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# *"Global outlook, Production and Environmental Impact Assessment of Green Biodiesel: A Brief Review"*

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**Abstract:** In this publication I attempt to present some important aspects of biodiesel, a renewable diesel substitute derived from vegetable oils, animal fats, and recycled cooking oils. In the respect of global warming and green economy, Biodiesel is one of the strong contenders. The production process involves catalyst-assisted reactions with methanol/ethanol, yielding glycerin and biodiesel. Biodiesel can be used as a neat fuel or blended with diesel. It reduces emissions of pollutants like particulates, Sulphur, CO, and hydrocarbons. Blends up to B20 work without engine modifications. Biodiesel decreases solid carbon and sulfate fractions in particulate emissions, compatible with advanced emission reduction technologies. With Biodiesel offers a cleaner diesel alternative with potential for emission reductions, many countries are keeping it as a priority for, non-fossil fuels alternative. Further research is needed on nitrogen oxide emissions and feedstock optimization.

**Keywords:**Biodiesel, Vegetable oil. Methyl esters, Alternative fuel, B20, Renewable energy,green fuel, global warming.

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## Introduction-

Biodiesel, a sustainable alternative to diesel fuel derived from renewable sources [1]. Biodiesel is synthesized from various renewable lipid sources, such as vegetable oils, animal fats, and recycled cooking oils. Chemically, it consists of mono alkyl esters of long chain fatty acids obtained from these renewable sources [2]. The production process involves reacting vegetable oils or animal fats with methanol or ethanol, facilitated by a catalyst, resulting in the creation of glycerin and biodiesel (referred to as methyl or ethyl esters) [3]. This biodiesel can be utilized in its pure form or blended with traditional petroleum diesel for combustion in diesel engines. Its operational characteristics closely resemble those of conventional diesel fuel [4].

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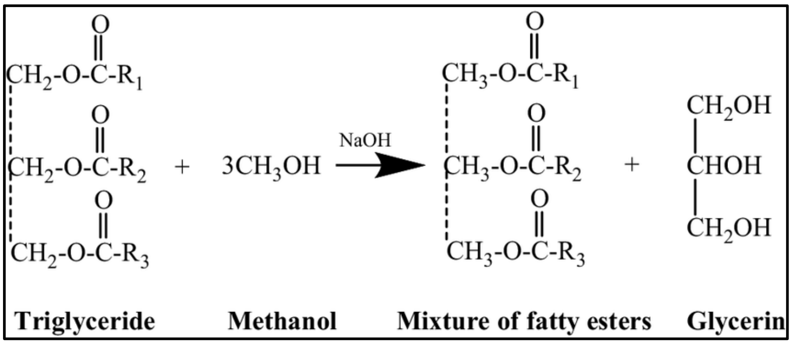
This publication focuses on the potential production route, brief Environmental Impact Assessment, and global activities of Biodiesel, derived domestically from vegetable oils, animal fats, or recycled restaurant oils. This renewable fuel offers several advantages, including its environmentally friendly nature, biodegradability, and capacity to reduce significant air pollutants like particulate matter, carbon monoxide, hydrocarbons, and air toxics [5]. For instance, biodiesel blends of up to 20% (B20) can be employed in unmodified diesel engines. While even higher concentrations (B100) are feasible, some engine modifications might be necessary to optimize performance and minimize maintenance concerns [6].

**1. Biodiesel:**

Biodiesel is a renewable and environmentally friendly alternative to traditional diesel fuel. It is a type of biofuel made from renewable resources primarily plant oils [ waste oil, vegetable oil, fried oil, non-edible vegetable oil] or animal fats, through a chemical process known as transesterification. In this process, triglycerides (fats and oils) are reacted with an alcohol, usually methanol or ethanol, in the presence of a catalyst to produce biodiesel and glycerin as byproducts [7].

The reaction may be shown.

Triglyceride + methanol → Glycerol + Esters



## 2.Biodiesel Vs Conventional Diesel:

**2.1: Ecological Advantages:** Biodiesel outperforms traditional petroleum diesel in terms of environmental impact [8]:

**a. Carbon Dioxide Reduction:** Biodiesel production significantly curbs carbon dioxide emissions by harnessing the carbon dioxide absorption process of crops supplying palm oil feedstock. biodiesel reduces carbon dioxide emissions by 78% compared to petroleum diesel [9].

**b. Decreased Sulphur Emissions and Harmful Compounds:** The developed world is embracing stricter standards to diminish Sulphur compounds in diesel. in 2006, all nations were asked to limit Sulphur in diesel to under 50 ppm, in contrast to the general 500 ppm levels that time [10].

**2.2: Biodiesel Exhibits Biodegradability:** Research demonstrates that biodiesel samples decompose more swiftly than a dextrose control, achieving 95% degradation in just 28 days. Additionally, biodiesel blends expedite the breakdown of petroleum diesel. For instance, a blend of 20% biodiesel accelerates degradation twice as fast. Biodiesel has also demonstrated effectiveness in remediating soil contamination from petroleum diesel [11].

**2.3: Enhanced Engine Longevity:** The introduction of biodiesel, which compensates for the lost lubrication properties in low-Sulphur petroleum diesel, can substantially mitigate engine wear without necessitating chemical additives. Biodiesel operates as a fuel rather than an additive, promoting normal combustion without generating extra emissions [12].

**2.4: Engine Performance:** Despite having a caloric value about 90% that of mineral diesel, biodiesel showcases combustion properties closely resembling conventional diesel [13]. This outcome arises from both higher cetane numbers compared to mineral diesel and the innate oxygenation trait of methyl ester (biodiesel), enabling more efficient combustion. Distinct from natural gas vehicles, ethanol, hydrogen, and hybrid solutions, biodiesel can seamlessly power any diesel engine with minimal or no adjustments to the engine or fuel system. Biodiesel yields virtually identical horsepower and torque. Biodiesel affords better acceleration due to its lower fuel viscosity [14]. In new engines, biodiesel fuel consumption mirrors diesel. For engines in operation, biodiesel significantly enhances fuel economy by perpetually cleansing the system. Biodiesel keeps fuel lines, injectors, and other engine components clean, thereby refining combustion. Biodiesel boasts a cetane number 10-15 points higher than diesel, yielding improved combustibility, smoother engine operation, and reduced noise levels [15].Biodiesels generally exhibit higher gel points than petroleum diesel, making winter use more challenging [16]. Though petroleum diesel holds a slight advantage here, biodiesel's cold-weather performance is aided by additives and varietal blends of vegetable oil feedstock.

The use of biodiesel eradicates the characteristic black smoke particles associated with older diesel engines. In warm climates, condensation varies between biodiesel and mineral diesel, resulting in water accumulation in diesel but not in biodiesel. This discrepancy arises from the distinct solvent properties of the two fuels [17]. Consequently, in warm climates, algae growth can obstruct fuel lines and engines due to the presence of this water layer [18].

**2.5: Warranties:** Generally, the use of biodiesel does not void warranties. Prominent engine manufacturers affirm that a 20% [ B20] biodiesel blend will not invalidate their parts and workmanship warranties. Companies such as John Deere and Caterpillar appear indifferent to all fuel types [19].

**2.6: No Need for New Handling Equipment and Storage Facilities:** In general, the standard procedures for storing and handling petroleum diesel can be applied to biodiesel. Biodiesel does not necessitate specialized safety containers. Due to its higher flashpoint, biodiesel storage is notably safer than that of petroleum diesel [20].

**3:Properties of Biodiesel:** Biodiesel has physical properties very similar to conventional diesel.

**Acceptable Biodiesel's Physical Characteristics [21]**:

Specific gravity @ 25°C 0.87 to 0.89

Kinematic viscosity @ 40°C 3.7 to 5.8

Cetane number 46 to 70

Higher heating value (btu/lb) 16,928 to 17,996

Sulfur, wt% 0.0 to 0.0024

Cloud point °C -11 to 16

Pour point °C -15 to 13

Iodine number 60 to 135

heating value (btu/lb) 15,700 to 16,735

**4: Properties of Biodiesel Vs Conventional Diesel:** Biodiesel exhibits lower greenhouse gas emissions, reduced sulfur content, and enhanced lubricity compared to conventional diesel. Its renewable origin and biodegradability contribute to a smaller environmental footprint. However, biodiesel's slightly lower energy content and potential compatibility issues in cold temperatures warrant consideration for optimal usage.

| Fuel Property | Diesel | Biodiesel |
|---|---|---|
| | ASTM D975 | ASTM D6751 |
| Lower Heating Value, BTU/gal | 129,050 | 118,170 |
| Kinematic Viscosity @ 40$^0$ C., cSt | 1.3-4.1 | 4.0-6.0 |
| Specific Gravity @ 60$^0$ C., g/cm³ | 0.85 | 0.88 |
| Carbon, wt % | 87 | 77 |
| Hydrogen, wt % | 13 | 123 |
| Oxygen, by dif. Wt % | 0 | 11 |
| Sulfur, ppm | 500 | 0 |
| Boiling Point, $^0$C | 180 to 340 | 315 to 350 |
| Flash Point, $^0$C | 60 to 80 | 100 to 170 |
| Cloud Point, $^0$C | ~15 to 5 | ~3 to 12 |
| Pour Point, $^0$C | ~35 to ~15 | ~15 to 10 |
| Cetane Number | 40-50 | 48-65 |
| Lubricity (HFRR), µm | 300-600 | <300 |

Table1- Reproduced from Ref.[22] Latif, Mohd et all.

**5: Biodiesel production in USA:** As USA is one of the most advanced technological countries. It is expected to have a greater focus on bio diesel production. As per US Energy Information Administrator [23]

**"***As of January 1, 2021, total U.S. biofuels plant production capacity reached 21 billion gallons per year (gal/y) (or 1.3 million barrels per day [b/d]), as reported by 278 facilities. Fuel ethanol producers accounted for 85% of U.S. total biofuels production capacity, followed by biodiesel producers at 11%, and the remaining 4% by renewable diesel fuel and other biofuels producers*."

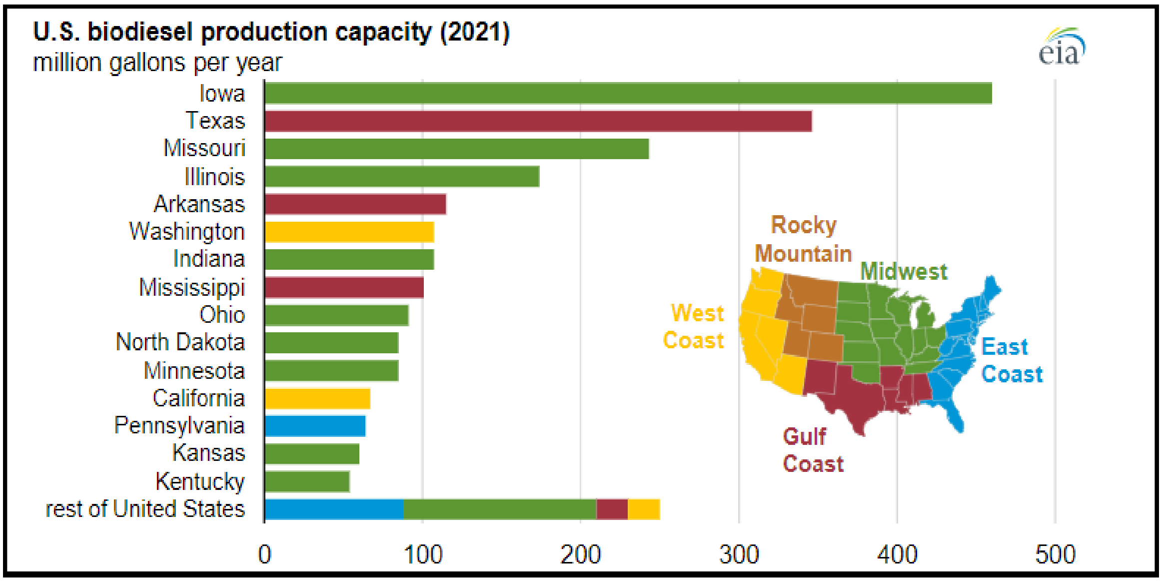



**Figure1: Source** U.S. Energy Information Administration, *2021 Biodiesel Plant Production Capacity*

**6: Biodiesel global activity**: It's important to have an outlook on the global activity of biodiesel production. Since the environmental impact is not due country but it depends on the collective effort of the global initiatives. In 2021, the global biodiesel production landscape showcased a diverse range of contributions from various countries, reflecting both individual and collective efforts to mitigate the environmental impact of traditional fossil fuels [Figure 1]. Biodiesel, a renewable and cleaner-burning alternative to conventional diesel derived from fossil fuels, has gained significant traction to reduce greenhouse gas emissions, promote energy security, and foster sustainable development on a global scale.

Country-wise, several nations emerged as key players in the production of biodiesel, with each contributing to the larger goal of reducing carbon footprints and transitioning towards a more environmentally sustainable energy mix. The production capacity of biodiesel witnessed notable expansions in countries such as the United States, Brazil, Germany, Argentina, and Indonesia. These countries not only demonstrated their commitment to combating climate change but also showcased the economic potential of biofuels as a viable and valuable sector within their respective economies. The United States, for instance, continued to be in top three global biodiesel producers, supported by its advanced agricultural infrastructure and extensive feedstock resources. The country's diverse feedstock base, including soybean oil and waste cooking oil, played a pivotal role in driving biodiesel production growth. Similarly, Brazil's robust sugarcane industry enabled it to harness the power of ethanol and biodiesel, contributing significantly to its renewable energy targets and overall sustainability agenda.

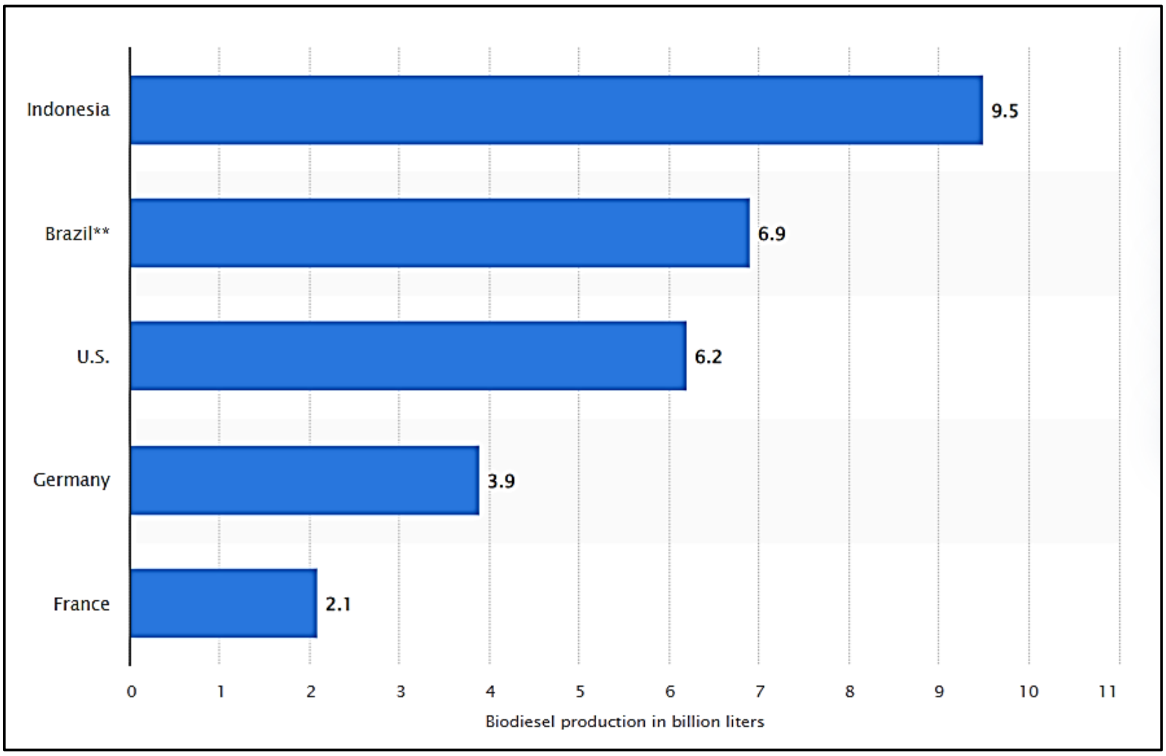



**Figure 2:** Global biodiesel production in 2021. Source © Statista 2023

In Europe, Germany maintained its status as a frontrunner in biodiesel production, leveraging a combination of legislative incentives, technological advancements, and a well-established supply chain [Figure 2]. This commitment aligned with the European Union's broader vision for achieving carbon neutrality and reducing dependence on fossil fuels [24].Meanwhile, countries such as Argentina and Indonesia demonstrated the potential of utilizing non-traditional feedstocks like palm oil to produce biodiesel [25]. While the use of palm oil has raised concerns regarding deforestation and habitat loss, these nations have taken steps to implement more sustainable practices, highlighting the complex interplay between economic development, environmental conservation, and renewable energy goals.

The global biodiesel production landscape in 2021 underscored the significance of collaborative initiatives and knowledge sharing among nations. The exchange of best practices, research findings, and technological innovations facilitated the advancement of biodiesel production methodologies and improved the overall environmental performance of the industry. Multilateral efforts, such as international agreements and partnerships, further catalyzed the transition towards a more sustainable energy future.

**6. Conclusion**:Biodiesel has emerged and continue to emerge as a progressive and eco-conscious substitute for conventional diesel, aligning with the imperative to address global warming and the greenhouse effect. The global outlook on biodiesel production underscores the significant role played by individual nations in shaping collective environmental impact. The inevitable progression toward biodiesel mandates reflects a proactive response to these concerns. Despite diverse circumstances, each nation's biodiesel production strategies converge on the shared mission of curbing carbon emissions and fostering sustainability, fostering a global unity of purpose. In an era defined by the urgent need to confront climate challenges, the collaborative and varied approaches undertaken by nations within the biodiesel sphere stand as a compelling testament to the power and necessity of a harmonized global endeavor.Further research is needed on nitrogen oxide emissions and feedstock optimization.

***Disclaimer****- Author claims no conflict of interest and the data / work presented in this paper is not the data/ work the author has done in Affiliated companies. These companies are cited only as to show a professional affiliation/ Experience of the author.*

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