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# Biodisel Development in Nigeria: Prospects and Challenges

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**Abstract** Biodiesel development in Nigeria over the years has been given little attention because of the myriads of economic strain and stress facing the country like any other third world country. Biodiesel is a renewable source of energy that has not been fully tapped. Biodiesel can facilitate clean air, readily usable in existing engines and transport facilities, capable of generating employment and income for citizens and country at large. The major biomass world-wide is *Jatropha* plant which is currently generating interest in every economy of the world. The major means of converting the biomass into viable fuel is transesterification. The major problems facing the full exploit of this modern fuel is surmountable including the fear of taking-up arable agricultural land. Various generations of biofuel feed-stocks can be made use of in place of agricultural crops. The benefits and prospects of biodiesel production is huge and numerous. Deliberate efforts should be made by the government in terms of massive capital investment, training of man-power in the field of biofuel or biodiesel development, granting tax holidays to would-be investors_ companies and individuals, amongst many other things. If adequate policy frame-work is put in place and necessary political will is expressed and applied to the development and production of biodiesel in the country the economy would be better for it.

**Keywords** Biomass, Transesterification, Algae, *Jatropha*, Photobioreactor, Triacylglyceride (TAG)

## 1. Introduction

Biodiesel development dates back to 1885 when Dr. Rudolf Diesel built the first diesel engine with the full intension of running it on vegetative sources. He ran the patented engine on any hydrocarbon fuel available_ which included gasoline and peanut oil. He concluded that: ‘ the use of vegetable oils - for engine fuel may seem insignificant today; but such oils may in the course of time (future) become as important as petroleum and the coal tar products of present time ( in 1912). Since then, several researches and exploits into the field of production of biodiesel from natural biomass have been made. With the constant needs to reduce carbon emissions and the dwindling reserves of crude oil, liquid fuels derived from plant materials_ (biofuels) are an attractive source of energy. Un-like other forms of renewable energy (such as wind, tidal, solar energy) liquid biofuels allow solar energy to be stored, and also used directly in existing engines and transport facilities or infrastructures.

The viscosity (thickness) of vegetable oils could be reduced in a simple chemical process and as such, could work well and efficiently as diesel fuel in modern engine. This modified fuel from vegetable oil and other agricultural, animal and plant products is called Biodiesel. Biodiesel is also a diesel fuel derived from plants or animal oils, usually composed of methyl esters of long-chain fatty acids (-the detailed chemical composition and the length of chain of fatty acids in particular depends on the source of the oil-). Biofuel is a type of fuel whose energy is derived from biological carbon fixation. Biofuels include fuels derived from biomass conversion, as well as solid biomass, liquid fuels and various biogases[1] Biofuels are gaining increased public and scientific attention driven by factors such as oil price hike and the need for increased energy security. Bioethanol is an alcohol made mostly from fermentation of carbohydrates derived or produced in sugar or starch crops such as corn or sugar-cane. Cellulose biomass derived from non-food sources such as trees and grasses, is also being exploited and developed as a feedstock for ethanol production. Ethanol can be used as a fuel for vehicles in its pure form, but it is usually used as a gasoline additive to increase octane level, and improves vehicle emissions. Bioethanol is widely used in the USA and Brazil. There is a large amount of variation in energy efficiency, the cost of production, as well as the cost of green- house gas abatement between the different types of biofuels[2,3]. As such the source of the biomass used in the production of biofuel matters and varies from one source to the other. For instance: major feed-stocks used for ethanol production are corn (USA ) and sugar cane (Brazil). Ethanol itself can be used as biofuel or as an additive to blend in with fossil fuel. USA and

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Brazil currently account for 70% of the global ethanol production, followed by China, which is the third largest producer in the world[3]. Biodiesel or Biofuel is a renewable energy produced from biological materials/biomass. Biomass means agriculturally produced raw materials which are available on renewable or recurring basis. It includes tree crops, plant fibres, cellulose based materials, industrial wastes and other biodegradable parts of municipal solid waste (Nigeria Biofuel Policy Development and Incentives, 2010)[4]. Many countries are introducing biodiesel blends to enhance the lubricating capacity or lubricity of low-sulphur diesel fuels[5]. Nigeria, like other developing countries are faced with the challenges of advancing the course of biofuel exploitation. This is majorly due to the abundant availability of fossil fuel in the country and the myriads of economic issues and problems that constantly deserve urgent attention from the local, state and federal government. As such, the government is particularly not keen on the exploitation of biodiesel and biofuel development. Of course, this shouldn't be the case because the opportunities available in this segment of the economy if fully incorporated into the scheme of affairs of the government can equally change the future of the country. The National Agency for Biotechnology Development (NABDA) which majorly concerns itself with improved agricultural seeds and other products should be fully expanded to accommodate other frontiers in biodiesel development which will not only generate income for the government alone but could also lead to massive employment for the teeming population of the youth in an energy economy like ours given that this technology has worked in most European countries. This review exploits the prospects and challenges associated with biodiesel production and development in developing countries of the world with particular reference to Nigeria.

## 2. Sources of Biodiesel

Biodiesel fuel can be produced from oil seed plants such as rapeseeds, sunflower, canola, *Jatropha curcas,* soyabeans oil, mustard, palm, coconut, waste vegetable oil, animal fats, by-products of omega 3 fatty acids from fish oils, algae, oil from halophytes such as *Salicomia_bigelovii*, corn starch, sugar cane or sugar beet, mahua, flax, hemp, field penny-cress, *Pongami_apinnata*, argemone, castor, sal, etc constitute an array of biomass from which biofuels could be made even on an industrial scale[6]. Germany is currently the greatest biogas producer in Europe with about 2.4_m toe in 2007[7] - as a result of high industrial activities and dependence on energy imports and the need to ensure energy security and independence led to massive biogas production to compensate for over-dependence on fossil fuel importation from other countries. Agricultural crops are the major raw materials and substrates for biogas production in Germany. In the same vein, in Hungary the large livestock holdings serve as the main input suppliers of the biogas plants. There is also the usage of energy crops as substrate input. Such crops include maize, sorghum, grass which is used up to 80% of the total input capacity for biogas production[8]. Hungarian agricultural biogas is based mainly on agricultural waste, by-products and residues and not energy crops. Nigeria and other developing countries can borrow a leaf from Germany and Hungary such that these sources_ majority of which are equally abundant in the country could be harnessed in biofuel production.

## 3. Types of Biofuels

Biofuels can be broadly divided into two thus:

First generation biofuels are those produced from sugar, starch, vegetable oils, corn, sorghum, etc. These are also referred to as conventional biofuels which has traversed ages. Internationally traded biomass feed-stocks are molasses, sugar from sugar cane or sugar beet, tapioca chips, rapeseed oil palm oil, soy oil and cereals such as corn, feed wheat and rye.

Second generation biofuels are biofuels produced from sustainable feed-stocks. These include: cellulosic ethanol which is produced from non-food crops or in-edible waste products. Enzyme catalysts, elephant yeast, the fungus *Gliocladium_roseum* (in producing myco-diesel); recombin ant DNA genetically engineered organisms can be used to produce biofuels from long-chained cellulose into glucose - these methods are still at their embryonic stages and under serious research. Other second generation biofuels include those gotten from algae, bio-hydrogen, bio-methanol, DMF, Bio-DME, Fischer_ Tropsch, etc.

Several other researchers believed that there are tertiary generation biofuel which could be deemed to include: solid biofuels from wood, saw-dust, grass trimmings, domestic refuse, charcoal, agricultural waste, non-food energy crops and dried manure and those produced from ligno-cellulose sources.

## 4. Process of Conversion

The major phenomenon used in the transformation or conversion of biomass into biofuels is known as transesterification. This is the process of converting vegetable oil into biodiesel which involves taking a triglyceride molecule, or a complex fatty acid neutralizing the free_ fatty acids, removing the glycerin, and creating an alcohol ester. This is accomplished by mixing into the vegetable oil. After the mixture has settled down, glycerin is left on the bottom and methyl esters, or diesel is left on the top. This can then be filtered. Biodiesel is usually produced from the oil by transesterification where the glycerol to which long-chain fatty acids are esterified in the source oil is replaced by another alcohol usually but not exclusively methanol. This biodiesels are commonly FAMES (Fatty acid methyl esters). (Hoydonox et al., 2004)[9] stated that transesterification reaction consists of transforming triglycerides into fatty acid alkyl ester, in the presence of an

alcohol, such as methanol, and a catalyst, such as an alkali or acid, with glycerol as a by-product.

Apart from above, some scientists from Minnesota have developed co-cultures of *Shewanella* and *Synechococcus* that produce long-chain hydrocarbon directly from water, carbon-dioxide and sunlight_ [10].

There are myriads of other processes that are not necessarily chemical processes and are not x-rayed in this review.

## 5. Prospects/Benefits of Biodiesel Production

The prospects and Benefits of biodiesel production or development are enormous and very crucial to the swift development of the economy of any nation. Some of these prospects/benefits include but not limited to the following:

◆ biodiesel can be used in car engines even when it is not yet refined. It can also be blended with normal diesel and used in cars. The vegetable oil can be refined and sold as pure diesel.

◆ source of foreign earnings since it can be exported as clean fuel to every part of the world. Biodiesel from sunflower, canola, *Jatropha* can be used as a substitute for or as an additive to diesel fuel thus providing an alternative source of energy for diesel-powered engines. Since, it is a renewable domestically provided liquid fuel it can reduce countries' dependence on oil importation.

◆ it is not subject to market forces and can be readily tapped unlike petroleum products.

◆ it is reputed as the most valuable form of renewable energy that can be used directly in any existing, un-modified diesel engine.

◆ economic growth is stimulated as it creates more market for agricultural products and stimulates rural development and generates interest in the youth towards taking up job opportunities in agriculture and farming instead of over-dependence on white scholar job that is not always there. This is particularly important for developing world or countries that are majorly agrarian or has the capacity or potential to become one.

◆ production of biofuel can lead to development of new industries, new jobs, new markets, new technologies, etc.

◆ the foreign earnings could be channeled towards the development of other sectors of the economy especially health and education sectors.

◆ biofuel generates fewer emissions of carbon monoxide, particulates, and toxic chemicals (that cause smog, aggravate respiratory and heart diseases and contributes to thousands or even hundreds of thousands of premature deaths each year.) un-like gasoline and diesel with high emissions. Studies show that biodiesel reduces carbon dioxide emission to considerable level and can even reduce its emissions to zero. As such, the uptake of carbon from atmosphere by plants and trees reduces the effects of global warming.

◆ biodiesel is as biodegradable as salt. _It is biodegradable as sugar, ten times less toxic than table salt. It is environmentally friendly and ideal for heavily polluted cities like Lagos and Portharcourt.

◆ biodiesel produces 80% less carbon dioxide and 100% less sulfur dioxide emissions, provides 90% reduction in cancer risk.

◆ it is cheaper than mineral oil diesel and capable of extending the life-span of engines; and a means of conserving natural resources. Biodiesel can be used in standard diesel engines, but is often blended with conventional diesel.

◆ according to the International Energy Agency, biofuels have the potential to meet more than a quarter of world demand for transportation fuels by 2050[11].

◆ biodiesel is an oxygenated fuel, meaning that it contains a reduced amount of carbon and higher hydrogen and oxygen content than fossil fuel. This improves the combustion of biodiesel and reduces the particulate emissions from un-burnt carbon and has high flash point of about 300F (148 C) compared to petroleum diesel fuel, which has a flash point of 125F (52 C)[12] hence, it is a better lubricant.

◆ biodiesel produced from *Jatropha_curcas* (50% of the fuel) has been used in January, 2009 by continental Airlines and Air New Zealand in December, 2008. (As such nothing stops Nigeria from following suit)

◆ *Jatropha* plant is poisonous and can grow on arid or semi-arid soil. It also grows very tall. Hence, it can not only be grown in desert-prone-areas of the country but can also serve as forest; and when inter-cropped with other crops like maize, beans and pea nuts, etc is capable of regenerating the soil. As such, the production of biofuel from *Jatropha* can be done while other benefits and, or revenue are being derived.

◆ biodiesels are renewable energy and can drastically reduce green house gases since its production and use is nearly carbon neutral. It can be gotten from various sources including algae making its prospects almost limitless.

◆ it leads to improved demand for raw materials and improvement in agricultural prices.

## 6. Challenges Associated with Biodiesel Development

There are challenges associated with biodiesel development all over the world. These challenges are much more obvious in developing countries. These include the following:

● lack of adequate man-power and expertise in the field of biodiesel development has limited the efficiency and awareness on the part of the public of the potentials that are yet to be tapped.

● other competing economic challenges of the third world countries have led to its neglect.

● lack of political will on the part of the government and policy makers are major issues militating against the swift advancement of biodiesel projects.

● food versus fuel debate: many researchers, scientists and public commentators have argued in favour of food

production rather than embarking on any form of fuel production either on the short or long-run because they see it as detrimental to the survival of the human race considering the fact that arable land is taken up by production of various feed-stocks for biodiesel production. According to Hill et al., 2006[13] to provide a significant proportion of transport fuel, the growth of these crops would compete for arable land with food crops. Andrew Bounds, 2007[14] expressed the fear that in the current corn- to ethanol production model in the US, considering the total energy consumed by farm equipment, cultivation, planting, fertilization, pesticides, herbicides and fungicides made from petroleum, irrigation systems, harvesting, drying, transporting of feed-stocks to processing plants, fermentation, distillation, transport to fuel terminals and retail pumps and lower ethanol fuel energy content, the net energy content value added and delivered to consumers is very small. And, the net benefit does little to reduce imported oil and fossil fuels required to produce the ethanol.

- some people have also argued against its sustainability over a long period of time to meet industry requirements.
- it can also lead to deforestation if the natural resource such as biomass from trees and wood are constantly used as feed-stocks without adequate replenishment.
- it could also lead to soil erosion; loss of biodiversity and negative impact on water resources, energy balance and efficiency, etc.
- high cost of virgin vegetable oil and other sources of triglycerides play a large role in process profitability.
- according to Vasudevan and Briggs, 2008,[15] many technical challenges remain and these include development of better and cheaper catalysts, improvement in current technology for producing high quality biodiesel, use of solvents that are non-fossil based, conversion of the by-products such as glycerol to useful products like such as methanol and ethanol, and development of low cost photobioreactors.
- because it is capital intensive it is dominated by large agri-businesses. The impact on the local communities may not be felt directly by the citizens. It can also lead to hike in the staple food prices of the general populace and the less privileged in particular further exacerbating the poverty crunch already experienced.

## 7. Possible Panacea to the Challenges

Research into the possibilities of generating ethanol from lignocellulose could serve as source of alleviating the concerns raised in this article especially when it is produced from algae[16, 17] due to the following reasons:

- algae have higher productivities than land plants with some species having doubling times of a few hours;
- some species can accumulate very large amounts of triacylglycerides (TAGs) _ the major feedstock for biofuel production;
- high quality agricultural land is not required to grow the biomass.

However, the optimization of algal biomass production and TAG content still need to be tackled especially in developing countries where other economic challenges need urgent attention.

According to the journal 'Renewable fuels from algae: An answer to debate-able land based fuel'[18] algae is a source for biofuels that could utilize currently unprofitable land and waste water which does not affect the land or fresh water needed to produce current food and fuel crops. Also, algae are not part of the human food chain, and therefore, don't take away food resources from humans.

Non-food crops could be used in the production of biodiesel. *Jatropha* plants could be planted in arid and semi-arid land such that arable land for food crops is not used for the purpose of fuel production.

Low cost feed-stocks such as non-edible oils, waste frying oils, animal fats could be used as replacement for virgin vegetable oils with additional steps to remove water and any free fatty acids to make it effective in biodiesel production.[19]

Soyabean oil-derived biodiesel possess enhanced biodegradation, increased flash-point, reduced toxicity, lower emissions, and increased lubricity. Cold climate limits the usefulness of soyabean oil-derived biodiesel as a fuel. The tools of biotechnology could be utilized to modify the fatty acid profile of soyabean for performance enhancement, which may increase the attractiveness of biodiesel derived from this commodity crop[20]. Soyabean oil has a high iodine value compared to many other biodiesel feed-stocks (indicating a relatively low level of saturation compared to other oils, such as rapeseed and canola)- hence it can be used in place of other oils that have high level of fatty acids. The use of lipase as a catalyst through the transesterification of olive oil has also been reported[21] under optimum temperature of 60℃.

An open pond system could be used in cultivating high quality oil algae through the approach taken by Huntley and Radalje (2007)[22] in which nutrient restriction in the pond prevents any other form of algae from growing well. However, the use of photobioreactor to selectively grow some algae in preference to another is costly and could only be handled by large firms. Scott et al., 2010[23] suggested a model for production of algal biomass and TAG content from algae which could ease the cost of using photobioreactor.

## 8. Conclusions and Recommendations

According to Zeller and Grass (2007)[24] in their paper tittled "Prospects and challenges of Biofuels in Developing countries" concluded that in order to master the challenges and capitalize on the promising prospects biofuels hold for susteinable development, massive investments in agricultural research and appropriate institutional and policy framework are required. In addition, it is pertinent to know

that the challenges are surmountable. Reseach is currently exploring the use of sweet sorghum, cassava, sweet potato, wood, switch grass, edible and non-edible oil, animal fats, *Jatropha* oil, palm oil, coconut, cotton-cellulose, manure and other biomass generators _ hence the prospects are numerous and could be highly enriching if adequately tapped.

It could also be recommended that tax holidays should be given to companies and individuals that may be interested in biodiesel development. There should be direct and deliberate development of man-power in the field of biodiesel production by stimulating and susteining interest of individual citizens of the countries especially in developing world.

Government should show interest and political will in developing essential policies and infrastructures useful in biodiesel production and development. The effort of the Federal Government of Nigeria in this is quite commendable since it signed 414 billion Naira project on biofuel production.

Various developed countries that have gone miles ahead in the field of biofuels and biodiesel production should carry-along other developing countries in this giant stride _ with these in place the prospects of biodiesel and biofuel production is not only enormous but also feasible given that the challenges are very much surmountable.

It was reported by Biofuel Digest in September, 2011[25] that farmers were being trained by the university of Benin (South-south Nigeria) through its National Centre for Energy and Environment (NCEE) in growing *Jatropha* plants for use in the twelve new biodiesel production equipment and has also begun production of ethanol from pineapple peels – this is a project in the right direction. Infact, more of such monumental projects are needed to drive home the production of biodiesel in large quantity. Governments and well-meaning individuals should support the proliferation and replication of this type of project in other parts of the country.

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