LA GRANJA:
REVISTA DE
CIENCIAS DE LA VIDA
pISSN:1390-3799; eISSN:1390-8596
http://doi.org/10.17163/lgr.n32.2020.02

Scientific paper/ Artículo científico

CARBON FRONTIERS

ENGINE PERFORMANCE AND EMISSION ANALYSIS USING NEEM AND JATROPHA BLENDED BIODIESEL

RENDIMIENTO DEL MOTOR Y ANÁLISIS DE EMISIONES UTILIZANDO BIODIÉSEL DE NEEM Y JATROPHA

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Article received on May 8th, 2019. Accepted, after review, on June 6th, 2020. Published on September 1st, 2020.

Abstract

This paper presents the production of biodiesel from indigenous species of Jatropha curcas and Neem (*Azadirachta indica*) oils, then its engine performance and emission characteristics of B10 blends measured at 1000 rpm. Biodiesel production yields were found 90% and 68% by weight from Jatropha curcas and Neem (*Azadirachta indica*), respectively. Three prepared biodiesel blends were 10% Neem biodiesel (NB10), 10% Jatropha biodiesel (JB10) and 5% Jatropha + 5% Neem biodiesels (NJB10). The engine emission test showed less carbon monoxide production from NB10 (94 $\pm$ 2.15 ppm), followed by JB10 (100 $\pm$ 2.44ppm) and NJB10 (121 $\pm$ 3.65ppm) as compared to diesel (135 $\pm$ 2.18ppm). However, the carbon dioxide emissions were found higher due to the better combustion characteristics of biodiesel blends as NB10 (3.21%), JB10 (3.06%) and NJB10 (2.53%) than diesel (2.13%) by volume. The reduced amounts of sulphur dioxide (SO_2) emissions were found with blended biodiesel fuel in comparison to mineral diesel. Nitrogen dioxide (NO_2) emissions were 5 ppm from diesel at 73°C exhaust temperature, while it was increased by using blended biodiesel, to 8 ppm with NB10 due to higher exhaust temperatures 85,33°C. The measured engine power and torque produced from the blended biodiesel samples were slightly lower than the conventional diesel by 12% and 7.7%, respectively. The experimental results showed that an engine performance and emission characteristic of Neem biodiesel (NB10) was better as compared to other biodiesel blends.

Keywords: Biodiesel, *Jatropha curcas*, Neem (*Azadirachta indica*), engine emissions, engine performance.

Resumen

Este documento analiza la producción de biodiésel a partir de especies autóctonas de aceites de Jatropha curcas y Neem (*Azadirachta indica*), junto con el rendimiento del motor y las características de emisión de mezclas B10 a 1000 rpm. Los rendimientos de la producción de biodiésel fueron 90 % y 68 % en peso de Jatropha curcas y Neem (*Azadirachta indica*), respectivamente. Las tres mezclas preparadas de biodiésel fueron 10 % Biodiésel de Neem (NB10), 10 % de biodiésel de Jatropha (JB10) y 5 % de Jatropha + 5 % de Biodiésel de Neem (NJB10). La prueba de emisiones del motor mostró menos producción de monóxido de carbono con NB10 (94 ± 2,15 ppm), seguida de JB10 (100 ± 2,44 ppm) y NJB10 (121 ± 3,65 ppm) en comparación con el diésel (135 ± 2,18 ppm). Sin embargo, las emisiones de dióxido de carbono fueron más altas debido a las mejores características de combustión de las mezclas de biodiésel como NB10 (3,21 %), JB10 (3,06 %) y NJB10 (2,53 %) comparado con el diésel (2,13 %) por volumen. Las cantidades más bajas de emisiones de dióxido de azufre (SO_2) se observaron con el combustible de biodiésel mezclado, en comparación con el diésel mineral. Las emisiones de dióxido de nitrógeno (NO_2) fueron de 5 ppm de diésel a $73°C$ de temperatura de escape, mientras que se incrementó a 8 ppm mediante el uso de biodiésel mezclado con NB10 debido a las altas temperaturas de escape de $85,33°C$. La potencia y la carga del motor producidos a partir de las muestras de biodiésel mezclado fueron ligeramente inferiores al diésel convencional en un 12 % y un 7,7 %, respectivamente. Los resultados experimentales mostraron que el rendimiento del motor y la emisión del biodiésel de Neem (NB10) era mejor en comparación con otras mezclas de biodiésel.

Palabras clave: Biodiésel, *Jatropha curcas*, Neem (*Azadirachta indica*), emisiones del motor, rendimiento del motor.

Suggested citation: Ali, M. and Jamshed-Rind, S. (2020). Engine performance and emission analysis using Neem and Jatropha blended biodiesel. La Granja: Revista de Ciencias de la Vida. Vol. 32(2):19-29. http://doi.org/10.17163/lgr.n32.2020.02.

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1 Introduction

The climate change and global warming issues are caused by greenhouse gas emissions (GHG's) such as carbon dioxide, methane and nitrous oxide in the atmosphere due to the human induced activities by burning fossil fuels used in transportation and energy generation sector (Climate Change Indicators, 2015). The two most common liquid biofuels for transportation (i.e. bioethanol and biodiesel) can replace the petroleum derived gasoline and diesel fuels, producing harmful gas emissions with detrimental impacts on the environment. Bioethanol and biodiesel are alternative fuels produced almost entirely from vegetable oil seed crops, having environmental benefits. The biggest difference between biofuels and petroleum feedstocks is the concentration of oxygen content, which makes biofuels environmental friendly with complete combustion producing carbon dioxide instead of carbon monoxide, causing harmful impact on the health of humans (Chauhan and Shukla, 2011).

Biodiesel as a biodegradable and an alternative fuel, getting more importance due to the depletion of crude oil reserves and its environmental benefits (Berchmans and Hirata, 2008). In fact, biodiesel fuel is a form of renewable fuel which can be obtained from various feed stocks including edible and non-edible oil seed crops. While it can be produced from non-edible oils example; mahua, neem, karanja and Jatropha curcas to avoid conflict with the edible food crops (Masjuki Kalam, 2013). The use of biodiesel fuel in diesel engine does not require engine modifications, it gives significant reduction in emissions of oxides of sulfur (SO_x), carbon monoxide (CO) and particulate matter (PM) with other benefits such as higher flash point and lower aromatic content in the exhaust gases due to the complete combustion of fuel (Ali and Shaikh, 2012).

In previous research investigation, methyl ester of Pongamia, Jatropha and Neem were produced by transesterification reaction and the experimental study carried out to test the emission characteristics of different blends ($B10, B20$, and $B40$) in comparison with petroleum diesel. The blended fuel samples showed lower smoke, carbon monoxide and unburned hydrocarbons (HC) emissions as compared to petroleum diesel (Rao et al., 2008). Another investigation showed that the exhaust emissions from neem biodiesel B30 were having lower smoke opacity (5%) than with regular diesel fuel (55%) at maximum brake power (5 kW). Similarly, the carbon monoxide (CO) is one of the intermediate products formed during the combustion reaction of hydrocarbons in the engine cylinder, and it was observed that the amount of CO produced decreases with increase in load on the engine for diesel and various blends of neem biodiesel. It was noticed that unburned hydrocarbons (HC) emission increases with respect to the increased engine load for diesel and blends of neem biodiesel due to more fuel consumption at high engine loads, with incomplete combustion. However, it was found that HC emissions decrease with increase in percentage of biodiesel in the blends, due to availability of more oxygen percentage leading to complete combustion of fuels (Mall, 2015).

The Pakistan's major portion of energy production is met by burning crude petroleum oil derived fuels, which are non-renewable resources. Currently the country is facing an electricity shortfall between 6,000 to 7,000MW (Yuosafzai, 2018). The Pakistan's oil import bill increased from US $ 7.4 billion in 2015-16 to US $ 9.1 billion in fiscal year 2016-17 as a result of increase in international crude oil prices and increase in import of petroleum products. Therefore, it is being assumed that the demand of petroleum crude oil will have an increasing trend in future for power generation and transportation sector in the country (Pervaz, 2018). However, for the sustainable future through the renewable energy, it is necessary to reduce the dependency on imported crude oil. These steps would not only help to save valuable foreign exchange of the country but also it would help in mitigating climate change and global warming issues (Ali, 2016).

Moreover, the Alternative Energy Development Board of Pakistan (AEDB) took an initiative under its National Biodiesel Program to minimize quantity of diesel consumption (10% by volume) of the total diesel usage by the year 2025 with alternative biodiesel fuel (Ahmed et al., 2015). The past research studies have conducted limited investigation on Neem and Jatropha curcas blended biodiesel fuels related to engine performance and emission characteristics. Therefore, the aim of this research study was to characterize the produced biodiesel from Neem and Jatropha curcas oils, followed by engine performance and emission characteristics of Neem and Jatropha curcas blended biodiesel fuel samples in order to comply with AEDB target to use 10 % blended biodiesel by the year 2025 in Pakistan.

2 Materials and methods

The *Jatropha curcas* non-edible vegetable seed oil was obtained from Arid Zone Research Institute, Pakistan Agricultural Research Council, Umerkot, while neem oil (*Azadirachta indica*) was extracted with a mechanical oil expeller from locally available oil seeds. All the experiments were conducted in the Department of Environmental Engineering and the Department of Automotive Marine Engineering, NED University of Engineering & Technology, Karachi, Pakistan. The temperature and humidity in the laboratory were measured as $28 \pm 1°C$ and 45 % RH with (Temperature Humidity Meter Digital Thermometer, China).

2.1 Acid value test

For both non-edible oils, the free fatty acid (FFA) content % and acid value test were measured by following the standard titration method (The American Oil Chemists' Society Official Method Ca 5a-40) mentioned in literature (Berchmans and Hirata, 2008). According to the literature if vegetable oils have FFA content more than 1 % by weight, it will produce soap and a low yield of biodiesel product. Therefore two step reactions (i.e. acid esterification and base catalyzed transesterification) are usually adopted to reduce the oil FFA to produce biodiesel (Berchmans and Hirata, 2008).

2.2 Two-step (acid esterification and base catalyzed transesterification)

A two-step process, acid-catalyzed esterification process and base-catalyzed transesterification process were conducted according to the literature (Berchmans and Hirata, 2008). The first step was carried out with 0.60 w/w methanol to oil ratios in the presence of 1 % w/w H_2SO_4 (BDH, England) as an acid catalyst in 1 hr reaction at $50°C$ using a hot plate heater with magnetic stirrer operating at 400 rpm (Wise stir, MSH-20A, Daihan Scientific, Korea). After reaction, the mixture was allowed to settle for 2 hrs and the methanol water mixture collected at the top layer was removed with the help of pipette. The second step was base catalysed transesterification using 0.24 w/w methanol (BDH, England) to oil and 1,4 % w/w $NaOH$ (Merck, Germany) to oil as alkaline catalyst to produce biodiesel at $65°C$ for 2 hrs reaction time using a hot plate heater with magnetic stirrer with a mixing speed of 400 rpm (Berchmans and Hirata, 2008). The two layers were formed after the reaction i.e. biodiesel (upper layer) and bottom layer glycerine were separated out in a separating funnel (1L). The biodiesel phase and glycerine phase were washed with 10 % by volume of warm distilled water at $70°C$ and then dried in a conventional oven (YCO-N01, Gemmy Industrial Corp., Taiwan) for 1 hr at $80°C$ (Ali et al., 2018). The amount of biodiesel and glycerine produced after separation and drying were collected in a pre-weighted beaker (50 mL) and the quantity was measured by weight in grams with the help of a weight balance (AB 304-S, Mettler Tolendo, Switzerland).

2.3 Physicochemical properties of biodiesel produced

The following physicochemical properties of biodiesel produced were measured and the results are presented as mean ± standard deviation, for sample size (n=3).

2.3.1 Density:

Density of the extracted oil and the biodiesel produced were measured in g/mL with density meter (DA-130N, Kyoto Electronics Manufacturing Co. Ltd, Japan).

2.3.2 Kinematic viscosity:

Kinematic viscosity in mm^2/sec of the vegetable oils (Jatropha curcas and Neem oils) and its blended biodiesel samples were measured by using Kinematic/ Dynamic viscometer (VDM-300, AS Lemis, EU).

2.3.3 Calorific value:

The calorific value in MJ/kg of Jatropha curcas, Neem oils and its blended biodiesel samples were determined with an oxygen bomb calorimeter (IKA C200, Germany) according to the ASTM D2015 standard method.

2.3.4 Flash point:

The flash point of Jatropha and Neem biodiesel and blended fuel samples were measured with a flash point tester (AD 0093-710, SCAVINI, Italy) according to the ASTM D93 standard method.

2.4 Methyl esters (oleic acid) content

The oleic acid composition in the Jatropha and Neem oil samples were determined using GC-FID (GC-2014, Shimadzu, Japan) equipped with flame ionization detector at the Institute of Chemical Engineering Technology, University of the Punjab, Lahore.

2.5 Biodiesel-diesel blending ratios

Each fuel sample (1 L =1000 mL) was prepared by mixing biodiesel produced with the conventional diesel procured from the company operated fuel station of Pakistan State Oil (PSO) in the following ratios as shown in Table 1 as per the requirement of AEDB to blend the conventional diesel with 10 % biodiesel fuel.

2.6 Engine emissions and performance testing protocol

The prepared fuel samples emission characteristics were measured with operating a diesel engine, having specifications mentioned in Table 2, at a constant speed of 1000 rpm at the Department of Automotive & Marine Engineering, NED University. The gaseous emissions concentration measurement of carbon dioxide (CO_2), carbon monoxide (CO), oxides of nitrogen (NO_X), sulphur dioxide (SO_2) and oxygen content (O_2) were measured using flue gas analyzer (340, Testo Instruments Ltd, Germany). The gas emission results are presented as (mean ± standard deviation) for sample size n=3.

Engine performance was measured for 100 % diesel fuel, NB10 neem biodiesel, JB10 Jatropha biodiesel and NJB10 (mixed neem and Jatropha) biodiesel. The engine performance was studied at a constant speed of 1000 rpm following the procedures mentioned in the literature (Calder et al., 2018). After the engine reached its stabilized working condition, external restraining load torque (10 %) was fitted with a water brake dynamometer connected with a servo controller installed on the water load release to control engine load. The corresponding engine brake power was calculated using the equation 1, where torque is measured in N-m and engine speed in revolution per minute.

$$\text{Brake Power}(hp) = \frac{\text{Torque} \times \text{Engine Speed}}{5252} \quad (1)$$

2.7 Estimation of potential of biodiesel production to meet local requirement

The production of biodiesel from neem oil crop and waste cooking oil was calculated based on the marginal land available in the country to meet local diesel demand per annum.

Table 1. Fuel samples prepared blending ratios.

Sample	Mineral diesel (mL)	Neem biodiesel (mL)	Jatropha biodiesel (mL)
Diesel fuel	1000	-	-
NB10	900	100	-
JB10	900	-	100
NJB10	900	50	50

3 Results and Discussion

3.1 Biodiesel and glycerol yield

The measured quantity of biodiesel and glycerol produced from Jatropha curcas oil were found 90 % (36.28 g/ 40 g oil) and 11 % (4.36 g / 40 oil), respectively. While the quantity of biodiesel and glycerol produced from Neem oil were found 68 % (27.49 g/ 40 g oil) and 30 % (12.50 g / 40 oil), respectively.

Table 2. Engine specifications used in this study.

Engine make	Rotronics, France
No. of cylinders	2
Volume of cylinders	380 cc
Maximum speed	2700 rpm
Maximum power output	2.0 kW
Bore	62 mm
Stroke	72 mm
Type	4 stroke, direct injection, air cooled
Compression ratio	8.5:1

3.2 Physical and chemical properties of fuel

The Jatropha curcas and Neem biodiesel fuel properties were determined following the ASTM standards and procedures as summarized in Table 3 and then were compared with the international biodiesel standard (ASTM D 6751). It was interesting to note that kinematic viscosity of Neem biodiesel was found lower i.e. 2.91 mm^2/sec as compared to Jatropha biodiesel 4.18 mm^2/sec. The reduced kinematic viscosity is good in terms of biodiesel fuel quality, but the Neem biodiesel yield was 24.33% less in contrast to Jatropha biodiesel yield.

3.3 Methyl oleate content results

The methyl oleate concentration in % by weight was measured with GC-MS analysis and the results showed methyl oleate concentration in Jatropha oil (41.12% wt) and Neem oil (50.77% wt), respectively. The results showed Neem oil has value comparable to Jatropha oil, having more favorable property with longer biodiesel storage time with good oxidation stability and decreased cold filter plugging point during winters, keeping the biodiesel in liquid phase for proper atomization. Furthermore, it is recommended to measure the complete free fatty acids profile of both vegetable oil samples.

Table 3. Physicochemical properties of vegetable seed oils and its biodiesel produced.

Parameters	Jatropha Curcas	Neem (Azadirachta indica)	Test method	ASTM D 6751 Biodiesel standard
Density of oil (g/cm^3)	0.877	0.914	ASTM D1298	-
Kinematic viscosity of oil (mm^2 /sec) at 40°C	44.5	33.37	ASTM D 445	-
Biodiesel yield (g)	36.28	27.49	-	-
Density of biodiesel (g/cm^3)	0.884	0.875	ASTM D1298	0.86 – 0.90*
Kinematic viscosity of biodiesel (mm^2 /sec)	4.18	2.91	ASTM D445	1.9 – 6.0
Glycerine yield (g)	4.36	12.5	-	-
Calorific value of biodiesel (MJ/kg)	38.96	39.67	ASTM D240	-
Flash point (°C) of biodiesel	120	130	ASTM D93	130°C (minimum)

*According to European biodiesel standard EN 14214

3.4 Engine emissions test results

The gas emissions profile of different biodiesel fuel blends were plotted to compare the difference between their emission characteristics. Figure 1 shows the percentage of oxygen content present in the exhaust flue gas emissions and it was observed that the mineral diesel (17.12 ± 0.05%) has more oxygen content as compared to biodiesel blended fuel samples. The possible reason could be due to high temperature and high oxygen content present in biodiesel fuel, the excess oxygen present in biodiesel was used in the production of nitrogen oxides (NO_x). Generally excess oxygen does not react with nitrogen in the engine cylinder, but it reacts with atmospheric nitrogen at high exhaust temperatures (Nair et al., 2017). Similarly, the exhaust temperature profile of flue gas from the diesel engine operating on different fuel blends (see Figure 2) showed higher temperatures were obtained from biodiesel blend fuel combustion as compared to the diesel fuel. This is due to the presence of oxygenated property of biodiesel, with complete combustion, resulting in higher exhaust temperatures (i.e. 14% and 8.75% from neem and jatropoha blended biodiesel fuels higher than mineral diesel). A previous research study on palm biodiesel showed 5.6% higher exhaust gas temperature than petroleum diesel. The improved combustion characteristic of biodiesel with higher cylinder temperature is due to the effect of excess oxygen content present in its composition (Arunkumar et al., 2018).

Figure 3 depicts the emission of carbon monoxide (CO) from different fuel samples, showing less CO emissions from biodiesel blended fuels (such as NB10= 94 ± 2.15, JB10= 100 ± 2.44 and NJB10=121 ± 3.65 ppm) as compared to the mineral diesel (135 ± 2.18 ppm). As the previous literature, the main reason for higher CO emissions from mineral diesel combustion is due to its incomplete combustion (Nair et al., 2017). Therefore, the presence of higher percentage of oxygen in biodiesel leads to more complete combustion process resulting in lower emissions of CO (Dincer, 2008). In the results of carbon dioxide (CO_2) emissions were found higher from biodiesel blended fuel samples as compared to the mineral diesel fuel (see Figure 4). Neem biodiesel NB10 showed higher CO_2 emissions in contrast to Jatropha biodiesel JB10. The CO emissions were reduced for Neem biodiesel blend (NB10) by 30.37% volume as compared to mineral diesel. The CO emission value was found close with an average reduction for Neem B10 by 26% volume, as mentioned in literature (Nair et al., 2017).

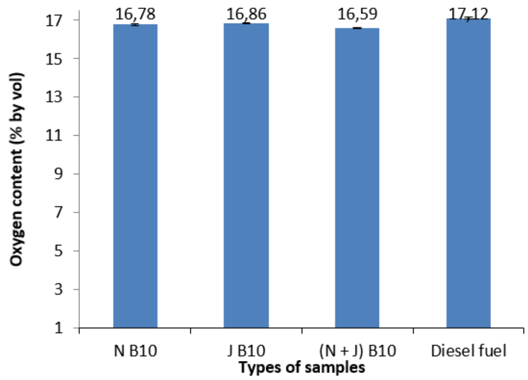

Figure 1. Oxygen content in exhaust emissions.

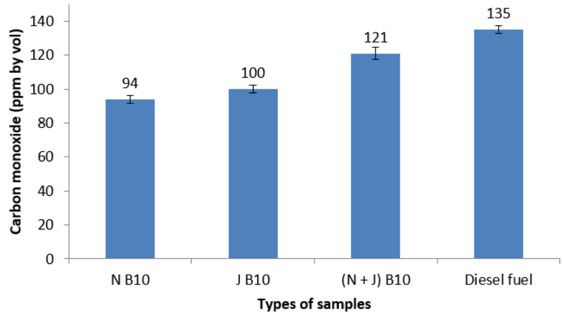

Figure 3. Carbon monoxide content in exhaust emissions.

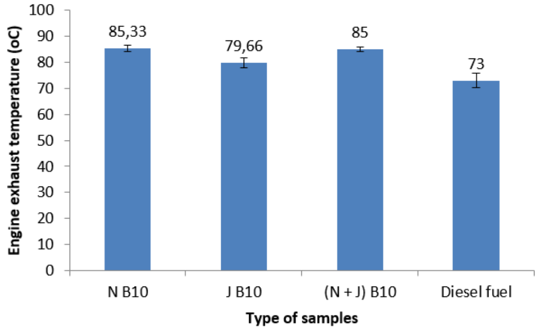

Figure 2. Exhaust temperatures with different fuel blends.

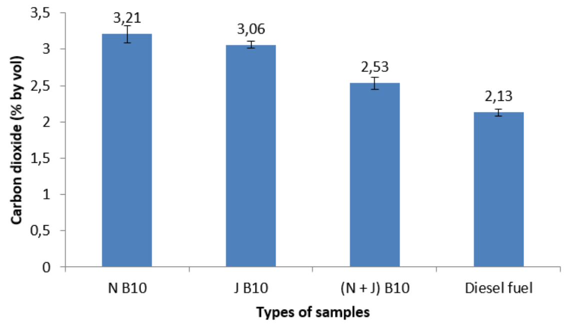

Figure 4. Carbon dioxide content in exhaust emissions.

Figure 5 shows the nitrogen dioxides (NO_x) emissions from the combustion of different blended fuel samples. It was observed that NO_x emissions were higher from biodiesel blended fuel samples as compared to mineral diesel (i.e. 37.5% from NB10 and 28.57% from JB10, respectively). It was also observed by the past research studies showing 20% increase in *NOx* emissions from neem B10 as compared to neat diesel fuel (Nair et al., 2017). Higher temperature results from combustion of biodiesel, produces NO_x with a reaction between excess percentage of oxygen content present in biodiesel blended fuel emissions and atmospheric nitrogen. The emissions of sulphur dioxide (SO_x) are presented in Figure 6, the results showed reduction of SO_x emissions by over 38.46% from NB10 and 34.61% from JB10, respectively as compared to mineral diesel. It is an advantage using biodiesel blended fuel, since low sulphur content for mitigation of air pollution causes global warming and acid rain issues.

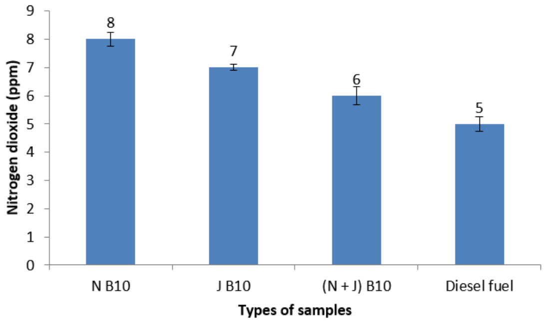

Figure 5. Nitrogen dioxide content in exhaust emissions.

3.5 Engine torque and brake power measurements

The variation of brake power of different blended fuel samples (mineral diesel, NB10, JB10 and NJB10) at a constant 1000 rpm engine speed is presented in Table 4. The results showed slightly less power generated from blended biodiesel fuel as compared to petroleum diesel, due to its lower calorific value (38 to 39 MJ/kg) in comparison to mineral diesel (42MJ/kg) and it is also endorsed by the literature (Chakrabarti and Ali, 2008). In addition, it was observed that engine torque and power generated by Neem biodiesel NB10 were higher compared with the Jatropha biodiesel JB10. It was due to higher calorific value of the Neem biodiesel (39.67 MJ/kg), in contrast to the Jatropha biodiesel (38.96 MJ/kg). The mineral diesel combustion produced higher torque during engine testing against different biodiesel blends due to its greater calorific value (42 MJ/kg) (Chakrabarti and Ali, 2008). The results indicated that B10 have closer engine performance to mineral diesel due to its kinematic viscosity comparable to mineral diesel (Chakrabarti and Ali, 2009). The power generated by Neem biodiesel NB10, Jatropha JB10 and mixed Neem / Jatropha biodiesel NJB 10 were found 7.7%, 16.4% and 12% lower compared to mineral diesel.

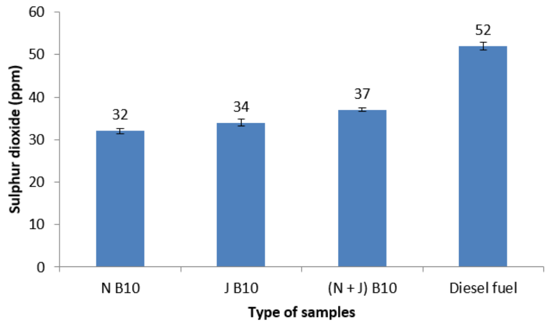

Figure 6. Sulphur dioxide content in exhaust emissions.

3.6 Estimation of production of biodiesel to meet local requirement

Neem (*Azadirachta indica*) seed contains approximately 20-35% by weight oil content and it produces about 2670 kg of oil/ hectare (Aransiola et al., 2019). According to the literature, Pakistan has arid/ semi-arid and marginal land approximately 350,000 acres (141640 hectares) that can be used to grow non-edible crops for biodiesel production (Ali, 2016). Table 5, shows the production of neem oil in the country is 378178.8 kgs per annum (i.e. 0.3781 million tonnes) obtained by multiplying 2670 kg of oil /hectare with the marginal land area 350,000 hectares. It is assumed that 90% by weight of neem oil produced per annum is converted into biodiesel, it comes to 0.3402 million tons, while 10% by weight is converted into its by-product glycerine (i.e. 0.0378 million tons). Moreover, according to the previous literature (Qamar et al., 2020) Pakistan has a capacity of producing 468,842 tonnes (0.4688 million tonnes) of biodiesel annually using waste cooking oil (WCO).

Table 4. Showing engine torque and its corresponding brake power at a constant speed (1000 rpm).

Samples	Engine Torque (N-m)	Engine Brake power (hp)
Diesel fuel	2.854	0.543
NB10	2.634	0.501
JB10	2.387	0.454
NJB10	2.514	0.478

Table 5. Estimation of local production of biodiesel per year.

Statistics of local production per year		
(1)	Demand of petro-diesel per year (million tons)	6.764
(2)	Demand of blended biodiesel (B10) per year (million tons)	0.6764
(3)	Neem oil production per year (million tons)	0.3781
(4)	Estimated Neem biodiesel production per year (million tons)	0.3402
(5)	Estimated WCO biodiesel production per year (million tons)	0.4688
(6)	Quantity of biodiesel (B10) production per year (million tons)	0.1326

The total demand of high speed diesel in the country per annum is 6.674 million tonnes (DAWN, 2019) and if blended biodiesel (B10) is used in the country, the quantity of biodiesel required will be 0.6764 million tons per year to comply with AEDB requirement of using B10 blended biodiesel. To meet the required quantity of biodiesel, the difference between column (2) minus the estimated quantities of neem biodiesel (column 4) and waste cooking oil biodiesel (column 5) gives a surplus quantity of biodiesel production that meets consumers demand (0.1326 million tons) in the country per year, without competing with the vegetable cooking oils obtained from edible seed crops.

4 Conclusions

The indigenous Jatropha and Neem vegetable seed oils can be converted into biodiesel, and then blended biodiesel (B10) can be used as an alternative fuel in diesel engines to meet the target set by Alternative Energy Development Board. The emission of carbon monoxide (CO) from different fuel samples showed less CO emissions from biodiesel blended fuels.

The amount of CO_2 concentration showed increasing trend in exhaust emissions with respect to increasing biodiesel quantity in the fuel mixture, converting more CO into CO_2. NO_x emissions were found higher with increasing ratio of biodiesel fuel with mineral diesel. Results indicated that B10 have closer engine performance with mineral diesel, this is mainly due to their comparable kinematic viscosities. Less engine power being generated was observed by neem biodiesel NB10, Jatropha JB10 and mixed neem / Jatropha biodiesel NJB10 i.e. 7.7%, 16.4% and 12%, respectively as compared to the mineral diesel.

The estimated production of biodiesel in the country from Neem seed oil crops and waste cooking oil is was found producing a surplus quantity of biodiesel (0.1326 million tons per year) to meet local demand of using B10 fuel in the future.

Acknowledgments

The authors are thankful to the NED University of Engineering and Technology, Karachi, Pakistan for providing laboratory facilities. Furthermore, special gratitude to Arid Zone Research Institute (Pakistan Agricultural Research Council, Umerkot, Pakistan) for providing the Jatropha curcas vegetable seed oil for experimental work. The authors are also grateful to the Institute of Chemical Engineering Technology, University of the Punjab, Lahore, Pakistan for GC-MS analysis of vegetable seed oils.

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