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Biofuels for Sustainable Development in Nigeria: A Review

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Abstract
The unsustainable nature of fossil fuels (non-renewable) has led to the search for other alternative fuels such as biomass derived fuels. Biofuel technology is a promising endeavour towards a sustainable development in any nation, as Nigeria has a vast arable land that is good for agriculture and biomass production. Biofuels include bioethanol, biodiesel, biobutanol and biogas with each having different method of production and use. The rural women energy security project of the Federal Ministry of Environment has already empowered 10 rural women cooperatives, among the benefits of biofuel are: increase in national income, sustainability, mitigation of greenhouse gases, proper and effective waste recycling, employment, energy security among others. The biomass resources, research and knowledge needed for biofuel production is readily available and with the appropriate entrepreneurial and political will; Nigeria will be a key player in the biofuel business. This paper reviewed the potential of biofuels production and benefits as it relates to sustainable development in Nigeria. Lack of continuity of projects after a change of leadership in the government has hindered the rapid progress in many sectors including the biofuels. Government should ensure the full implementation and continuity of projects in biofuel and other green areas of development.
Keywords: Biofuel, Sustainable development and Nigeria.

INTRODUCTION

Energy is an indispensable part of human life in all sectors of the economy such as agriculture, transportation and industries (Ibrahim *et al.*, 2011). The major sources of energy today are the non-renewable sources such as crude oil in which there are concerns over fossil fuels causing environmental contamination involving greenhouse gas emissions and global warming (Ibrahim *et al.*, 2011). The decrease in crude oil reserves and the non-stable prices coupled with the lots of crisis in the oil region is also an issue of concern (Manish and Kalyan, 2012; Ibrahim *et al.*, 2011). Other factors affecting fossil fuel energy production are energy security, rising political and economic conflict; thus, the unsustainable nature of non-renewable energy is obvious and the need for sustainability in the energy sector (Ibrahim *et al.*, 2011).

Biofuels, being an alternative to the fossil fuels are attracting the attention researchers. Biofuels are liquid or gaseous renewable products that are produced from biomass and are used for either transportation or burning purposes (Annie, 2006; Segun, 2012). On the other hand, sustainable development is a plan and actions that satisfies the demand of today's population without compromising that of the future population (Ibrahim *et al.*, 2011; Organization for Economic Cooperation and Development (OECD), 2001). Common examples of biofuels are bioethanol, biobutanol, biogas and biodiesel which can greatly replace the petroleum fuels (Manish and Kalyan, 2012; Abubakar *et al.*, 2017). The production of biofuels is now a global effort and the government of many countries such as Brazil, China, USA, and Germany have set up many biofuel programs and initiatives, this shows biofuels are important to all nations including African countries (Segun, 2012). The purpose of this paper is reviewing the potential of biofuels production and benefits as it relates to sustainable development in Nigeria.

Biomass

Nigeria has abundant renewable energy resources of which the most widespread are solar, wind, biomass and hydro power (Nigerian Electricity Regulatory Commission (NERC), 2020).

Biomass is all forms of matter derived from biological activities which include crops, trees, agricultural wastes and residues, and organic municipal solid waste (Chukwuma *et al.*, 2012; Edirin and Nosa, 2012; Thomas and Emmanuel, 2012). Biomass is the major source of energy in Nigeria contributing up to 78% of Nigerian energy supply (Edirin and Nosa, 2012). Biomass energy in Nigeria is produced primarily from wood then by waste and alcohol fuels, while wood constitutes most of the biomass energy over the years, ethanol has been the fastest growing renewable energy source over the past years (Edirin and Nosa, 2012; Thomas and Emmanuel, 2012). The poor depends heavily on biomass for energy mainly in the form of wood and agricultural residues, which causes negative impacts such as indoor air pollution and immense pressure on natural resources (Akande and Olorunfemi, 2009). The production of energy from biomass include various technologies such as solid combustion, gasification and fermentation which results in various liquid and gaseous fuels from many biological resources (Akande and Olorunfemi, 2009; Abubakar *et al.*, 2017).

Feedstock for biofuel production

Based on different types of raw materials, biofuels are categorized into four (Ibrahim *et al.*, 2011; Manish and Kalyan, 2012):

1. First generation biofuels: these are produced from agricultural feedstock, vegetable oil, animal fat, sugar, starch and cereals (Ibrahim, *et al.*, 2011; Manish and Kalyan, 2012; Kumar, 2015). Such include maize and sugar cane among others. First generation biofuel feedstocks are unsustainable due to food security and land use but the use of Lignocellulosic biomass is more sustainable and ethically acceptable and therefore must be promoted (Graeme, 2011; Ibrahim *et al.*, 2011)
2. Second generation biofuels: these are produced from non-food sources such as lignocellulose (Graeme, 2011). Lignocellulose are divided into either bio-waste (straws, corn residues, woody wastes, old paper/cardboard, bagasse, spent grains, municipal solid waste, agricultural residues like oilseed pulp, sugar beet pulp or energy Crops such as short rotation coppice (basket willow *Salix viminalis*) and energy grasses like *Miscanthus giganteus*(Graeme, 2011).
3. Third generation biofuels: also referred to as advanced biofuels, which are produced from microalgae and cyanobacteria (Ibrahim *et al.*, 2011).
4. Fourth generation biofuel: these are produced by photosynthetic generation of biohydrogen and bioelectricity (Ibrahim *et al.*, 2011).

Types of biofuel and their mode of production

Biobutanol: This is an organic alcohol produced through Acetone-Butanol Fermentations using *Clostridium acetobutylicum* from molasses and cereal grains (C_4H_9 OH) (Manish and Kalyan, 2012; Ruth *et al.*, 2018). It has many advantages such as high energy content, high hydrophobicity, good blending ability, does not require modifications in internal combustion engines and is less corrosive than other biofuels (Manish and Kalyan, 2012).

Biodiesel: This is a fatty acid methyl ester produced from edible, non-edible oil crops (jatropha, and rape seed), and waste frying oil (Samuel *et al.*, 2013). It is a clean burning alternative to fossil fuel produced by transesterification reaction of fat or oil with an alcohol to give mono-alkyl esters and glycerol (Annie, 2006; Ibrahim *et al.*, 2011; Daniyan *et al.*, 2014). As glycerol is separated, the fatty acid methyl esters are used as biodiesel. Biodiesel production from seeds usually starts with an oil extraction (Ibrahim *et al.*, 2011). It can be used either in its pure form or as blends with fossil diesel in diesel engines without any engine modifications, it is sustainable, biodegradable, environmentally friendly, non-toxic, and has better combustion characteristics compared to fossil diesel (Annie, 2006; Daniyan *et al.*, 2014).

Bioethanol: This is a promising biofuel produced by fermenting sugars and cereal crops (C_2H_5OH) (Annie, 2006; Ibrahim *et al.*, 2011). The liquid wash from the yeast fermentation of biomass derived sugars is distilled and used as liquid fuel (Graeme, 2011; Annie, 2006). Bioethanol is produced from sugar cane, maize and lignocellulose. Bioethanol from lignocellulose is sustainable and has the potential to become a substitute to or replace gasoline (Annie, 2006). Bioethanol can be used in pure form in special engines or blended with gasoline in any proportion up to 10% without the need for engine modification (Annie, 2006).

Biogas**:** This is a mixture of gases mainly methane (CH_4) and carbon dioxide (CO_2), produced through anaerobic fermentation of household, agricultural and industrial waste (Juliet *et al.*, 2016). It is mostly used for cooking purposes and can also be used to generate electricity (Edirin and Nosa, 2012; Thomas and Emmanuel 2012).

POTENTIALS FOR BIOFUEL PRODUCTION IN NIGERIA

According to FAO 2017 statistics, the total country area of Nigeria is approximately 92,377,000 hectares (ha) with a land area of 91,077,000 ha, of this; agriculture has 70,800,000 ha, 37% of Agricultural land is arable, 7% permanent crops, 8% forest crops and 15% other land (FAO, 2019). Nigeria has high potentials for biofuel production because of the level of water availability and arable land free for production of energy crops (Segun, 2012; Ohimain, 2013).Energy Crops such as sugar cane, cassava, sorghum, maize, oil palm, soybean and jatropha are grown widely in the country. Globally, Nigeria is the largest producer of cassava, among the top four producers of sorghum, among the top three producers of oil palm and 13th largest producer of soybeans (Juliet *et al.*, 2016).

Significant amount of organic waste is produced in every part and cities of the country which is just dumped around contributing to environmental littering, such biogenic waste could serve as substrate for biofuel production (Suberu *et al.*, 2013). Crop and forest residues which are bye-products of either agricultural and forest resources harvest and processing. These residues do not require separate land for cultivation and can be converted to biofuels through fermentation, gasification or hydrolysis (Juliet *et al.*, 2016). Municipal solid waste (MSW), food waste and industrial waste dumped in the cities can be used as feedstocks especially for biogas production through anaerobic fermentation (Chukwuma *et al.*, 2012; Juliet *et al.*, 2016).

Livestock production is distributed all over the country, this generate high amount of animal manure that is also a good substrate for methane (biogas) production (Suberu *et al.*, 2013; Juliet *et al.*, 2016). Cattle, goat and sheep are reared in the north while pig and chicken predominates in the south. Northern Nigeria's agricultural local economy revolves around livestock rearing; hence, it has great potentials for biogas production because of the amount of cattle waste generated in the region from manure to slaughter house waste (Suberu *et al.*, 2013; Juliet *et al.*, 2016). It is estimated that Nigeria produces 227,500 tons of fresh animal waste daily where approximately 1 kg of fresh animal waste produces approximately 0.03 m^3gas; thus, Nigeria can produce 6.8 million m^3 of biogas daily from fresh animal waste (Akinbami *et al.*, 2001; Juliet *et al.*, 2016). Table 1 (Suberu *et al.*, 2013) shows the solid waste statistics and characteristics of some urban cities in Nigeria and Table 2 (FAO, 2020) shows the population of livestock from 2015 to 2018. Biofuel project are all integrated and as such will not distort the current food supply and will also boost agriculture and add to Nigeria's food production through mechanized farming. Hence, the Nigerian Biofuels Policy and incentives was documented and approved on 20th June 2007 (Peter and Gbenga, 2009).

Table 1: Solid waste statistics and characteristics of some urban cities in Nigeria

City	Cap/person/ day (kg	Monthly waste (t)	Annual waste (t)	Organic waste (%)	Annual organic (t)
Lagos	0.73	255,556	3,066,672	36	1,104,001.92
Kano	0.56	156,676	1,880,112	51	958,857.12
Ibadan	0.31	135,391	162,4692	61	991,062.12
Abuja	0.281	14,684	176,208	65	114,535.20
Port Harcourt	0.7	117,825	1,413,900	60	848,340.00
Benin	0.63	27,459	329,508	54	177,934.32
Maiduguri	0.28	32,956	395,472	66	261,011.52
Kaduna	0.23	44,433	533,196	63	335,913.48
Aba	0.31	64,347	772,164	70	540,514.80
Bauchi	0.31	25,395	304,740	64	195,033.60
Yola	0.28	25,365	304,380	68	206,978.40
Katsina	0.32	18,452	221,424	70	154,996.80
Ilorin	0.25	34,560	414,720	70	290,304.00
Onitsha	0.7	84,137	1,009,644	62	625,979.28
Abuja	0.281	14,684	176208	65	114,535.20

Source: Suberu *et al.*, 2013.

Table 2: the population of livestock (Head) from 2015 to 2018

Year	Cattle	Chicken	Goats	Horses	Pigs	Sheep
2015	20184763	142895000	72527691	102147	7368216	41632158
2016	20581831	147116000	73776693	100708	7481750	42060088
2017	20953379	143232000	78049310	89109	7498342	42500000
2018	21418189	139431000	79382178	85941	7499165	42971860

Source: FAO, FAOSTAT, Productions (Live Animals) (Latest update, March 4, 2020). Accessed 15th June, 2020. URL: http://www.fao.org/faostat/en/#data/QA

State of Biofuel Production in Nigeria

After the signing of the biofuel policy incentive in 2007, the substitution of kerosene with ethanol gel and the use of 10% ethanol blend with gasoline started. This leads to a demand of 5.14 billion litres of bioethanol/year which leads to some emerging projects from the government and private sector (Ohimain, 2010). Nigeria's Bioethanol production is developing but still insufficient to meet the current demand and there is a shortfall of about 5 billion litres per annum (Ohimain, 2010; Edirin and Nosa, 2012; Juliet *et al.*, 2016). Alconi/Nosak, UNIKEM and Intercontinental Distilleries which uses imported crude ethanol precursors produces 118.6 million L/year. However, currently there are two companies producing bioethanol from local feedstocks; Dura Clean located in Bacita Kwara State and Allied Atlantic Distilleries Ltd. (AADL) located in Sango-Ota Ogun State which has a production capacity of 4.4 and 10.9 million L/year respectively. (Ohimain, 2010; Chukwuma *et al.*, 2012; Edirin and Nosa, 2012; Juliet *et al.*, 2016). Another pioneer company, Global Biofuel limited is devising a method for production of ethanol from sweet sorghum stalk juice and also biodiesel from safflower where it already has flagged off the plant construction in Ondo and Ekiti state (Obada, 2008; Obilana, 2008; Obada, 2009a). In an interview, the managing director of Global Biofuels Limited, Dr Felix Obada explained that the refinery at Ekiti is expected to produce 350,000 litres per day, also states like Nassarawa, Plateau and Zamfara has a good arable land than can produce 500,000 thousand litres per day, and the company plans to build a refinery per state for biofuel production (Obada, 2009b). Ohimain, (2010) reported for the first time 20 emerging bioethanol projects in Nigeria which the major pioneers include the Nigerian National Petroleum Corporation (NNPC), Biofuels Nigeria Ltd, Ekiti and Ondo State Governments, and partnerships between private companies and state governments to be located in various states in the country. Future ethanol projects in Nigeria are listed in Table 3 (Ohimain, 2010). In the year 2007, Kaduna state government has set up a bioethanol pilot plant using local design and materials (Chukwuma *et al.*, 2012).

There is no record of industrial biobutanol production in Nigeria, However, a study was conducted in Nassarawa state for isolation of biobutanol producing Clostridium species and also the highest producer (*C. acetobutylicium*) was used to produce bioethanol from waste paper and sugar cane molasses (Makut *et al.*, 2018; Owuna *et al.*, 2018).

Biodiesel production has been reported in Nigeria only at a research scale level for example, Ahmadu Bello University Zaria, has designed a pilot plant for biodiesel productionand the initiatives of using safflower as previously mentioned by Global Biofuels Limited (Obada, 2009a; Chukwuma *et al.*, 2012; Juliet *et al.*, 2016).

The industrial production of biogas in Nigeria is good and feasible but biogas plants are not yet available in the Nigerian energy market, however, substantial research has been done and is still in progress across the country; for instance, as at 1990's Usman Danfodio University Sokoto has built a digester that can provide 425 litres of biogas per day (Akinbami *et al.*, 2001; Juliet *et al.*, 2016). Aigbodion and co-workers of the Rubber Research Institute of Nigeria (2018) reported the production of biogas from cow dung using a fixed dorm digester in which materials for the construction of the plant were sourced locally while the accessories were imported from India. The plant produced 8.5 to 7.6 m^3gas per day for 28 days of the research (Aigbodion *et al.*, 2018).

Table 3: Future ethanol projects in Nigeria

Company	Project	location
Global Biofuels Ltd.	Integrated bio-ethanol refinery and sweet sorghum farm in 10 Nigerian states	Edo, Kogi, Osun, Ondo, Kwara, Niger, Kaduna, Ekiti, Oyo and Plateau
Casplex	Cassava ethanol refinery and farm	Oyo and Ekiti States
Alconi Nigeria	Ethanol plant	Calabar in Cross River
Nasarawa state	Integrated ethanol bio-refineryand Cassava farm	Doma, Nasarawa state

Source: Ohimain, 2010

BENEFITS OF BIOFUEL

The benefit of biofuel is clearly reflected in the increasing number of countries introducing or planning to introduce policies to increase the proportion of biofuels within their energy portfolio (Annie, 2006). The benefits of biofuel can be divided into:

Environmental benefits

The primary advantage of biofuels and the driving force for worldwide production is their alleged reduced greenhouse gas emissions, reduce emissions of key toxic substances associated with fossil fuels (CO_2, sulphate, etc.) and thus will reduce climate change and global warming (Annie, 2006; Graeme, 2011). Fermentation of plant derived biomass to bioethanol photosynthetically re-fix CO_2 during production and combustion and do not result to toxic gas emissions (Graeme, 2011). There is also reduction in household pollution and deforestation when biogas substitutes traditional fuels such as wood (Annie, 2006). According to Akande & Olorunfemi (2009), The Group Managing Director of the Nigeria National Petroleum Commission (NNPC) said that "the ethanol programme was expected to improve automotive exhaust emissions in the Country, reduce domestic use of petrol, free up more crude for export and position Nigeria for development of green field". The production of biofuel from waste is an effective way of waste recycling. The great green wall programme with a mission "to halt and reverse land degradation, prevent depletion of biological diversity, ensure that by 2025, ecosystems are resilient to climate change and continue to provide essential services that would contribute to human"; will only be achieved by a switch from fuel wood to Biogas for cooking (Federal Ministry of environment (FME, 2019a).

Job creation and rural development

The driving force for renewable energy development is more likely to be employment potential and job creation rather than environmental (FME, 2019b). Biofuel production will ignite a need for agricultural produce other than food, feed and fiber, this will provide employment for many young men and women especially in rural areas; for instance, the rural women energy security (RUWES) project of the FME's Clean Energy initiatives has already empowered 10 women rural women cooperatives with RUWES business model package with cleaner lighting and cooking kits which will create market potential for the women and also provide jobs for foundry workers, welders, mechanics etc. in cookstoves production (Annie, 2006; FME 2019b). Sugarcane in Brazil employs around 1 million workers, bioethanol production in the US has provided more jobs in the rural areas better than any other activity (Annie, 2006; Daniyan, *et al.*, 2014). According to Akande & Olorunfemi (2009), the Group Managing Director of NNPC said that "Nigeria would be $150 million (about N21 billion) annually richer when it adopts the development and application of biofuel as an alternative energy source to crude oil".

Conflict resolution

Since the energy crisis of the 1970s, developing new energy sources from the agricultural sector has been viewed as a way to expand the domestic energy supply and help mitigate growing dependence on oils from conflict prone areas (Akande & Olorunfemi, 2009). Nigeria's oil reserves are not evenly distributed and the recurring conflicts in those areas affects the supply and hence the market price which affects the socioeconomic welfare of the populace (Ohimain, 2010; Ibrahim *et al.*, 2011).Biofuel feedstocks are abundant and distributed across the country; therefore, it will be more widely distributed and less liable to political crisis (Ohimain, 2010).

CONCLUSION

Nigeria is among the top producers of important energy crops in the world and also generates a significant amount of organic waste which can be used to achieve a twin benefit of fuel and environmental cleanliness. The biofuel business sector will help curb the high rate of unemployment in the country by engaging the youths, local farmers and entrepreneurs.

Government and other stake holders should ensure and encourage the continuity and full realization of the emerging bioethanol projects in the country so as to meet the demand of the nation.There is a need to scale up from the research level and pilot plant to industrial commercialization of biobutanol, biodiesel and biogas in Nigeria.The policies and plans in the National biofuel policy incentive, FME and other relevant authorities if implemented, will accelerate the development in the biofuel sector and solve many environmental problems faced by the nation.

REFRENCES

Abubakar, S. A., Abdulkarim, A. D., Haruna, S., Ibrahim, L. M., Mohammed, M. U. (2017). Biofuel development in Nigeria: Prospect and challenges. *Journal of Advanced Research in Fluid Mechanics and Thermal Sciences,* **36**, (1) 1-9.

Aigbodion, A. I., Bakare,I. O.,Fagbemi, E. A., Abolagba, E. O.,Omonigho, B.,Ayeke, P. O., Bausa,M. and Musa, E. (2018). Viability of Biogas Production from Manure/Biomass in Nigeria Using Fixed Dome Digester. *Universal Journal of Agricultural Research* **6**(1): 1-8. DOI:10.13189/ujar.2018.060101

Akande, S.O. & Olorunfemi, F.B. (2009). Research and Development Potentials in Biofuel Production in Nigeria. *African Research Review*, **3** (3), 34-45.

Akinbami, J.-F.K., Ilori, M.O., Oyebisi, T.O., Akinwumi, I.O. & Adeoti, O. (2001). Biogas energy use in Nigeria: current status, future prospects and policy implications. *Renewable and Sustainable Energy Reviews*, **5,** 97–112.

Annie, D. (2006). *Biofuels production, trade and sustainable development: emerging issues,* International Institute for Environment and Development, London.

Chukwuma S. E., Richard T., Ephraim N. A., Obinna, A. O. & Ikechukwu, N. E. O. (2012). Biotechnological Tools for Environmental Sustainability: Prospects and Challenges for Environments in Nigeria—A Standard Review. *Biotechnology Research International*. http://doi:10.1155/2012/450802

Daniyan, I.A., Daniyan, O. L., Adeodu, A. O., Aribidara, A. A. (2014). Towards Sustainable Development in the Third World: Design of a Large-Scale Biodiesel Plant. *Journal of Bioprocessing and Chemical Engineering*. 1-9.

Edirin, B. A. and Nosa, A. O. (2012). A Comprehensive Review of Biomass Resources and Biofuel Production Potential in Nigeria. *Research Journal in Engineering and Applied Sciences* **1**(3) 149-155.

Federal Ministry of environment (FME) (2019a). Clean Energy Initiatives. Accessed on 16th June, 2020. URL: https://environment.gov.ng/clean-energy-initiatives/

Federal Ministry of environment (FME) (2019b). Great Green Wall Programme. Accessed on 16th June, 2020. URL: https://environment.gov.ng/great-green-wall-programme/

Food and Agricultural Organization of the United Nations (FAO), FAOSTAT (2019). Inputs (Land use) (Latest update, December 3, 2019). Accessed 17th June, 2020. URL: http://www.fao.org/faostat/en/#data/RL

Food and Agricultural Organization of the United Nations (FAO), FAOSTAT (2020). Productions (Live Animals) (Latest update, March 4, 2020). Accessed 15th June, 2020. URL: http://http://www.fao.org/faostat/en/#data/QA

Graeme, M. W. (2011). 125th Anniversary Review: Fuel Alcohol: Current Production and Future Challenges. *Journal of the Institute of Brewing*, **117** (1) 3–22.

Ibrahim, K. A., Ahmad, G., Auwalu, I. M. (2011). Biofuels in the Quest for Sustainable Energy Development. *Journal of Sustainable Development*, **4** (3). http://doi:10.5539/jsd.v4n3p10

Juliet, B., Vasilije, M. & Philip L. (2016). Biomass resources and biofuels potential for the production of transportation fuels in Nigeria. *Renewable and Sustainable Energy Reviews***63,** 172–192. http://dx.doi.org/10.1016/j.rser.2016.05.050

Kumar, K.S.K. (2015). *Biofuels and Sustainable Development*., Center of Excellence in Environmental Economics, Dissemination Paper – 32. Madras School of Economics, India.http://coe.mse.ac.in

Makut, M. D., Obiekezie, S. O. &Owuna, G., (2018). Isolation and Screening of Biobutanol Producing *Clostridium* Species from the Soil Environment of Keffi Metropolis. *South Asian Journal of*

Research in Microbiology, **1**(3), 1-6. https://doi.org/10.9734/sajrm/2018/v1i3805

Manish, K. and Kalyan, G. (2012). Biobutanol: The Future Biofuel. In: Biomass Conversion; the interface of Biotechnology, Chemistry and Material Science. Chinnappan B., Shikha, B. and Ranjit, S. D. (Editors). Springer-Verlag Berlin Heidelberg, 221-236. http://doi: 10.1007/978-3-642-28418-2_7

Nigerian Electricity Regulatory Commission (NERC), (2020). Renewable Energy Sourced Electricity. Accessed on 16th June, 2020. URL: https://nerc.gov.ng/index.php/home/operators/renewable-energy

Obada, F.B. (2008). Official Ground Breaking & Foundation Laying Ceremonies at Ilemoso, Ekiti State, Nigeria.Accessed on 13th July, 2020. URL:http://globalbiofuelsnig.com/home/?p=4652

Obada F.B. (2009a). Biofuels: Nigeria ahead in feedstock technology. Accessed on 13th July, 2020. URL:http://globalbiofuelsnig.com/home/?p=4660

Obada, F.B. (2009b). Biofuel Production to resolve Nigeria's economic meltdown.Accessed on 13th July, 2020.URL:http://globalbiofuelsnig.com/ho006De/?p=4662

Obilana, A. B. (2008). Brief Project Description of Global Biofuels Ltd, Ekiti State. Accessed on 13th July, 2020. URL:http://globalbiofuelsnig.com/home/?p=4650

Ohimain, E. I. (2013). A review of the Nigerian biofuel policy and incentives. *Renewable and Sustainable Energy Reviews* **22**, 246–256. http://dx.doi.org/10.1016/j.rser.2013.01.037

Ohimain, E. I. (2010). Emerging bio-ethanol projects in Nigeria: Their opportunities and challenges. *Energy Policy***38**, 7161–7168. http://doi:10.1016/j.enpol.2010.07.038

Organisation for Economic cooperation and development (OECD) (2001). The Application of Biotechnology to Industrial Sustainability. www.oecd.org/sti/biotechnology

Owuna, G., Makut, M. D., Ekeleme, I. K., & Obiekezie, S. O. (2018). Isolation, Identification and Production of Biobutanol by Different Clostridium species Isolated from Soil Using Waste Paper and Sugar Cane Molasses. *South Asian Journal of Research in Microbiology*, **2**(1), 1-9. https://doi.org/10.9734/sajrm/2018/v2i129237

Suberu, M. Y., Bashir, N., Mustafa, M. W., (2013). Biogenic waste methane emissions and methane optimization for bioelectricity in Nigeria. *Renew Sustain Energy Rev*. **25**, 643–54. http://dx.doi.org/10.1016/j.rser.2013.05.017

Segun, O. (2012). Designed to Fail? Nigeria's Quest for Biofuel. *Afro Asian Journal of Social Sciences*, **3**,

Peace, O.O., Uche, M. N., and Mariano J.B. (2019). *Nigerian Agricultural Biotechnology Annual*, USDA foreign agricultural services, Global Agricultural Information Network (GAIN) report GAIN Report Number: NG-19003

Peter, K. O. and Gbenga, S. (2009, June 21 to 24). *The Nigerian Bio-fuel Policy and Incentives (2007): A Need to Follow the Brazilian Pathway*. Proceedings of the 32nd International Association for Energy Economics (IAEE) International Conference. San Francisco CA USA. 35-39

Ruth, C.A., Cristina, R., Andy, D. and Abdul, G.O. (2018). Micro-Macroalgae Properties and Applications. In: Reference Module in Materials Science and Materials Engineering. University of the West of Scotland, Paisley, United Kingdom. http://doi:10.1016/B978-0-12-803581-8.09259-6

Samuel, O. P., Zalliat, A. & Ismaila. M. B. (2013). Biodisel Development in Nigeria: Prospects and Challenges. *International Journal of Modern Botany*, **3**(1): 4-9. http://doi: 10.5923/j.ijmb.20130301.02

Thomas, O. K. A. and Emmanuel, O. A. (2012). Potentials of Bioenergy and Biofuels Technology Development in Nigeria. *Petroleum Technology Development Journal*, **1**. 1-7.