC.

The CO_2 emissions reduced compared to the traditional diesel fuel. Where loading 8.5 kg the emission rate of normal diesel 1.10% and karanja biodiesel fuel 0.7%.

The CO emissions slightly varied compared to the traditional diesel fuel. Where the CO emission in diesel fuel 0.03% and karanja biodiesel fuel CO emissions 0.03 to 0.04%.

Biodiesel is non-toxic and environment friendly as it produces substantially less carbon monoxide and nitrogen monoxide the combustion gases contain no sulphur dioxide and unburnt hydrocarbons.

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