Review Article

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# A Review on Biofuel Production from Fish Waste Oil

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## ABSTRACT

Biodiesel is a sustainable alternative to petroleum-based diesel. Waste Fish Oil (WFO) is a promising raw material for biofuel production due to its high lipid content. This study attempts to review the IC engine performance characteristics using WFO-based biofuel. The results showed improved engine performance, reduced emissions, and improved fuel efficiency. The benefits are attributed to the unique properties of WFO-biodiesel, including its high cetane number, low viscosity, and lower sulfur and aromatic content. Waste fish oil is a low-cost and readily available source of lipid, making it a promising alternative to petroleum diesel. Long term performance characteristics of fish oil-based biofuel should be evaluated more extensively for future use.

**Keywords**: Biodiesel; Waste fish oil; Engine performance; Emissions reduction; Fuel efficiency.

## 1. INTRODUCTION

Biodiesel is a renewable fuel alternative to diesel. The high lipid content of waste fish oil (WFO) makes it a more suitable source for biofuel production. This paper aims to review the performance of engines fueled by biodiesel derived from WFO. Fish waste, also known as fish processing waste or fish by-products, is a significant source of organic material that can be converted into biofuels. The utilization of fish waste as a source on biofuel produced from WFO. It has multiple advantages, such as decreasing the emission of harmful gases, greenhouse gases, generating fresh energy sources, and lowering the expenses of waste management. Anaerobic digestion is a prevalent technique for transforming fish waste into biofuel. This involves breaking down the organic matter in the fish waste using microorganisms to generate methane, which can serve as an energy source.

Another method of converting fish waste into biofuels is through the use of algae. Algae are known for their high growth rates and ability to convert organic matter into biomass, which can then be converted into biofuels. Studies have shown that fish waste can be used as a feedstock for algae cultivation, and that this method has the potential to produce high yields of biofuels. Fish oil-based bio fuel possesses the same characteristics as that of diesel and hence can be used in diesel engines. Numerous studies have reported that emission of harmful gases such as $CO_2$, NOx etc., from WFO is significantly less compared to diesel and hence can be considered as a promising alternative to fossil fuels.

## 2. LITERATURE SURVEY

Energy is the fundamental need of mankind used for all the basic services and is indispensable in various sectors. Hence, the immediate requirement is the access to reliable and clean energy. The estimated coal reserves, crude oil reserves and natural gas reserves in India are given in Fig 1 and Fig 2 (Source: Government of India, 2023). The same report also points out that the potential renewable energy usage is mainly from solar and wind and the other renewable energy resource deployment is only 3.1% of the requirement, as shown in Fig 3.

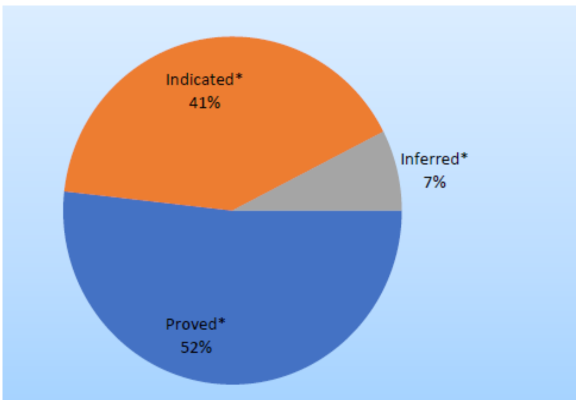


**Fig. 1: Estimated coal reserves in India in 2022-23**

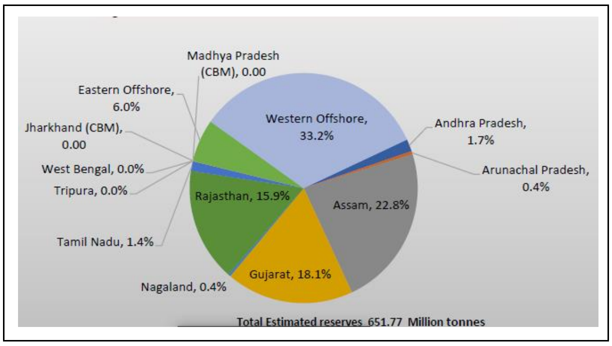


**Fig. 2: Estimated coal reserves in India (state-wise) in 2022-2023**

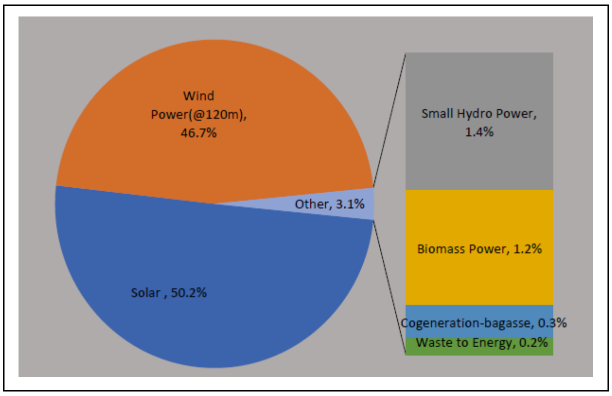


**Fig. 3: Source wise Estimated Potential of Renewable Power in India as on 31.03.2022**

Of the other sources, the biomass usage is roughly 1.2%, which is far below the potential. With the population of 1.3 billion, the average waste produced by India is 62 million tonnes per year and only 12 metric tonnes are treated. This untreated biodegradable waste is a potential source of bio-energy. This paper attempts to review the methodologies adopted to produce biofuel from waste fish oil and engine performance characteristics with WFO.

The pressing need for energy around the world and the difficulties in satisfying this demand due to the declining availability of fossil fuels have been discussed (Holechek *et al.* 2022). Fish processing produces substantial amounts of waste that contain high levels of fatty acids. By harvesting the oil from this waste and converting it into biodiesel, a new energy source can be established while also reducing pollution. The first step is to extract the oil from the fish waste, followed by transesterification to produce the biodiesel. Finally, it's essential to assess the performance, combustion, and emission properties of the biodiesel thoroughly.

Fish oil is nontoxic and biodegradable compared to other fuels (Yuvaraj *et al.* 2019). Narayanan (2020) reported transesterification process of waste fish oil. The author reported production of 0.9 L of biofuel from 1 L of fish oil. Ramesh Kumar *et al.* 2020 investigated the performance of internal combustion engines using biodiesel produced from waste fish oil. The performance indicators studied were brake power, thermal strength, mechanical strength and fuel ingestion and emissions from the engine. The study reported that calorific value and density of the fish oil-based biodiesel showed higher values than the other diesel.

The engine performance characteristics and emission characteristics using different biodiesel blends (Mahua biodiesel of 10%, 20% and 30%) and diesel have been examined (Tamilselvan *et al.* 2020). The study aimed to improve the efficiency of diesel fuel by using biodiesel blends. The engine tested had a direct injection system with a variable compression ratio and was evaluated using various injection timings and compression ratios (15:1, 16:1, 17:1) at a constant speed of 1500 RPM. The impact of compression ratio on performance characteristics was analyzed. The results showed that the B10 blend with a compression ratio of 17:1 offered the highest mechanical efficiency (27.32%) and lowest specific fuel consumption compared to diesel fuel. Emissions of carbon monoxide and hydrocarbons increased with increasing mixing ratio and compression ratio, while carbon dioxide emissions were higher than diesel fuel. The best engine performance was seen when using the B10 fuel at a compression ratio of 17:1 during full load conditions.

A similar study, published in IOP Conference Series (Fardilah *et al.* 2023) focuses on reducing environmental pollution and decreasing reliance on fossil fuels by using biofuel additives in diesel engines. The research investigates the combined effect of a mixture comprising biodiesel, alcohols, and other additives on engine performance and emissions. The emission profile of diesel engines was studied using blends of 20% biodiesel and diesel, 20% biodiesel with 10% ethanol and diesel, and 20% biodiesel with 10% butanol and diesel. The study determined the optimal combination by testing each blend under different loads and compression ratios. Engine tests were conducted at varying levels of load, from no load to full load (15 Kg) at 1500 RPM on a single-cylinder diesel engine, using two compression ratios (CR16 and CR18). The study measured engine performance parameters such as brake-specific fuel consumption, brake thermal efficiency, and emissions including $NO_X$, CO, HC, and $CO_2$. The results of the modified blends were compared to pure diesel fuel to determine the improvements in terms of performance and emissions.

Another study (Uyumaz *et al.* 2020) focuses on finding alternative fuels to replace petroleum, which is a non-renewable source of energy. The depletion of natural fuel resources has led to exploration of various fuels for compression ignition engines. The objective of the study was to evaluate the performance of a dual blend of linseed oil and hydrogen in a diesel engine with a variable compression ratio. The study examines the emission characteristics of linseed oil blends with hydrogen and diesel. The experiments were conducted using a water-cooled VCR engine with various engine load conditions and compression ratios. The study reported that B20 blend shows a comparatively similar brake thermal efficiency as that of diesel fuel, with minimal vibrations and less emissions of CO and hydrocarbons. The study also found that the combined increase in compression ratio and injection timing improved the brake thermal efficiency and reduced specific fuel consumption. Using a Python module, it was determined that 25% diesel could be saved, which would meet the demand for fuel in automobiles.

## 3. BIODIESEL EXTRACTION FROM WASTE FISH OIL

Existing literature has described many methods of producing biofuel from fish waste. The production of biodiesel from WFO involves the transesterification of WFO with methanol, followed by purification and drying to remove any residual methanol and water. The process is diagrammatically represented in Fig. 4.

Anu *et al.* 2023 studied the existing literature on the various methods available for the extraction process (El-Mashad *et al.* 2008; Lin *et al.* 2009; Yahyaee *et al.* 2013; Zhang *et al.* 2020).

1. **Methods used:** Squeezing, grinding, crushing and pyrolysis.

2. **Conversion process:**
   - Esterification
   - Transesterification
   - Alkaline transesterification
   - Catalyzed transesterification
   - Enzymatic transesterification
   - Thermally induced transesterification.

3. **Solvents:** Organic solvents (hexane, petroleum ether), inorganic solvents (NaOH) and water.

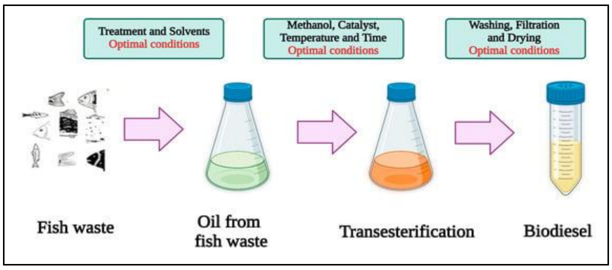


**Fig. 4: Biodiesel production from WFO (Anu, 2023)**

### 3.1 Types of Fish Waste

The characteristics of biodiesel depend on the type of fish waste used.

a) Fresh fish waste
b) Old dried fish waste
c) Naturally available fish waste
d) Industry grown fish waste

### 3.2 Engine Performance using WFO-biodiesel

Gharehghani *et al.* 2017 analysed the engine performance using WFO based biodiesel. The study reported that

- Thermal efficiency of WFO based biodiesel is 2.9% more than the pure diesel.
- Combustion loss was lesser than pure diesel fuel.
- CO and UHC emissions have reduced considerably but higher $NO_X$ emission.

Studies have shown that the use of WFO-biodiesel as a fuel in engines results in improved engine performance, including increased engine power and torque, reduced emissions, and improved fuel efficiency. These benefits are attributed to the unique properties of WFO-biodiesel, including its high cetane number and low viscosity, which improve combustion efficiency and reduce engine wear.

### 3.3 Emission Reduction

WFO-biodiesel has resulted in less emission of harmful pollutants viz., carbon monoxide (CO), nitrogen oxides ($NO_X$), and particulate matter (PM), compared to petroleum diesel. This reduction in emissions is attributed to the lower sulfur and aromatic content of WFO-biodiesel, which leads to reduced formation of $NO_X$ and PM during combustion.

### 3.4 Fuel Efficiency

The WFO-biodiesel has also been shown to improve fuel efficiency compared to petroleum diesel. This improved fuel efficiency is due to the higher calorific value of WFO-biodiesel, which provides more energy per unit volume compared to petroleum diesel.

## 4. CONCLUSIONS

In conclusion, the use of WFO-biodiesel as a fuel in engines has shown to improve engine performance, reduce emissions, and improve fuel efficiency. It is a readily available and low-cost source of lipid for the production of biodiesel, making it a promising alternative to petroleum diesel. Further research is needed to evaluate the long-term performance and durability of engines fueled by WFO-biodiesel.

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## CONFLICTS OF INTEREST

The authors declare that there is no conflict of interest.



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