# Performance Testing on Diesel Engine Using Diesel & Biodiesel.

Shipra Rajvansh, Tejas Jain, Pankil Jain, Uma Kale

Abstract— Growing concern regarding energy resources and the environment has increased interest in the study of alternative sources of energy. To meet increasing energy requirements, there has been growing interest in alternative fuels like biodiesel to provide a suitable diesel oil substitute for internal combustion engines. It is a promising substitute as an alternative fuel and has gained significant attention due to the predicted shortness of conventional fuels and environmental concern. The utilization of liquid fuels such as biodiesel produced from non-edible seeds like Jatropha & Karanja by transesterification process represents one of the most promising options for the use of conventional fossil fuels .In this study biodiesel has been produced by the well known transesterification process This paper also investigated the performance and emission characteristics of dual biodiesel blends (mixture of Jatropha biodiesel and karanja biodiesel) with diesel on a stationary double cylinder, four stroke direct injection compression ignition engine.

**Index Terms**— biodiesel, blends, emissions, feed stocks, IC engines, Jatropha, Karanja, transesterification

## 1 Introduction

India homes to 1.2 billion people which are about 17% of world population, and its thirst for energy is unquenchable. One harsh result of its meteoric growth is the widening gap between the energy produced and energy required by the country. On an average India produces about 826,000 barrels of oil per day and requires about 3,319,000 barrels of oil per day (statistical review of world energy, 2011) [1]

The World Energy Forum has predicted that world oil reserves will be depleted in less than another 10 decades. Other believes that if consumed at an increasing rate of 3% per annum it will be depleted in fewer than 45 years. [2]

In the year 2010 India imported about 75% of its need for oil at a rate of 27 billion U.S. Dollar (121,500 crore) and the demand for diesel in India is about 5 times more than gasoline. One of the reasons for this could be, diesel engine has greater efficiency, durability, and good fuel economy compared to gasoline engines. The wide uses of diesel engines lead to increase the requirement for diesel derived from fossil fuel. Due to the depletion of fossil fuels and to solve both energy concern and environmental concern, the renewable energies with lower environmental pollution impact should be necessary. Biodiesel is one such and in fact the most promising alternative fuels for diesel engines.


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Table 1 - The percentage import and import value of gasoline and diesel in India.

| YEAR | %IMPORT | IMPORT VALUE | |
|---|---|---|---|
| | | CRORE | U.S.D (BILLION) |
| 1971 | 63 | 107 | 0.024 |
| 1981 | 91 | 3349 | 0.744 |
| 1991 | 39 | 6118 | 1.360 |
| 2001 | 64 | 30,695 | 6.821 |
| 2005 | 73 | 81,000 | 18 |
| 2010 | 75 | 121,500 | 27 |

## 2 What is Biodiesel?

*The ASTM D6751* states the definition of biodiesel as, *"The mono alkyl esters of long fatty acids derived from renewable lipid feedstock such as vegetable oils or animal fats, for use in compression ignition (diesel) engines."*[3]

"Biodiesel" — diesel fuel made from animal or vegetable materials — is an alternative fuel that has been used in motor vehicles since the beginnings of the automobile industry. It can be substituted for petroleum-based diesel fuel ("Petrodiesel") in diesel engines. [4]

The term "biodiesel" itself is often misrepresented and misused. Biodiesel only refers to 100% pure fuel (B100) that meets the definition above and specific standards given by the American Society of Testing and Materials (ASTM) International (D 6751) However, it is often used to describe blends of biodiesel with petroleum diesel. Such blends are generally referred to as "B2," "B5," "B20," etc., where the number indicates the percent of biodiesel used.

Most biodiesel used today is B20 which is 20% biodiesel and 80% is diesel. [5]

## 3 Benefits

### 3.1 Handling & Transportation:

Biodiesel is safe to handle and transport because it is as biodegradable as sugar, ten times less toxic than table salt, and

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burns at a relatively high temperature. It actually degrades about four times faster than petroleum-based diesel fuel when accidentally released into the environment. [6]

### 3.2 Emissions Benefits from Using Biodiesel:

The production and use of biodiesel creates 78% less carbon dioxide emissions than conventional diesel fuel. Carbon dioxide is a greenhouse gas that contributes to global warming. Burning biodiesel fuel also effectively eliminates sulfur oxide and sulfate emissions, which are major contributors to acid rain. That's because, unlike petroleum-based diesel fuel, biodiesel is free of sulfur impurities. Combustion of biodiesel additionally provides a 56% reduction in hydrocarbon emissions and yields significant reductions in carbon monoxide and soot particles compared to petroleum based diesel fuel. Also, biodiesel can reduce the carcinogenic properties of diesel fuel by 94%. [6]

### 3.3 Biodiesel Improves Engine Operation:

It lubricates better than petroleum-based diesel fuel and has excellent solvent properties. Even in very low concentrations, biodiesel improves fuel lubricity and raises the cetane number of the fuel. Diesel engines depend on the lubricity of the fuel to keep moving parts, especially fuel pumps, from wearing prematurely. Tests have shown that blending biodiesel with petroleum-based diesel fuel at just a 1% level could increase the lubricity of diesel fuel by up to 65%. Biodiesel is also being considered as a replacement for some petroleum-based lubricants. The hydrotreating processes used to reduce fuel sulfur and aromatics contents also reduces polar impurities such as nitrogen compounds, which provide lubricity. [6] [7]

### 3.4 Biodiesel Provides a High Energy Return and Displaces Imported Petroleum:

Life-cycle analyses show that biodiesel contains 2.5 to 3.5 units of energy for every unit of fossil energy input in its production, and because very little petroleum is used in its production, its use displaces petroleum at nearly a 1-to-1 ratio on a life-cycle basis. This value includes energy used in diesel farm equipment and transportation equipment (trucks, locomotives); fossil fuels used to produce fertilizers, pesticides, steam, and electricity; and methanol used in the manufacturing process. Because biodiesel is an energy-efficient fuel, it can extend petroleum supplies. [7]

### 3.5 Biodiesel Is Easy To Use:

One of the great advantages of biodiesel is that it can be used in existing engines, vehicles and infrastructure with practically no changes. No vehicle modifications or special fueling equipment — just pump and go. [8]

### 3.6 Power, Performance and Economy:

Proven performance and economy make biodiesel a renewable winner. Just like petroleum diesel fuel, biodiesel can gel in cold weather. The best way to use biodiesel during the colder months is to blend it with winterized diesel fuel. [8]

## 4 Selection of Feed stocks

A variety of feed stocks are available for biodiesel production such as vegetable oils, animal fats, waste cooking oil, algae, oil from halophytes, sewage sludge, etc, but more than 95% of the biodiesel production comes from edible vegetable oils. However, due to the problems like competition in the edible oil markets, increased deforestation, high content of saturated fatty acids in animal fats and undesired impurities in used cooking oil (UCO), lately the research is being more focused on production of biodiesel from non-edible feed stocks.[9]
Such as:

- Camelina
- Castor beans
- Field Pennycress
- Jathropa
- Jojoba
- Karanja

### 4.1 Jatropha curcus:

Fig. 1 Seeds of Jatropha corcus linn.



In 2007, Goldman Sachs cited Jatropha curcas as one of the best candidates for future biodiesel production.[10]
Jatropha curcus is a drought-resistant perennial, growing well in marginal/poor soil. It is easy to establish, grows relatively quickly and lives, producing seeds for 50 years. Jatropha the wonder plant produces seeds with an oil content of 30%. The oil can be combusted as fuel without being refined. It burns with clear smoke-free flame, tested successfully as fuel for simple diesel engine. The by-products like press cake a good organic fertilizer, oil contains also insecticidal property. It is found to be growing in many parts of the country, rugged in nature and can survive with minimum inputs and easy to propagate. [11]

### 4.2 Karanja (Pongamia Pinnata):

Fig. 2 Seeds of Karanja

Pongamia pinnata is a species of family Leguminasae, native in tropical & temperate Asia including part of India, China, Japan, Malaysia and Australia. [12] Commonly it is called as karanja ( in M.S.) , pong am ( in Gujarat) , dalkaramch ( in Tamilnadu). Karanja is drought resistant, semi-deciduous, nitrogen fixing leguminous tree. It grows about 15-20 meters in height with a large canopy which spreads equally wide. The leaves are soft, shiny burgundy in early summer & mature to a glossy, deep green as the season progresses. Flowering starts in general after 4-5 years. Cropping of pods & single almond sized seeds can occur by 4-6 years & yields 9-90 kg's of seed. The yield potential per hectare is 900 to 9000 Kg/Hectare. As per statics available pongamia oil has got a potential of 135000 million tones per annum and only 6% is being utilized. The tree is well suited to intense heat & sunlight & its dense network of lateral roots & its thick long tap roots make it drought tolerant. [13]

## 5 Production Process

Different methods used for production of Biodiesel:

1. Transesterification (alcoholysis)
2. Micro emulsions
3. Pyrolysis

The Process adopted for this study is Transesterification.

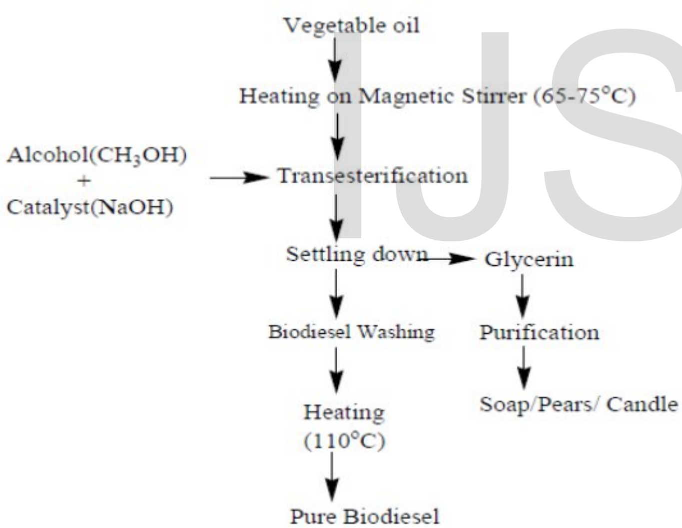


Fig. 3 Flow chart of Biodiesel production process[14]



### 5.1 Transesterification Method:

Animal and plant fats and oils are composed of triglycerides, which are esters formed by the reactions of three free fatty acids and the trihydric alcohol, glycerol. In the transesterification process, the added alcohol (commonly, methanol or ethanol) is deprotonated with a base to make it a stronger nucleophile. As can be seen, the reaction has no other inputs than the triglyceride and the alcohol. Under normal conditions, this reaction will proceed either exceedingly slowly or not at all, so heat, as well as catalysts (acid and/or base) are used to speed the reaction. It is important to note that the acid or base are not consumed by the transesterification reaction, thus they are not reactants, but catalysts.

Almost all biodiesel is produced from virgin vegetable oils using the base-catalyzed technique as it is the most economical process for treating virgin vegetable oils, requiring only low temperatures and pressures and producing over 98% conversion yield (provided the starting oil is low in moisture and free fatty acids). However, biodiesel produced from other sources or by other methods may require acid catalysis, which is much slower. [15]

Triglycerides (1) are reacted with an alcohol such as ethanol (2) to give glycerol (3) and ethyl esters of fatty acids i.e. Biodiesel (4). The alcohol reacts with the fatty acids to form the mono-alkyl ester (biodiesel) and crude glycerol.

$CH_2OCOR'''$ | $CH_2OCOR''$ | $CH_2OCOR'$ + 3ROH --Catalyst--> $CH_2OH$ | $CH_2OH$ | $CH_2OH$ + R'''COOR + R''COOR + R'COOR

(1) Oil or Fat + (2) Alcohol → (3) Glycerin + (4) Biodiesel

Transesterification Reaction

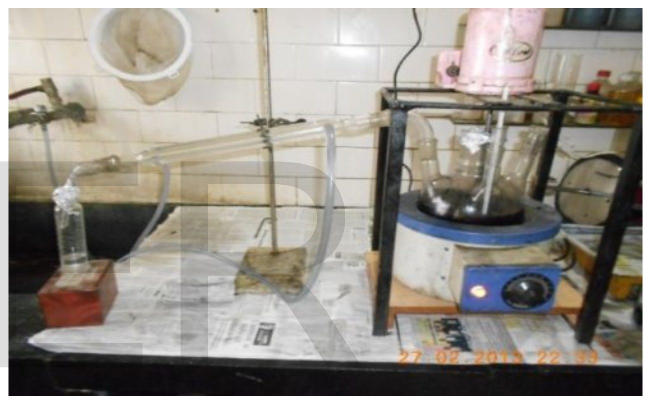

Fig. 4 Batch Process For Transesterification

Fig. 5 Jatropha Methyl Ester

The base catalyzed production of biodiesel generally occurs using the following steps:

1) Mixing of alcohol and catalyst.
2) Separation.

3) Alcohol Removal.
4) Glycerin Neutralization
5) Methyl Ester Wash.
6) Drying
7) Preparations of blends of Biodiesel.

## 6 Results

Experimental investigation were carried out for performance and exhaust emission of the engine for blends of diesel and methyl ester of karanja and Jatropha oil in various proportions as fuel and are compared with mineral diesel. The diesel engine ran well on all the fuel samples mentioned above. There were no faults happening during the whole experiment process. The test results obtained from the comprehensive experimental investigations are analyzed and described below.

### 6.1 Engine Performance and Emission parameters of Blends:

### 6.1.1 Brake Thermal Efficiency:

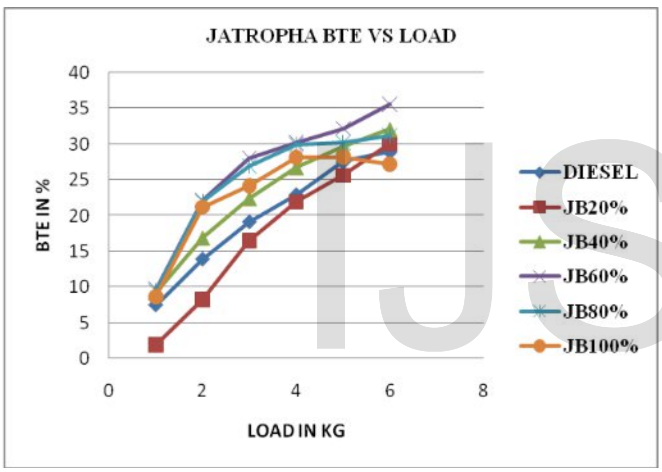


Fig. 6 JATROPHA BTE VS LOAD

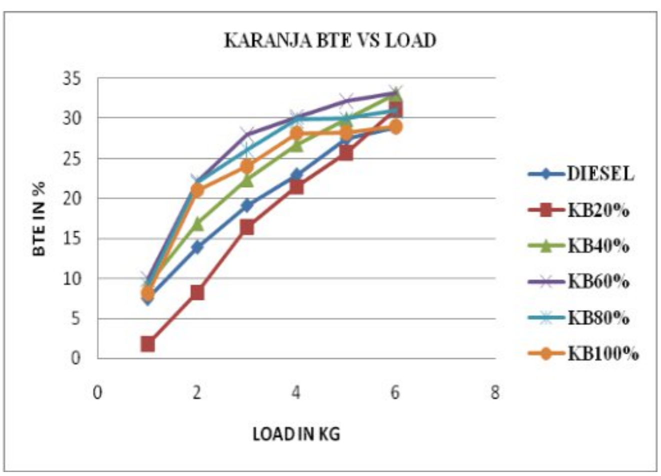


Fig. 7 KARANJA BTE VS LOAD

- As compared to that of the diesel, most of the blends of jatropha as well as karanja gives more brake thermal efficiency.
- Among the blends, the brake thermal efficiency goes on increasing as the percentage of biodiesel increases.
- From the observation, we come to know that the blend B20% of Jatropha and Karanja gives the highest brake thermal efficiency among the tested fuels. Hence that can be used in accordance with the brake thermal efficiency.

### 6.1.2 Brake Specific Fuel Consumption:

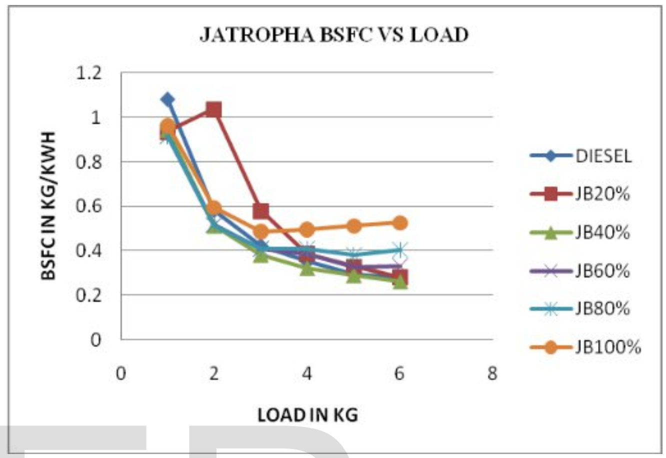


Fig. 8 JATROPHA BSFC VS LOAD

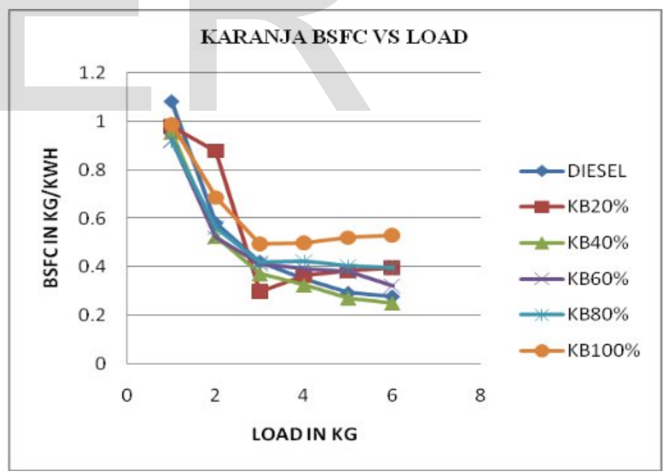


Fig. 9 KARANJA BSFC VS LOAD

- As compared to that of the diesel, most of the blends of jatropha as well as karanja have less BSFC.
- In case of the Jatropha blend and Karanja blend, BSFC decreases as the percentage of biodiesel in the fuel increases.
- Among all the analyzed blends including the diesel, the blend B40% of Jatropha and Karanja serves the best option in terms of BSFC as it has the lowest BSFC (As seen from the readings).

### 6.1.2 Volumetric Efficiency:

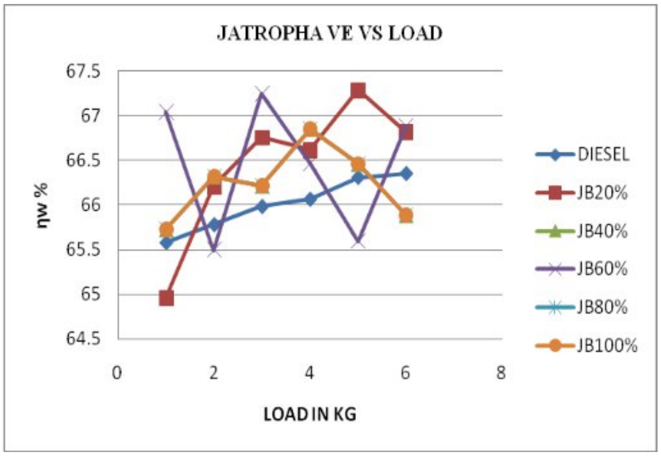


Fig. 10 JATROPHA VE VS LOAD

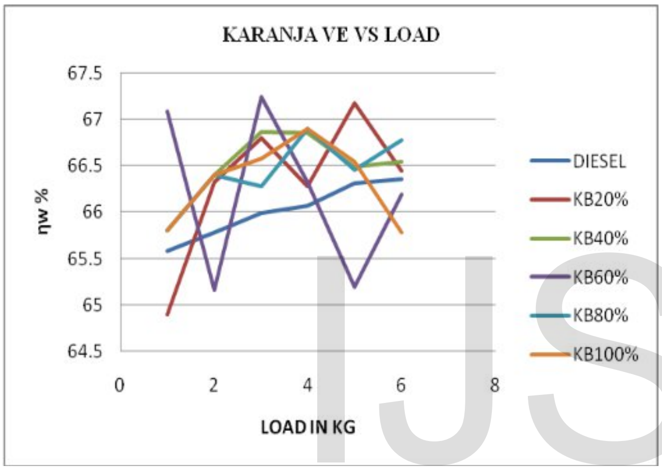


Fig. 11 KARANJA VE VS LOAD

- Volumetric efficiency is much higher in case of all the three blends as compared to that of diesel alone.
- From graphs it is clear that as the percentage of bio fuel increases in the blend the volumetric efficiency increase

### 6.1.4 Brake Power:

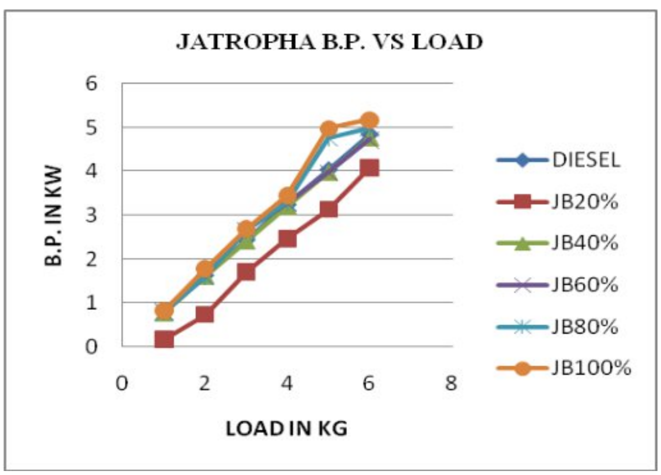


Fig. 12 JATROPHA B.P. VS LOAD

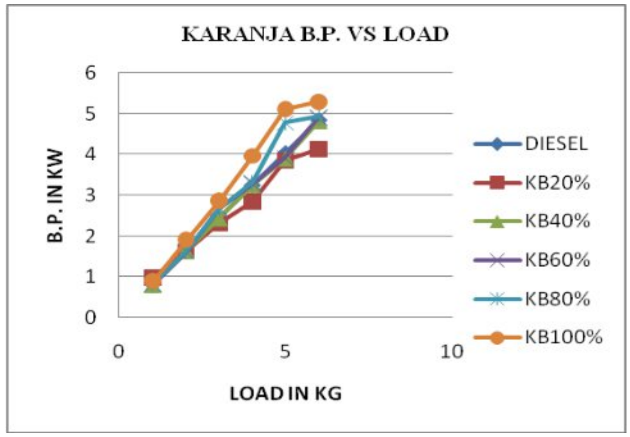


Fig. 13 KARANJA B.P. VS LOAD

- From the above graph we can conclude that brake power of engine is not affect by bio fuels and is almost similar in nature to that of Diesel.

### 6.1.6 Emissions –

#### 6.1.6.1- Carbon Monoxide (CO) Emission-

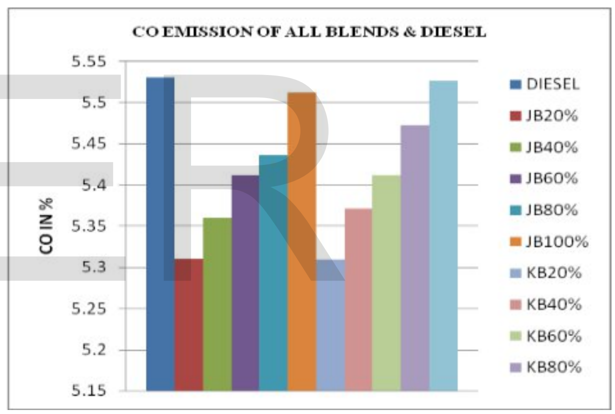


Fig. 14 CO % EMISSIONS OF ALL BLENDS AND DIESEL

#### 6.1.6.2. Carbon Dioxide ($CO_2$) -

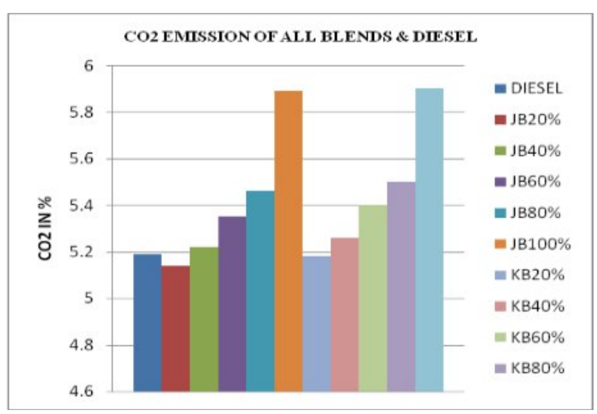


Fig. 15 $CO_2$ % EMISSIONS OF ALL BLENDS & DIESEL

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**Nitrogen Oxide ($NO_x$):**

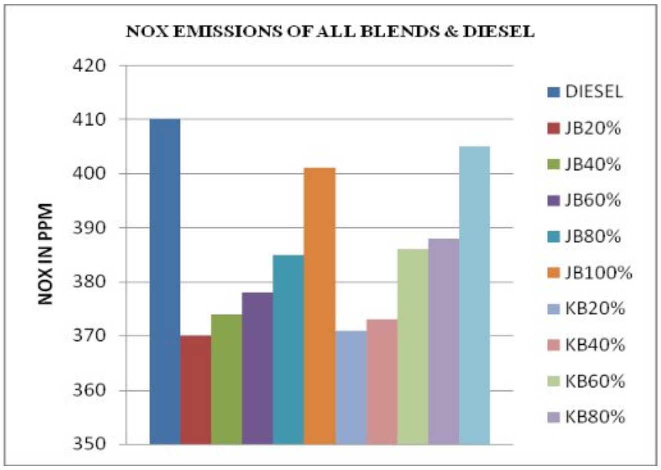


Fig. 16 NOx EMISSIONS OF ALL BLENDS AND DIESEL

- Compared to that of diesel, most of the blends of jatropha and karanja biodiesel emits lesser NOx.
- Among the blends, the Jatropha blend emits out least NOx compared to karanja biodiesel blends. And the concentration of emissions increases with increase in percentage of bio fuel. Hence we can say that the neither the fuel should fully comprise of diesel nor it should comprise larger amounts of biodiesel.
- According to the observations made, a B20% blend of both the biodiesel will be a good solution for solving the problem of NOx emission. Both the biodiesel B20 serves the best option in accordance with the emission of NO.

## 7 Conclusion

From the readings obtained from the experimentation, we can conclude that Jatropha and Karanja as feedstock gives significant results when compared to diesel with respect to Brake thermal efficiency, Brake specific fuel consumption, Volumetric efficiency, Brake power, Lubricity, Emmisions. Major production centers on the level of modern petroleum refineries have not been developed. The economics of biodiesel fuels compared to traditional petroleum resources are marginal; public policy needs to be revised to encourage development. Increased Jatropha oil production would be required. To meet the challenges of excessive import, we have to strengthen our oilseed sector and lay special emphasis on harnessing the existing and augmenting future potential source of green fuel. The organized plantation and systematic collection of Jatropha & Karanja oil, being potential bio-diesel substitutes will reduce the import burden of crude petroleum substantially. The emphasis should be made to invest in agriculture sector for exploitation of existing potential. There is also need to augment the future potential by investing largely on compact organized plantation of Jatropha & Karanja on the available wastelands of the country. This will enable our country to become independent in the fuel sector by promoting and adopting bio-fuel as an alternative to petroleum fuels. It is evident that there are new work opportunities in biodiesel production related sectors, and the industry can be grown in a manner that favors many prosperous independent farmers and farming communities.

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