Petroleum and Coal

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BIODIESEL: REDUCING ENVIRONMENT POLLUTANT AND DEPENDENCY ON PETROLEUM DIESEL

Ved Kumar*[1], Padam Kant[2] and Aniruddh P. Chaudhary[2]

[1] *Department of Chemistry, H.B.T.I. Kanpur-208002, India*
[2] *Department of Chemistry, University of Lucknow, Lucknow-226007, India*

Received July 11, 2016; Accepted October 7, 2016

Abstract

As India, the sixth largest producer of greenhouse gases (GHG), contributing almost 3% of the world's total emissions and fifth largest energy consumer country in the world. India imports 70% of crude oil and experts anticipate that over 94% of its crude oil will be purchased from foreign country by 2030. Economically, biodiesel reduced country's reliance on crude oil imports, foreign exchange saving. Transesterification process is mainly used to decrease the viscosity of edible, non-edible oil and waste oil, however other properties of the oil remain same and this new fuel has been called biodiesel. Biodiesel can be used in any diesel engine without any modification such as B5 to B50 are safe for operation in any compression-ignition engine. Various studies showed that pollutants like CO, CO_2, SO_X, HC, PAH, PM can be reduced by using blended and pure biodiesel. NO_X emissions are increased by using biodiesel. Biodiesel is an environment friendly biofuel since it provide a means to recycle of CO_2; biodiesel does not contribute global warming. This review paper focuses on the biodiesel production and its potential for reducing environmental pollution that ensure overall sustainable development in India.

Keywords: Biodiesel; Transesterification; Environmental friendly; Blending; Demand in India.

1. Introduction

Recently, biodiesel has been receiving increasing attention as an alternative fuel to its environmental benefits. Also, it is derived from renewable sources which are considered as strategic opportunities to favour environmental sustainability, to improve the population's quality of life and to promote the development of more efficient and equitable economic system. Since the petroleum crisis in 1970, increasing prices and uncertainties concerning petroleum-diesel availability, a growing concern of the environment and the effect of greenhouse gases during the last decades, has revived more and more interests for using the edible and non-edible oils as a substitute of petroleum diesel [1]. The production and commercialization of biodiesel in India could provide an opportunity to diversify energy and agriculture activity, reducing dependence on petroleum diesel and contributing to economic growth in a sustainable manner.

1.1. Energy scenario of India

In India, 70% of people live in rural areas and rural energy is most vital for sustaining their livelihood. 21% of the villages and about 50% of rural households are still not electrified. There is also wide disparity in the per-capita energy consumption between rural and urban areas like: 75% of rural households depend on firewood for cooking, 10% on dunk cake and about 5% on LPG as against 22% of urban households depend on firewood for cooking, another 22% on kerosene and 44% on LPG. Similarly for home lighting, while 50% of rural households depend on kerosene and another 48% on electricity, 89% of urban households depend on electricity and another 10% on kerosene. Energy occupies the centre stage in almost all the daily activities-cooking, access to clean water, agriculture, education, transportation, employment generation and environment sustainability. About 80% the rural energy used is derived from biomass; this puts heavy pressure on the already declining vegetation in villages. Use of inefficient chulhas often increases the drudgery of women and children who are involved in collection of fuel wood [2]. Cooking accounts for about 60% of the overall energy and 80% of the non-commercial energy used in rural India. More than 90% of the cooking is done with fire wood and bovine dung, i.e., cow-dung [3], show in following figure1. Increased energy conservation, improved energy efficiency and enhanced energy production from renewable sources (such as edible and non-edible oil) may definitely help India to become self sustaining in terms of energy availability.

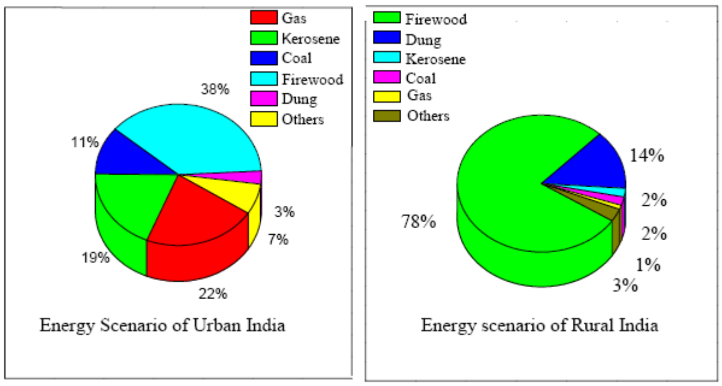

Fig.1 Cooking and lightning energy scenario of rural and urban India

Renewable energy can facilitate economic and social development in communities if the policies are intelligently designed and carefully planned with local inputs and cooperation. In poor rural areas, the cost of renewable energy projects will absorb a significant part of participants, small incomes. Renewable energy sources can be replenished in a short period of time and it is clean i.e. it produces lower or negligible level of greenhouse gases and other pollutants when compared with petroleum energy sources [4].

1.2. Petro-diesel energy demand in India

India's energy demand is primarily met through non-renewable sources such as coal, natural gas and oil. These will continue to play a dominant role in its energy scenarios in the next few decades. The highest role in its energy comes from industry, followed by the transportation sector which consumed about 16.9% (36.5 m oil equivalent) of total energy (217 million t) in 2005-06. Figure 2 shows increasing petroleum diesel demand in India.

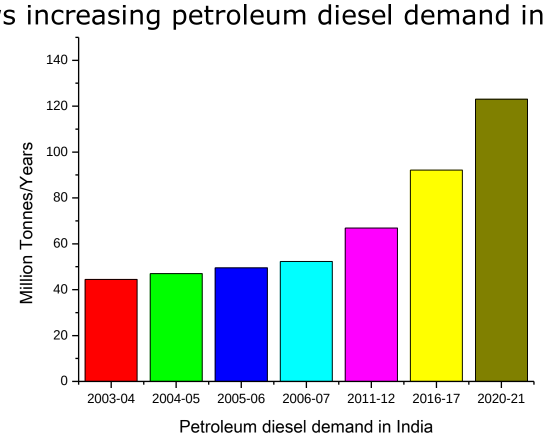

Fig. 2 Petroleum diesel demand in India (2016-21)

This growth will only escalate over the next several years since India's vehicular population is expected to grow by 10-12% per annum. Hence securing a long term supply of energy sources and prioritizing development are critical to ensuring the country is looking for alternative energy option from biofuel to meet the transportation sector demand. To promote biodiesel as an alternative fuel source, the government of India stipulated mandatory blending requirement of petroleum diesel with biodiesel, aided by policy incentives designed to facilitate optimal development and utilization of indigenous edible and non-edible feed stocks for biodiesel production [5].

1.3. Biodiesel demand in India

India depends on imports of crude oil to satisfy energy demands. As the population and economy continue to grow, the demand will continue to increase. Concurrently, the pressure to reduce environmental impact and mitigate climate change mounts. The hope is that domestic production of biodiesel will replace some of the petroleum fuel use to reduce dependence on imported oil and address environment issues [5]. The National Mission on biodiesel stated a five percent blending target of biodiesel in conventional diesel, with a 20-percent blending target for 2020-21. The mission also announced an expansion of the existing ethanol production to reach the same target. To produce a sufficient amount of biodiesel to achieve the 20 percent blending target in transportation, agriculture and industry sector in India given in figure 3 [5].

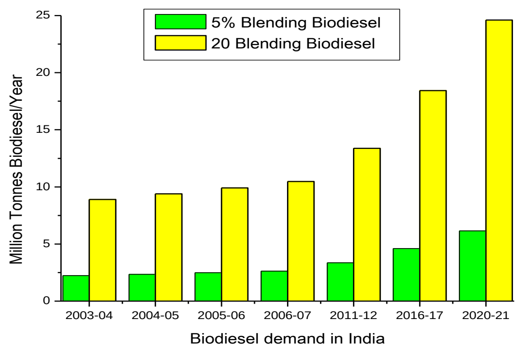

Fig. 3 Biodiesel demand and blending target (2020-21) in India

1.4. Combustion of petroleum diesel in India

Compared to biodiesel, petroleum diesel contains a much wider variety of chemical molecules, including for more sulphur. Most of these have been sequestered in the earth for ten and seven years of millions years. The burning of petroleum fuels releases host pollutants and heavy metals that effect local and regional air quality and these are well linked with global warming issues. Transport related air pollution leads to reduce visibility damage to vegetation and building and increased incidence of human illness and premature death. Road transport is also growing contributing to air pollution in many developing countries and cities particularly where diesel remains the predominant. Table 1 is summarized below shows the main environmental and health impacts associated with the petroleum primary combustion products including CO_2, CO, unburned hydrocarbon, NO_x, SO_x, particulates.

Table 1. Environmental and health impacts of emissions from petroleum combustion

Combustion product	Impact
CO_2	Contributes to Global Warming and Climate change.
CO	Results incomplete combustion or burning. In the atmosphere, CO reacts with Oxygen to form Ozone, highly reactive molecules that damages plant leaves, human and animal lungs.
Benzene PAH & nPAH	The smallest aromatic hydrocarbon and a highly toxic carcinogenic.
NO & NO_x	Ozone precursor, they also react with atmospheric water and create acid rain.
SO_2 & SO_3	Acid rain precursors.
Lead	Has been phased out from gasoline in most of the countries, but is still used as an octane enhancer
PM	Formed from SO_x, NO_x and hydrocarbons

2. Biodiesel

Biodiesel is an alternative fuel formulated exclusively for diesel engines. It is made from edible, non-edible oil or animal fats or it is the name for a variety of ester based fuels generally defined as the mono alkyl ester made from edible and non-edible oil through simple Trans-esterification process. Biodiesel is defined as mono- alkyl esters of long chain fatty acids derived from edible, non-edible oil and animal fats or waste oil, which conform to ASTM D6751 specification for use in diesel engines. Fuel grade biodiesel must be produced to strict industry specification in order to ensure proper performance. Biodiesel contains no petroleum, but it can be blended at any level with petroleum diesel to create a biodiesel blend [6]. Biodiesel is defined as an environmentally friendly fuel due to the biodegradability, non-toxicity, no sulphur and oxygen content. The best part of the biodiesel (90-98%) is mineralized in 21-28 days under aerobic or anaerobic conditions [6-7]. Chemically, biodiesel is fatty acid methyl esters (FAME) and they are called biodiesel only when used as fuel in diesel engines and heating system [8].

2.1. Chemical composition of edible and non-edible oils

Edible and non-edible oils also known as triglycerides, its chemical structure is given in the figure 4, comprising of 98% triglyceride and small amount of mono- and diglyceride. Triglycerides are esters of three molecules of fatty acids and one of glycerol and contain substantial amounts of oxygen in their structure.

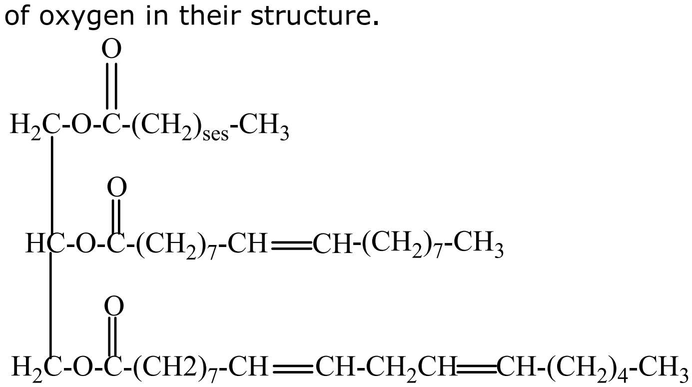

Fig. 4. Structure of Typical triglyceride molecules

In the triglycerides, alkyl chain of edible oils predominate the palmitic oleic and linoleic fatty acids. Different types of edible and non-edible oils have different types of acids. The empirical formula and structure of various fatty acids present in edible and non-edible oils are given in table 2 [9]. Fatty acids fully saturated with hydrogen have no double bond [10]. Fully saturated triglycerides are solid at room temperature and thus as such cannot be used as fuel. Triglyceride molecules have molecular weight between 800 and 900 and are thus nearly four times larger than petroleum diesel. Due to higher molecular weights, vegetable oil has low volatility and because of their unsaturation, edible and non-edible oils are inherently more reactive than diesel fuels. As a result, they are much more susceptible to oxidation and thermal polymerrization reaction.

2.2. Physical and chemical properties of edible and non-edible oil as fuel

Fuel properties of edible and non-edible oils have been studied by many researches. Compared to the diesel the fuel properties of edible and non-edible oil as listed in table 3 indicate that the kinematics viscosity of vegetable oils varies in the range of 30-40 cSt at 30˚C. The high viscosity of these oils is due to their large molecular mass in the range 600-900, which is about 20 times higher than the petroleum diesel fuel. The flash point of edible and non-edible oils is very high (above 200˚C). The volumetric heating values are in the range of 39-40 MJ/Kg, as compared to diesel fuels (about 45 MJ/Kg). The presence of chemically bound oxygen in edible and non-edible oils lowers their heating values by approx. 10%. The cetane numbers are in the range of 32-40 [11]. The major problem with the direct use of vegetable oils as fuel into compression ignition CI engine is their higher viscosity. It interferes the fuel injection and atomization and contributes to incomplete combustion, nozzle clogging or chocking excessive engine deposits, ring sticking contamination of lubricating oil *etc.* The problem of higher viscosity of vegetable oils can be overcome to a greater extend by various technique, such as heating, dilution, emulsification, esterification and transesterification *etc.* [12].

Table 2. Chemical structure of common fatty acid of edible and non-edible oils

Name of Fatty Acid	Chemical name fatty acid	Structure (xx:y)	Chemical formula of fatty acid
Lauric	Dodecanoic	12:0	$C_{12}H_{24}O_2$
Myristic	Retradecanoic	14:0	$C_{14}H_{28}O_2$
Palmitic	Hexadecanoic	16:0	$C_{16}H_{32}O_2$
Stearic	Octadecanoic	18:0	$C_{18}H_{36}O_2$
Arachidic	Eicosanoic	20:0	$C_{20}H_{40}O_2$
Behenic	Docosanoic	22:0	$C_{22}H_{44}O_2$
Lignoceric	Tetracosanoic	24:0	$C_{24}H_{48}O_2$
Oleic	Cis-9-Octadecenoic	18:1	$C_{18}H_{34}O_2$
Linoleic	Cis-9, Cis-12-Octadecenoic	18:2	$C_{18}H_{32}O_2$
Linolenic	Cis-9, Cis-12,Cis-15-Octadecenoic	18:3	$C_{18}H_{30}O_2$
Erucle	Cis-13-Octadecenoic	22:1	$C_{22}H_{42}O_2$

Table 3 Physical and chemical properties of edible and non-edible oils.

Edible& non-edible oil	Kinematic viscosity at 38°C (mm^2/s)	Cetane number	Heating value (MJ/kg)	Cloud point (°C)	Pour point (°C)	Flash point (°C)	Density (Kg/m^3)
Corn	34.9	37.6	39.5	-1.1	-40.0	277	909.5
Cottonseed	33.5	41.8	39.5	1.7	-15.0	234	918.8
Cramble	53.6	44.6	40.5	10.0	-12.2	274	904.8
Linseed	27.2	34.6	39.3	1.7	-15.0	241	923.6
Peant	39.6	41.8	39.8	12.8	-6.7	271	902.6
Rapessed	37.0	37.6	39.7	-3.9	-31.7	246	911.5
Safflower	31.3	41.3	39.5	18.3	-6.7	260	914.4
Sezame	35.5	40.2	39.3	-3.9	-9.4	260	913.3
Soybean	32.6	37.9	39.6	-3.9	-12.2	254	913.8
Sunflower	33.9	37.1	39.6	7.2	-15	274	916.1
Palm	39.6	42.0	-	31.0	-	267	918
Babassu	30.3	38.0	-	20.0	-	150	946.0
Diesel	3.06	50.0	43.8	-	-16.0	76	855

3. Process of biodiesel production

3.1. Transesterification process

The transesterification of edible and non-edible oils with simple alcohol has been the preferred method for producing biodiesel. There are some methods are transesterification as base, acid enzyme catalysed and without catalysed transesterification. The former method has a long history of development and the biodiesel produced by this method is now available in North America, Japan and some western European countries.

3.2. Chemistry of transesterification

The overall transesterification reaction [13], is give by three consecutive and reversible equation

$$\text{Triglyceride} + \text{ROH} \underset{}{\overset{\text{Catalyst}}{\rightleftharpoons}} \text{Diglyceride} + \text{R}^1\text{COOR}$$

$$\text{Diglyceride} + \text{ROH} \underset{}{\overset{\text{Catalyst}}{\rightleftharpoons}} \text{Monoglyceride} + \text{R}^2\text{COOR}$$

$$\text{Monoglyceride} + \text{ROH} \underset{}{\overset{\text{Catalyst}}{\rightleftharpoons}} \text{Glycerol} + \text{R}^3\text{COOR}$$

The process yields glycerol as a by-product. The stoichiometry of the reaction requires 3 moles of alcohol and 1 mole of triglyceride to give 3 moles of fatty acid methyl ester and 1 mole of glycerol show in figure 5. The overall process is a sequence of three consecutive reactions, in which diglyceride and monoglyceride are formed as intermediate. Transesterification is a reversible reaction thus; excess alcohol is used to increase the yields of the alkyl esters and allow its phase separation from the glycerol formed. Conversion of edible and non-edible oil to biodiesel is affected by several parameters namely [14]: time of reaction, types of catalyst, temperature of reaction, amount of catalyst, reactant ratio (molar ratio of alcohol to edible and non-edible oils)

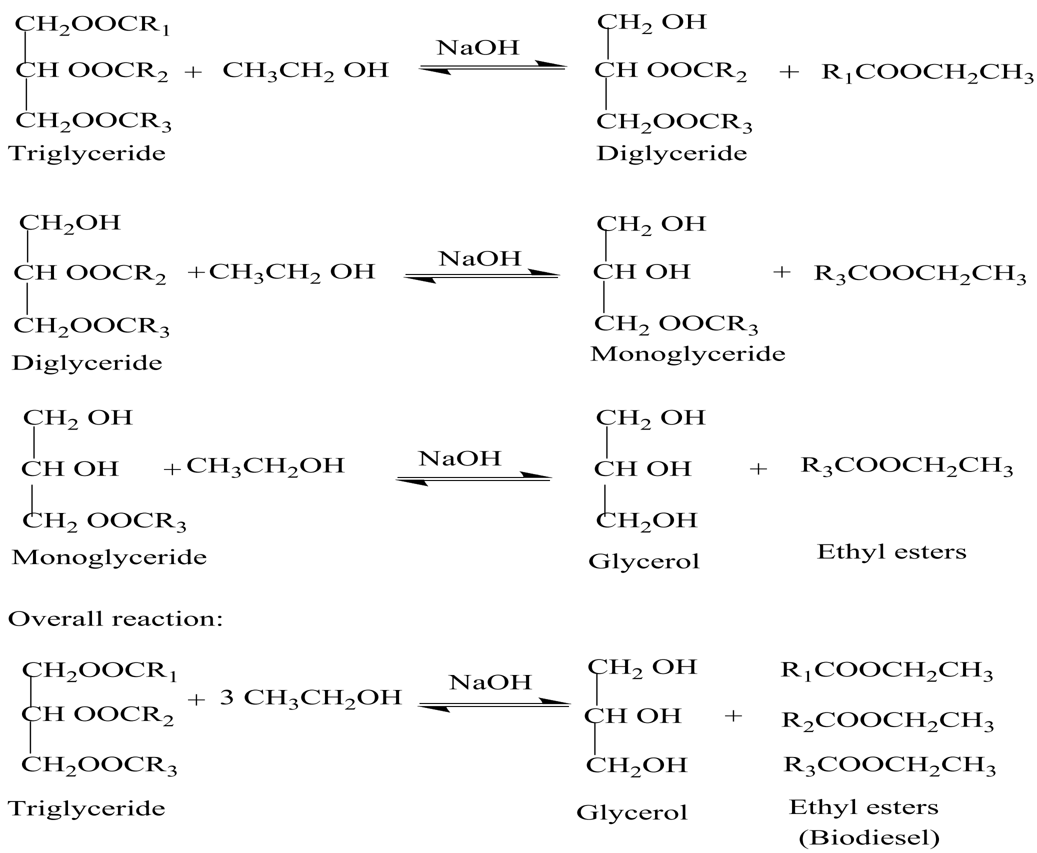

Fig. 5 Transesterification reaction of triglycerides

3.3. By- product

There are three important by-products from the production of biodiesel from edible and non-edible oils; the seed husk from the seed production, the seed cake production in the oil extraction and the glycerol from the transesterification.

3.3.1. Seed husk

The seed husk that removed before oil extraction can be used directly for combustion, but also as feed stock for gasification. Fuel characteristics are reported to be comparable to those of wood [15].

3.3.2. Seed cake

Remaining from the oil extraction from seed and kernels is a seed cake with an oil content that depends on the efficiency of the extraction method. The seed cake contains high quality proteins but also various toxins which make it unsuitable as a fodder. However, if detoxification methods become feasible, the use of the seed cake as animal feed becomes beneficial [15], otherwise it is used as an organic fertilizer. The toxins make it worked as a biopesticide [15]. It is also possible to combine the use of seed cake as a fertilizer with production of biogas, through anaerobic digestion of the cake before using it in agriculture soil [15].

3.3.3. Glycerol

Glycerol is produced in the transesterification of edible and non-edible oil into biodiesel. The glycerol can be used to produce heat by combustion, but it can also be used in the pharmaceutical, food industries and cosmetic industry as a feedstock for production of soap and other products or in recently developed application in the field of animal feed, carbon feedstock in fermentations, polymers, surfactants and lubricants [16].

4. Physical and chemical properties of biodiesel

Table 4 shows a brief comparison of biodiesel physical and chemical properties obtained from this study with petro-diesel, ASTM standard.

Table 4. Physical and chemical properties of biodiesel compared with petro-diesel.

Fuel Properties	Petro-diesel	Biodiesel
Fuel standard	ASTM D975	ASTM PS121
Fuel composition	C_{10}- C_{21} HC	C_{12}- C_{22} FAME
Lower heating value, KJ/Kg	47216.4	37900.8
Kin. Viscosity,@ 40°C	1.3 to 4.1	1.9 to 6.0
Specific Gravity kg/m^3 @ 30°C	0.861	0.926
Density, Kg/m^3 @ 30°C	861.0	926.0
Flash Point °C	60 to 80	100 to 170
Cloud Point °C	-15 to 5	-3 to 12
Pour Point °C	-35 to -15	-15 to 16
Boiling Point °C	188 to 343	182 to 338
Cetane number	40 to 55	48 to 60
Oxygen, by dif.wt %	0	11
Carbon, wt.%	87	77
Hydrogen, wt. %	13	12
Sulfur, wt.%	0.05	0 to 0.024
Water, ppm by wt.	161	0.05% max

5. Use of biodiesel

In vehicle engine, biodiesel can be used as pure or as blending component to fossil fuel, with biodiesel amount usually from 5% to 20%. These low – level blends are compatible with most storage and distribution equipment and do not require any engine modification. Higher blends and pure biodiesel can be used in many engines built with little or no modification. Biodiesel is safer compared to petroleum diesel because its flash points, cetane number are higher than petroleum diesel.

Blends of biodiesel and conventional hydrocarbon based diesel are produced by mixing biodiesel and petroleum diesel in suitable proportions under appropriate conditions. Much of the world uses a system known as the "B" [17] factor to state the amount of biodiesel in any fuel mix: 100% biodiesel in referred to as B100, while, 20% biodiesel, 80% petroleum diesel labelled B20, 5% BD, 95% petroleum diesel labelled B5, 2% biodiesel, 98% petroleum diesel labelled B2.

6. Fuel properties of biodiesel from different oils

The properties of biodiesel and diesel fuels, as given in table 5, [18-19] show many similarities, and therefore biodiesel is rated as a strong candidate as an alternative to diesel. This is due to the fact that the conversion of triglycerides in to methyl or ethyl esters through the transesterification process reduces the molecular weight to one third reduces the viscosity by about one – eighth , and increase the volatility marginally. Biodiesel contains 10-11% oxygen (w/w), thereby enhancing the combustion process in an engine. It has also been reported that the use of tertiary fatty amines and amides can be effective in enhancing the ignition quality of the biodiesel without having any negative persist in cold conditions. Further, biodiesel has low volumetric heating values (about 12%), a high cetane number and high flash point. The cloud points and flash points of biodiesel are 15-25°C higher than those of petroleum diesel.

Table 5 Fuel properties of biodiesel from edible and non-edible oils

Edible& non-edible oil esters	Kinematic viscosity at 38°C (mm²/s)	Cetane number	Heating value (MJ/kg)	Cloud point (°C)	Pour point (°C)	Flash point (°C)	Density (kg/m³)
Peanut	4.9	54	33.6	5	-	176	883
Soybean	4.5	45	33.5	1	-7	178	885
Babassu	3.6	63	31.8	4	-	127	875
Palm	5.7	6	33.5	13	-	164	880
Sunflower	4.6	49	33.5	1	-	183	860
Jatropha	2.37	61	39.1	-	2	135	880
Karannja	4.78	42	37.0	19	6	144	860
Castor	10.7	-	3.4	-	-13	160	900
Diesel	3.06	50	43.8	-	-16	128	855

7. Benefits of biodiesel

Biodiesel is a domestically produced, clean-burning, renewable substitute for petroleum diesel. Using biodiesel as a vehicle fuel increases energy security, improve public health and environment, employment generation reduced foreign oil dependency.

7.1. Increasing energy security

India imports more than 70% of its petroleum, two-thirds of which is used to fuel vehicles in form of gasoline and diesel. The demand for petroleum imports in increasing with much of the worldwide petroleum reserves located in politically volatile countries, the India is vulnerable to supply disruption. Biodiesel can be produced domestically and used in petroleum diesel engines, directly substituting for or extending supplies of traditional petroleum diesel. Biodiesel helps to preserve and protect natural resources. Because of this high energy balance and since it is domestically produced, biodiesel use can greatly contribute to domestic energy security.

7.2. Protecting public health and the environment

Compared with petroleum diesel, using biodiesel in a petroleum diesel engine, substantially reduce emission of unburned hydrocarbon (HC), carbon monoxide (CO), sulphates, polycyclic aromatic hydrocarbon (PAH), nitrated polycyclic aromatic hydrocarbon (nPAH), and particulate matter (PM). Reduction increase as the amount of biodiesel blended into petroleum diesel fuel increases. B100 provides the best emission reduction, but lower-level blends also provide good benefit. B5 to B100 has been shown to reduce PM, HC, CO, NO_x, SO_2, CO_2 emission percentage [20] shows in figure 6. Typically, emissions of nitrogen oxides are either slightly reduced or slightly increased depending on the duty cycle of engine and testing methods used. Increases in NO_x can be effectively eliminated with the use of normal mechanical remediation technique (e.g. catalyst or timing changes). Research also documents the fact that ozone forming potential of the hydrocarbon emissions of pure biodiesel is nearly 50% less than that of petroleum fuel.

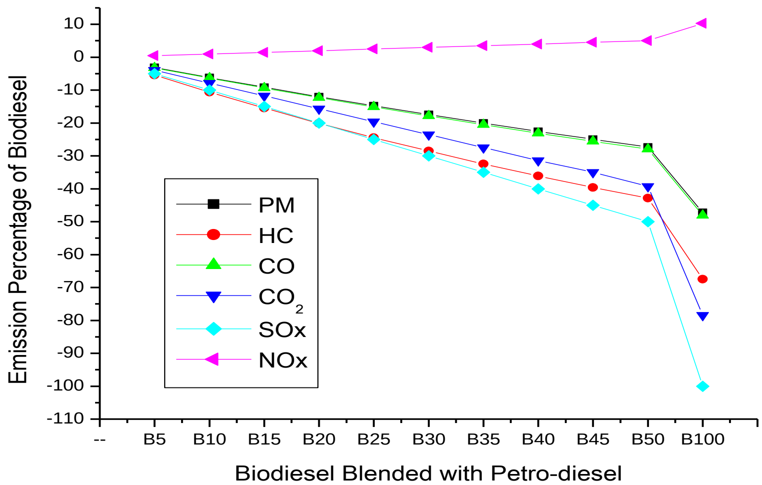

Fig. 6 Used biodiesel blend to reduce PM, HC, CO, NO_x, SO_x, CO_2 emission percentage

Pure biodiesel does not contain sulphur and it reduces sulphur dioxide exhaust from diesel engine to virtually zero. All of these reductions are due to the fact the biodiesel fuel contains no aromatic compounds. Using biodiesel also reduces greenhouse gases emission because CO_2 released from biodiesel combustion is offset by the CO_2 sequestered while growing the edible and non-edible oil crops or other feedstock. Using B100, reduces CO_2 emissions by more than 75% compared with petroleum diesel and B20 reduces CO_2 emission by 15%.

7.3. Biodegradability and Toxicity

Biodiesel is fully biodegradable, so spills are much less of a problem than with petroleum diesel. A 1993 Austrian study found that 98% of biodiesel biodegrades in three weeks. This benefit has made biodiesel a particularly attractive fuel in significant natural areas and marine applications. Biodiesel is non-toxic and biodegradable. Tests sponsored by the United States Department of Agriculture confirms that biodiesel is ten time less toxic than table salt and biodegrades as fast as dextrose (a test sugar).

7.4. Positive energy balance

Biodiesel produced from edible and non-edible oils, the energy balance is far better. A 1998 report sponsored by the U.S. department of energy (DOE) and U.S. department of agriculture(USDA) with technical contribution from the life-cycle assessment(LCA) firm Ecobalance, Inc.," an overview of biodiesel and petroleum diesel life cycles" examined cradle to grave impacts of these two fuels for powering urban buses. This study found that for every unit of fossil-fuel energy consumed in biodiesel production, 3.2 units of biodiesel are produced. On a percentage basis, the net energy gain with biodiesel is 220%. Petroleum fuels have a negative energy balance (a net energy loss) because it takes energy to extract, process and transport that fuel gasoline, petroleum diesel and biodiesel are compared below in the table 6 [21-22].

Table 6 Energy balance of petroleum fuel and biodiesel

Fuel Type	Energy Balance	Net Energy Gain or loss, %
Gasoline	0.74	26
Petroleum diesel	0.83	17
Ethanol	1.34	34
20 % Biodiesel blend (B20)	0.98	2
100 % Biodiesel (B100)	3.20	22

7.5. Biodiesel improve engine life

Biodiesel improves fuel lubricity and raise the cetane number of the fuel. Diesel engines depend on the lubricity of the fuel to keep moving parts from wearing prematurely. Federal regulations reduced sulphur in diesel fuel to 15 ppm a few year ago, which resulted in reduced lubricity of petroleum diesel. Diesel specification ASTMD975 was modified to require lubricity; biodiesel provides adequate lubricity to meet this requirement at blends as low as 1% [23].

7.6. Reduced foreign oil dependence

While not strictly an environmental benefit, the use of domestically produced biodiesel can reduce Indian reliance on imported oil. The Indian administration has shown considerable interest in biodiesel in an effort to attain greater energy self sufficiency, though most research funding and financial incentives to date have been for edible and non- edible oil derived biodiesel.

7.7. Employment generation

One of the major economic benefits that would accrue to a state from the increased use of biodiesel is the presence of a facility that create energy from locally generated input that adds value to the state's industrial and income base. On employability parameters, it can result in manifold increase in employment opportunities. As crops cultivation, seed collection, oil production and marketing for poor people living in rural and urban areas may prove to be a potential source of income generation. The uneven distribution of wealth and with a large population base, India is passing through social unrest in many parts of the country leading to large scale of violence in many forms. Creation of such locally developed employment opportunities for rural and urban poor will also help in diluting social unrest generated due to poverty.

8. Conclusions

Biodiesel is a good alternative fuel for diesel engines because it is environmentally friendly and renewable in nature, since it can be made from edible and non-edible oil resources. Biodiesel is much less polluting than petro-diesel, resulting in much lower emission of almost every pollutant such as CO_2, SO_x, PH, CO, nPAH, air toxins and unburned hydrocarbons. Economic advantage of biodiesel includes reduction in dependency on imported crude oil, it also promotes agriculture, and industrial development generates new employments, helps in sustainnability and stability in energy supply. Therefore, from this review we concluded that the biodiesel is a better alternative renewable, cleaner and greener fuel for the future.

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*Corresponding author: * E-mail: vedchem21@gmail.com