Scientific Journal Impact Factor (SJIF) : 3.518
International Journal of Modern Trends in Engineering and Research
ISSN (ONLINE) : 2349 - 9745 ISSN (PRINT) : 2393 - 8161

CONCEPT OF BIODIESEL, METHODOLOGIES AND IMPACT INFORMATION AND ENVIRONMENTAL FACTORS OF BIODIESEL

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Abstract—Biodiesel is one of the most necessary and important upcoming fuel for industrial as well as regular use. Rapid degradation of fossil fuels has given a large impact on fuel consumption and its availability. Use of such nonrenewable fossil fuels like petrol diesel etc to a great extent and fast rate has given a knock on worlds door to find new alternative fuels which can be used as substitution to fossil fuels. Biodiesel is very clean type of fuel made up from cryogenic waste such as animal and vegetable fats, used oil. It is made up by a chemical reaction called Transesterification in which fatty acids are reacted with alcohol to give esters which in turns produces Biodiesel. Biodiesel is used a blend with normal diesel or can be used separately. Biodiesel is biodegradable and if it mixes with diesel then it helps to increase biodegradability of normal diesel by co-metabolism. Biodiesel reduces greenhouse gas emission also it has got capacity of reducing percentage of hydrocarbons emitted in environment due to burning of diesel which is very dangerous. Biodiesel has no suspended particles in it thereby reducing air pollution.

Keywords—nonrenewable, degradation, alternative, trans esterification, hydrocarbons, greenhouse

I. INTRODUCTION

As the name suggests Biodiesel is a new kind of petroleum product coming into account and made up of cryogenic waste. The decreasing percentage of fuel which are currently in use points us towards the need of other types of useful fuels or energy. Biodiesel is a new kind of fuel which is being used in automotive industry. The need of Biodiesel is increasing day by day and the new types of methodologies are developing for production of Biodiesel from cryogenic waste.

Biodiesel is a liquid fuel, technically known as a mono alkyl ester, made from fats or oils and alcohols. Biodiesel is nothing but a renewable fuel that can be produced in any climate using already developed agricultural practices. Biodiesel is generally made up of renewable resources such as vegetable oils, animal fats, or other types of biomass. B100 is a representation of 100% biodiesel. Biodiesel is available widely in its neat form (B100) as well as in blends with petroleum diesel (for e.g. B2, B5, B20). In Europe rapeseed oil is the primary feedstock used for making of make biodiesel. In USA soybean oil is the primary feedstock used for making biodiesel as it is the largest soya producer in the world.

II. CASE STUDY

2.1. About biodiesel

Based on all this a basic question arises as why should we use Bio fuels and to be more specific why should we use Biodiesel? The answer for this question is it provides a market for excess production of vegetable oils and animal fats. An increasing demand of soybean meal around the world to provide the essential protein for human and animal consumption. Farmers may face some more difficulty in producing a profit for soybean oil if new markets are not found and it will lower its price too.

It decreases the country's dependence on imported petroleum. Even though the country's percentage of fuel supply that can replaced by bio diesel is very small, an additional source of fuel can have a surprising impact on fuel price stability. It is renewable as well as it does not contribute to global warming due to its closed carbon cycle [1].

Carbon in the fuel was originally removed from the air by plants so there is no net increase in carbon dioxide levels. In a deeper way the question is why should we use Bio Diesel specifically? The answer for this question is it provides substantial reductions in carbon monoxide, unburned hydrocarbons, and particulate emissions from diesel engines. Slight oxides of nitrogen (NOx) increase with biodiesel have been shown by some tests. New research on real-time vehicles have claimed a considerable decrease in NOx emissions [1].

Biodiesel has excellent lubricating property. When added to regular diesel in an amount equal to 1-2%, it can probably convert a fuel of poor lubricating property into acceptable fuel such as modern ultra-Sulphur diesel fuel.

Biodiesel in some kind is sustainable due to its effect of reduced reliance on petroleum & crude oil products, all finite resources eventually helped in reducing emissions of greenhouse gases. Employment in regional & rural areas would also be helpful in economic growth due to biodiesel. Diversification of income & economy in such regional & rural sectors. Quality improvement of air, particularly in high smog & population dense areas. Reduced production of waste oil whereas positive environmental impact with sustainable production of feed stocks and reduced pollution for water and soil sources. Decreased reliance on foreign supplies of oil increased security for energy supplies [1].

There are some main other points in using bio diesel or alternative fuels in industries as well as regular fields. Some researchers have proven the fact that the consumption of crude oil or we can specifically we can say Diesel has increased on a very big scale. U.S. used 13.62 million barrels of petroleum for transportation per day only in 2004, in 2003 60 billion gallons of diesel for on road utilization and 30 million gallons of biodiesel in the year 2004. These figures are very large and for us, if we continue in using fuel by this rate then results are quiet menacing. [1]

Total oil used since 1850 is about 1000 billion barrels (GB) all over the world, total world reserves of oil are about 1000 billion barrels. 70% of oil which is used currently is discovered before 1973. Current world usage is about 29 billion/year and time left is 33 years, time left for US if it uses oil left in US fields is about 3 years, time left for US if it uses all of Iraq's oil for itself is about 15 years, time left if whole world uses oil at US's current rate is about 6 years, 25% oil is used by US for food production including packaging, refrigeration, trucking, cooking. [1].

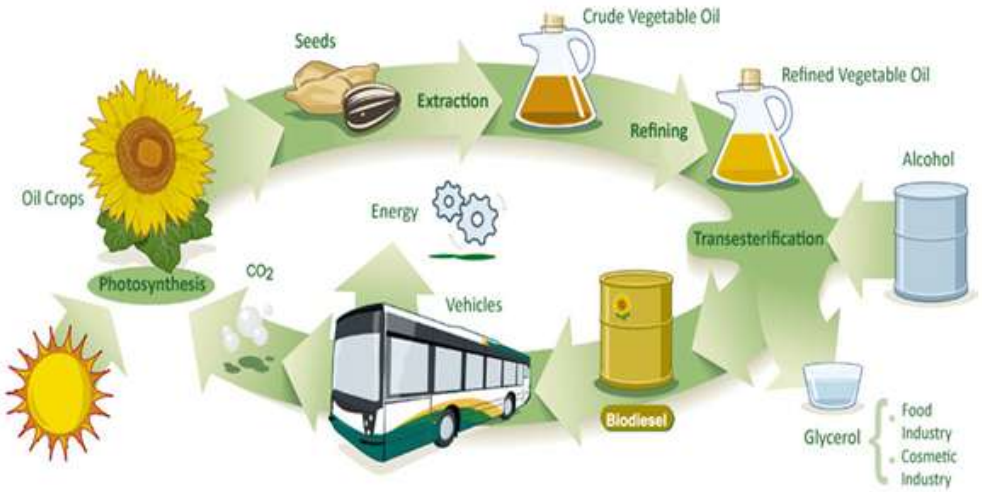


Fig 1. Cycle of biodiesel

2.2 Life cycle of biodiesel

Biodiesel generally B100, yields 3.2 units of fuel energy for every 1 unit of fossil fuel energy consumed in its life cycle. Whereas B20 yields 0.98 units of fuel energy for every unit of fossil fuel energy consumed.

If we substitute 100% biodiesel (B100) instead of petroleum diesel in buses, then it would reduce the life cycle consumption of petroleum by 95%. Such benefit settles a proportion with the level of blend of biodiesel to be used. When a 20% blend of biodiesel and petroleum diesel (B20) is

used in urban buses as a substitute, the life cycle consumption of petroleum drops by 19%. To produce 1 unit of petroleum diesel, 1.2 units of fossil resources are needed by petroleum diesel.
After knowing all these basics about Bio Diesel now let's see the general methods to prepare it by which the Bio Diesel can be actually used in day to day life.

2.3 REACTIONS INVOLVED IN PRODUCTION PROCESS

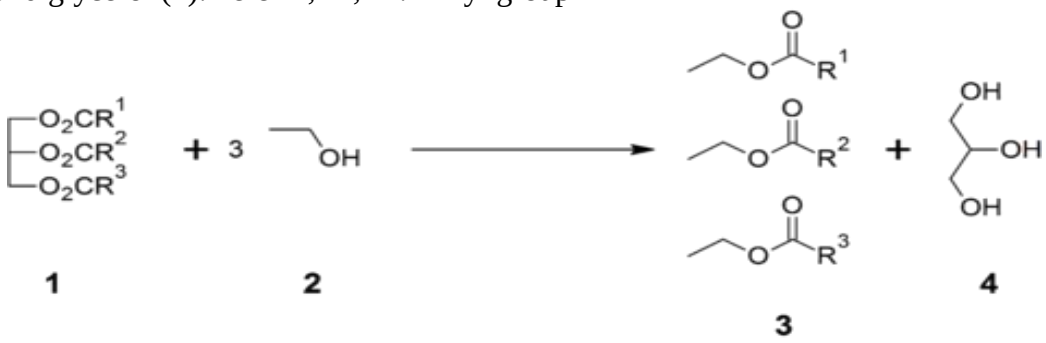
Biodiesel production is the process of producing the bio fuel specifically biodiesel, through the chemical reactions known as trans-esterification and esterification. This involves vegetable or animal fats and oils being reacted with short-chain alcohols typically methanol or ethanol[2].

2.3.1 TRANS-ESTERIFICATION

Animal, plant fats and oils are made up of triglycerides, which are nothing but esters formed by the reactions of three free fatty acids and glycerol. In the transesterification process, addition of alcohol, commonly, methanol or ethanol is deprotonated with a base making it a stronger nucleophile. It can be seen that the reaction has only triglyceride and the alcohol as input parameters. Under normal conditions, this reaction will proceed either slowly or it will stop, so heat as well as catalysts are used to speed the reaction. Important factor to note is that, the acid or base are not consumed by the trans esterification reaction, thus they are not reactants, but catalysts. Mostly catalysts used for trans esterification are sodium hydroxide, potassium hydroxide, and sodium methoxide[2].

Almost all biodiesel is a product of virgin vegetable oils. Base-catalyzed method is used as it is one of the most economical process for treatment of virgin vegetable oils. It requires only low temperatures and pressures and starting oil is low in moisture and free from fatty acids. However, such biodiesel produced from some other sources or by other methods may require acid catalysis, which is much slower. As it stands amongst the predominant method used for commercial-scale production, the process described below is base-catalyzed transesterification process only.

Triglycerides (**1**) are reacted with an alcohol for e.g. ethanol (**2**) to give ethyl esters of fatty acids (**3**) and glycerol (**4**): here R^1, R^2, R^3: Alkyl group

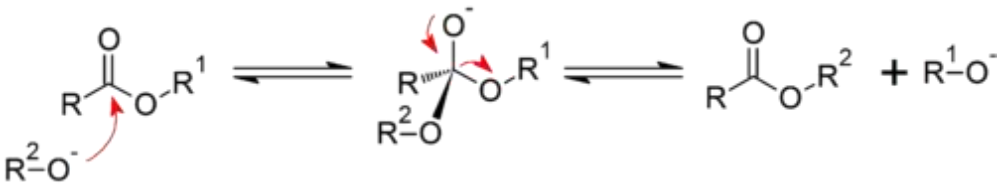


The alcohol reacts with the fatty acids to form the mono-alkyl ester (biodiesel) and crude glycerol. The reaction between the bio lipid (fat or oil) and the alcohol is a reversible reaction so excess alcohol must be added to ensure complete conversion.

2.3.2 BASE CATALYZED TRANS-ESTERIFICATION METHOD

The trans esterification reaction is base catalyzed. Any strong base capable of deprotonating the alcohol will be acceptable (e.g. NaOH, potassium hydroxide, sodium methoxide,) but the sodium and potassium hydroxides are often chosen because of their cost. The reaction must be kept dry as presence of water causes undesirable base hydrolysis.

In the trans esterification mechanism, the incoming alkoxide (R^2O^-) does a nucleophilic attack on carbonyl carbon of starting ester ($RCOOR^1$) to give a tetrahedral intermediate, which either reverts to the starting material, or proceeds to the trans esterified product ($RCOOR^2$). The relative energies of the reactant and product signifies that there exist various species in equilibrium.



2.4 METHODS OF PRODUCTION OF BIODIESEL

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2.4.1 SUPERCRITICAL PROCESS

Super critical methanol at high temperatures and pressures in a continuous process is an alternative method for catalyst free trans esterification. Oil and methanol are in a single phase, and reaction occurs spontaneously and rapidly when they are in supercritical state. The process can tolerate water in the feed stock with free fatty acids are converted to methyl esters instead of soap and so a wide variety of feed stocks can be used. Here the catalyst removal step is eliminated. Energy costs of production are similar or less than catalytic production routes even if it requires high temperature and pressure.

2.4.2 ULTRA HIGH-SHEAR INLINE AND BATCH REACTORS

Ultra-high Shear in-line or batch reactors allows production of biodiesel in a continuous manner in batch mode as well as semi- continuous mode. This mainly increases production volume and drastically reduces production time.

The reaction takes place in considerably high-energetic shear zone of the Ultra-high Shear mixer by reducing the droplet size of the immiscible liquids such as oil, fats and methanol. Therefore, smaller the droplet size larger the surface area and faster the catalyst can react.

2.4.3 ULTRASONIC REACTOR METHOD

In the ultrasonic reactor method, bubbles are constantly produced and collapsed in reaction mixture due to ultrasonic waves. Mixing and heating required to carry out the trans esterification process is simultaneously provided by such cavitation. So using such ultrasonic reactor for biodiesel production drastically reduces the reaction time, reaction temperatures, and energy input as well. As a result, the process of transesterification can run inline rather than using the time consuming batch processing.

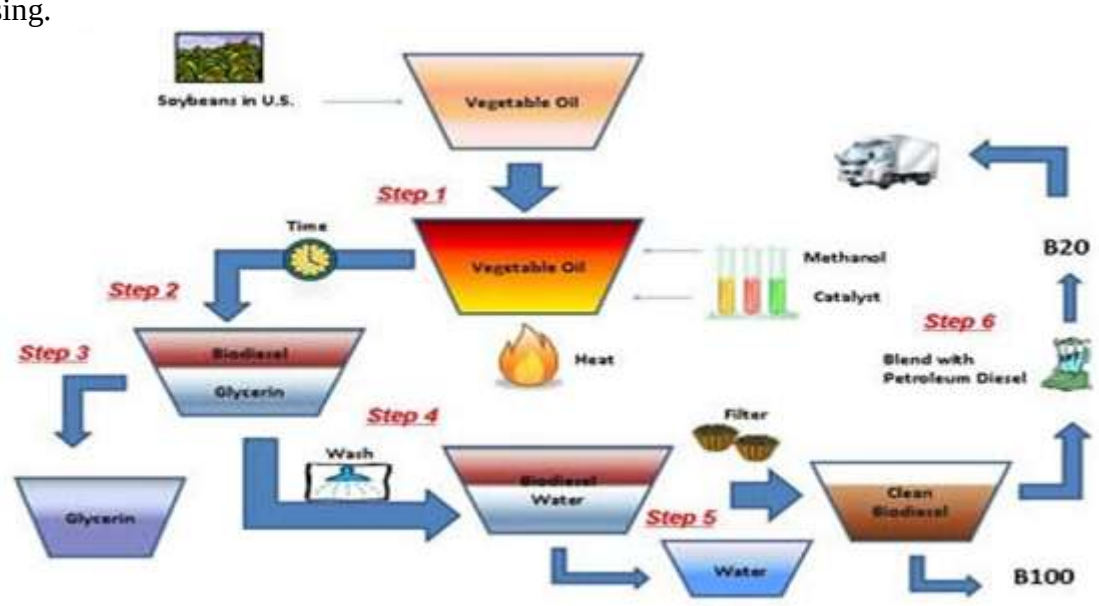

Fig 2. Biodiesel production process

2.4.4 LIPASE CATALYZED METHOD

Tremendous research has been recently focusing on the use of enzymes as a catalyst for the trans esterification. Researchers have discovered that very good yields could be derived from crude and used oils using lipases. The use of lipases makes the reaction less sensitive to high free fatty-acid content, which is nothing but a problem with the standard biodiesel process. Methanol cannot be used as it reduces activities of lipase catalyst after one batch which is a problem in lipase reaction. However, if methyl acetate is used in place of methanol, the lipase is not in-activated and can be used for several batches which makes the lipase system much more cost effective. [3]

2.4.5 VOLATILE FATTY ACIDS DERIVED FROM ANAEROBIC DIGESTION OF WASTE STREAM

Lipids drew considerable attention as a substrate for biodiesel production owing to its sustainability, non-toxicity as well as energy efficient properties. However, because of cost reasons this attention must be focused on the non-edible sources of lipids coming out of particular oleaginous microorganisms. Such microbes assimilate the carbon sources from a medium and convert the carbon into lipid storage materials. Trans esterification can be done by lipids accumulated by these oleaginous cells to form bio diesel. [3]

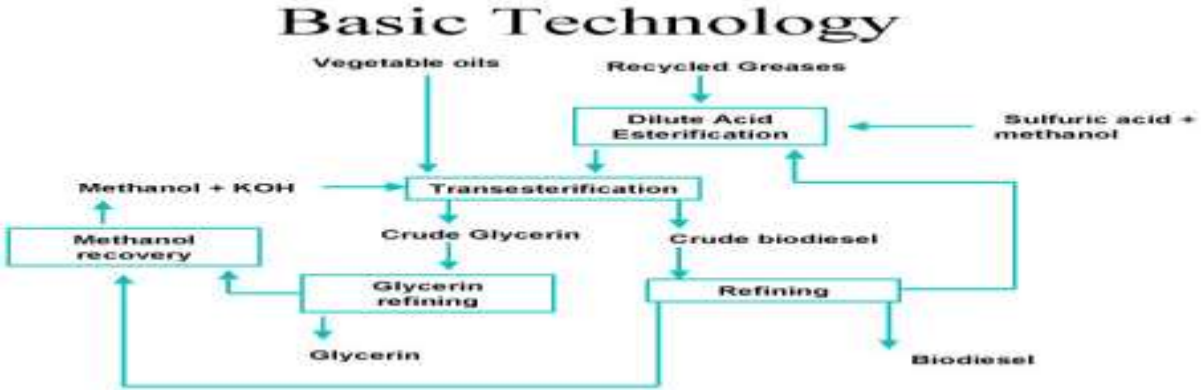

FIG.3 Biodiesel production by free fatty acids

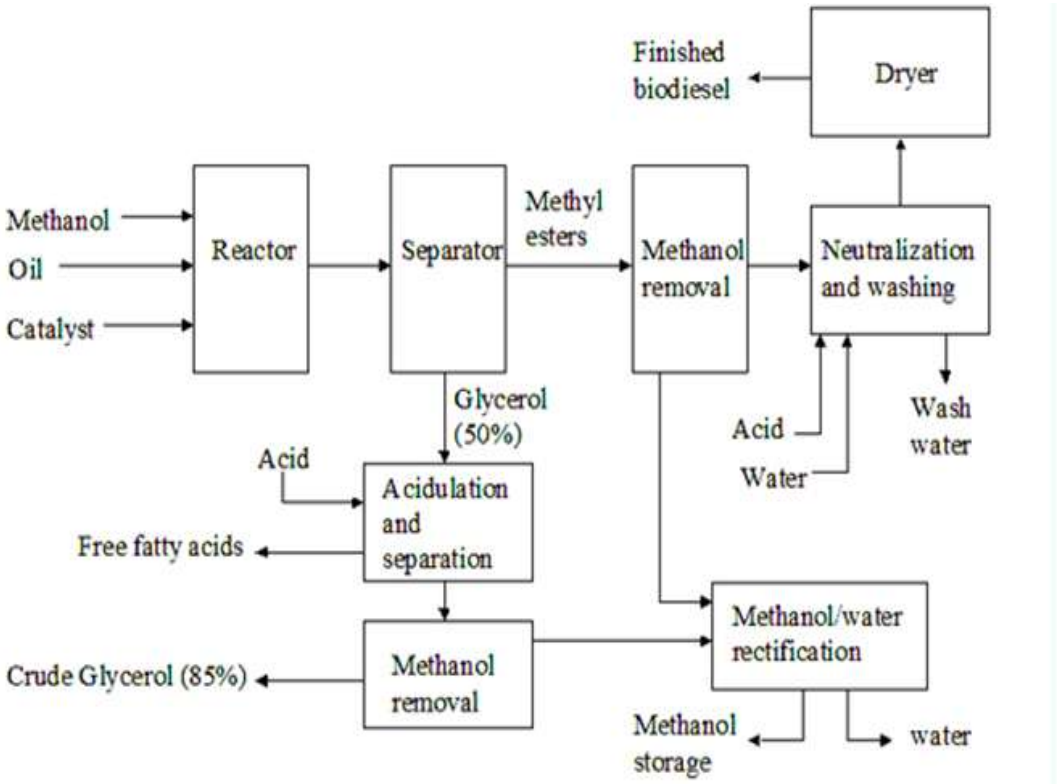

Fig.5 Biodiesel production by highly acidic oils or fats

2.5 ENVIRONMENTAL EFFECT OF BIODIESEL

The main incentive for using biodiesel is its capacity to lower greenhouse gas emissions as compared to fossil fuels.

Carbon dioxide is one of the dangerous greenhouse gases. Plants absorb CO2 via process known as photosynthesis which allows to store energy coming from sunlight in the form of sugars and starches. When biomass is converted in the form of biodiesel and burnt as fuel results in emission of energy and carbon is again. Some of this energy is generally used for supplying power to an engine and carbon dioxide is emitted back to the atmosphere every time.

If we consider total amount of greenhouse gas emissions, it becomes important to consider the whole production process and some indirect effects which these productions might cause. The carbon dioxide emissions are highly dependent on production methods as well as the type of feedstock used. A calculation of carbon intensity of bio fuels usually includes:

- Emissions during growing the feedstock such as Petrochemicals used in fertilizers
- Emissions during transportation of feedstock to the factory
- Emissions during processing such feedstock into biodiesel
- Other factors are sometimes not considered even if they are significant.
  These include:
- Emissions which occurs due to change in land use of the area where the fuel feedstock is grown.
- Emissions during transportation of the biodiesel from factory particular point
- The efficiency of biodiesel in comparison with others

If we assume today's production methods and neglect change in land use, biodiesel from rapeseed and sunflower oil produces 45%-65% lower greenhouse gas than normal diesel. However, the research is going on to improve the efficiency of the production process. Biodiesel made up used cooking oil or other waste fat could reduce CO2 emissions up to 85%. Land use change has no significant effect on greenhouse gas emissions until the feedstock is grown on existing cropland. But increased feedstock production directly affects the rate of deforestation. Such clear cutting initiates release of carbon stored in the forest, soil and peat layers. The benefits from lower emissions would be negligible for hundreds of years as the amount of greenhouse gas emissions from deforestation is so large. Bio fuel produced from feedstock such as palm oil could cause much higher carbon dioxide emissions as compared to some other types of fossil fuels.

2.5.1 POLLUTION

For United States, biodiesel is the only alternative fuel which is successful in completing the Health Effects Testing requirements such as Tier I and Tier II of 1990's clean air act.

Biodiesel can reduce the direct tailpipe-emission of particulates as well as small particles of solid combustion products by as much as 20 percent compared with low-Sulphur diesel (< 50 ppm). Particulate emissions are reduced by around 50 percent as compared with conventional diesel. Biodiesel has got comparatively higher cetane rating than conventional diesel, which in turns cleans the emission and improves performance as compared to crude normal diesel (with lower cetane).

2.5.2 BIODEGRADATION

People from University of Idaho used low concentrations of the product which was to be degraded (amount of 10 ppm) in nutrient and sewage sludge amended solutions and they demonstrated that biodiesel degraded at surprisingly same rate as that of dextrose control. It also degraded at the rate of 5 times faster than petroleum diesel over a period of 28 days. Biodiesel blends doubled the rate of petroleum diesel degradation with co-metabolism process. The same study examined soil degradation using 10,000 ppm of biodiesel and petroleum diesel and reviled that biodiesel degraded by two times the rate of petroleum diesel in soil. In all such cases, it was determined that biodiesel degraded more completely than petroleum diesel. Toxicity studies were also done for the same project, which demonstrated only few toxic effects and zero mortality on rats and rabbits which was up to 5000 mg/kg of biodiesel. Petroleum diesel also did not show any ill

effects at the same concentration but some toxic effects e.g. hair loss and urinary discoloring were observed specifically with concentrations of >2000 mg/l in rabbits.

2.5.3 CARBONYL EMISSION

Major pollutants such as hydrocarbons are typically focused in various research while considering the emissions from fossil fuel and use of bio fuel. It is generally found that using biodiesel in place of diesel results in a considerable reduction in regulated gas emissions, a study focused on the emissions of non-criteria carbonyl compounds from burning of biodiesel blends as well as pure diesel in heavy-duty engines(diesel), as a results it found that carbonyl emissions of formaldehyde, acetaldehyde, acetone, propionaldehyde and butyl aldehyde were higher in biodiesel mixtures as compared to emissions from pure diesel. Use of biodiesel results in higher carbonyl emissions but it lowers total hydrocarbon emissions, which resembles a better alternative fuel source. Some studies conflict with such results, but still comparisons are difficult to make due to various factors differing between studies such as, types of fuel and engines used. Out of 12 research articles on carbonyl emissions from biodiesel, it found that 8 of such papers showed increased carbonyl compound emissions while 4 showed the opposite which proves that there is still much research required on these compounds.

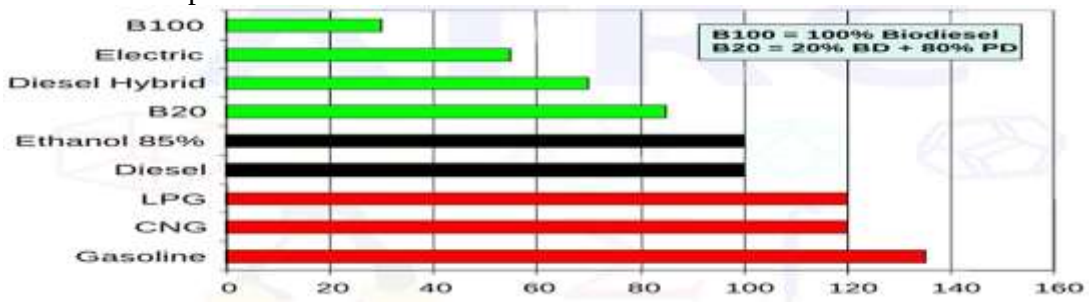

Table 1. Relative greenhouse gas emission

III. CONCLUSION

With reference to above information about biodiesel including the depletion in oil level all over the world, need of alternative fuels such as biodiesel, methods of preparation of biodiesel and its environmental impacts we can conclude that the use of biodiesel will help in reduction of overall carbon production in world as well as pollution can be controlled by means of use of alternative fuel, as also it will help in encouraging farmers to develop lands and production of vegetables rather than selling them for unnecessary urbanization. Use of alternative renewable fuel will help in restoring and saving non renewable energy sources by giving then enough time to restore and it will reduce the load on use of nonrenewable energy source.

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