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Review

Biodiesel Emissions: A State-of-the-Art Review on Health and Environmental Impacts

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Abstract: Biodiesel is an alternative source of fuel for various automotive applications. Because of the increasing demand for energy and the scarcity of fossil fuels, researchers have turned their attention to biodiesel production from various sources in recent years. The production of biofuels from organic materials and waste components allows for the use of these waste resources in transporting resources and people over long distances. As a result, developing sustainable measures for this aspect of life is critical, as knowledge of appropriate fuel sources, corresponding emissions, and health impacts will benefit the environment and public health assessment, which is currently lacking in the literature. This study investigates biodiesel's composition and production process, in addition to biodiesel emissions and their associated health effects. Based on the existing literature, a detailed analysis of biodiesel production from vegetable oil crops and emissions was undertaken. This study also considered vegetable oil sources, such as food crops, which can have a substantial impact on the environment if suitable growing procedures are not followed. Incorporating biodegradable fuels as renewable and sustainable solutions decreases pollution to the environment. The effects of biodiesel exhaust gas and particulates on human health were also examined. According to epidemiologic studies, those who have been exposed to diesel exhaust have a 1.2–1.5 times higher risk of developing lung cancer than those who have not. In addition, for every 24 parts per billion increase in NO_2 concentration, symptom prevalence increases 2.7-fold. Research also suggests that plain biodiesel combustion emissions are more damaging than petroleum diesel fuel combustion emissions. A comprehensive analysis of biodiesel production, emissions, and health implications would advance this field's understanding.

Keywords: vegetable oil; biodiesel; health effect of biodiesel; environment effect of biodiesel; emission

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1. Introduction

The use of vegetable oil as a fuel source in diesel engines is a long-standing practice [1]. Transesterification of vegetable oil was first accomplished in 1853 by the scientists E. Duffy and J. Patrick, which was a good number of years before the first diesel engine was ever put into operation [2]. On 10 August 1893, at Augsburg, Germany, Rudolf Diesel's prime model, which consisted of a single 10-foot (3 m) iron cylinder with a flywheel at its base, successfully ran on its own power for the first time. Later, in 1898, Diesel presented a demonstration of his engine at the World's Fair in Paris, France. Because it was powered by peanut oil, a biofuel, this engine illustrated Diesel's vision for the future. He was under the impression that the exploitation of biomass fuel was the most promising avenue for developing his engine.

However, the current demand for developing and utilizing vegetable or plant oil and animal fats in biodiesel fuel form is quite limited. Biodiesel is technically described as mono-alkyl esters of fatty acids generated from renewable lipid feedstock, such as animal fats or plant oils, and intended for use in compression-ignition diesel engines [3]. Biodiesel is a renewable fuel made from vegetable oil, methanol, and fats or recycled cooking fats [4,5]. Biodiesel fuel is often obtained from renewable natural resources that are continually replenished. The fuel can be created directly from plant oils, animal fats or oils, tallow, or recycled cooking oil via a transesterification process. Currently, the majority of biodiesel is made from waste plant oils supplied by stores, restaurants, and industrial food producers [6].

Although oils straight from the agricultural business are the most common biodiesel source, they are rarely produced for commercial purposes due to high raw oil prices [7]. Furthermore, the additional expense of converting to biodiesel makes it far more expensive than fossil fuel [8]. Waste plant oil can generally be obtained at a lower cost. However, it must be extensively processed to remove contaminants before being converted into biodiesel, as the goal is to make biodiesel from waste plant oil of sufficient quality to compete with fossil fuels [9]. Although biodiesel is now employed on a modest scale, it is an important fuel alternative since it has the potential to become a part of a country's energy infrastructure due to its commercial practicality [10]. In simpler terms, researchers believe that biodiesel fuels will become a component of the nation's energy infrastructure due to their importance in the future. Biodiesel can be used in any blend with petroleum fuel since its application is identical to that of petroleum diesel in that both are utilized as fuel compression-ignition engines [11]. It has long been debated whether biodiesel use has a major environmental impact in the form of lower emissions, enhanced energy independence, favorable effects on agriculture, or a reduction in the impact of global warming [12]. All of these characteristics, however, are dependent on the fuel source and the manufacturing method. Biodiesel contains less sulphur but a higher level of cetane than other low-sulphur diesel fuels [13].

The use of biodiesel frequently reduces wear in fuel systems and increases the longevity of fuel injection equipment [14]. Moreover, biodiesel's energy density variations largely depend on the type of feedstock [15]. Because the carbon dioxide produced into the atmosphere during fuel burning is recycled and reused to grow plant oil crops, it has a higher concentration of cetane than diesel due to its long chains of fatty acids with a few double bonds [16]. Depending on the feedstock utilized, researchers evaluate biodiesel fuels higher in terms of engine maintenance and efficiency. Humans have overexploited petroleum deposits as a natural resource for fuel. In order to conserve petroleum reserves, the shortage of petroleum reserves tends to promote the creation of renewable energy resources, such as solar energy production and biofuel production. Biodiesel is a well-known alternative fuel that is utilized as a substitute for petroleum-based diesel fuels. Mono-alkyl esters derived from vegetable oils and fats are used to make biodiesel. This is regarded as an environmentally beneficial fuel that reduces carbon footprints and regulates ecological footprints [17]. According to the US DOE (Department of Energy), biodiesel is carbon-neutral since the plants that act as the sources of feedstock for producing biodiesel, such as palm oil trees, soybeans, etc., absorb atmospheric carbon dioxide while growing. These plants' carbon dioxide absorption usually offsets the carbon dioxide produced during biodiesel production and burning [18]. Most of these are produced from soybeans, and some are also produced from utilized vegetable oils and animal fats [19]. There are places where large, cultivated lands and forests have been cleared to grow these trees for producing biodiesel. Although biodiesel is more preferred than other diesel fuels, this deforestation causes greater negative impacts on the environment due to the burning and clearing of lands compared to the benefits of biodiesel produced from these plants (IPCC, 2017) [20]. Biodiesel is preferable as a renewable fuel for promoting a green environment, and the production of biodiesel from natural resources or waste material of crops is helpful in maintaining sustainability. Transesterification is used to convert fats and oils into eco-fuel, such as biodiesel.

Fresh diesel exhaust is a complicated combination that emerges from the engine. When diesel exhaust is discharged into the atmosphere, it "ages" and undergoes different changes owing to photochemical reactions and the aggregation of sulphate particles into fine particulate air pollution, making it even more complicated. Fresh diesel engine exhaust contains coarse and fine particulate matter, nitric oxide, carbon dioxide, some carbon monoxide, and oxidized sulphur compounds (sulphur dioxide and sulphates), the amount of which varies depending on the sulphur content of the fuel. Fresh and aged diesel exhaust is known to be carcinogenic and has been linked to human cancer, particularly lung cancer, among populations and vocations exposed to diesel exhaust. The International Agency for Research on Cancer (IARC) reclassified diesel-engine exhaust as a Class 1 carcinogen in June 2012, indicating that there is sufficient evidence to conclude that diesel exhaust causes cancer in humans [21]. These conclusions were based on epidemiology studies of exposed populations and toxicology studies of animals. IARC is universally considered authoritative in the field of cancer research. The gas phase of fresh diesel exhaust does not include many secondary pollutants that contribute to urban air pollution, although it may be high in formaldehyde (a severe respiratory and mucosal irritant and upper airway carcinogen) and acetaldehyde depending on operating circumstances [22]. The particulate phase of diesel exhaust is also irritating and may cause irritation. According to the then-recent subchronic and acute animal investigations, fresh (non-aged) diesel-engine exhaust has comparatively low inflammatory effects [22].

All of the research described above investigated various methods of biodiesel manufacturing and their application as fuel in diesel engines. Estevez et al. [23] discussed green diesel, biodiesel-like biofuels, and straight vegetable oil (SVO) blending with less viscous and lower cetane (LVLC) biofuels as immediate solutions to replace fossil diesel in a diesel engine application. They stated that the production of fuel from lignocellulosic sources is not feasible in the short term but that it would be extremely beneficial in the medium to long term. It should be noted that biodiesel has already been widely adopted in a variety of regions around the world and that quality control standards for this fuel have already been established. This refutes the authors' assertion about short-term viability.

The emission of various types of biodiesel from diesel engines, and the related effects on human respiratory and public health, is critical for the environment and health. This study thoroughly explores the production process of biodiesel from various sources and the associated environmental and health implications. Because of contemporary scenarios of growing respiratory difficulties, the study of biodiesel and respiratory health implications is a significant and widespread topic. Research has been carried out to evaluate the effects of biodiesel on the respiratory system in order to understand its consequences on human health. This article seeks to emphasize the importance of biodiesel as an energy resource by thoroughly analyzing health impacts in past research.

2. Biodiesel as a Renewable Energy Source

Because it is a clean-burning process that gives energy, biodiesel is a domestic product that provides renewable energy resources. These resources are becoming increasingly popular in the energy production and environmental management industries. Additionally, the use of biodiesel can provide energy security while also improving air quality. As the demand for energy resources grows, the use of extensive carbon-emitting fuel resources accumulates a considerable amount of carbon-based pollution in the atmosphere [24]. It can be added with petroleum to increase the oxygen content and thus improve the combustion process while decreasing the oxidation potential of the fuel [24].

Biodiesel is critical for advancing green technologies, encouraging renewable energy sources, and emphasizing sustainable development by reducing environmental contaminants. As a result, Table 1 shows the applications of biodiesel.

Table 1. Applications of biodiesel.

Application	Explanation	Application	References
Automobiles	Mining, Hybrid electric	Biodiesel may be used as fuel for automobiles and farm machinery, off-road work of construction, and mining. Biodiesel is also applied within hybrid electric automobiles	[24,25]
Agricultural adjuvants	• Pesticides' carrier • Fertilizer • Biodegradable	They can be used as a carrier for pesticides and fertilizers in agricultural sprays because of their non-toxic and biodegradable properties	[26,27]
Boiler fuel	Alternative for boiler use.	With the increasing price of natural gas, biodiesel is a better alternative, with slight modifications required for boiler use	[28,29]
Generation of power	• Standby power • Engine deterioration's minimizer	Generators that run on biodiesel provide standby power at the time of power shortage. Additionally, the enhanced lubricity of such generators can potentially minimize engine deterioration	[30]

2.1. Biodiesel Production

Biodiesel is made directly from plant oil, animal fats and wastes, and waste oils. There are three methods for producing biodiesel from fats and oils [31,32]:

- Base-catalyzed transesterification [33];
- Acid-catalyzed esterification [34]; and
- Simultaneous esterification and transesterification of oil [35].

The majority of biodiesel is produced utilizing the base catalyst process. Transesterification is the most inexpensive method, requiring only low pressures and temperatures and yielding a production yield of over 98% [36,37]. A triglyceride has a glycerine molecule as a base, with associated long chains of fatty acids [5,38]. The triglyceride combines with alcohol during the transesterification process under the influence of any catalyst, which should be a strong alkaline base such as sodium hydroxide [39]. Figure 1 depicts regional biofuel production from 2016 to 2021.

A reaction between alcohol and fatty acids produces a mono-alkyl ester and crude glycerol and biodiesel. The majority of the alcohol used in the process is ethanol or methanol, which is base-catalyzed by sodium or potassium hydroxide [40,41]. However, potassium hydroxide is better suited for the production of biodiesel via ethyl ester. An increase in biofuel production immediately benefits human life by reducing pollution and conserving natural resources and atmospheric pressure caused by the over-emission of fumes from carbon-based fuels. This is why biodiesel manufacturing helps reduce atmospheric pollution, and increasing biodiesel production means greater use of green fuel, which ultimately aids in sustainable development and reducing carbon footprints.

2.2. Production Process Considerations

Figure 2 shows the associated steps that are involved in the production process [42].

A mixture of alcohol and the catalyst—The catalyst can be sodium or potassium hydroxide, which is dissolved in alcohol with the use of a normal mixer or agitator. Following the reaction, the mixture is charged within a closed reaction container, and fat/oil is added to the mixture. An atmospheric state totally prevents the process, ensuring that no alcohol is sublimed. To speed up the reaction, the temperature of the mixture is kept at just above 78 degrees Celsius (alcohol boiling point). It should be permitted for one to eight hours at regular room temperature. Any extra alcohol is usually used to guarantee that the oil/fat is converted into esters [43]. It is critical to keep track of the levels of water and fatty acids in the input fat/oil. If the concentration of water or free fatty acids is too high, it will interfere with soap synthesis and by-product separation [42].

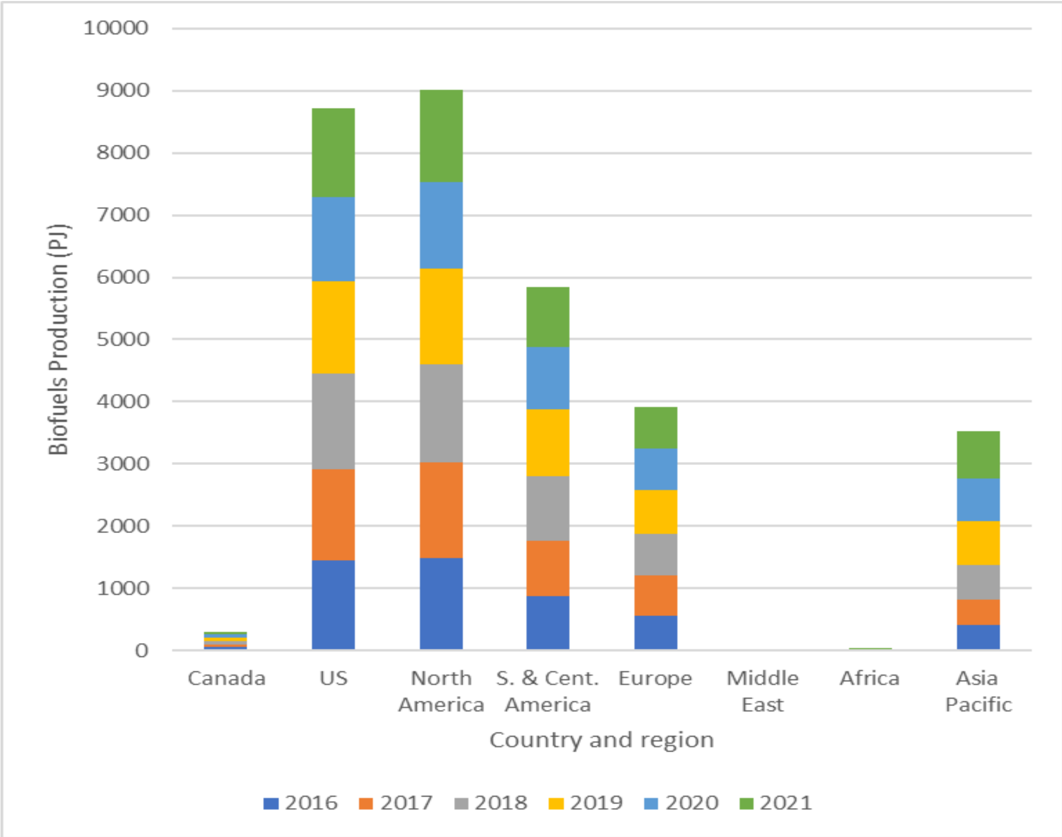

Figure 1. Biofuel production by region from 2016 to 2021.

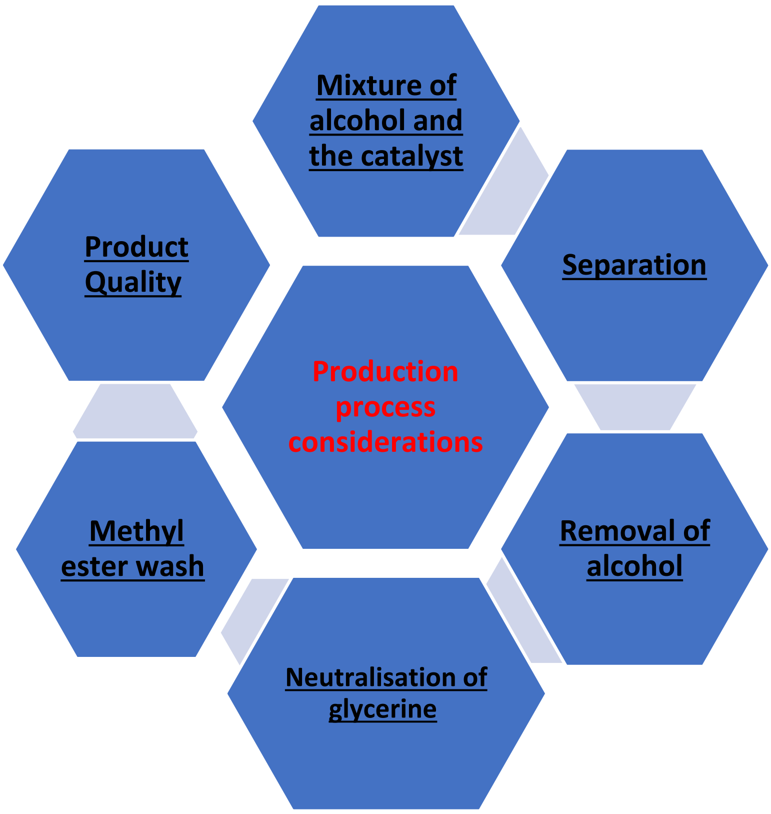

Figure 2. Production process of biodiesel.

Separation—Following the process, two separate products are generated, namely glycerine and biodiesel, both of which contain an excess of methanol, which was previously utilized during the reaction [44]. When necessary, the finished mixture is subjected to neutralization during this phase. Glycerine is denser than biodiesel [45]. Both are separated by gravity at the same time, with glycerine easily dragged off the bottom of the settling tank, and sometimes centrifugal force is used for quick separation [42].

Removal of alcohol—Following the separation of the biodiesel and glycerine phases, the excess alcohol is removed through flash evaporation or distillation [46]. It is also removed by various techniques, and the mixture is neutralized before the separation of esters and glycerine occurs [42]. In both circumstances, the alcohol can be collected and reused using distillation apparatus. In both circumstances, the alcohol can be collected and reused using distillation equipment [47]. However, no water should be allowed to build in the recovered alcohol stream.

Neutralization of glycerine—Glycerine by-products contain unutilized catalysts and soaps, which can be neutralized with acid and stored as crude glycerine [46]. Occasionally, the salt generated during this phase can be collected and used as fertilizer. Water and alcohol are removed in this process to produce the purest glycerine possible; in more modern processes, it is sometimes distilled to around 99% purity for sale in medicinal or cosmetic industries [48].

Methyl ester wash—When separated from glycerine, the resulting biodiesel can be refined further by gently washing in warm water to remove leftover soaps or catalysts, followed by proper drying and storage. It is usually the final stage of the manufacturing process that results in an amber-yellow liquid with the viscosity of petro-diesel [42].

Product Quality—The final product of biodiesel should be adequately analyzed for commercial application using advanced analytical techniques. This is carried out to guarantee that the essential commercial biodiesel criteria are met [49]. Some of the fundamental parts of production for ensuring smooth operations within the diesel engine include completed reaction elimination of glycerine, alcohol, and a catalyst and the removal of free fatty acids [50]. Table 2 shows the characteristics that must be addressed during the manufacturing process.

Table 2. Important steps in the production process.

Process Name	Things to Note	References
A mixture of alcohol and the catalyst	Careful about alcohol excess and monitor level of water and fatty acids.	[46]
Separation	Gravity and centrifugal force	[42]
Removal of alcohol	No water should be accumulated in recovered alcohol	[51]
Neutralization of glycerine	Purity of glycerine	[48]
Methyl ester wash	Color and viscosity	[3]
Product Quality	Analyzed through advanced analytical techniques	[52]

Biodiesel is easy to use, non-toxic, and biodegradable [53]. According to researchers, the fuel is mostly utilized in most engines, particularly newer ones, because it releases fewer amounts of greenhouse gases, with the exception of nitrogen oxides [54]. Biodiesel is generally safe to use and has a slightly lower energy content than petroleum fuel. Furthermore, when compared to fossil fuels, their lubricity is an extra benefit [55]. Biodiesel's blending capabilities are adequate, and it greatly reduces carbon-based emissions [56]. Because of the rising cost of petroleum products and fuels, biodiesel is becoming more popular as a low-cost option for commercial use [57]. The widespread use of biodiesel also minimizes reliance on limited natural resources. Furthermore, biodiesel is simple to produce and can be obtained through a variety of methods. It has been scientifically demonstrated that biodiesel exhaust particles are less harmful to human health than petroleum products [55].

3. Emission from Biodiesel Production and Combustion

When it comes to the manufacturing process, the amount of energy that is used is a major source of environmental concern. Because of the higher pressure or higher temperature, the steps that involve pretreatment and extraction are the ones that use the most energy. Transesterification is the most popular method used for the production of biodiesel due to the fact that it is an environmentally friendly and renewable process [58]. The ratio of alcohol to glycerides, amount of catalyst used, reaction time and temperature, and amount of free fatty acids contained within feedstock are all factors that can affect the outcome of this process [59]. Utilizing supercritical alcohol and ultrasound, in addition to more traditional methods of producing biodiesel, is thought to result in a higher overall yield of production. The cost of production presents a significant obstacle throughout the process, particularly with regard to the process's potential for commercialization [60]. According to Sánchez Faba et al. [61], the reason for this is that the cost of using plant oil as a source of raw materials in the production of biodiesel is relatively higher. Because of this, it is not possible to utilize this resource in a commercial setting. However, in order to bring down the overall cost of production, a continuous transesterification process may be of great assistance. In a similar vein, it is a prudent business move to ignore the high cost of using plant oil as feedstock in favor of recovering a high-quality product such as glycerol for use in other applications [60]. Studies suggest that additional research and development efforts are required to identify more advanced methods of biodiesel production in order to include properties in biodiesel that make it more feasibly sustainable. Despite the fact that the production of biodiesel is quite pricey, studies suggest that these efforts are necessary.

Biodiesel fuel, which can be produced from either animal fats or plant oils, is regarded as an essential alternative to the use of diesel engines due to the fact that it functions as a renewable energy resource. It is also non-toxic, biodegradable, and friendly to the environment [6]. The combustion of liquid biofuels in internal combustion engines has been the primary focus of performance and emissions analysis to date. The fact that burning biodiesel results in emissions of carbon dioxide that are comparable to those of conventional fossil fuels is the primary motivation behind the production of biodiesel. When the plant feedstock that is used in the production grows, it takes in carbon dioxide from the air and uses it for growth. However, the various processes that are used in the production and utilization of biodiesel (mostly through combustion in a diesel engine) often result in the production of harmful by-products in the form of exhaust particles that have the potential to negatively impact human health. Micro-emulsification, pyrolysis, and transesterification are just three of the many processes that are involved in the production of biodiesel (chemical and enzymatic). A chemical reaction involving a catalyst (a strong base) is required to produce industrial biodiesel. This process is analogous to the one described above [42]. Table 3 contains a list of the emissions that result from the production and combustion of biodiesel.

Table 3. The emissions from biodiesel production and combustion.

Name	Comparison with Other Fuels	Emission	References
Ozone	Less than other diesel fuels	Gas	[56]
Sulfur	Very less, only in impure biodiesel	Oxides and sulphates	[53]
Carbon Monoxide	48% less	Unburned Carbon monoxide	[62]
Hydrocarbons	66% less	All series	[63]
Particulate	46% less	Inhaling particulate	[62]
Carbon dioxide	78% less	CO_2	[62]
Nitrogen Oxides	10%	NO_2	[64]

Diesel engine exhaust contains a wide range of gaseous and particulate phased organic and inorganic compounds with higher aromatics and sulphur than gasoline engines. The particles have hundreds of chemicals adsorbed onto their surfaces, comprising many recognized or suspected mutagens and carcinogens. The gaseous phase also contains many toxic chemicals and irritants. These have a serious adverse effect on human health and an environmental impact [53,54].

3.1. Biodiesel Gaseous Emissions

3.1.1. Carbon Dioxide

Carbon dioxide acts as one of the most concerning greenhouse gasses. Though biodiesel, when burnt, emits carbon dioxide equally to ordinary fossil fuel, the use of plant feedstock within the production process usually absorbs a certain quantity of atmospheric carbon dioxide while growing. Estimations show that biodiesel is produced from waste cooking oil or fat and reduces carbon dioxide emissions by approximately 85% [65]. Biodiesel has been proven to have benefits over other petroleum diesel due to its emission composition. Biodiesel combustion usually emits negligible sulphur dioxide emissions, reduced polyaromatic hydrocarbons, carbon monoxide, and soot [62].

3.1.2. Ozone (O_3)

Ozone is extremely vital in our atmosphere since it shields all living species on Earth's surface from damaging solar UVB and UVC radiation. Because it absorbs both solar UV and terrestrial IR radiation, ozone has an important function in the stratosphere's energy balance [66]. Furthermore, ozone in the tropopause is a powerful glasshouse gas, and rising ozone levels at these altitudes contribute to climate change [67]. Ozone is one of the primary pollutants in the air during hot summer days, particularly in the urban cores of cities [68]. It is believed that vehicular traffic is the source of the chain reactions of volatile organic compounds (VOCs) that lead to the formation of ozone when these compounds are exposed to sunlight and nitrogen oxides. Ozone at ground level is a priority air pollutant because it is responsible for approximately 22,000 additional deaths each year in Europe and significant reductions in crop yields and loss of biodiversity [69,70]. Because ground-level ozone is a high-priority air pollutant, a significant amount of effort has been put into developing strategies for lowering emissions of the NOx and VOCs that it is derived from [69].

3.1.3. Nitrogen Oxides (NOx)

The combustion efficiency idea can be represented as the ratio of energy released during combustion to the high heating value of the fuel. Its efficiency can be improved by altering the air entrance to a combustion chamber, which may also affect the composition of the end emissions. The ability of a combustion system to utilize fuel fully without producing carbon monoxide or leaving hydrocarbons unburned is often referred to as combustion efficiency. In this step, the burner is "tuned up" to burn more effectively [65]. In general, a higher combustion efficiency often relates to a lower NOx emission [71].

NOx (nitrogen oxides) is commonly explained by the emission regulations along with the protocol of regulatory measurements involving the two gases nitrogen dioxide (NO_2) and nitric oxide (NO). Nitric oxide is an odorless and colorless gas:

$$N_2 + O_2 \leftrightarrow 2NO\ - 182.4\frac{kJ}{mol}$$

Thus, NO can be oxidized by oxygen into nitrogen dioxide:

$$2NO + O_2 \leftrightarrow 2NO_2 + 113.8\frac{kJ}{mol}$$

Nitrogen oxides are highly reactive in nature that encompass compounds including nitrous and, finally, nitric acid. The compounds are basically released in heavy vehicles, off-road equipment exhaust, and power plants [64]. On the same point, scientists insist that nitrogen oxides are formed when nitrogen in the atmosphere and oxygen start reaction at a higher temperature and pressure within a combusting cylinder that may have an excessive temperature of over 2200 °C and 20 bar [72].

The fuel is sprayed into it to produce tiny droplets during the direct injection procedure. It comes into contact with oxygen at the boundary surface between fuel droplets and air, where the local temperature within the fuel droplet is higher than the temperature required to create nitrogen oxide [73]. Typically, increasing amounts of oxygen and temperature are required to produce significant levels of nitrogen oxide. Such situations are common in diesel engines since they operate with a lean air-fuel combination and higher compression ratios [64]. Furthermore, diesel fuel is known to emit fewer nitrogen oxides during combustion than gasoline.

Diesel engines, on the other hand, might emit more nitrogen oxides into the environment if catalytic converters are used [74]. Nitrogen oxide emissions from biodiesel are frequently variable based on the engine family and testing methodologies. Nitrogen oxide emissions from pure biodiesel can be increased by 10%. However, the lack of sulphur in biodiesel allows for the use of nitrogen oxide management technologies, which is not applicable to regular diesel [56]. Furthermore, certain commercial additives for decreasing nitrogen oxide emissions in biodiesel blends have been successfully produced by some businesses [63].

3.1.4. Carbon Monoxide (CO)

CO is crucial in the oxidation of hydrocarbons. Fuel would break down into CO during combustion before oxidizing the carbon dioxide. As a result, the oxidation of CO is extremely slow. When the combustion reactions are not fully completed, CO is created due to a shortage of oxygen or insufficient mixing. CO is an odorless and colorless gas. Turns [75] described two ways to form CO and UHC, including overly lean and rich. In the case of an overly lean mixture, the flame cannot propagate through the mixture, and fuel pyrolysis with partial oxidation causes CO and UHC. For an overly rich mixture, fuel cannot mix with a sufficient amount of air, or the mix does not have a sufficient amount of time to be oxidized. This results in a significant amount of CO and UHC. The larger the air fraction and the better the blending, the lower the CO emission within the limits reported by Turns [75]. Because carbon monoxide emissions behave similarly to many other hydrocarbon emissions, their miles are frequently used for regulatory purposes to measure combustion's overall efficiency.

3.1.5. Sulphur Dioxide (SO_2)

SO_2 is a poisonous gas that is colorless and has a terrible odor. It is part of a broader series of chemicals known as SO_x. SO_x are emitted through the combustion of fuel, oil, and coal, in addition to other sulphur-containing materials. Various sources include smelting factories, electricity plants, and metal processing for various vehicles. The equipment, similar to diesel, is a significant producer of sulphur dioxide, but a recent federal law has lowered the sulphur content of biodiesel fuel, resulting in a significant improvement in the sector of gaseous emissions.

3.1.6. Hydrocarbon (HC)

Organic substances such as unburned hydrocarbons, which are made up of only carbon atoms and hydrogen, are also found in crude oil, fossil fuels, coal, and natural gas. All of these are classified into five different primary homologous and familial series (Alkadiene, alkenes, alkanes, cycloalkanes, and alkynes) [76]. In the homologous series, hydrocarbon also shares a unique formula that is similar to the physical and chemical, which is the most recognizable by hydrocarbons and the alkene family such as butane, methane, and propane, which also share the single bone of carbon-carbon construction. It substitutes fossil fuels, traditional glasshouse gases that cause and deplete ozone, with sustainable, environmentally friendly fuels that reduce the glasshouse effect, global warming, climate change, and regional growth. Figure 3 depicts the gaseous phase emission from biodiesel burning.

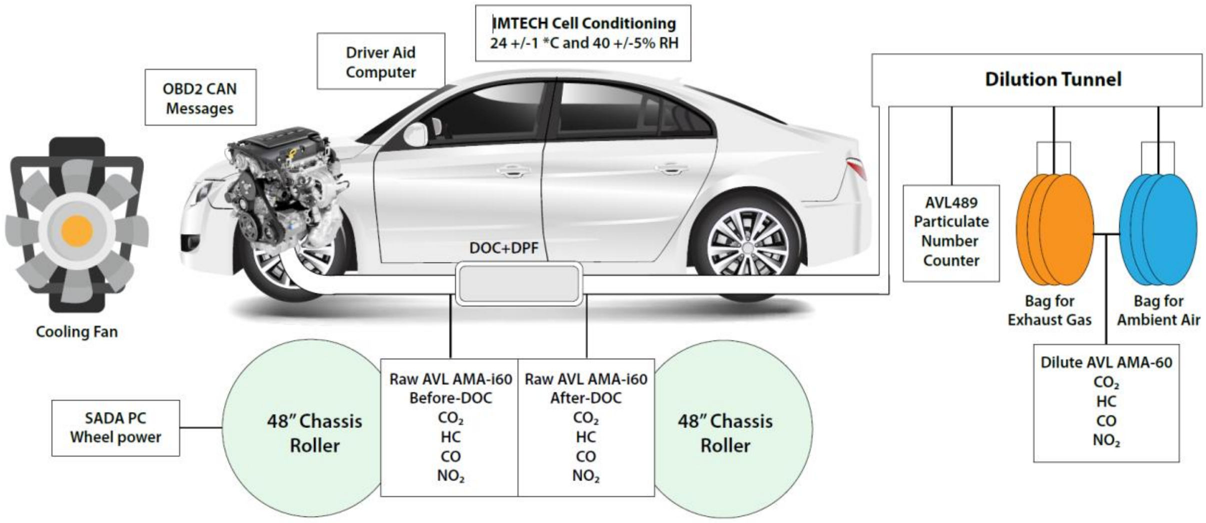

Figure 3. Biodiesel gaseous phase emission.

In conventional diesel combustion, the primary causes of hydrocarbon (HC) emissions are the accumulation of fuel in the crevice volumes of the combustion chamber, low-temperature bulk quenching of the oxidation reactions, locally over-lean or over-rich mixture, liquid wall films for excessive spray impingement, and incomplete evaporation of the fuel [77]. Other factors include low-temperature bulk quenching of the oxidation reactions, locally over-lean or over-rich mixture, and locally over-lean or over-rich.

3.2. Biodiesel Solid-Phase Emissions

Generally, solid-phase emissions include the presence of a wider range of particle constituents, such as sulphates, organics, and carbon, and the availability of metal oxides and metallic ash and toxic compounds such as PAH, carbonyls, reactive oxygen groups, inorganic ions, and quinones. Research suggests that biodiesel's burning rate is lowered by around 11 %; however, biodiesel emits fewer pollutants than diesel in terms of the environmental impacts of emissions. The emitting performance of every methyl ester usually varies depending on the attributes of the feedstock [52]. Emissions related to the pure form of biodiesel are less than conventional diesel except that of nitrogen oxides. The emission of nitrogen oxides from pure biodiesel increases by around 10 percent based on the engine's combustion properties and the test procedure [56]. Apart from this, sulphur emissions are eliminated in pure biodiesel more efficiently than in other diesel. Research has found that the emissions of exhaustive particles such as carbon monoxide, hydrocarbons, and particulates are less on an average by 66%, 47%, and 45%, respectively, for biodiesel than diesel fuel [78]. The extent of polycyclic aromatic hydrocarbons (PAHs), identified as cancer-causing compounds, is reduced by approximately 80% in biodiesel exhaust emission.

The physical characteristics of diesel particulate matter (DPM) include aspects that demonstrate the structure and sizes, such as the surface area, mass, particle distribution, and state of the physical mixture [79]. These properties in DPM impact human respiration in multiple ways. For example, the particle surface area influences how toxic compounds condense or adsorb on particles; the particle size governs where diesel particulate matter is deposited in the human respiratory tract; and the particle number determines their ability to coagulate, thereby growing larger [80,81]. Additionally, the state of the physical mixture of particles should be considered while ascertaining respiratory health impacts [79]. Moreover, incomplete combustion of fuel that contains traces of nitrogen, sulphur, and oxygen (such as biofuels) emits more products due to incomplete combustion. The presence of metals, sulphur, and ash from the partial combustion of lubricants contributes to a mixture of combustion engine chemicals [82]. Diesel engine exhaust contains up to 20,000 different chemical compounds, with only around 700 having been identified to the present time, including carbon monoxide, hydrogen cyanide, and diesel particulate matter [83]. In general, determining the chemical constituents of diesel particulate matter entails examining the presence of a broader range of particle constituents, such as sulphates, organics, and carbon, and the availability of metal oxides and metallic ash, and toxic compounds such as PAH, carbonyls, reactive oxygen groups, inorganic ions, and quinones.

The scientists who study public health are specifically concerned about the cancerous and non-cancerous impacts of diesel exhaust emission exposure. Thoai et al. [84] found an enhanced risk of lung cancer and associated mortality due to increased diesel exhaust exposure. Although biodiesel is believed to have a lesser adverse effect than diesel exhaust, problems related to respiration and inhalation are inevitable for those close to biodiesel production processes [85]. Moreover, the US regulatory body has determined that diesel exhausts act as an occupational carcinogen and pose a threat to humans when exposed to the environment. Diesel particulate matter has been associated with cellular oxidative stress and proinflammatory responses [86]. While studies related to biodiesel emissions have suggested better air quality and health benefits due to reduced particulate matter and concentrations of hydrocarbons, related literature on biodiesel exposure is not adequately available [15]. Generally, exposure refers to a contract between a target (say a person) and any chemical, biological, or even physical agent. The intermediary step within the process is based upon a risk model conceptualization comprising pollutants, dose, exposure, and health impacts [87]. It is common logic that evaluating every step in the risk model is crucial for understanding biodiesel's overall effects on human health and air quality. A study about tailpipe emission enables an initial step toward the cause [88]. Even after placing all the cards on the table, it is still not clear if reducing biodiesel tailpipe emissions would lead to a similar reduction in exposure within a nearby field environment or workplace.

Conventional biodiesel production uses alcohol as an acyl acceptor; the product is glycerol [55]. Thus, biodiesel's expanded production also refers to the increased availability of glycerol in the global market, causing a substantial pricing decline. With the increasing demand and adverse environmental issues, there has been a shift in the focus toward renewable energy sources, including biodiesel [89]. Despite these facts, this fuel is used in several countries as an essential alternative to diesel fuels.

As mentioned earlier, biodiesel fuels are mostly produced for commercial purposes through the esterification of plant oil and animal fats in the presence of a catalyst under controlled conditions. The compositions of emission exhaust of biodiesel have contributed to reducing environmental pollution at the place they have been used [42]. This gained a lot of attention and concerns in the present scenario and eventually would be impactful in the future. Thus, constant development and improvement of biodiesel production processes are required to produce cleaner emissions with much lesser effects on the environment and, at the same time, with a minimized cost of production compared to fossil fuels [87]. Hence, government initiatives may spur the sector and maintain biodiesel as a highly sustainable fuel for commercial purposes.

3.2.1. PM Emission

Particulate matter (PM) is a complex mixture of solid particulates and liquid droplets suspended in the air. PM could also originate from dust storms and fires along with volcanoes plus man-made sources (for example, emissions from vehicles, combustion, and industrial processes). Thus, PM emission from automobiles is regarded as a very serious problem, which is also similar to the NO_x regulations and PM emission, which is also imposed regionally and worldwide. Thus, mineral particles in coal are also left behind, such as the ash in the combustion, plus the prime sources of the particle emission. Agarwal et al. [90] reported that at all operating temperatures, biodiesel and its blends produced more benzene soluble organic fraction (BSOF) in engine exhaust PM than mineral diesel. When compared to mineral diesel, pure biodiesel's exhaust contains a greater number of particles of a smaller size; however, pure biodiesel also produces a greater number of particles of all sizes. The particle sizes of biodiesel that had the highest peak concentrations of particles were reduced. The control of particle emission has been researched for many years, and their technologies are included and well established. Figure 4 summarizes the diesel particulate matter reduction strategies.

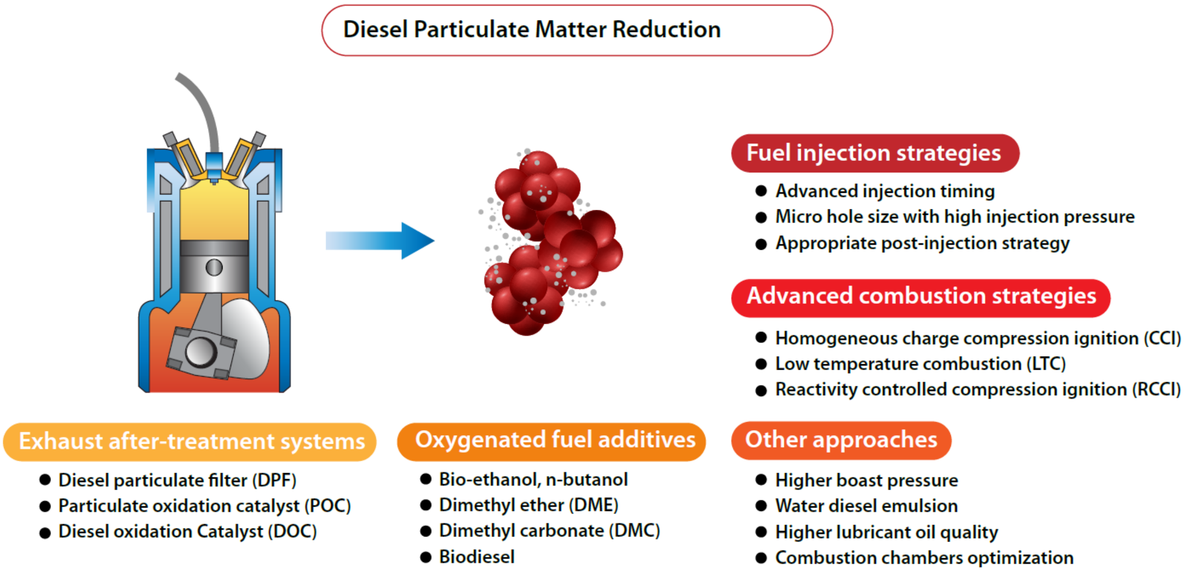

Figure 4. Diesel exhaust particulate matter reduction technologies.

3.2.2. Elemental and Organic Carbon

The operationally elaborated method routinely quantifies the elemental and organic carbon fractions. Therefore, the distinction between the elemental and the organic is not based on the molecular structure but rather on the optical absorption of the PM sample during the thermal evolution process. As a result, an analytical method that begins with the sample being heated in an oxygen-free (helium) environment to determine the amount of organic carbon is then continued through an oxygenated environment to determine the amount of "elemental carbon". As a result, some of the carbonaceous material is pyrolyzed in an environment rich in helium and at high temperatures, which results in an increase in optical attenuation [91].

3.2.3. Trace Metals

As mentioned earlier, diesel engine exhaust contains up to 20,000 different chemical compounds. Agarwal et al. [90] investigated the differences between the concentrations of metals in the exhaust emissions produced by diesel and biodiesel. Metals such as Ca, Mg, Fe, and Zn were discovered in higher quantities in biodiesel exhaust for almost all operating conditions. On the other hand, metals such as Cu, Pb, Cr, Ni, and Na were discovered in excess in the exhaust particulate of mineral diesel. Experiments investigating metal concentrations showed that some metals were found to be in excess in mineral diesel while others were found in excess in biodiesel. The most important findings from the research indicated that biodiesel's self-lubricating properties prevented metals typically produced by engine wear from being found in the particulate matter of biodiesel exhaust. The presence of metals, sulphur, and ash from the partial combustion of lubricants contributes to a mixture of combustion engine chemicals.

4. Impact of the Biodiesel Combustion Process

4.1. Gaseous Emission Effect

Different fuel sources have been proposed and are evolving in response to the growing demand for environmental concerns. Alternative fuel sources, such as biodiesel, are appealing because they reduce engine emissions. As a result, biodiesel produces a higher NOx emission than regular diesel fuel. Many factors contribute to the increased NOx emission from biodiesel. As a result, the effects of biodiesel combustion on NOx and approaches to reduction are also included in diesel engines. The mechanism of NOx formation is the kinetics behind the NOx-forming action reactions. The combustion of biodiesel results in higher levels of NOx emissions, which are determined by a number of factors, including the physicochemical properties and molecular structure of the biodiesel, the temperature of the adiabatic flame, the ignition delay time, the injection timing, and the load conditions of the engine [92].

4.2. Solid Emission Effect

Compared to petroleum diesel emission, biodiesel emission contains fewer amounts of particles. Bünger et al. [93] reported a lower mutagenic potential and higher toxicity of exhaust particles produced by biodiesel compared to that of diesel. They suggested that lower emissions of polycyclic aromatic compounds are responsible for this. The higher toxicity was attributed to the carbonyl compounds and unburned fuel, and it lessens the benefits of biodiesel's lower emissions of solid particulate matter and mutagens.

4.3. Cultivation and Production Impact on Human Health

The human body is subjected to polluted groundwater as a result of the presence of biodiesel in contaminated underground water resources (drinking water). The effect that this contamination has on human health is inversely proportional to the concentration of the contamination [94]. Both the manufacturing and agricultural sectors present a significant risk to human health. The vast majority of cases that have been reported across the world are due to exposure in this field [95]. After the extraction, the next human health concern is the processing of biodiesel. Many humans are exposed to biological and chemical agents in the processing, e.g., ethanol manufacturing consists of sodium hydroxide, ammonia, and sulfuric acid. These three caustic chemicals can cause skin and eye infections [96]. The chances of cancer are meagre, where at least minimum hygiene regulations are available.

Fatty acid esters, the primary constituents of biodiesel resources, are harmful to human health [97]. Until recently, the impact was limited to cardiovascular disease. Nonetheless, it is now clear that fatty acids have a wide range of effects on metabolic diseases such as type 2 diabetes, inflammatory disease, and cancer [98]. Similarly, biodiesel production involves the reaction of lipids with methanol; methanol is a highly toxic chemical to human health and is linked to a variety of health problems. Sodium and potassium are caustic chemicals that act as catalysts in the production of biodiesel [99]. Many fuel products contain hydrocarbons, which have long-term consequences such as skin and systemic disease [99]. Other risks to human health include air pollution, explosions, and fires caused by these highly reactive chemicals.

An increase in crop cultivation for biodiesel production will have indirect effects on human health. The system effects due to biodiesel are shown in Table 4. For example, corn is cultivated for biodiesel resources, increasing nitrate concentrations in surface and underground water. As a result, most of the underground drinking water storage is full of maximum contamination levels; a small increase will increase waterborne diseases. To mitigate this problem, an energy-intensive drinking water treatment should be carried out [100]. This will require an additional 2360 million kWh energy annually for nitrate treatment; if not performed thoroughly, the nitrate may cause human disease [101]. The nitrate cannot be seen; the taste, the smell in water, and too much drinking lead to methemoglobinemia, also called blue baby syndrome. As the name indicates, it happens to children of a lower age. It causes the skin to turn bluish, and consuming too much nitrate in water results in death [102]. The system effects due to biodiesel are shown in Table 4. For adults, it increases heart rate, decreases blood pressure, and other symptoms include vomiting and stomach cramps. Medical experts also suggest an increased risk of cancer, especially gastric cancer. Hence different water treatment plants are constructed to minimize these effects [102]. The comparison of diesel and biodiesel properties' effect is shown in Table 5.

Table 4. Biodiesel effects on functional body systems.

Systems Affected	Diseases	References
CVS (Cardiovascular System)	Cardiovascular Diseases, Increased Heart Rate, Decreased Blood Pressure.	[102]
Hematological Disorder	Blue Baby Syndrome, Met Hemoglobinemia	[101]
Infections	Skin and Eye Infection	[101]
Skin effect	Skin to turn bluish	[101]
Others	Increased Risk of Cancer, Inflammatory Diseases, Type II Diabetes, Vomiting and Cramps	[101]

Table 5. Comparison of diesel and biodiesel effect.

Properties	Biodiesel	Diesel	References
Environmental Impact	Less	More	[56]
Emission of Particulate Matter	Less	More	[99]
PAH (Cancer Causing)	Decreases to 80%	Increased	[99]
Sulphur Emission	More Efficient	Less Efficient	[44]
CO (Carbon Monoxide)	Decreases to 66%	Increases	[103]
Hydrocarbons	Decreases to 47%	Increases	[103]
Other Particulate Matter	Decreases to 45%	Increases	[56]
Air Quality	More Improved	Less Improved	[104]
Sulphates, Carbon Metal oxides, Metal Ash, Toxic Compounds, Carbonyl, Reactive Oxygen Groups.	Decreased	Increased to Wide Range	[96]
Lungs Cancer, Mortality, Respiratory Problems	Reduced Rate	High Rate	[46]

4.4. Biodiesel Combustion Impact on Human

The combustion of biodiesel has been shown to induce cytotoxic effects in living organisms. These effects are induced in BEAS-2B and A549 cells, as was previously discussed, and they are manifested as cell death [105]. This also induces the production of intracellular reactive oxygen species and increases antioxidant genes in the human body. According to Lankoff et al. [106], the attack on intracellular reactive oxygen (ROS) is an indirect attack on DNA, which may generate a whole series of damaged DNA. The Southwest Research Institute conducted the most in-depth investigation into the effect of biodiesel on the emission of toxic compounds, and the findings were strikingly similar to the findings obtained from animal testing of their susceptibility. Additionally, this fatty liquid is known to be the cause of erratic heart rhythms and kidney damage [100].

Children with asthma who were exposed to NO_2, PM_{10}, and $PM_{2.5}$ had a higher prevalence of respiratory symptoms and a greater need for medication than children without asthma, according to one of the first studies evaluating the acute effects of air pollution, which included 3676 children from 12 locations in the state of California, USA [107]. The most significant association was with NO_2 exposure, with a 2.7-fold increase in symptom prevalence for every 24 ppb increase in the NO_2 concentration [108]. A study conducted in Hubei province, China, on 4454 asthma deaths between 2013 and 2018, discovered increases in mortality associated with $PM_{2.5}$, O_3, and NO_2, respectively [109]. According to the findings of an Australian study on adults, those who had been exposed to NO_2 for at least 5 years and lived less than 200 m away from a major road were at an increased risk of developing asthma and experiencing a significant decline in lung function [110].

Research indicates that exposure to biodiesel affects phagocytic cells, and the long-term repercussions include an increased risk of respiratory infections and a worsening of lung conditions that were already present [101]. Because biodiesel fumes can adhere to the lungs' surface, the immune cells that attempt to eliminate them end up destroying the lining of the airways instead [111]. It becomes difficult to breathe due to the alveoli, which are one of the places in the lungs and blood that exchange oxygen and carbon dioxide during inhalation and exhalation. This is one of the complications that can result from chemical pneumonia, which is an irritation of the lungs. T cell responses are found to be altered more frequently by PM. PM creates a Th2-like microenvironment with excessive

IL-4 and IL-13 production in the lung [112]. According to Leikauf and Jang [104], alveolar macrophages are considered to be important players in innate immunity because they influence inflammatory responses to take on a Th2 phenotype by producing IL-13, as shown in Figure 5's adaptive immune response.

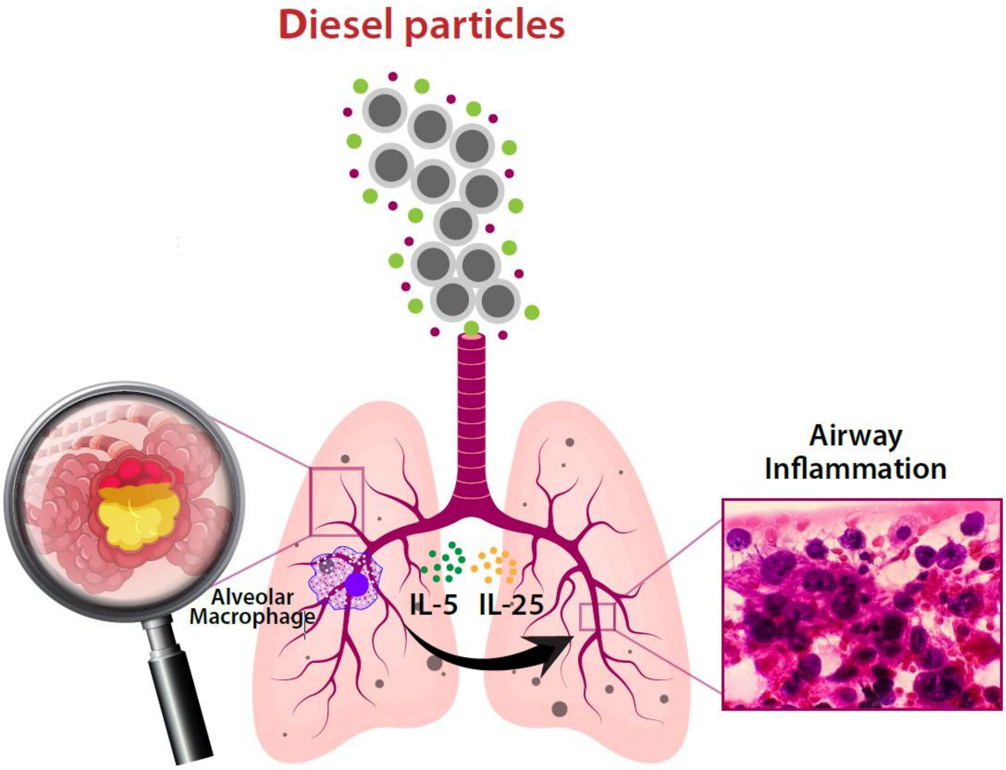

Figure 5. Changes in Th2 cytokines in macrophages after exposure to TiO_2 particles.

Every cell in our body needs oxygen to function; oxygen is then used by cells to obtain energy from food. Respiratory epithelial cells are present in the respiratory tract and used for breathing functions, and these cells protect the airway tract from potential pathogens, infections, and tissue injuries [113]. When biodiesel fumes become stuck to the lungs' surface, and immune cells try to remove them, the respiratory airway paths are destroyed. Moreover, Duan et al. [111] insist that if a person is exposed for a long time, the air canals become thin and respiratory diseases occur. All breathing diseases, such as asthma, cancer, etc., develop due to these canals' collapse. Hydrocarbons have low surface tension and low viscosity; they penetrate deep into the lungs, resulting in the above diseases [113]. In general, these chemical fumes degrade surfactant, airway epithelium, alveolar septae, and pulmonary capillaries, resulting in pneumonia, CNS effects (slurred speech, headache, disorientation, dizziness, syncope, hallucination, and violent behavior), skin irritation, and mucous membrane irritation [114]. Epidemiologic studies of different occupational cohorts consistently show that the risk of lung cancer among workers classified as having been exposed to diesel exhaust is approximately 1.2 to 1.5 times the risk in those classified as unexposed [115]. Yenamala et al. [116] demonstrated that combustion emissions from plain biodiesel are more harmful than petroleum diesel fuel, as evidenced by increased recruitment of bronchoalveolar lavage (BAL) inflammatory cells, increased tissue damage and oxidative stress, and increased release of inflammatory mediators. Mice exposed to biodiesel particles showed longer retention and worse particulate clearance. The damages to the human structure are shown in Table 6.

Table 6. Biodiesel damages human.

Stimulus	Structure Damaged	Ref.
Reactive Oxygen Species	Damages DNA	[56]
Oily liquid	Irregular Heart Rhythm Damage to Kidney	[100]
Biocidal Fumes	Destroys Walls of Breathing System Which Causes Chemical Pneumonia	[111]
Stimuli destroying surfactants, Airway Epithelium, Alveolar Septa, Pulmonary Capillaries	Pneumonia, CNS effects (Slurred Speech, Headache Disorientation, Dizziness, Syncope, Hallucination, Violent Behavior), Skin Irritation, Mucous Membrane Irritation, Asthma, Cancer	[113]
Fumes	Asthma, cancer, destroy surfactant, airway epithelium, alveolar septae, and pulmonary capillaries	[113]
Combustion	Cell death	[104]

5. Future of the Biodiesel Landscape

Although biodiesel is now employed on a modest scale, it is an important fuel alternative since it has the potential to become a part of a country's energy infrastructure due to its commercial practicality. It is considered carbon-neutral since the carbon dioxide produced in the environment during fuel burning is recovered and utilized to grow plant oil crops. Because of its lengthy chains of fatty acids with a few double bonds, it has a higher percentage of cetane than diesel [117]. Furthermore, it is free of aromatics and contains 10 to 11 percent oxygen by weight, which reduces emissions such as carbon dioxide, hydrocarbons, and other particles in the exhaust gas [103]. Biodiesel is said to have less energy than petro-diesel, which means that more biodiesel is needed to generate the same amount of energy.

Research has looked at varying concentrations of biodiesel chemicals and the effects these chemicals had on the health of human subjects. According to the study's findings, a one billion dollar increase in ethanol, the primary component in biodiesel production, will affect the production processes and increase ozone in areas with a high population density. Studies also emphasize a proper policy structure for the use of biodiesel in vehicles [118]. Three types of health hazards influenced by fuels are soil and water pollution; the effects of this pollution will only be limited to farmers and local harvesters. Second is the air pollution due to vehicle emissions, which will have a national impact, and many people will be affected. Moreover, the most lethal disease is the pre-existing cardio-respiratory disease. Third and last is the burning of these chemicals, which will have an impact on the regional and the national level [119]. A sample of biofuel mandates for each nation is shown in Table 7.

Biodiesel's environmental benefits are numerous. Because the plants used to make biodiesel, such as soybeans and palm oil trees, absorb CO_2 from the air, the US government views it as a carbon-neutral fuel. Therefore, the plants' absorption of CO_2 neutralizes it, allowing for these combustions [119]. The greenhouse effect weakens, the amount of CO_2 in the atmosphere does not rise quickly, and there is no early onset of climate change. Biodiesel biodegrades quickly, and scientists have shown that this process occurs more rapidly in water [119]. The newest studies show pollutants' consequences on marine life [120]. Regarding the fuel category, such as the beginning of the feedstock, engine type, and operating circumstances, there is not enough information available to determine the possible mutagenicity of biodiesel emissions. PAHs cause the majority of the mutagenic activity in biodiesel exhaust.

Biodiesel is seen as an alternative to oil and coal because it reduces carbon dioxide and global warming [121]. Because of this, the government started to set the target of converting fuel petroleum to biodiesel. However, new findings suggest that health and environmental costs (agriculture) will outweigh the benefits to the climate. According to Professor Nick from the Environmental Centre, who is leading a biodiesel research program, the land use for biodiesel is up to 215 million hectares [122]. We need to plant at least one-third of this to meet the biodiesel requirement. To overcome this model, scientists are advised to grow fast-growing trees [56]; hence, people have started to populate the whole of Europe with poplar and willow. However, due to these trees, a chemical is released into the environment, which is called isoprene. Moreover, when this chemical is combined with air, it forms ozone, which is a key component of smog and is considered a cause of crop losses [123].

Table 7. Biofuel mandates for different countries.

Country	Current Target	Targets for the Future
Argentina	B7, E5	B10 by 2019
Brazil	B2, E22–23	B5 by 2022
Canada	B2, E5	*
USA	Biodiesel: 1.0 billion gallons; 0.91% Advanced biofuels: 2.01 billion gallons; 1.22% Cellulosic biofuels: 3.46–12.9 million gallons; 0.001–0.010% Total renewable fuels: 15.3 billion gallons; 9.22% 7.7 billion US gallons (approximately 29 billion liters) of renewable fuel be blended with gasoline by 2012	36.5 billion gallons of biofuels by 2022 21.9 billion gallons from lignocellulosic biofuels
Costa Rica	B20, E7	*
EU Stats	5.77% renewable transport fuel	11% renewable transport fuel by 2020
China	N/A	E10 by 2020
India	E5	21% biofuels by 2020
Japan	N/A	11.5% biofuels by 2030
Australia	Queensland: E5 New South Wales: E10	*

* B refers to biodiesel and E to ethanol. The number beside B or E is the percentage integrated into transport fossil fuel.

According to studies, in order to fulfil the biodiesel growth objective, the quantity of isoprene in the air would rise by up to 39%, resulting in an increase in ozone levels. Biodiesel greatly influences human health and the environment, and substantial study is being conducted to analyze the outcomes. Biodiesel has three sorts of impacts on the human body: influence on the body, cells, and internal system [124]. On the other hand, environmental repercussions include ozone depletion, a rise in hydrocarbons, marine life, and so on. Particles from both combustion and no combustion processes are closely related to oxidative stress. The factor's effect on the biodiesel landscape is shown in Table 8.

After the exposure to these biodiesel particles, many reactions also follow closely. The responsive reaction activates cell signaling and releases proinflammatory mediators [125]. The factors that affect the biodiesel landscape are shown in Table 8. This result can also be seen through biodiesel exhaust. Various life cycle assessment analyses on biofuels have provided us with results about biodiesel life. It was concluded that the biofuel span consists of 5 to 6 months to years depending on its storage conditions [126]. Generally, biodiesel fuel is a good biodegradable fuel; hence, it is beneficial for human use compared to other gallons of diesel.

Table 8. Factors' effects on the biofuel landscape.

Factors	Effect	References
Increased ethanol	Increase in ozone, isoprene up to 39 % increase in injury, Asthma, and Lung Cancer.	[40]
Soil and water pollution	Former and local harvesters are affected.	[40]
Air pollution	Cardiorespiratory diseases, National Impact	[127]
Burning effect	National and regional effect	[127]
Combustion	activation of cell signaling and the release of proinflammatory mediators	[125]

When determining the viability of biofuels, it is necessary to consider the effects they have on the surrounding environment and a great number of other aspects of sustainability. These include the costs of production and the competitiveness with fossil fuels, the provision of employment, the development of rural areas, the impacts on human health, and the security of food, energy, and water. To avoid shifting the burdens from one part of the life cycle or supply chain to another, it is essential that the sustainability aspects of biofuels are evaluated on a life cycle basis across full supply chains. This evaluation must take place across the full supply chain. It is essential to keep in mind that life cycle analysis (LCA) and other types of sustainability assessments are of little use if the findings cannot be relied upon, which is another thing to keep in mind. As a result, stringent auditing of biofuel supply chains is absolutely necessary in order to forestall unfavorable socio-economic effects and to guarantee the fuels' traceability and reduce the possibility of fraud. In addition, if life cycle assessment is going to be taken seriously and used for policymaking, improving transparency, data availability, and data sharing is essential. In the same way that national inventories have been developed for GHG reporting under the Kyoto Protocol, this goal could be accomplished by creating open databases on both the national and international levels. It is also very important to ensure that the data and models from the various fields of study used in LCA maintain reasonable levels of transparency, rigor, and robustness. This will help prevent the data and models from being misused and misinterpreted [113].

6. Conclusions and Future Research Direction

Overall, the need for sustainable measures for energy use today is more critical for the environment and public health. The increasing levels of adverse side effects of human practices on the environment have become a serious issue, especially for respiratory health. However, the use of these fuel sources has also been linked explicitly to respiratory health effects, cancer, the breakdown of ozone, compromised ecosystems, extreme changes in weather patterns, and various other issues. So, resources such as coal and petroleum sources are no longer proving sustainable. While these fuel sources have been useful for the past few years, the need for new alternatives is essential to help safeguard the environment for future generations. Some of the key conclusions of the present study are listed below:

- An essential resource of alternative fuel would be biodiesel fuel sources, which seem to be both affordable and effective for fuel. However, before people can make the most of these resources, the relevant parties must conduct further research and gain more insight into this topic.
- The challenges in producing oil and the possible side effects on the environment or public health in the long term need to be considered.
- Biodiesel fuel will significantly reduce carbon emissions but increase the ozone in atmospheric air.
- Biodiesel fuel usually emits higher NOx than other regular diesel.
- While biodiesel seems like a suitable investment as a future fuel source, more research is required to ensure that it is a feasible alternative fuel source.

The future perspective for managing fuel sources will still be an important topic. Even though people are choosing other alternatives, such as solar and electric sources of power, fuel is still important for the running of economies and various livelihoods [16,128]. It is already clear that the current power sources are still important, but they also have a serious consequence on people's lives, especially regarding respiratory health effects [129].

- Biodiesel is an important fuel source and using it the right way will have many benefits for the environment.
- Use of the fuel in the right way will require immense research and analysis to ensure its compatibility with modern-day sources of fuel.
- Research will make it easy to acquire information on the different and essential fuel sources in our lives today, including biodiesel.
- Future research on these fuel sources might include resources such as artificial intelligence, big data, and technical expertise for the best results.
- It influences the protection and conservation of the climate by controlling the emission of harmful chemicals from conventional fuels.
- It enhances the production of renewable fuel for sustainable development and maintaining atmospheric emissions.

- Advanced production of mass quantities of biodiesel as a bio-fuel helps to initiate a shift in the trend towards the utilization of innovative energy production, smart energy generation, and smart energy utilization.
- Respiratory syndromes or issues are highlighted to highlight the harms on human life due to excessive usage of fuels that can be controlled by different means such as reducing the transportation pressure in urban areas, facilitating urbanization, controlling fuel emissions, etc.
- It will add to the apex of low-carbon transport using biodiesel, which encourages further research on alternative sources for biodiesel production.
- The futuristic significance of the present work includes the human health aspects of using biodiesel, which is also causing a few issues that can be minimized using advanced research techniques and technologies.
- It covers the gap in the past literature to elaborate on the significance of vegetable and organic components based on biodiesel that can encourage research on gaining a higher biomass yield per acre to make it more profitable.
- Future research should focus on the full characterization of biodiesel combustion products and the specific mechanisms of interactions of these emissions in connection with the observed inflammatory responses and poor clearance to further understand the negative effects of biodiesel usage on human health.

There is no doubt that there is a link between biodiesel exposure and human health, but most of the data is unavailable between emissions and human health effects. These biodiesel studies are absent from most of the literature; hence, many see this as "green," i.e., more friendly than other alternate types of diesel.

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