

Investigation on Impacts of contamination of Oil exploration and Production on Environment and its Implications on people's health.

Case Study: NIGERIA

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DOI: 10.29322/IJSRP.10.04.2020.p10008

<http://dx.doi.org/10.29322/IJSRP.10.04.2020.p10008>

Abstract- The contamination of fossil oil in the environment with inspection and production activities is a common thread of the surrounding oil producing countries, especially in a developing countries including Nigeria. This country has been suffered from civil terrorist attacks in which affected different countries in West Africa, like **Cameroon, Chad, Niger**, but especially in **Nigeria** where this paper focused on and this problem has affected the oil fields production, and oil amenities such as the pipeline, are removed by causing oil storage and spills; thus causing significant pollution of the entire environment (**biota, soil, water and air**), and human health effects. The infection occurs in the period of production of all rock oil production and explorations processes and negatively affects the environment which in turn reflect health risks through food chain such as apparition of heavy metals; Lead, and Barium in hair of some of Nigerians people. This review examines and checks some the environmental effects related to black gold discovered and produced in Nigeria and its implications to human health. It has further highlighted some recommendations that may help sustainable practices for the exploration and production of this resource which may yield in less negative effects for both environment and human health.

Index Terms- Fossil oil, Environment, Exploration, implications, human health, Boko Haram

I. INTRODUCTION

Nigeria's fossil oil infection from boring processes creates issues that destroy the lives of people living nearby oil camps area, wells, bobbing stations, and pipelines. In addition, oil contamination creates unhealthy to the native environment. The population living on oil-rich sites around the world is subjected to contamination of drinking water, top soil, and livestock due to toxic pollution that can result from the oil extraction process. In some contaminated sites, serious illnesses resulting from exposure have been documented.

Before the establishment of petro-chemical industries, environments around the world that sat upon large black oil reserves supported healthy of human life and vibrant environment.

Petroleum infection from drilling processes, however, has adversely affected the population living in these different areas by environment polluting around them. Air, water, soil and have been severely tainted by oil pollutants. As a result, wildlife, livestock, and population have been sickened. Fossil Oil infection has adversely affected the lives of many people living in areas near oil discovered sites. With the crude oil and producing chemicals polluting water supplies, air, and surrounding plant and animal life, population health has suffered. Because a level of those affected by oil contamination lives of the land, local economy has also been impacted by the deterioration of environment in West-Africa.

In addition to physical impacts, economic stress affects the [subconscious](#) health of the persons living in contaminated areas. A range of total number of explorations have focused on specific diseases noted in particular contaminated. Many problems have arisen because of oil exploration and extraction and their associated pollution. This Paper focused on health problems affecting population living in areas contaminated by that kind of Oil. The prior investigation in orients that there is a significant lack of available information regarding health problems or issues from exposure to oil contamination. This report Studies conducted by researchers are scarce and tend to be the specific location. In kind, at the initiation of this project paper, I know that the short- and long-term effects resulting from oil contamination have not been thoroughly explored as well, and there is not sufficient understanding of the psychological and physical implications that kind of Oil exploration and its eradication present for human Social communities.

The paper project achievement is to create a clearinghouse for available research on oil contamination and its health effects on humans being.

The first step in investigating the real problematic breaks in this area of research was contacting people who have studied health issues arising from petrochemical exposure. I established sites that stores documents, audio files, and video files related to health-related effects of oil contamination exposure from several spill sites [all over the world](#).

I think many countries in West Africa have such as the issues like Niger and one country called South-Soudan etc. With this paper project we expect that this with different organizations in the way of Sustainable development like UN and EU will help in protection of human health in contaminated areas in Nigeria Country.

II. BACKGROUND

In our days in the world environment recognizes the significance of environmental sustainability to the development of country. So, one of the cardinal objectives of the sustainable Development Goals is to ensure environmental sustainability. It then implies that they should be [decreased](#) in environmental degradation as well as pollution. Multinational and other industrial establishments are expected to play an important role in the development of the society and host communities (2009-2010).

The literature on the Nigeria highlights soil erosion, water pollution, oil spillage, soil erosion, and global warming as the consequences of oil exploration in the region

Nigeria is currently the biggest fossil oil producer in Africa and was the world's fourth-largest exporter of LNG in 2015. Nigeria's back oil production is hampered by instability and supply [disturbances](#), while its natural gas sector is restricted by the lack of infrastructure to commercialize natural gas that is currently flared. Nigeria is the largest oil producer in Africa, holds the largest natural gas reserves on the continent, and was the world's fourth-largest exporter of liquefied natural gas in 2015. Nigeria became a member of the Organization of the Oil Exporting Countries in 1971, more than a decade after oil production began in the oil-rich Bay Elsa State in the 1950s. Although Nigeria is the leading black oil producer in Africa, production is affected by sporadic supply disruptions, which have resulted in unplanned outages of up to 500,000 barrels per day.

Nigeria's black oil and native gas industry is mainly located in the south of Niger- Delta area, where it has been a source of issue. Local groups seeking a share of the wealth often attack the petroleum [facilities](#), forcing [enterprises](#) to declare force majeure on fossil oil shipments. At the same time, oil theft leads to pipeline damage that is often severe, causing loss of production, pollution, and forcing some companies to shut in production.

Aging infrastructure and poor repairing have also resulted in oil spills. Natural gas flaring has contributed to environmental pollution. Protests from local groups over environmental damages from oil spills and natural gas flaring have exacerbated tensions between some local communities and international oil companies [IOCs]. The industry has been blamed for different kind of pollutions that has damaged air, soil, and water, leading to losses in arable land and decreases in fish stocks. Nigeria's oil and natural gas resource is the mainstay of the country's economy. According to the International Monetary Fund [IMF], oil and natural gas export revenue, which was almost 87 billion dollars in 2014, accounted for 58percent of Nigeria's total government revenue in that year. Black Oil and natural gas revenue is the country's main source of foreign exchange, making up more than 95percent of Nigeria's total exports to the world in 2014. Because Nigeria heavily depends on oil revenue, its economy is noticeably affected by crude oil price changes. The International Monetary Fund projects that Nigeria's oil and natural gas exports earned 52 billion dollars in 2015, 35 billion dollars less than in 2014, which is mostly attributed to the fall in oil prices. Nigeria's fiscal buffers the Excess Crude Account and the Sovereign Wealth Fund include savings generated when oil revenues exceed budgeted revenues. However, those funds have declined from 11 billion dollars at the end of 2012 to 2 billion dollars at the end of 2014. Nigeria also held 34.25 billion dollars in gross international reserves at the end of 2014.

1.1 Primary energy consumption in Nigeria

The United State Energy Information Administration estimates that in 2013 total primary energy consumption in Nigeria was about 4.8 quadrillion British thermal units of this amount, traditional biomass and waste accounted for 74percent. This high share represents the use of biomass to meet off-grid heating and cooking needs, mainly in rural areas. It's important to note that estimates of traditional biomass consumption are imprecise because biomass sources are not typically traded in easily observable commercial markets. The electrification rate in Nigeria is estimated at 45percent leaving approximately 93 million people in Nigeria without access to electricity. The International Energy Agency estimated that 115 million of population in Nigeria rely on traditional biomass and waste as their main sources of energy in their country.

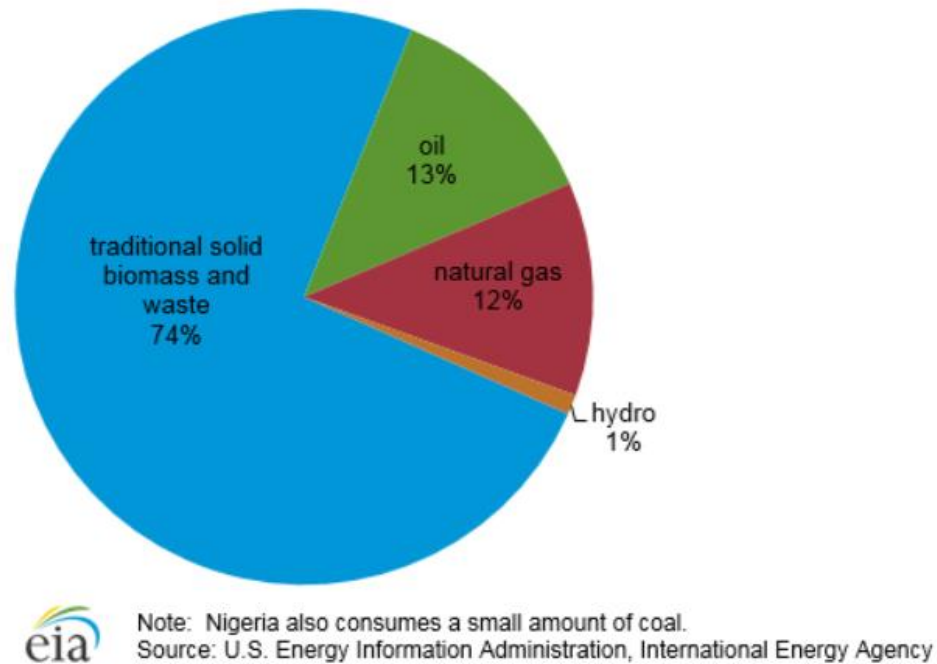


Figure 1: Nigeria's total primary energy consumption in 2013

What we call a Crude oil typically means **unrefined oil**. Petroleum is a fossil fuel found underground formed different millions of years ago as a result of the decomposition and pressurization from the remains of small animals and plants. The remains which is covered by mud begins to pile up forming more and more sediment thus leading to its change into rock due to increase in the temperature variability and pressure which in turns makes the plants and animals remain get heated up turning it into that crude oil which is a mixture of hydrocarbons these hydrocarbons in the rock strata can be conveniently extracted and refined to produce fuels like diesel oil including paraffin, gasoline and petrol. Crude oil Extraction begins with the boring of wells into the underground reservoir and with the use of a drill bit breaks through the ground driving the particles to the area using boring fluid, a perforated casing is added in the production zone for the oil to flow into the well. The boring rig is removed and pumps installed once the well is complete. The machine pump then removes the oil and distributes it to a network for transportation to the refinery. The improving process is carried out using fractional purification, the issue is subjected to heat at about 700°F making the crude oil explode into various components or fractions at a certain piping point range.

Below is the table of crude oil components and their different boiling range

Component	Boiling point
Fuel Gas, LPG, refinery gas	< 25°C
Gasoline - petrol	25°C – 75°C
Naphtha	75°C – 190°C
Paraffin, kerosene	190°C – 250°C
Diesel oil, gas oil	250°C – 350°C
RESIDUE (fuel oil, lubricating oils, waxes)	>350°C
Bitumen	500°C – 700°C

1.2 Important Main locations of crude oil in Nigeria

The past years Petroleum was discovered in Nigeria in 1956 in Oloibiri. This discovery was made by shell D'Arcy Petroleum Development Company of Nigeria, as a consortium of Shell. And British oil then had known as Anglo-Iranian. This post, it shows the location of a known place of oil in Nigeria as well as the Oil enterprises that have been involved in its oil production. When we briefly talk about the history of this, the prior to this discovery in Oloibiri, Shell has commenced drilling work in 1951, with the first test well drilled in **Owerri** area and Oil was discovered in non-commercial quantities at **Akata**, near **Eket** in 1953. The Company was unrelenting despite the fact that it had spent 6million pounds but was yet to find Oil in commercial quantities. The current, Nigeria produces an average of 2.5million barrels of crude oil per day which makes the country the largest producer of crude oil in Africa. The production of petroleum in Nigeria plays a very important as over 90percent of the country's gross earnings comes from the place of black oil production. *The location of Crude oil in Nigeria* let first take look at the oil states in the Country. The oil producing states include **Abia, Akwa Ibom, Bayelsa, Delta, Edo, Lagos, Imo and Rivers.**

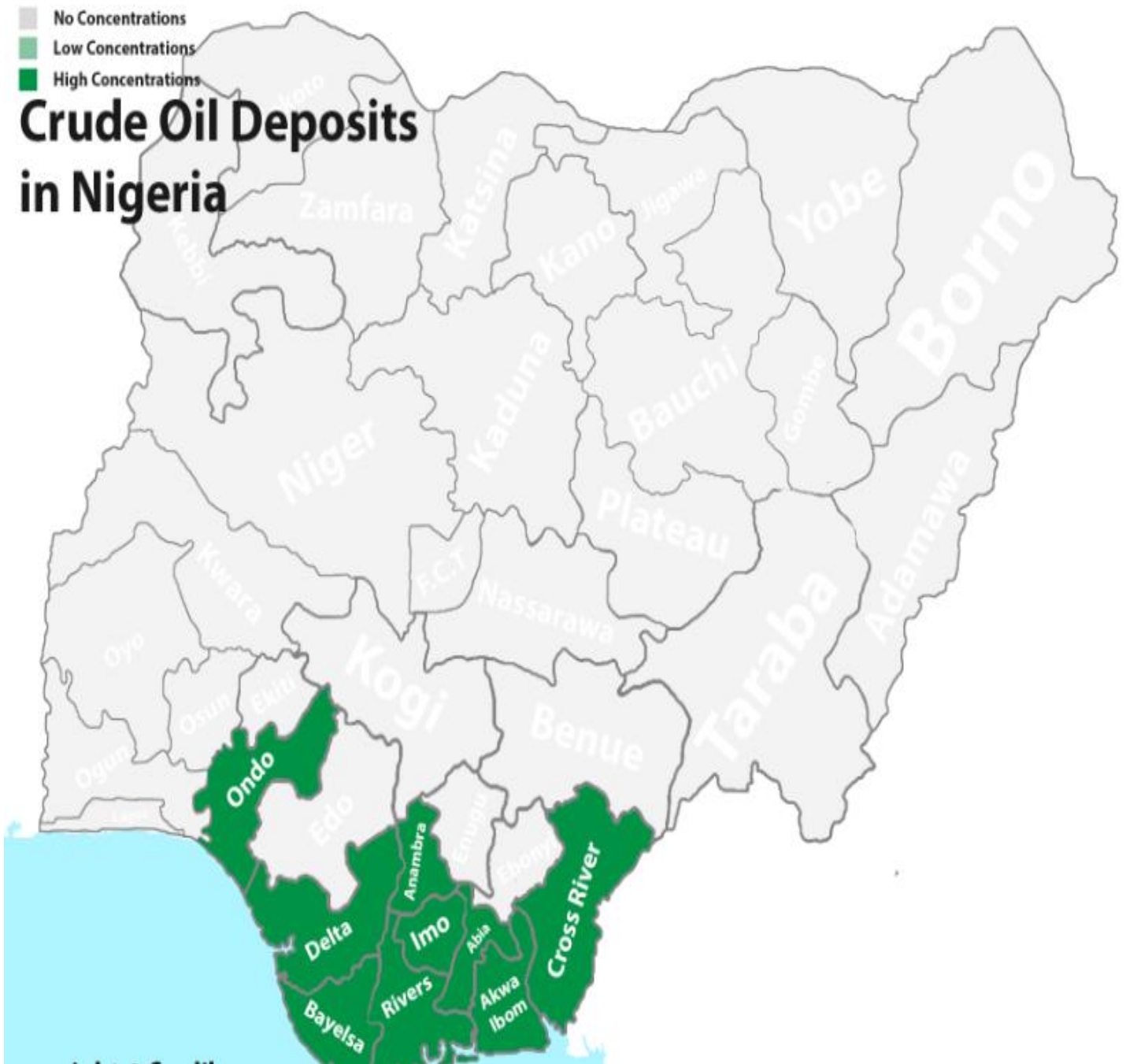


Figure 2: This shows the locations of Crude Oil in Nigeria/ Picture from: <https://community.oilprice.com/topic/4752-nigerian-crude-oil/>

Abia Atate has over one hundred oil wells and three installed flow stations in Abia State. In 2012, the boundary commission revealed that it returns forty two oil wells from neighboring Rivers State to **Abia** which made Abia the fourth largest oil production. And Shell holds the most of the licenses for the wells in Africa with a focus on 50 wells that it has considered high-yield. Abia produces “36000” barrels of crude oil per day. A breakdown of this reveals that Imo that Imo produces “23000 barrels” per day while the Ismail flow station produces over “8000 barrels” of crude oil per day. **Akwa Ibom**, is the highest oil and gas producing State in Country with over “500000 barrels” and **Bayelsa State**, which is one of the biggest crude oil and natural gas deposits in the country. Despite the crude oil found in this state, the majority of Baselessness live in poverty which is a big issue in that Area in Nigeria. We have **Delta State** which is also the second major provider of black oil and gas in the country with a daily production of “346000 barrels”. Also, the state has one of the biggest deposits of place of oil production and natural gas in the country. Apart from that deposits place, Delta is also rich in natural resources like limestone, decorative rocks, tar sand, Kaolin, limonite, silica and Industrial clay.

We have **Edo State** which is the seventh largest producer of oil and gas in the country with a daily output of “33000 barrels” and this state produces mining resources like Limestone and quarry. The last is Imo State which has over 163 oil wells at over twelve different locations in the state. The biggest petroleum companies in this state include **Addax petroleum, Chevron Corporation, Royal Dutch Shell and Agip**. After this Nigeria has the ten top best restaurants in Abuja to distribute the black oils which cause many issues of pollutants from oil to population health in Nigeria, these restaurants are the following: **Ohaji-Egbema, Oguta, Oru-East, Iho, Oru -West, Obowo and Ngor-Okpala**.

2.3 The Impact of oil Exploration and Production on the Environment.

The Oil pollution has affected on the black oil producing community-based under study in several ways. The present situation of the **Akwa Ibom** State environment especially the black oil producing areas is appalling. Though natural phenomena like erosion, flood and climate change are major factors which adversely the environment, consequences of people activities like gas flaring and black oil spillage have threatened an imminent collapse of the ecosystem. Black Oil spillage that occurred in the host- communities of **Akwa Ibom** State are the cost or the attendant issues the people are facing and suffering from since the advent of black oil discover in the area. In fact, it could be seen as the major cause of environmental degradation, black oil conflict within the state. The situation is worsened by the lack of commitment in rectifying the abnormality.

This laissez fair the manner has pursued unabated despite outcry by the victims as well as relevant environment protection laws. While the stakeholder especially the transnational petroleum companies, have exhibited zero concern for the wellbeing of their operational domain and its inhabitants, the victims of this acts of destruction are left to their fate. This has led to countless litigation against the black oil companies.

The effects of the negative activities of the black gold companies include air, soil pollution, soil degradation, health risk among others. In most of the black oil producing Communities of **Akwa Ibom** State under study, despite being the highest place of black oil producer in Niger-Delta, they are perhaps the most underdeveloped place in the State. They play host to oil firms including Exxon Mobil, Shell petroleum development company amongst others. In this section, the research work will look more specifically at various environmental and socioeconomic problems that have been identified as a result of the intensive extraction of native oil resources in the Del, Lagos communities- based on the productive area in Nigeria.

These impacts are grouped into three interrelated impacts and the proposed way of solution;

- Socio-Economic effect, Physical-Health effects, Socio-Culture Impacts,
- Socio-Economic effects and destruction of traditional means of livelihood.

From the paper
Of
The Impact
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and
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In the Niger
Delta Region
Of
Nigeria.

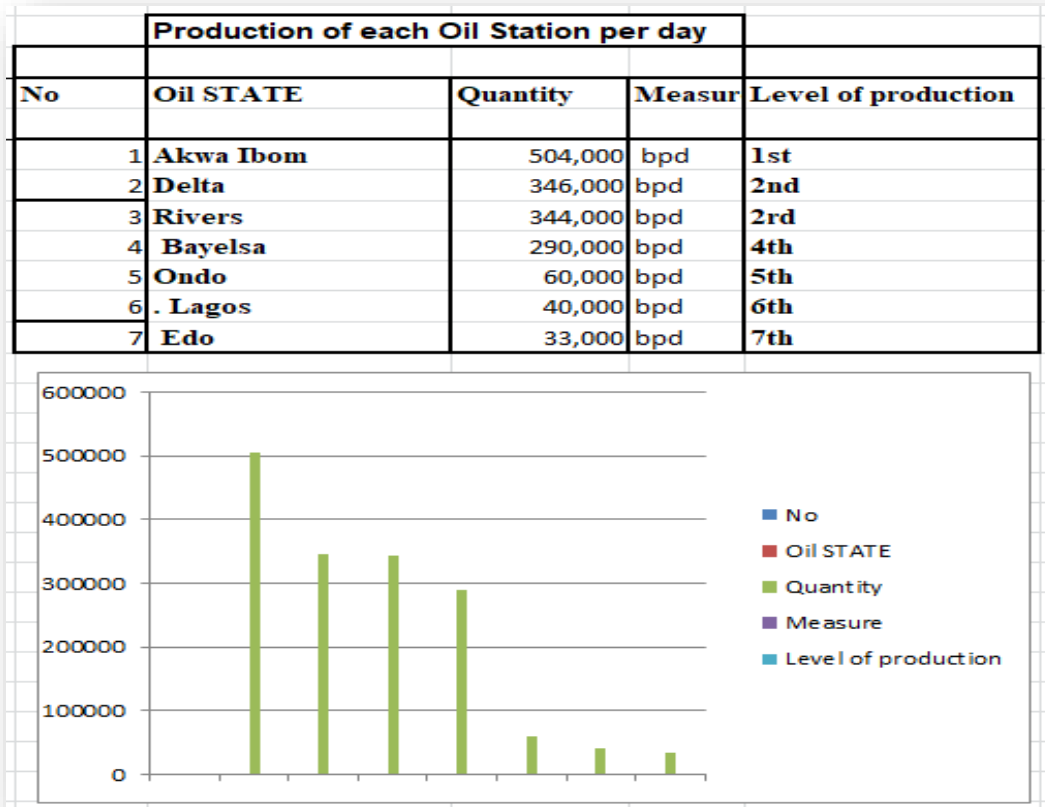


Figure 3: Table shows the production of each Oil state in Nigeria per day in 2019/ Own drawing in Microsoft excel

1.3 The uses of petroleum

- It is used as a transportation fuel, heating, and electricity generation like gas, petrol, and diesel.
- [coal oil](#) is used in aircraft and due to its same to diesel fuel can be used in either compaction ignition engines and It is used as a burning fuel such as kerosene oil.
- The bitumen or asphalt is used to pave or tar road as a binder for gravel to form asphalt concrete.
- Naive gas is also used in steam crackers and reformers as a major feed stock to produce hydrogen gas, ethylene and other Olefins.
- Paraffin wax is a by-product of the refining of lubricating oil and is used as a lubricant and for other applications such as cosmetics. It is used to produce **Sulphur** since some crude oil has a little **Sulphur** content.
- It's also used in the production carbon and hydrogen.

Aim and Objective

- About objective of this paper project is to make orientation of researchers to know what about the place of production Oil (crude oil) in Nigeria and this can be very important to the country of Nigeria because if the big countries participate in sustainability of Nigeria, it will be good to the life of Nigerian's people to be in a known country and it's a profit to the Organization like **EU, UN, UA**, to create a partnership with this Country.

- Motivation, of people how to manage this place of production of Oil of Nigeria for protecting environment and call other companies to work with Nigeria for avoiding Jobless in that country through the Oil production.

-The broad objective of the study is to determine the impact of over-dependence on oil on Nigeria's economy.

-Determine the impact of over dependence on oil on Nigeria economic growth.

-Evaluate the long-run relationship between economic growth and oil revenue in Niger.

1.4 General Interests

- About the interest of a place of Oil production in Nigeria, it's is an orientation and encouragement of make effort of continue to explore and developing this country and create relationship between different country around world.
- The place of oil production is a very important source of foreign exchange and has become major influence to the Nigeria economy.
- Here we take a look at the history of this black gold as well as the economic importance of The place of oil production in the country with the focus of partnerships with other countries and International oil companies.

- It is very important in Africa to have big country like Nigeria because not only development of this Country, also other country in Africa develops through the crude oil of Nigeria.
- The place of oil production is one of the most actively traded commodities in the world. Petroleum still remains the primary energy source for transportation and manufacturing industries. For this reason, oil price movements may impose significant influence on economic situation in different countries.
- Here the Organization of the Petroleum Exporting Countries, OPEC and non-OPEC agreed to cut world supply by “1.8 million barrels” of oil per day, bopd in November 2016; with the cuts extended to last through 2018. OPEC’s intent was to limit output to 32.5 million bopd to shore up prices.

1.5 Social Interest

- About, the Social interest of place of production oil in Nigeria. In general, it’s very interesting to see Nigerian population work or have job in all activities of producing Oil in Nigeria.
- During activities in the place of oil production (Crude oil) in Nigeria a percentage shows us that the unemployment decrease, different students on this field they can get job easily this means no jobless of the engineer of this field and the distributor Companies recruit many people for the job, this can be one of goal in social economy of Nigeria.

1.5.1 Scope

About the limit of this paper was to show the level of oil production par day and percentage of population affected by production of Oil in Nigeria, the quantity of production of oil per month, and then how Nigeria developed through the crude oil since 2014 - 2018. This can determine how the next 4 years how the situation will be, if they will continue to improve their activities in Producing Oil and making partnership with other countries.

1.5.2 Conclusion and Recommendation

In conclusion, as we have mentioned the history of Oil in Nigeria, development through the oil production, different activities, exchange with different countries around world, importance and different impacts from the crude oil, I have seen that with partnership of Nigeria and other countries in the future this country will grow in development through the crude oil. Like a big country in production of Oil, it is better to make enough security of this country because at this time we can call it mother of Oil in Africa, and this security will make stability of all activities of this Country. After review, checking this paper and seeing the mistakes that I have made in this paper agree to correct and insert some updates on it. And this will help me to be oriented in constructing this good paper project through the comments from the reviewers. Because of the short time we did not achieved one of our objectives to show the percentage of population affected by production of black Oil in Nigeria, but I am preparing ring to do a deeply research on another paper I will try to maximize my effort to work on that one of the objectives was planned.

REFERENCES

- [1] [1] L.A. Daniel-Kalio, and B. Solomon Amabaraye, “The Impact of Accidental Oil Spill on Cultivated and Natural Vegetation in Wetland Area of Niger Delta, Nigeria,” *Ambio*, 31 (5). 441-442, 200.
- [2] [2] Secretariat of the Organization of the Petroleum Exporting Countries, Nigeria facts and figures, accessed January
- [3] [3] Eteng, A. (2010). *The Nigerian State, Oil Exploration Community Interest: Issues and Perspective*. Ababa, S. I. (2010). *Environmental Protection Laws and Sustainable Development in the Niger Delta*. Africana FEP. Publishers
- [4] [4]. Odalonu B H. (2015). *The Upsurge of Oil Theft and Illegal Bunkering in the Niger Delta Region of Nigeria: Is There a Way Out?* *Mediterranean Journal of Social Sciences* Vol 6, No 3 S2
- [5] [5] Nnanna O.J., S.O. Alade and F.O. Odoko (ed.), *Contemporary Economic Policy Issues in Nigeria*, (Central Bank of Nigeria; 2003).
- [6] [6] A.E. Ite, U. J. Ibok, M. U. Ite, and S. W. Petters, *Petroleum Exploration and Production: Past and Present* *Environmental Issues in the Nigeria's Niger Delta*, *American Journal of Environmental Protection*, 1 (4). 78-90(2013)
- [7] [7] E.J.a.C.O. Udo, some studies on the effect of crude oil pollution of soil on plant growth, *West African Journal of Biological and Applied Chemistry* 26 (1984)
- [8] [8] EIA and International Energy Agency statistical databases.
- [9] [9]BP, *Statistical Review of World Energy*, Excel workbook of historical data 2015. 2015.
- [10] [10].International Monetary Fund, Nigeria, IMF Country Report No. 15/84, (March 2015), page 85
- [11] [11]. A.E. Ite, U. J. Ibok, M. U. Ite, and S. W. Petters, *Petroleum Exploration and Production: Past and Present* *Environmental Issues in the Nigeria's Niger Delta*, *American Journal of Environmental Protection*, 1 (4). 78-90(2013)
- [12] [12]. A.L. Association, *Health Effects of outdoor Air Pollution*., 13 (1996) 18-20.
- [13] [13]. S. FR, *Environmental Impacts of Renewable Energy*, (2014).
- [14] [14]. Odalonu B H. (2015). *The Upsurge of Oil Theft and Illegal Bunkering in the Niger Delta Region of Nigeria: Is There a Way Out?* *Mediterranean Journal of Social Sciences* Vol 6, No 3 S2
- [15] [15]. Nnanna O.J., S.O. Alade and F.O. Odoko (ed.), *Contemporary Economic Policy Issues in Nigeria*, (Central Bank of Nigeria; 2003).
- [16] [16] H. Knight, J.C. Chamberlin and C.D. Samuels, *Plant Physiology*, 4 (1929) 299-321
- [17] [17] P.W. Rohrbaugh, *Penetration and accumulation of petroleum spray oils in the leaves Twigs and fruits of citrus*, *Plant Physiology* 9(1931) 699-730.
- [18] [18] P.A. Yongi, *Oil mass theory of petroleum penetration into Protoplasm*, *American Journal on Botan*, 22 (1936) 8.
- [19] [19] W.H.a.V.A.H. Minshall, *Herbicidal action of oils*. *Proc. American. Society of Horticulture Science* 53 (1949) 294-298.
- [20] [20] E. Laville, *Contribution a l’etude de la PenetracionetLaLocalisation des huilesdans la feuille da bananier*. ‘Fruits (Paris), 18 (1963) 339-344.

- [21] [21] H. Knight, J.C. Chamberlin and C.D. Samuels, Limiting Factors in the use of saturated petroleum Insecticides. *Plant Physiology*, 4 (1931) 299-321.
- [22] [22] A.S.a.H.G.R. Crafts, Herbicidal Properties of Oils, *Hilgardia*, 18 (1948) 77-156.
- [23] [23] J.R. Harris, Herbicidal properties of Petroleum Hydrocarbons. Cornell University. Agric Exp. Sta. memoir Ethaca, New York Cornell University. Agric Exp. Sta. memoir Ethaca, New York, 298, 20 (1950).
- [24] [24] S.C.-L. A. Swift, E. Shope, A joint report by Natural Resources Defense Council, National Wildlife Federation, Pipeline Safety Trust, Sierra Club, www.nrdc.org/.
- [25] [25] G. Olsson, Water and energy – threats and opportunities (2nd Ed.), Ch. 11, IWA Publishing, London., (2015.).
- [26] [26] J.Z. Otton, R.; Smith, B.; Abbott, M.; Keeland, B, Environmental impacts of oil production on soil, bedrock, and vegetation at the US Geological Survey OSPER Study Site A, Osage County, Oklahoma. *Environ. Geosci.* 12, 73-87., (2005).
- [27] [27] A.P. Fakhru'l-Razi, A.; Abdullah, L. C.; Biak, D. R.; Madaeni, S. S.; Abidin, Z. Z, Review of technologies for oil and gas produced water treatment, *J Hazard Mater*, 170 (2-3), 530-51. (2009.).
- [28] [28] Cordaid, Oil production in South Sudan: Making it a benefit for all. Baseline assessment of the impact of oil production on communities in Upper Nile and Unity States. The Hague: Catholic Organisation for Relief and Development Aid (Cordaid). (2014).
- [29] [29] NBS, Assessment of Health Status and the Environment in Oil Producing Areas. Juba: Ministry of Petroleum, Mining and Industry and National Bureau of Standards (NBS). Juba: Ministry of Petroleum, Mining and Industry and National Bureau of Standards, South Sudan, 2014.
- [30] [30] L.M. McKenzie, Guo, R., Witter, R. Z., Savitz, D. A., Newman, L. S., & Adgate, J. L, Birth Outcomes and Maternal Residential Proximity to Natural Gas Development in Rural Colorado. Colorado: National Institute of Health Sciences (NIHS), (2014).

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