Synopsis for the midterm evaluation of the projects sponsored under the 46th series of the Student Project Programme (SPP)

Project Reference Number	: 46S_BE_4713
Title of the project	: Synthesis and Testing of Sustainable Biodiesel through Mixed Oil Transesterification of Waste cooking oil, *Pongamia pinnata* Oil and *Ricinus communies* Oil
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Abstract

The work deals with synthesis and testing of composite biodiesel obtained from the mixed oil transesterification of waste cooking, pongamia, castor oils. Biodiesel samples are prepared from waste cooking oil, pongamia oil, castor oil and from separate blends of waste cooking oils with pongamia and castor oil, respectively WBD, PBD, CBD, WPBD and WCBD. Characterization is done on prepared biodiesel samples to determine their density, calorific value and kinematic viscosity. The performance and emission characteristics of the B30 samples of the prepared biodiesel is evaluated in single cylinder four stroke diesel engine. The WPBD biodiesel obtained through mixed transesterification is found to have superior properties compare to other biodiesel samples. WPBD exhibited similar performance with reduced carbon monoxide, carbon dioxide and NOx emissions when compared with the conventional diesel. The economic, environmental and sustainable attributes of biodiesel is spread to public through demonstration of biodiesel in different vehicles and by creating public awareness.

1. Introduction

Owing to downsides of fossil fuels like price escalation, greenhouse gas emission and depletion of reserves invoked researched more towards alternate energy sources like biofuel, biodiesel is considered as one of the economical options among the biofuels due to the modest price, biodegradability, and lower emission characteristics with comparable performance to that of conventional diesel. However, one of the major bottlenecks in the satisfying the steady and sustainable demand of biodiesel is the ample availability of feedstock. Even though, non-edible oil seeds are potential feedstock for biodiesel production, their availability depends on season, thus, it is not practical to establish a sustainable availability of diesel using a single feedstock. This leads to the concept of production of biodiesel using mixed oil feedstock. Waste cooking oil is a potential non edible raw material that to be economically converted to energy, there by solving the issue associated waste cooking oil disposal and reuse. Biodiesels offer a number of advantages over fossil fuels since they are non-toxic, biodegradable and environmental-friendly. Moreover, biodiesel have high flash points and they can be blended with diesel fuels because of their similar properties [5]. Biodiesel can be produced from different vegetable oils animal fats and waste cooking oil. From the review, it is observed that analysis of mixed transesterification with the waste cooking oil and pongamia oil combination and waste cooking oil, castor oil combination is not reported so far. The present work mainly deals with the preparation, characterization, performance and emission analysis of biodiesel prepared through mixed transesterification of waste cooking oil and pongamia oil and waste cooking oil and castor oil combination

2. Objectives:

The main objectives of the work are as follows:

- Determination of free fatty acid (FFA) of waste cooking oil and non-edible oil blends at various proportions.
- Transesterification of mixed oil consisting of waste cooking oil and non-edible oils.
- Characterization of biodiesels obtained from mixed oil transesterification.
- Determination of the performance and emission characteristics of mixed oil biodiesel – diesel blends and comparison of the same with that obtained from individual biodiesel blends.
- To create public awareness on biofuel by conducting talk and demonstration of prepared biodiesel in vehicles.

3. Methodology

The methodology for the preparation and testing of biodiesel through mixed oil transesterification is as follows:

- **Transesterification to produce mixed oil biodiesel**

Waste cooking oil is collected from local hotels and restaurants and is to remove food particles. Non-edible oil seeds such as pongamia and castor is collected from nearby villages and dried properly to extract oil. The extracted oil is left over night to settle the suspended particles before filtration. The filtered oil is stored in air tight containers. Composite dual oil blends are prepared by mixing waste cooking oil separately with pongamia oil and castor oil in different proportions. Free fatty acid is determined for various proportions of waste cooking oil-pongamia oil blends (WPO) and waste cooking oil-castor oil blends (WCO). FFA is determined by titrating the oil blends against NaOH solution using phenolphthalein indicator. Transesterification of individual oils and composite oil blends to prepare biodiesel. One liter of composite oil sample is mixed with calculated amount of alcohol and catalyst. The mixture is heated in a three neck flask at 65 °C for two hours with constant mixing. After two hours, the triglyceride in the oil is converted to biodiesel and glycerol by reacting with alcohol in presence of catalyst through transesterification reaction. Heating is stopped and the mixture is allowed to settle for 12 hours. After 12 hours, biodiesel is separated from the glycerol produced using a separating funnel. The biodiesel obtained from waste cooking oil and pongamia oil blend is represented as WPBD and that obtained from waste cooking oil and castor oil blend is represented as WCBD. The different stages of biodiesel preparation are shown in Fig.1-6.

- **Characterization and Performance evaluation**

Characterization tests are performed on biodiesel prepared from individual oils and composite oil blends to determine important properties such as density, viscosity, caloric value, flash point and fire point. The characterization test of the biodiesel samples is performed at bioenergy research and quality assurance laboratory, GKVK, Bengaluru. The performance and emission test of the biodiesel samples are conducted in IC engine research laboratory, NITK, Surathkal. The biodiesels are blended with diesel to form B30 samples and their performance and emission is tested in a Kirloskar TV1 single cylinder four stroke diesel engine. Brake thermal efficiency and specific fuel consumption of individual biodiesel and mixed oil biodiesels (WPB and WCB) are used to express the performance characteristics. Whereas, the emission characteristics of the biodiesel blends are evaluated by determining carbon monoxide, carbon dioxide, NOx and hydrocarbon in the engine exhaust. Properties, performance and emission of different biodiesel blends are compared to identify their individual characteristics. The diesel engine and its specification are given in Figure 7 and Table 1 respectively.

Fig 1. Titration

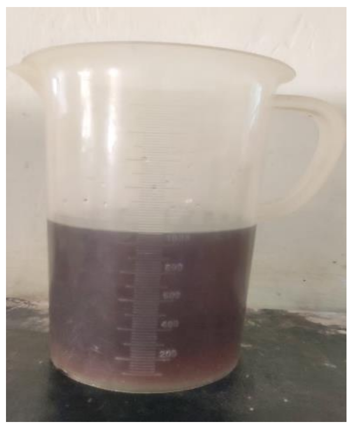

Fig.2 Mixed oil

Fig.3 Transesterification

Fig.4 Biodiesel and glycerol

Fig.5 Biodiesel washing

Fig.6 Biodiesel samples

Fig.7 Engine

Table 1 Engine specification

Sl	Engine specification	Values
1	BP	5.2 kW
2	No. of cylinder	1
3	Stroke	4
4	Dynamometer	Eddy current
5	Governor	Centrifugal type

In addition to this, demonstration of the prepared biodiesel on public vehicles and a public awareness on the benefits and application of biodiesel are performed as a part of the project.

4. Results and Conclusions

The findings obtained from free fatty acid test, transesterification, characterization and performance and emission tests are discussed here.

4.1 Free Fatty Acid test

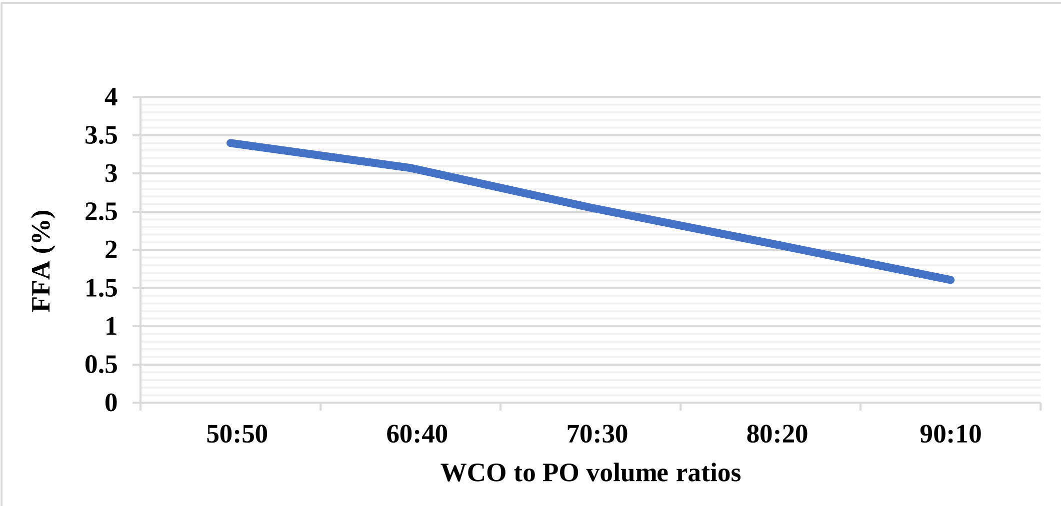

Fig.8 Variation of FFA with different WCO to PO blend ratios

In the Fig.8 variation of FFA with different WCO to PO blend ratios were plotted to find the FFA value of equal or below to 2. From figure it is observed that FFA value of WCO to PO blend ratio with 80:20 shows the value within 2%.

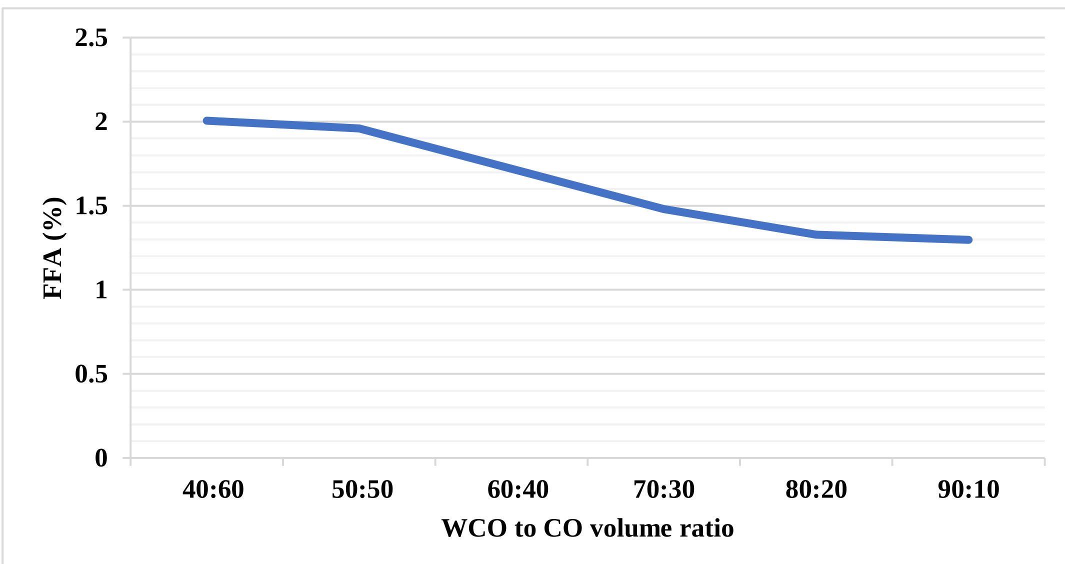

Fig.9 Variation of FFA with different WCO to CO blend ratios

In the Fig.9 variation of FFA with different WCO to CO blend ratios were plotted to find the FFA value of equal or below to 2. From figure it is observed that FFA value of WCO to CO blend ratio with 40:60 shows the value within 2%.

4.2 Characterization Test

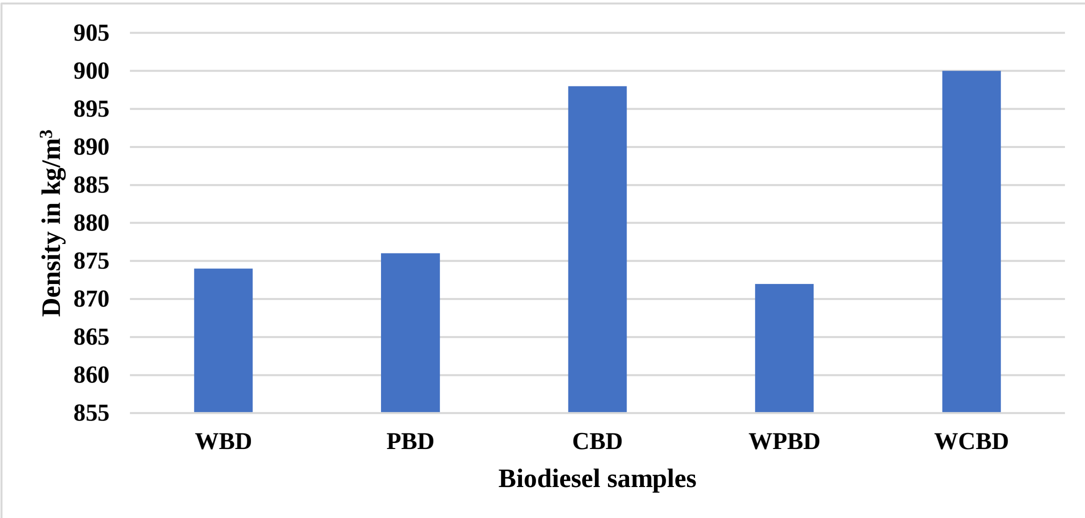

Fig.10 Density of various biodiesels

The density of different biodiesel samples is shown in Fig.10. The density of biodiesel from mixed oil transesterification of waste cooking and pongamia oil is found to be greater than that compared to biodiesel obtained from waste cooking oil and pongamia oil separately. The density of biodiesels derived from castor oil is found to be higher to others.

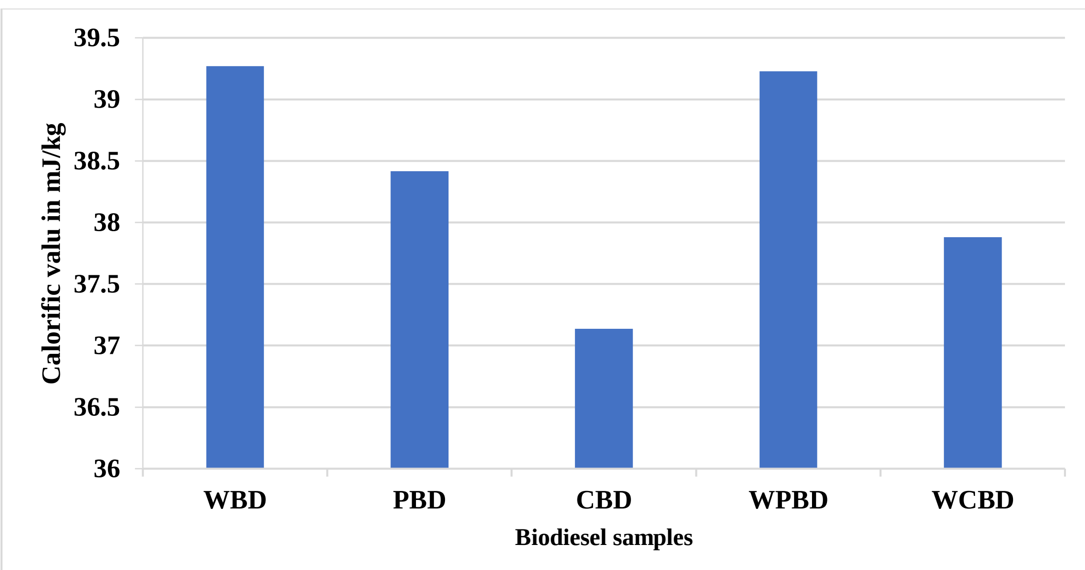

Fig.11 Calorific value of various biodiesels

The calorific value of different biodiesel samples is shown in Fig.11. The calorific value of biodiesel obtained from the mixed transesterification of waste cooking and pongamia oil and that from waste cooking oil is found to be more compared to other biodiesel samples.

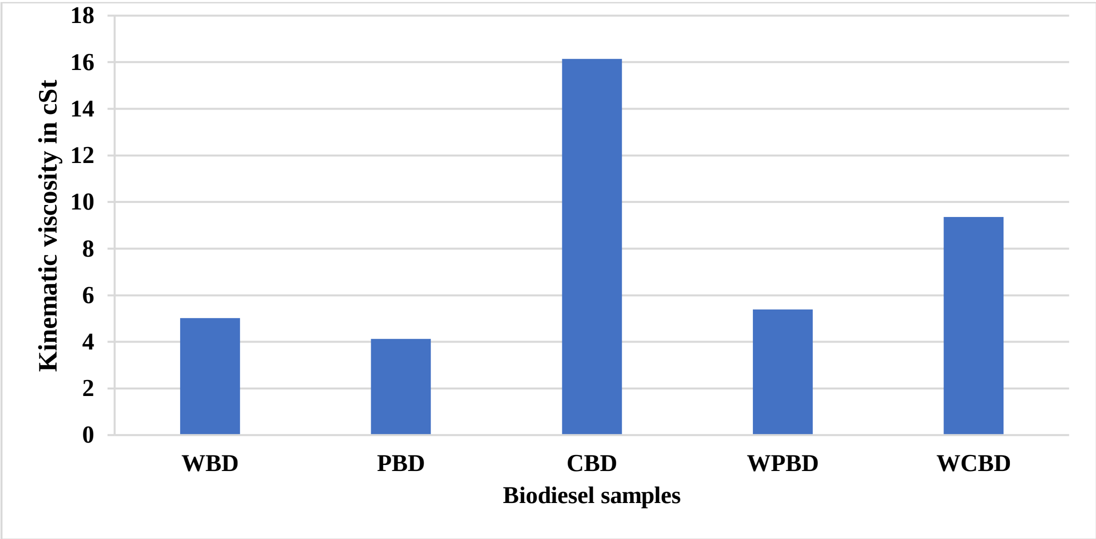

Fig.12 Kinematic viscosity of biodiesel samples

The density of different biodiesel samples is shown in Fig.12. The kinematic viscosity of biodiesel obtained from the mixed transesterification of waste cooking and pongamia oil is comparable with that from waste cooking oil and pongamia oil.

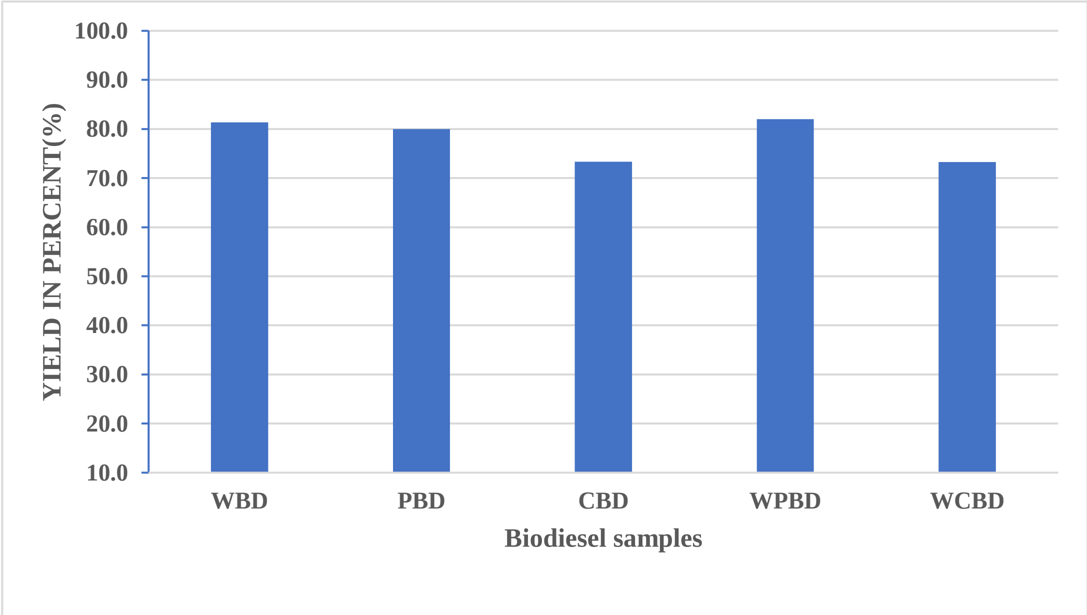

Fig.13 Yield of various biodiesels

The yield of different biodiesel samples is shown in Fig.13. The yield of biodiesel obtained from the mixed transesterification of waste cooking and pongamia oil is found to be highest when compared with the other biodiesel samples.

From the characterization it is found that biodiesel obtained from the mixed transesterification of waste cooking and pongamia oil has better density, viscosity, calorific value and yield compared to the biodiesel obtained separately from waste cooking oil and pongamia oil. The waste cooking and pongamia oil biodiesel has the highest calorific value of 39.228 MJ/kg and highest yield of 82%. Thus, from the characterization of biodiesel samples we can conclude that biodiesel obtained from the mixed transesterification of waste cooking and pongamia oil is superior compare to biodiesel obtained from waste cooking oil, pongamia oil, castor oil and waste cooking and castor oil biodiesel.

4.3 Performance and Emission of different biodiesel blends

The performance and emission characteristics of diesel and different biodiesel-diesel blends are discussed in the session.

4.3.1 Performance characteristics

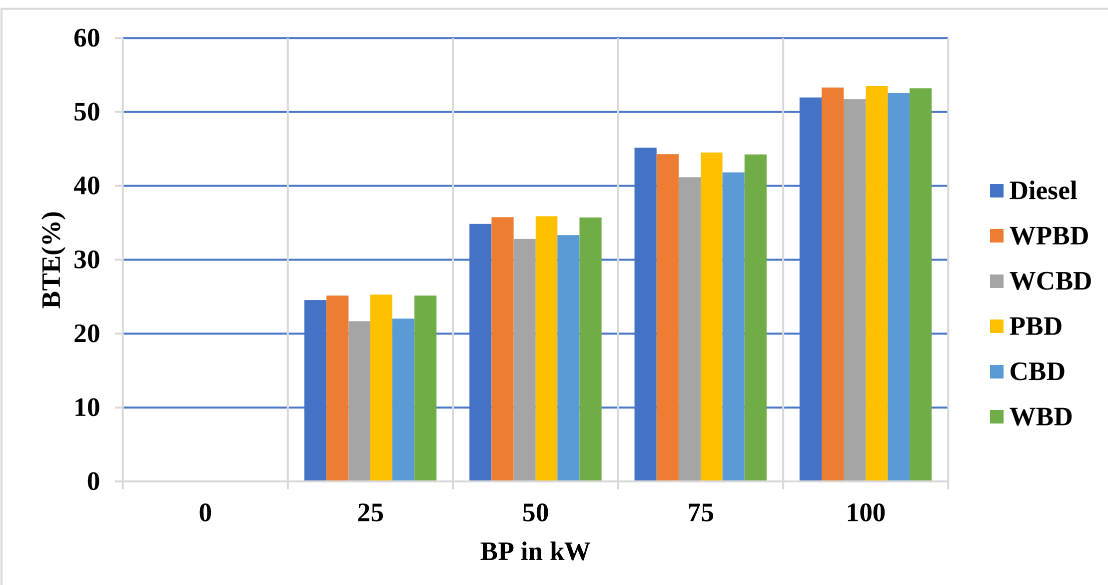

Fig.14 Variation of nitrogen oxides emission with BP for different biodiesel blends

The variation of brake thermal efficiency for different biodiesel blends with engine load is shown in Fig.14. From the figure it is observed that the Brake thermal efficiency of WPBD is comparable with diesel in all loads. The brake thermal efficiency decreases in the order as PBD, WBD, CBD & WCBD. The CBD & WCBD have lower BTE due to its high kinematic viscosity.

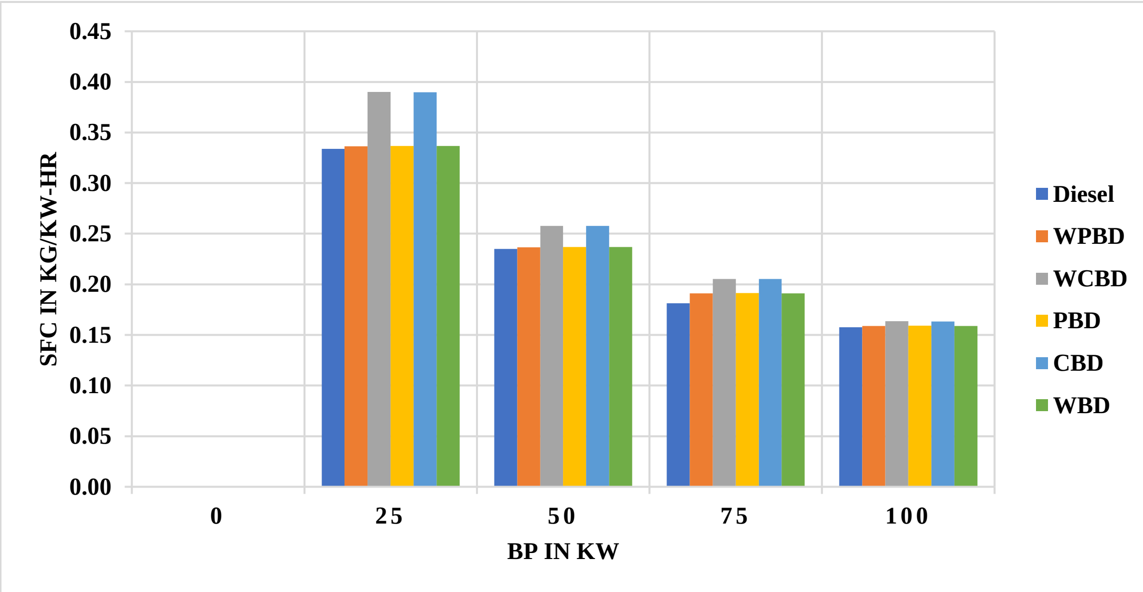

Fig.15 Variation of Specific fuel consumption with BP for different biodiesel blends

The variation of Specific fuel consumption for different biodiesel blends with engine load is shown in Fig.15. From the figure it is observed that the Specific fuel consumption will decreases as the load increases, SFC of CBD and WCBD is higher in all loads Due to its higher kinematic viscosity. And SFC of WPBD is comparable with the diesel.

From the characterization and performance and emission is found to be better compared to other biodiesel samples.

4.3.2 Emission characteristics

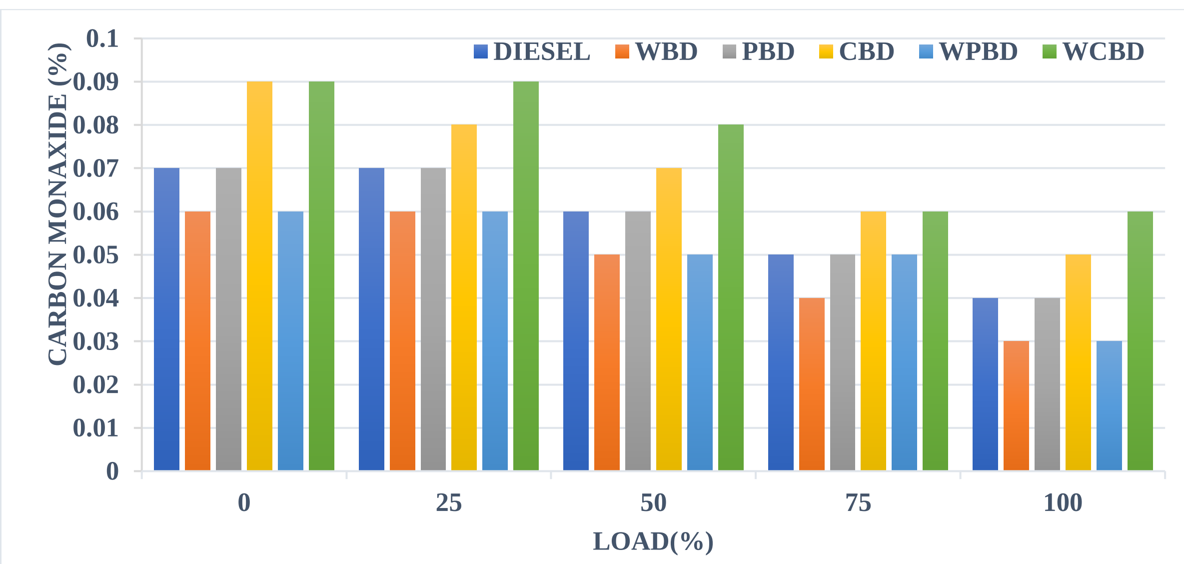

Fig.16 Variation of carbon monoxide emission with BP for different biodiesel blends

The variation of carbon monoxide emission for different biodiesel blends with engine load is shown in Fig.16.Castor oil biodiesel and castor oil and waste cooking oil mixed oil biodiesel has high viscosity and high density due to this the combustion will be low therefore the carbon monoxide will be high.

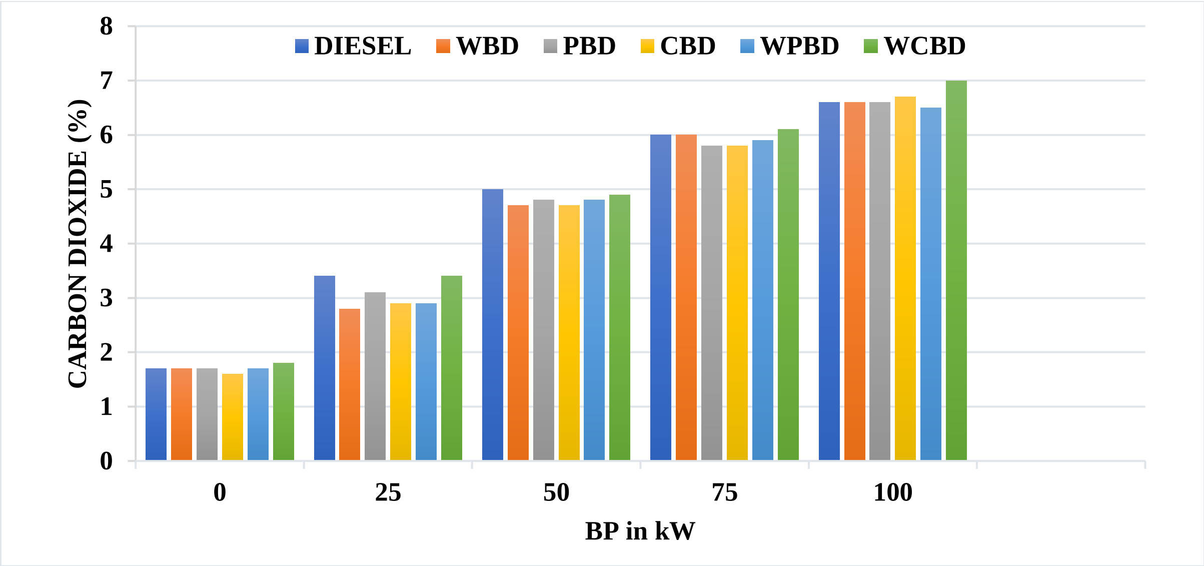

Fig.17 Variation of carbon dioxide emission with BP for different biodiesel blends

The variation of carbon dioxide emission for different biodiesel blends with engine load is shown in Fig.17. The carbon dioxide emission for all the biodiesel samples is found to be increasing with the BP. This is due to increase in combustion temperature with increase in BP, leading to formation of more carbon dioxide.

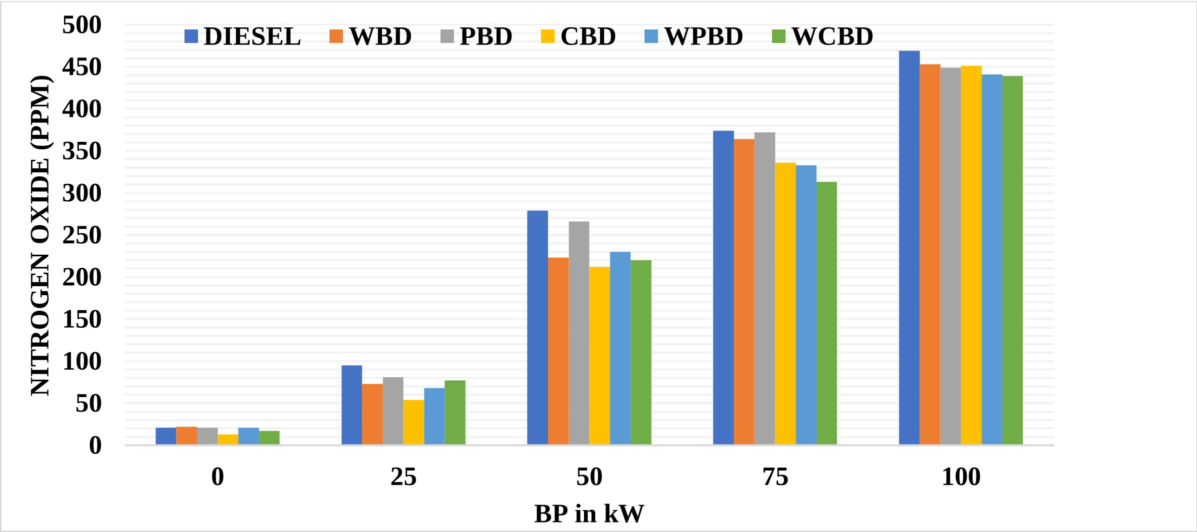

Fig.18 Variation of nitrogen oxide emission with BP for different biodiesel blends

The variation of nitrogen oxide emission for different biodiesel blends with engine load is shown in Fig.18. The nitrogen oxide emission for diesel and all the biodiesel samples are found to be increasing with the BP. This is due to increase in combustion temperature with increase in BP.

5. Demonstration and Public awareness

5.1 Demonstration of the prepared biodiesel in vehicles

The Demonstration of prepared biodiesel sample in different vehicles is shown in Fig.19

Tiller	Tractor	Tata Ace	Mahindra Bolero
Owner name: Linga Raju	**Owner name: Girish S**	**Owner name: Mohammed Anas**	**Owner name: Sharat j**

Fig.19 Demonstration

5.2 Public awareness on the benefits and application of biodiesel

A public awareness on the benefits and application of biodiesel is created by the project team members through oral communication and distribution of pamphlets at Bevinahalli village. Awareness is created for more than 75 people through this effort.

Fig.20 Public Awareness

6. Scope for future work

This project work involves the synthesis and testing of biodiesel produced from mixed oil transesterification of waste cooking oil with pongamia oil and castor oil. The work can be further extended performing mixed oil transesterification using different feed stocks. The effect of Nano additives and alcohols in the performance and emission of mixed oil biodiesel can be performed. Storage, thermal and oxidation stability of mixed oil biodiesel can also be performed.

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