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Use of Vegetable Oils as Biofuels for Environment Sustainability and Pollution control

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Abstract

Fossil oil based fuel is mainly used all over the world for providing energy in the transportation and agriculture sector. If it continues to be used in the manner it is being used presently, it may not last another century. Also, the increased use of fossil fuel has intensified air pollution and thus making the environment toxic for our children. Under these circumstances scientists have been compelled to look for economically and environmentally sound alternatives to fossil fuels. Here biofuels obtained from vegetable oil can play a very important role in a developing country like ours and can be rewarding both economically and environmentally. The common vegetable oils that can be used as biofuels in India are obtained from Karanj (Pongamia pinnata), Ratanjyot (Jatropha curcas) and Neem (Melia Azadirachta), Mahua (Madhuca latifolia) found in the wild or can be cultivated . These biofuels can efficiently replace or supplement the fossil fuels as they are renewable, less polluting and cost effective. Aim of our study is to review the most promising vegetable oils that can be used as biofuels in our country.

Keywords: *Biofuel, Vegetable Oil, Renewable Energy, Environment*

Introduction

Biofuels are fuels that are derived from organic matter, such as plants, and are used as an alternative to fossil fuels. Vegetable oils are one of the most widely used biofuels, and they have been gaining popularity in recent years due to their potential to reduce greenhouse gas emissions and promote environmental sustainability. Also, they have emerged as a popular biofuel source due to their availability, biodegradability, and easy integration in current diesel engines. This study will explore the use of vegetable oils as biofuels for environmental sustainability and pollution control. It will also provide an analysis of how vegetable oils can be used as biofuels in engines.

The Need for Biofuels

The world is facing a number of environmental challenges, including climate change, air pollution, and the depletion of natural resources. Fossil fuels are a major contributor to these problems, as they release large amounts of carbon dioxide and other pollutants into the atmosphere when burned. In addition, the extraction and transportation of fossil fuels can have significant environmental impacts, such as oil spills and habitat destruction.

Biofuels offer a potential solution to these problems. They are renewable, meaning they can be replenished over time, and they produce fewer greenhouse gas emissions than fossil fuels. In addition, they can be produced domestically, reducing dependence on foreign oil and promoting energy independence.

Vegetable Oils as Biofuels

Vegetable oils are one of the most commonly used biofuels. They can be produced from a va-

riety of crops, including soybeans, rapeseed, sunflower, canola, karanj, Neem, Ratanjyot, Mahua and palm tree. Vegetable oils have good energy content and physical properties that make them suitable for running in internal combustion engines. In addition, they can be used in a variety of applications, including transportation, heating, and electricity generation.

The main difficulty in using pure vegetable oils in engines is due to their higher viscosity.This problem can be solved either by blending the vegetable oil with the diesel or by chemically treating it so as to reduce its viscosity. The various chemical treatment processes are: transesterification, pyrolysis and microemulsion. Transesterification process is most commonly used for converting the oil into biodiesel which is more engine friendly and has properties similar to that of diesel fuel.

There are several advantages to using vegetable oils as biofuels

Reduced Environmental Impact: Blending diesel with vegetable oil-based biodiesel results in significant reduction of harmful emissions, such as CO2, NOX, SOX and PM, compared to using conventional petro-diesel alone. This leads to improvements in local air quality and helps meet regulatory requirements aimed at mitigating climate change.

Low-Cost Fuel Alternative: Blended diesel fuel often provides an economical option when compared to petro-diesel, especially in developing markets where the cost of crude oil importation may increase over time. By utilizing locally sourced vegetable oils, governments and businesses can reduce foreign exchange expenditure while supporting domestic agricultural industries. Additionally, the use of high-quality refined vegetable oils, processed from waste foodstuffs (such as restaurant grease) presents a cost-effective solution for achieving target levels of renewable energy consumption.

Improved Engine Performance: Diesel blends made from waste cooking oils demonstrate good viscosity stability at both high temperatures and subzero settings. Unlike synthetic biodiesel formulations, this enables their use throughout different seasons, minimizing downtime due to operational difficulties related to changes in temperature and humidity. Further, studies have indicated positive effects on fuel injection systems and engines themselves, particularly in cases where older equipment requires retrofitting for improved efficiency and reduced emissions output.

Sustainability Considerations: Utilization of waste materials, like discarded edible and inedible fats, contributes positively toward zero-waste efforts across commercial and residential sectors. Moreover, plant-oil crops grown specifically for conversion to biodiesel can serve multiple economic functions within rural communities, providing income opportunities and ensuring soil conservation measures remain in place. Overall, incorporation of degradable and reusable resources serves to move society closer to a circular economy mode.

Challenges of vegetable oils as biofuels

1. **High viscosity:** Vegetable oils have high viscosity causing spontaneous combustion and fuel injection difficulties in engines.
2. **Limited compatibility:** Engines designed for traditional petroleum products may not be compatible with vegetable oils alternative.
3. **Availability:** The availability of vegetable oils for use as biofuel also poses a major issue. Edible oils cannot be economically used as fuels as they are highly priced due to their demand in cooking.

Common Vegetable Oils for Use as Biofuel

Jatropha Oil

The most common inedible oil utilized for biofuel production is Jatropha, which has been extensively researched and used in biofuel production. Jatropha oil is a renewable energy source that is receiving increasing attention as a potential substitute for fossil fuels. Jatropha is a perennial and drought-resistant shrub that can grow in marginal or degraded lands, which makes it an attractive resource for developing countries with

limited arable land. Its oil content ranges from 30-40%, and the seeds have been found to yield a higher biofuel yield and have a lower carbon footprint than most other biofuel crops.The oil is extracted from the seeds of jatropha plants and has been shown to have properties that make it suitable for use as a transportation fuel. One of the main advantages of jatropha oil is that it is a carbon-neutral fuel. This means that using jatropha oil as a fuel will not increase atmospheric carbon dioxide levels, which contribute to global warming. The carbon dioxide emitted when jatropha oil is burned is offset by the carbon dioxide absorbed by jatropha plants as they grow.

Furthermore, jatropha oil has been shown to have similar properties to diesel fuel, which makes it a possible alternative. It has high energy content, good combustion characteristics, and can be used in unmodified diesel engines without any significant performance reduction. In fact, jatropha oil contains more energy per unit volume than diesel fuel, which means that a smaller volume of jatropha oil is required to produce the same amount of energy as diesel fuel.

Several studies have investigated the use of jatropha oil as a fuel. A study by Mohammed Khalaf et al. (2022) investigated the performance and emission characteristics of a diesel engine fueled with jatropha oil. The study found that the engine performance using jatropha oil was comparable to that of diesel fuel, with no significant difference in fuel consumption or engine power output. In terms of emissions, the study found that using jatropha oil resulted in lower levels of carbon monoxide and hydrocarbons, but higher levels of nitrogen oxides.

Another study by M. Mohamed Musthafa et al (2019) investigated the use of jatropha oil as a blend with diesel fuel. The study found that blending jatropha oil with diesel fuel up to a maximum of 20% did not result in any significant reduction in engine performance. However, the study found that increasing the percentage of jatropha oil in the blend led to higher levels of carbon monoxide and hydrocarbon emissions. Their study concluded that 10% blend could be alternative substitute for pure diesel fuel.

A study by C.C.M. Luitjen and E. Kerkhof (2011) investigated the use of jatropha oil in a dual fuel engine, where it was used in conjunction with biogas. The study found that thermal efficiency is hardly affected at high loads and a slight decrease at low loads.

While there have been some promising results from studies investigating the use of jatropha oil as a fuel, there are still some challenges that need to be addressed. One of the main challenges is the availability of jatropha oil. While jatropha plants can grow in a wide range of conditions, the amount of oil that can be produced per plant is relatively low. This means that large-scale production of jatropha oil for use as a transportation fuel would require large amounts of land and resources.

In conclusion, jatropha oil is a promising renewable energy source that has been shown to have properties that make it suitable for use as a transportation fuel. However, more research is needed to investigate the feasibility of large-scale production of jatropha oil and to address other challenges such as emissions and engine performance.

Karanj Oil

Another potential oilseed crop for biofuel production is Karanj tree, which is also a perennial plant found in tropical and sub-tropical regions. The increasing demand for petroleum fuels and the environmental hazards associated with them has paved the way for research on the use of alternative sources of energy. One such source of energy is biodiesel, which is derived from naturally occurring sources. Karanj oil is one such source of biodiesel that could contribute to the sustainability of energy resources. The oil content of Karanj seeds is between 30-45%, and studies have shown that it can produce high-quality biodiesel, similar to diesel fuel in terms of chemical properties. Pongamia has the added advantage of providing a high-quality protein cake as a by-product, which can be used as animal feed.

Karanj (Pongamia pinnata) is a tropical plant native to Northeast India and other parts of Southeast Asia. The plant is commonly referred to as the Indian Beech tree and produces a liquid oil that can be processed into a renewable diesel fuel called karanj oil or karanja oil. This oil is a non-edible oil that contains a high level of fatty acids and can be used as an energy source.

The use of karanj oil as a fuel source has shown promising results in various studies conducted across the globe. Research conducted so far has established that karanj has physical and chemical properties that make it a viable alternative to diesel fuel. Karanj oil holds great potential as a source of renewable energy due to environmental advantages, in addition to its low cost, and the nutritional value of the byproduct,. It, therefore, merits further exploration and a significant investment in research to make the use of karanj oil as a fuel more widespread. Nonetheless, given the promising results of the research so far, it is clear that karanj oil has the potential to revolutionize the energy industry and contribute significantly to the protection of our planet's environment.

Neem Oil

Neem oil is derived from the neem tree (Azadirachta indica) which is native to the Indian subcontinent. Neem oil has been traditionally used in medicine, cosmetics, and agriculture. However, recent studies have demonstrated the potential of neem oil as a biofuel. Neem oil contains high amounts of fatty acids, which can be converted into biodiesel through a process called transesterification.

Despite the promising results from these studies, there are some challenges that need to be addressed before neem oil-based fuel can become a mainstream biofuel. For instance, the availability of neem oil as a feedstock and the cost-effectiveness of producing neem oil-based fuel need to be carefully evaluated.

Neem oil has shown potential as a viable source of renewable energy. Studies have shown that neem oil-based fuel exhibits similar combustion characteristics to diesel fuel while having lower levels of carbon dioxide and smoke emissions. However, further research is needed to fully understand the potential of neem oil-based fuel as a mainstream biofuel.

Mahua Oil

Mahua is another common inedible oil crop, which is widely grown in the Indian subcontinent. The oil content in its seeds ranges from 38-49%, and it has been found to be a viable feedstock for biofuel production. Studies have confirmed that Mahua oil-based biodiesel meets international biodiesel standards and shows promise as a biofuel feedstock.

Mahua oil, extracted from the seeds of the tropical tree species Madhuca latifolia, has been used by indigenous communities for centuries as a source of food, medicine, and fuel. Recently, there has been renewed interest in the use of mahua oil as an alternative fuel source for diesel engines, as it has several advantages over conventional diesel fuels including reduced emissions, higher lubricity, and renewable availability. In this paper, we review the research done on the use of mahua oil as fuel and its potential as an alternative energy source.

Mahua oil has been found to have a higher cetane number, a measure of the combustion quality of diesel fuel, than traditional diesel fuels. This means that it is easier to ignite, and combustion is more complete, resulting in lower emissions of pollutants such as particulate matter, carbon monoxide, and nitrogen oxides. In addition, mahua oil has higher lubricity than conventional diesel fuels, which reduces engine wear and increases engine efficiency. This can lead to reduced maintenance costs and longer engine life.

While the use of mahua oil as a biofuel has many advantages, there are also some challenges associated with its use. One major challenge is the availability of the raw material, as mahua trees are only found in certain regions of the world. Additionally, the production process for mahua oil is not as well-established as for conventional diesel fuels, and more research is needed to optimize the production process and improve the quality of the fuel.

Linseed Oil

Linseed oil or flaxseed oil is derived from the seed of the flax plant, scientifically known as Linum usitatissimum. This oil has various applications, including its use as a fuel. The use of linseed oil as a fuel has gained interest in recent years due to the need for sustainable alternatives to fossil fuels, which are non-renewable and contribute to environmental pollution.

Research has shown that linseed oil can be used as a fuel in various industries, including transportation, heating, and electricity generation. Its use as a fuel has been extensively studied, and the results have been promising. One study found that blending linseed oil with diesel fuel resulted in lower emissions of carbon monoxide, nitrogen oxides, and particulate matter compared to the use of pure diesel fuel. This shows that linseed oil has the potential to reduce the emission of harmful pollutants and reduce carbon footprint.

Despite the promising results, the use of linseed oil as a fuel has some limitations. One of the main issues is that it is not as energy-dense as fossil fuels like diesel fuel. This means that a greater volume of linseed oil is required to produce the same amount of energy as fossil fuel, making it less efficient. Additionally, the cost of production of linseed oil is relatively high, making it less economically viable than traditional fuel sources.

Conclusion

As the world faces the challenge of reducing its carbon footprint, renewable energy sources have gained increasing attention. And among the various renewable energy sources, biofuels have gained prominence for their potential to significantly reduce greenhouse gas emissions. The use of vegetable oil as fuel is a viable alternative to traditional fossil fuels. It is a sustainable source of energy with a low impact on the environment, and it presents economic opportunities for developing countries. However, to realize its potential, there is a need for continued research and development, investment in infrastructure, and favorable policies to support its production and use.

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