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Production of Biodiesel as Commodity Chemical Using Plant Seed Oils and its Relevance for Nation Sustainable Development: A Review

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Abstract: Biodiesel is a fuel made from plants or animal fats. It is safe, biodegradable and produces significantly less air pollution than diesel fuel. It is much less combustible and toxic than petroleum diesel. When burned in a diesel engine, it replaces the exhaust odour of petroleum diesel with the acceptable smell of kitchen odours like French fries or popcorn. Its production begins with pressing the plant seeds, which yields an oil fraction to be later converted to biodiesel. The raw oil is filtered and chemically reacted with an alcohol (usually methanol) during etherification process in order to get methylesther (biodiesel) and glycerine another by-product used in the pharmaceutical and cosmetic industries. Typically, the agricultural machinery could be run on biodiesel that will lead to immediate environmental improvements in agriculture. Among other things, spillage and leaking of fuel would be harmless. Environmental pollution and diminishing supply of fossil fuels are the key factors leading to search for alternative sources of energy.

Key words: Biodiesel · Biodegradable · Combustible · Etherification · Pharmaceutical · Sustainable · Environmental

INTRODUCTION

Energy is one of the most important factors for global prosperity and sustainable development. It's believed that, the increase in World population and advancement in technology had led to an increased demand for fossil fuel. It is therefore predicted that in the nearest future, there will be crisis of fossil fuel depletion and degradation because it is non-renewable. Fossil fuels include: coal, crude oil and natural gas because they were formed from the fossilized, buried remains of plants and animals that lived millions of years ago. Because of their origins, they have high carbon content. Crude oil or petroleum is a liquid fossil fuel made up mostly of hydrocarbons (hydrogen and carbon compounds). They are usually found in underground reservoirs; in the cracks, crevices and pores of sedimentary rock; or in tar sands [1]. Some of the most significant hidden costs of fossil fuels are from the air emissions that occur when they are burned. Unlike the extraction and transport stages, in which coal, oil and natural gas can have very different types of impacts, *all* fossil fuels emit carbon dioxide and other harmful air pollutants when burned. These emissions lead to a wide variety of public health and environmental costs that are borne at the local, regional, national and global levels [1].

This review seeks to assess the relevance of developing biodiesel from plant seed oils as commodity chemicals to be used in the replacement of the more toxic, non-renewable and non-biodegradable petroleum diesel. The review will also compare biodiesel from seed oils with petroleum diesel in terms of combustion, productivity, biodegradability, toxicity, environmental safety and oil spillage, which are global challenges associated with the use of petroleum diesel as energy source. Since the world's accessible oil reservoirs are gradually depleting, it is important to develop suitable long-term strategies based on utilization of renewable fuel that would gradually substitute the declining fossil fuel production. In addition, the production and consumption of fossil fuels have caused environmental damage by increasing the CO_2 concentration in the atmosphere [2]. It is expected that being of natural origin, the production and use of biodiesel instead of petroleum diesel will improve overall productivity, reduce toxicity associated with oil leakage and spillage into the environment and increase agricultural and industrial output on the whole.

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Some Disadvantages of Using Fossil Fuel

Global Warming Emissions: Of the many environmental and public health risks associated with burning fossil fuels, the most serious in terms of its universal and potentially irreversible consequences is global warming. In 2014, approximately 78% of US global warming emissions were energy-related emissions of carbon dioxide. Of this, approximately 42% was from oil and other liquids, 32% from coal and 27% from natural gas [3]. Non-fossil fuel energy generation technologies, like wind, solar and geothermal, contributed less than 1% of the total energy related global warming emissions. Even when considering the full lifecycle carbon emissions of all energy sources, coal, oil and natural gas clearly stand out with significantly higher greenhouse gas emissions [4].

Air Pollution: Burning fossil fuels emits a number of air pollutants that are harmful to both the environment and public health, which include:

- Sulphur dioxide (SO_2) emission: This results from burning coal, which contributes to acid rain and the formation of harmful particulate matter. In addition, SO_2 emissions can exacerbate respiratory ailments, including asthma, nasal congestion and pulmonary inflammation [5]. In 2014, fossil fuel combustion at power plants accounted for 64% of US SO_2 emissions [6].
- Nitrogen oxide (NO) emission: This is a by-product of all fossil fuel combustion, it contributes to acid rain and ground-level ozone, which can burn lung tissue and make people more susceptible to asthma, bronchitis and other chronic respiratory diseases. Fossil fuel-powered transportation is the primary contributor to US NO emissions [6]. Acid rain is formed when sulphur dioxide and nitrogen oxides mix with water, oxygen and other chemicals in the atmosphere, leading to rain and other precipitations that may be mildly acidic. Acidic precipitation increases the acidity of lakes and streams, which can be harmful to fish and other aquatic organisms. It can also damage trees and weaken forest ecosystems [6].
- Particulate matter (soot) emission:This produces haze and can cause chronic bronchitis, aggravated asthma and elevated occurrence of premature death. In 2010, it was estimated that fine particle pollution from US coal plants resulted in 13, 200 deaths, 9, 700 hospitalizations and 20, 000 heart attacks. The impacts were particularly severe among the young, the elderly and those who suffered one respiratory disease or the other. The total health cost was estimated to be more than $100 billion per year [7].
- Mercury emission: Coal-fired power plants are the largest source of mercury emissions to the air in the United States [6]. As airborne mercury settles onto the ground, it washes into bodies of water where it accumulates in fish and subsequently passes through the food chain to birds and other animals. The consumption of mercury-laden fish by pregnant women has been associated with neurological and neurobehavioral effects in infants. Young children are also at risk [5].

A number of studies have sought to quantify the health costs associated with fossil fuel-related air pollution. The National Academy of Sciences assessed the costs of SO_2, NO and particulate matter air pollution from coal and reported an annual cost of $62 billion for 2005, National Research Council[8]. A separate study estimated that the pollution costs from coal combustion, including the effects of volatile organic compounds (VOCs) and ozone, was approximately $187 billion annually [5]. A 2013 study also assessed the economic impacts of fossil fuel use, including illnesses, premature mortality, workdays lost and direct costs to the healthcare system associated with emissions of particulates, NO and SO_2. This study found an average economic cost of 32 cents per kWh for coal, 13 cents per kWh for oil and 2 cents per kWh for natural gas [9]. While cost estimates vary depending on each study's scope and assumptions, together they demonstrate the significant economic costs that unpriced air emissions impose on society.Fossil fuel transportation emissions represent the largest single source of toxic air pollution in the U.S., accounting for over a third of carbon monoxide (CO) and NO emissions [1].

Land Degradation: Unearthing, processing and moving underground oil, gas and coal deposits take an enormous toll on our landscapes and ecosystems. The fossil fuel industry leases vast stretches of land for infrastructure such as wells, pipelines, access roads, as well as facilities for processing waste storage and waste disposal. In the case of strip mining, entire swaths of terrain, including forests and whole mountaintops are scraped and blasted away to expose underground coal or oil. Even after operations cease, the nutrient-leached land will never return to what it once was. As a result, wildlife habitat and land crucial for breeding and migration end up fragmented and destroyed. Animals that manage to survive end up suffering, as they're often forced into less-than-ideal habitat and must compete with existing wildlife for resources [1].

Water Pollution: Coal, oil and gas development pose myriad threats to our waterways and groundwater. Coal mining operations wash acid runoff into streams, rivers and lakes and dump vast quantities of unwanted rock and soil into streams. Oil spills and leaks during extraction or transport can also pollute drinking water sources and jeopardize entire freshwater or ocean ecosystems. Fracking and its toxic fluids have also been found to contaminate drinking water. All drilling, fracking and mining operations generate enormous volumes of wastewater, which can be laden with heavy metals, radioactive materials and other pollutants. Industries store this waste in open-air pits or underground wells that can leak or overflow into waterways and contaminate aquifers with pollutants linked to cancer, birth defects, neurological damage and much more [1].

Biofuel is the alternative means of energy employed by various governments around the world in recent times. Biofuels energy include; Bioethanol, Biodiesel, Biohydrogen, alkanes and various other hydrocarbon mixtures [10]. Ethanol and biodiesel are the two main types of biofuels derived from organic matter (obtained directly from plants, or indirectly from agricultural, commercial, domestic and/or industrial wastes) (Clemente). Biodiesel is a renewable fuel that can be manufactured from seed oils. It is produced domestically and thus can improve the situation in the agricultural sector and bring new income for farmers[11]. Biodiesel can be made from many oils and fats such as rapeseed, palm oil, sunflower, soy, canola, tallow, mustard or even from used vegetable oils and animal fats. These feedstocks are non-toxic, biodegradable and renewable resources. In Europe, rape seed oil is the major biodiesel feedstock, while in the United States soybeans are the dominant biodiesel feedstock [12]. India, Indonesia, Malaysia and China are already producing biodiesel successfully from *Jatrophacurcus* and oil palm.

The search for alternative sources of fuelhas made it necessary to explore plant options with potential to serve as biofuels. Biodiesel is considered"carbon dioxide neutral" because all of the carbon dioxide released during combustion is sequestered out of the atmosphere during crop growth [13]. Recent environmental and economic concerns have prompted resurgence in the use of biodiesel throughout the world. In 1991, the European Community proposed a 90% tax reduction for the use of biofuels, including biodiesel.The superior lubricating properties of biodiesel increases functional engine efficiency. Their higher flash point makes it safer to store. These biodiesel molecules are simple hydrocarbon chains, containing no sulphur, nor aromatic substances unlike fossil fuels. They contain higher amount of oxygen (up to 10%) that ensures more complete combustion of hydrocarbons [14]. Biodiesel almost completely eliminates lifecycle of carbon dioxide emissions. When compared with petro-diesel it reduces about half of the emission of particulate matter, unburned hydrocarbons, carbon monoxide and most part of the polycyclic aromatic hydrocarbons and entire sulphates on an average [15]. Biodiesel can be used mixed with petroleum-based diesel in any proportion [16]. Biodiesel blends can be used in most compression-ignition (diesel) engine with little or no modifications. The biodiesel on production is accessed based on the following properties; viscosity, density, flashpoint, sulphur content, cloud and pour points [17]. Using biodiesel in a conventional diesel engine substantially reduces emissions of hydrocarbons, carbon monoxide, sulphates, aromatic hydrocarbons and particulate matter. Most importantly, biodiesel reduces air toxics and cancer-causing compounds. Pure biodiesel (100% biodiesel) can reduce cancer risks by 94%.. Mixture of 20% of biodiesel and 80% of petroleum diesel (B20) will reduce that risk by as much as 27%.Biodiesel does not contain sulphur, so it will not contribute to sulphur dioxide emissions [18].

Due to the fact that more oxygen in biodiesel leads to more complete combustion into CO_2, biodiesel decreases the solid carbon fraction of particulate matter in emissions. It therefore works well with emission control technologies such as diesel oxidation catalysts. In Germany, tractors run on biodiesel, primarily because of environmental considerations. The inventor of the diesel engine, Rudolf Diesel, used peanut oil as a fuel for demonstration purposes at the World Exhibition in Paris in 1900. Biodiesel is similair to diesel fuel except that it is produced from renewable biomass. Many farmers in the EU or USA who raise oilseeds use a biodiesel blend in tractors and equipment as a matter of policy to foster production of biodiesel and raise public awareness. Biodiesel is a proven fuel with over 20 years of experience in Europe and the USA [18].

With properties very similar to those of fossil diesel, biodiesel can go almost directly into existing diesel vehicles and it mixes with fossil diesel in any ratio. It has higher fuel density and better ignition quality with its higher cetane number than ordinary diesel fuel.

Blends of 20% biodiesel with 80% petroleum diesel (B20) can generally be used in unmodified diesel engines. Biodiesel can also be used in its pure form (B100), but may require certain engine modifications to avoid maintenance and performance problems during wintertime utilization. Biodiesel can be stored anywhere like petroleum diesel [19]. Its use can extend the life of diesel engines because it is more lubricating than ordinary diesel fuel. Edible oil seed crops, such as rapeseed, sunflower, soyabean and safflower and non-edible seed oil plantation crops Jatropha and Pongamia have proved to be internationally viable commercial sources of vegetable oils for biodiesel production [20].

Biofuels as source of power generation are environmentally friendly having specific advantages over fossil fuel: The production of biofuels will encourage extensive agricultural activities thereby furnishing the atmosphere with more oxygen while depleting carbon dioxide (CO_2) concentration in the atmosphere. Furthermore, biofuel production will serve as a catalyst to boost National economy thereby providing Jobs for both skilled and unskilled people [21]. Other advantages of biofuel over fossil fuel include:

Greenhouse Gas Emissions: Plants that produce oil seeds, which are used for cooking or making biodiesel, absorb CO_2 from the atmosphere to build stems, leaves, seeds and roots. When the biodiesel is burned and the leftover plant material decomposes, carbon dioxide returns the carbon from the fuel and plant matter to the atmosphere again as carbon dioxide (CO_2). This recycling of carbon from CO_2 in the atmosphere to carbon in plant material and back to the atmosphere results in no accumulation in the atmosphere [22]. Also, sulphur content of petrol diesel is 20-50 times higher than biodiesels [23].

Energy Balance: Based on a report by the US DOE and USDA entitled "Life Cycle Inventory of Biodiesel and Petroleum Diesel for Use in an Urban Bus", biodiesel produced from soy had an energy balance (output:input ratio) of 3, 2:1. That means that for each unit of energy put into growing the soybeans and turning the soy oil into biodiesel, we get back 3, 2 units of energy in the form of biodiesel. That works out to an energy efficiency of 320%. The reason for the energy efficiency being greater than 100% is that the growing soybeans turn energy from the sun into chemical energy (oil). With the improved energy balances of other crops such as palm oil, waste oils, mustard or algae, this energy balance is usually even better [24].

Energy Consumption: Calculated with the Danish Energy Agency's method with correction for the differences between cold pressed rape seed oil and biodiesel, the gross energy consumption for cultivation and processing of rapeseed amounts to 10, 83 MJ/l rape seed oil, corresponding to 3, 922 GJ/ton rape seed or 12, 2 GJ/ha. Out of the 12, 2 GJ/ha, 7, 0 GJ/ha comprises local energy consumption in the form of 4, 9 GJ/ha diesel oil and 2, 1 GJ/ha electricity; this local fossil energy consumption can be replaced by renewable energy from the crop in the form of rape seed oil and electricity produced from rape straw.The energy content in the rape straw is 4, 5 times higher than the total gross energy consumption. It may be noted that, as an alternative to fodder, the energy content in the rape cakes may be used for energy production, either in a biogas plant or as fuel in combined heat and production plant or heat producing plants [25].

Plant Seed Oils Used for Biofuel Production

Rapeseed and Canola: Rapeseed and canola produce about 75 to 240 gallons of oil per acre. They are excellent rotation crops because they have deep root systems that scavenge well for water and nutrients. These crops use planting and harvesting equipment similar to what is used for small-grain production and the meal commands high prices in the feed market. One of the many possible plant oil sources for transportation is the winter rape, which is grown in Europe. The oil produced is useful both as food and as fuel, while the press cake is a valuable fodder. Winter rape can be produced through pesticide-free cultivation. In general pesticide-free cultivation of agricultural products results in a large overall yield loss (23% in average for corn), but according to Danish experience such cultivation is least affected for winter rape, with only 7 % yield loss [26]. Winter rape is now finding a place as a natural part of Danish organic agriculture. The production has increased by a factor of four in just two years.The cold pressed rape seed oil presents the energetically and environmentally best alternative to fossil diesel with a strongly positive energy and CO_2 balance. The use of rape seed oil for transport can substitute the agricultural industry's own fuel consumption. It is estimated that with conventional cultivation of winter rape, the total fuel consumption of the Danish agricultural industry could be covered by 10% of the agricultural area along with covering 20% of the protein fodder consumption and 81% of agriculture's total gross energy consumption [26].

Soybeansand Mustard: Soybeans produce approximately 1.5 gallons of oil per bushel. U.S. farmers produced a record-breaking yield in 2009 of 44 bushels per acre. This translates to an oil yield of 66 gallons per acre. Soybean oil is a co-product with soybean meal, a popular high-protein feed for animals. Although soybeans do not produce as much oil per acre as other crops, such as canola or rapeseed, soy oil is the most popular oil in the United States. It is commonly grown as a rotation crop with corn. The United States has an established infrastructure to process soybeans into oil and meal. Mustard, a relative of canola and rapeseed, has also been shown to be an excellent cover crop with high potential as a biodiesel feedstock. Although it produces less oil than canola, it is drought tolerant, grows well on marginal soils and contains compounds that act as natural fumigants against soil pathogens [27].

Camelina, Safflower and Sunflower: Camelina is a relative of mustard and rapeseed. Camelina can potentially be grown at a lower cost compared to rapeseed because it does not require as much fertilizer or pesticides. Researchers in the Pacific Northwest have been growing and studying Camelina for some time now. Safflower and sunflower both produce oil that can be used for biodiesel, although these oils tend to be more highly prized as premium cooking oils [27].

Oil Palm and Coconut: Tropical oilseed trees such as oil palm and coconut are used as biodiesel feedstocks in some parts of the world. Other warm climate crops are also being researched as biodiesel sources. In most cases, these plants grow wild and are well adapted to their environments. However, some are yet to be domesticated, so little information is available about diseases and insect pests that could cause problems when plants are grown in high density. Palm oil from Southeast Asia has emerged as a low cost feedstock for biodiesel production [27].

Castor Beanand Algae: A major constraint for using castor oil as a feedstock for biodiesel is the high price castor oil commands as an industrial and pharmaceutical feedstock. Castor oil boasts high lubricity characteristics, so biodiesel derived from castor oil could achieve the required lubricity for biodiesel standards at concentrations much lower than that of rapeseed (*Brassica napus* L.) or soybean (*Glycine max* L.). However, castor oil's high viscosity may limit its use to lower percentages in biodiesel blends or to warm climates. In addition to the main oilseed crops listed above, several plants are currently being researched as biodiesel feedstock, they include; Lesquerella and pennycress, both relatives of mustard, which show promising qualities as oilseed crops. Hazelnuts could also prove to be cost-effective, productive new biodiesel feedstock if current disease problems can be overcome. The tree is adapted to less productive soil and produces a high quantity of oil — about 90 gallons per acre.Microalgae have long been recognized as potentially good sources for biofuel production because of their relatively high oil content and rapid biomass production. There are however, production challenges which need to be overcome for successful commercialization [27].

Jatrophacurcas**:** *Jatrophacurcas* is a species of flowering plant in the spurge family, *Euphorbiaceae*, that is native to the American tropics, most likely Mexico and Central America [28]. Seed extraction is made simple with the use of the Universal Nut Sheller, an appropriate technology designed by the Full Belly Project. The oily seeds are processed into oil, which may be used directly ("Straight Vegetable Oil") to fuel combustion engines or may be subjected to trans-esterification to produce biodiesel. Jatropha oil is not suitable for human consumption, as it induces strong vomiting and diarrhea. When Jatropha seeds are crushed, the resulting Jatropha oil can be processed to produce a high-quality biofuel or biodiesel that can be used in a standard diesel car or further processed into jet fuel, while the residue (press cake) can also be used as biomass feedstock to power electricity plants, used as fertilizer (it contains nitrogen, phosphorus and potassium), or as animal fodder. The cake can also be used as feed in digesters and gasifiers to produce biogas [29]. Currently the oil from *Jatrophacurcas* seeds is used for making biodiesel fuel in Philippines, Pakistan and in Brazil, where it grows naturally and in plantations in the SouthEast, North and Northeast of Brazil. Likewise, Jatropha oil is being promoted as an easily grown biofuel crop in hundreds of projects throughout India and other developing countries. In Africa, cultivation of *Jatropha* is being promoted and it is grown successfully in countries such as Mali [30].

Considering the paucity of edible oils and unsustainability of arable land under perennial plantation of oil seed plants especially in countries such as India, the prospects of seed oil producing *Cleome viscosa;* an annual wild short duration plant species of the Indogangetic plains, were evaluated for it to serve as a resource for biodiesel. The seeds of *C. viscosa* resourced from its natural populations growing in Rajasthan, Haryana and Delhi areas of Aravali range were solvent extracted to obtain the seed oil. The oil was observed to be similar in fatty acid composition to the non-edible oils of Rubber, Jatropha and Pongamia plantation crops and soybean, sunflower, safflower, linseed and rapeseed edible oil plants in richness of unsaturated fatty acids [31]. The Cleome oil shared the properties of viscosity, density, saponification and calorific values with the Jatropha and Pongamia oils, except that it was comparatively acidic. The *C. viscosa* biodiesel had the properties of standard biodiesel specified by the American Society for Testing and Materials(ASTM) and Indian Standard Bureau, except that it had low oxidation stability. It proved to be similar to Jatropha biodiesel except in cloud point, pour point, cold filter plugging point and oxidation stability. In view of the annual habit of species and biodiesel quality, it can be concluded that *C. viscosa* has prospects to be developed into a short-duration biodiesel crop [31].

Steps Required to Proces Seed Oils into Biofuels: The seeds are prepared for oil extraction by applying mild heat treatments to precondition the seed prior to processing. Next, it is crushed and flaked and then heated slightly to enhance oil extraction. The flakes are then pre-pressed in a screw press or expeller to reduce the oil content in the seed. For canola this step reduces the oil content from about 42% to 16-20%. The press cake is then subjected to one of two types of oil extraction to remove much of the remaining oil. Oil may be extracted using either hexane (solvent extraction) or by cold-pressing. The oil which is produced during the extraction process is referred to as "crude oil" [32].

There are several forms of biofuel, often manufactured using sedimentation, centrifugation and filtration. The fats and oils are turned into esters while separating the glycerin. At the end of the process, the glycerin settles and the biofuel floats [33]. The process through which the glycerin is separated from the biodiesel is known as trans-esterification. Trans-esterification is a simple chemical reaction that neutralizes the free fatty acids present in any fatty substance. Glycerin is another by-product from Jatropha oil processing that can add value to the crop. In Jatropha, a chemical exchange takes place between the alkoxy groups of an ester compound and an alcohol. Usually, methanol and ethanol are used for the purpose. The reaction occurs in the presence of a catalyst, usually sodium hydroxide (NaOH) or caustic soda and potassium hydroxide (KOH), which forms fatty esters (e.g., methyl or ethyl esters), commonly known as biodiesel. It takes approximately 10% of methyl alcohol by weight of the fatty substance to start the trans-esterification process [33]. Seed yields of Jatropha under cultivation can range from 1, 500 to 2, 000 kilograms per hectare, corresponding to extractable oil yields of 540 to 680 litres per hectare (58 to 73 US gallons per acre) [34]. In 2009, *Time* magazine cited the potential for as much as 1, 600 gallons of diesel fuel per acre per year [35]. The plant may yield more than four times as much fuel per hectare as soybean and more than ten times that of maize (corn), but at the same time it requires a five times as much water per unit of energy produced as corn. A hectare of Jatropha has been claimed to produce 1, 892 litres of fuel [36]. However, as it has not yet been domesticated or improved by plant breeders, yields are variable. However, despite its abundance and use as an oil and reclamation plant, none of the *Jatropha* species has been properly domesticated and, as a result, its productivity is variable and the long-term impact of its large-scale use on soil quality and the environment is unknown [37].

Transesterification: The formation of fatty acid methyl esters (FAME) through trans-esterification of seed oils requires raw oil, 15% of methanol & 5% of sodium hydroxide on mass basis. However, trans-esterification is an equilibrium reaction in which excess alcohol is required to drive the reaction very close to completion. The seed oil is chemically reacted with an alcohol in the presence of a catalyst to produce FAMEs. Glycerol is separated as a by-product of trans-esterification reaction [38]. The trans-esterification process is usually carried out using two litres round bottom flask equipped with reflux condenser, magnetic stirrer, thermometer and sampling outlet. A litre of the crude oil is firstly filtered and heated up to 120°C to remove the moisture. The trans-esterification reaction is performed at 6:1 molar ratio of methanol/oil, using NaOH as catalyst. The temperature and the reaction time are maintained within a specific range. The resultant mixture is cooled to room temperature, the upper phase containing biodiesel and the lower phase containing glycerin (by-product). Crude biodiesel contains the excess methanol, the remaining catalyst together with the soap formed during the reaction and some entrained methyl esters and partial glycerides [39].

Purification: After separation of the two layers, the upper layer which contains the biodiesel is purified by distilling the residual methanol at a certain temperature. The remaining catalyst is removed by successive rinsing with distilled water and adding 1-2 drops of acetic acid to neutralize the catalyst. The residue can then be eliminated by treatment with anhydrous sodium sulphate (Na_2SO_4) followed by filtration. A transparent blackish liquid is usually obtained as the final product [39].

Table 1: Oil yields from various oil producing crops

Plant	Yield (seed) lbs/acre	Biodiesel gal/acre	Plant	Yield (seed) lbs/acre	Biodiesel gal/acre
Corn	7800	18	Safflower	1500	83
Oats	3600	23	Rice	6600	88
Cotton	1000	35	Sunflower	1200	100
Soybean	2000	48	Peanut	2800	113
Mustard	1400	61	Rapeseed	2000	127
Camelina	1500	62	Coconut**	3600	287

** Yield given in lbs of oil/acre

Source: [45]

Biodiesel Blends: Blending oils with diesel fuel was found to be a method to reduce chocking and extend engine life [40]. Investigation on the use of blends of methyl esters of soybean oil and diesel in a turbo-charged, four cylinders, direct injection diesel engine modified with bowl in piston and medium swirl type revealed that the blends gave a shorter ignition delay and similar combustion characteristics as diesel [41]. The amount and type of fatty acids in the biodiesel determines the viscosity, which is one of the most important characteristics of biodiesel.

Jet Fuels Manufactured from Plant Seed Oils: Aviation fuels may be more widely replaced by biofuels such as Jatropha oil than fuels for other forms of transportation. There are fewer planes than cars or trucks and far fewer jet fueling stations to convert than gas stations. On December 30, 2008, Air New Zealand flew the first successful test flight from Auckland with a Boeing 747 running one of its four Rolls-Royce engines on a 50:50 blend of Jatropha oil and jet A-1 fuel [42]. In the same press release, Air New Zealand announced plans to use the new fuel for 10% of its needs by 2013. At the time of this test, Jatropha oil was much cheaper than crude oil, costing an estimated $43 a barrel or about one-third of the June 4, 2008 closing price of $122.30 for a barrel of crude oil [43].

On April 1, 2011 Interjet completed the first Mexican aviation biofuels test flight on an Airbus A320. The fuel was a 70:30 traditional jet fuel biojet blend produced from Jatropha oil provided by three Mexican producers, Global Energías Renovables (a wholly owned subsidiary of U.S.-based Global Clean Energy Holdings), Bencafser S.A. and Energy JH S.A. Honeywell's UOP processed the oil into Bio-SPK (Synthetic Paraffinic Kerosene) [44]. On October 28, 2011 Air China completed the first successful demonstration flight by a Chinese airline that used Jatropha-based biofuel.

DISCUSSION

Despite the strong reasons stated above, for the replacement of fossil fuels by biofuels, certain group of scientists are of the opinion that biofuels are not a green alternative to fossil fuels. According to this school of thought, burning biomass whether directly as wood or in the form of ethanol or biodiesel, emits carbon dioxide just like burning fossil fuels. In fact, burning biomass directly emits a bit more carbon dioxide than fossil fuels for the same amount of generated energy. They believe that most calculations claiming that bioenergy reduces greenhouse gas emissions relative to burning fossil fuels do not include the carbon dioxide released when biomass is burned. They exclude it based on the assumption that this release of carbon dioxide is matched and implicitly offset by the carbon dioxide absorbed by the plants growing the biomass.Thus if those plants were going to grow anyway, simply diverting them to bioenergy does not remove any additional carbon from the atmosphere and therefore does not offset the emissions from burning that biomass. Furthermore, when natural forests are felled to generate bioenergy or to replace the farm fields that were diverted to growing biofuels, greenhouse gas emissions go up [46].

Since more than 95% of the biodiesel is synthesized from edible seed oils, there are many claims that a lot of problems may arise. By converting edible oils into biodiesel, food resources are actually being converted into automotive fuels. It is believed that large-scale production of biodiesel from edible oils may bring global imbalance to the food supply and demand market. Recently, environmentalists have started to debate on the negative impact of biodiesel production from edible oil [47]. They claimed that the expansion of oil crop plantations for biodiesel production on a large scale may increase deforestation in countries like Malaysia, Indonesia and Brazil. Furthermore, the line between food and fuel economies is blurred as both of the fields are competing for the same oil resources. In other words, biodiesel is competing limited land availability with food industry for plantation of oil crops. In fact, this trend is already being observed in certain parts of the world. There has been significant expansion in the plantation of oil crops for biodiesel in the past few years in order to fulfil the continuous increasing demand of biodiesel. Eventually, the implementation of biodiesel as a substitute fuel for petroleum-derived diesel oil, may lead to the depletion of edible-oil supply worldwide [47].

In order to overcome this devastating phenomenon, suggestions and research have been made to produce biodiesel by using alternative or greener oil resources like non-edible oils. The non-edible vegetable oils such as *Madhucaindica, Jatrophacurcas*and *Pongamiapinnata* are found to be suitable for biodiesel production under experimental conditions. Meher*et al.* [48] found that the yield of methyl ester fromKaranja oil under optimal condition is 97–98%, while oil yield from Castor bean, Hemp andPongame seed is around 50, 35 and 30-40 % respectively, while Neem seed contains 30% oil.

As of 2011 skepticism about the "miracle" properties of *Jatropha* has been voiced. For example: "The idea that Jatropha can be grown on marginal land is a red herring", according to Harry Stourton, business development director of UK-based Sun Biofuels, which cultivates *Jatropha* in Mozambique and Tanzania. An August 2010 article warned about the actual utility and potential dangers of reliance on *Jatropha* in Kenya. *Jatrophacurcas* is lauded as being sustainable and that its production would not compete with food production, but the Jatropha plant needs water like every other crop to grow. This could create competition for water between the Jatropha and other edible food crops. In fact, jatropha requires five times more water per unit of energy than sugarcane and corn [49].

Also, to be a viable alternative for petroleum, a biofuel should provide a net energy gain, offer clear environmental and economic benefits and not reduce food supplies and/or increase their costs. Biofuels fall short of these requirements and should therefore stay a niche market, used moderately and optionally instead of mandated at wide-scale public use [50]. A major hurdle to commercialization of biofuels is their cost in comparison to petroleum-based fuels. Lower energy density and the price of raw materials make biofuels more expensive when producing heat. And the higher the biofuel content of the fuel, the lower the energy density and thus energy efficiency. A vital concept when considering alternatives to petroleum is the energy return on investment (EROI), or how much net energy gain resides in the finished product compared to the total energy that was used in its production. EROI directly impacts the price, rate of adoption, economic development and the environmental benefits of the society that consumes it. Petroleum has an EROI of 16, versus just 5.5 for biodiesel from soybeans. In reality, this means that biofuels contradict state and national goals/mandates to deploy energy efficiency as a "priority resource" to reduce both energy usage and greenhouse gas emissions [50].

Biofuels are corrosive and cause cracking in steel, so the industry is dominated by trucks and rail, not our extensive and cheaper pipeline system. Trucks can up transport costs by a factor of five and rail by a factor of three or four. As a traded commodity, used cooking oil from deep fryers is regarded as the most sustainable type of biodiesel and demand is surging. The unrefined, raw material alone is now referred to as “liquid gold, ” fetching over $3 per gallon in New York City, when restaurant owners had to pay to have it taken away just a few years ago. Besides, additional costs of biofuels often go unaccounted for. A study released in January by the World Resources Institute found that biofuel mandates fail to consider their opportunity costs, a common mistake made by those pushing renewables over conventional forms of energy like oil. The inconsistency of biofuels and the varying strength of blends create significant problems, particularly from a fuel efficiency standpoint. The EPA, for instance, has delayed its 2014, 2015 and 2016 RFS blending volumes due to higher prices, equipment damage (ethanol can harm engines), costly repairs and supply shortages [50].

Biofuels increase food prices (plus the volatility of those prices) and therefore don't have many of the positive benefits for humanity claimed by proponents. The rising competition between “fuel and food” is a moral issue. Reports have it that with mounting ethanol production and mandates since 2006 food prices have sharply risen. Over 40% of U.S. corn is used to produce ethanol. Biodiesel demand increases the price of soybeans and this has a tremendous trickling down effect because soybeans have literally hundreds of uses in industrial products from engine oil to crayons to food products and animal feeds [50]. Rising food and energy prices are already dangerously expanding the problem of "food insecurity. Higher domestic food prices have dire global consequences: since 2008, developing countries, already burdened with low incomes and rising debt, have constituted the bulk of U.S. food exports. Further, despite significant subsidies and protectionist policies, biodiesel is obviously more expensive than heating oil, still requiring government aid to survive [50].

Again, total life-cycle greenhouse gas emissions from biofuels are virtually impossible to measure. There is disagreement about the actual energy and greenhouse gas savings of biofuels displacing fossil fuels. A large number of publications that analyze the life-cycle of biofuel systems present varying and sometimes contradictory conclusions. Greenhouse gases are emitted throughout the various stages in the production and use of biofuels, in producing the fertilizers, pesticides and fuel used in farming, during chemical processing, transport and distribution, up to ?nal use. This process involves a significant amount of fossil energy itself along the entire supply chain, which often makes biofuels less environmentally friendly than petroleum-based fuels. From crushing through transport, it can take 18 megajoules of fossil energy to make just one liter of soybean-based biodiesel. The unaccounted for environmental problems that indirectly arise from biofuel use include: 1) direct conflicts between land for fuels and land for food, 2) other land-use changes, 3) water scarcity, 4) loss of biodiversity and 5) nitrogen pollution through the excessive use of fertilizers [50].Soy-based biodiesel is especially land intensive, taking five times more land than ethanol to produce the equivalent amount of biofuel energy. Biodiesel has significantly higher NO emissions compared to ordinary diesel fuel because it has much more oxygen. According to the Union of Concerned Scientists, biofuels have serious secondary impacts that undermine their climate benefits and pose a threat to water resources. In 2014, the Inter-governmental Panel on Climate Change reported that indirect emissions from biofuels could lead to greater total emissions than when using petroleum products[50]. Also a study commissioned by the European Union reported that CO_2 emissions from biofuels are four times higher than those of petroleum-based products. The International Institute for Sustainable Development has also estimated that the climate benefits from replacing petroleum fuels with biofuels are basically zero. A recent study by Chatham House was even more blunt "Biodiesel from vegetable oils is found to be worse for the climate than fossil diesel [50].

CONCLUSION

Agriculture and forestry are the only production industries which are directly based upon solar energy through production of various forms of biomass which can be used for food, directly and indirectly in the form of fodder and energy. From a general consideration of sustainability, it would therefore be natural for agriculture to contribute a significant part of the country's energy supply. Oil seeds form plants presents no fire and health hazards and is non-polluting contrary to the production of fossil fuel which has been associated with a lot of air, land and water pollution as well as various health hazards. It is advisable to establish sustainable bio energy crops within existing and future cropping systems and agro climates and to develop new, value-added technologies to make in-state production of biofuels more economical. These trials should be established on at least one site (and in most cases two or more sites) in each of the thirty six states in Nigeria. Organic trials should also be included at selected sites to: improve the yield and economic performance of suitable crops through best agronomic management and genetic selection, identify viable crop rotation schemes that take advantage of these crops in providing rotational benefits to the productivity of other crops in the system, evaluate the efficacy of applying residual bioprocessing wastes (i.e. glycerine from biodiesel, anaerobically digested dairy manure, etc.), document the economic performance of crops and technologies andprovide educational opportunities and demonstrations for farmers.Also, the various concerns raisedabout the suitability of replacing fossil fuel with biodiesel as well as environmental problems that indirectly arise from biofuel production and use as revealed in this review, should be thoroughly investigated and put into fair consideration before taking decisions about what fuel to use.Factors such asdirect conflicts between land for fuels and land for food, other land-use changes, water scarcity, loss of biodiversity and nitrogen pollution through the excessive use of fertilizers should be considered when making a decision.

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