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Research Article

THE IMPACTS OF EXPLOITATION OF NATURAL GROUND HYDROCARBON DEPOSITE AND BIOGAS PRODUCTION ON THE CLIMATE: A CASE STUDY OF NIGER DELTA HYDROCARBON DEPOSITE AND NATIONAL BIOTECHNOLOGY DEVELOPMENT AGENCY (NABDA), ABUJA – NIGERIA, BIOGAS PRODUCTION

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Abstract

Studies on the Impact of Natural Ground Hydrocarbon exploitation and Biogas Production on the Climate have been carried out. The Niger Delta (South Eastern Nigeria) hydrocarbon exploitation and the National Biotechnology Development Agency (NABDA), Nigeria, Biogas (CH_4) production, offer very useful information to understanding the objectives of the research, which is to: study biogas production and natural hydrocarbon exploitation effects on climate; to highlight the benefits of using a bio digester in the production of methane and to proffer solutions that will reduce the negative impact on climate. 150 liters designed and constructed anaerobic bio digester was used for this study. Under mesophilic condition, 100kg of food waste from restaurant was used as feed stock, inoculated with the content of the cow rumen and digested for 60 days anaerobically. The temperature of the system was controlled between 20 – 35^{o}c; PH between 7 – 8; substrate and water mixing ratio 1:1. 4.5kg of methane was recorded after scrubbing, 1.5kg of $NaCo_3$ crystals, 0.1kg of NH_3 and H_2S were trapped in the scrubbers. The result shows that during anaerobic digestion in the biodigester, no form of Co_2 escaped to the environment. The $NaCo_3$ is useful during saponification. Studies on the "Niger Delta: Stratigraphy, Depobelts and Samples Locations", shows that hydrocarbon are trapped with the help of the faulting systems. The gravity controlled rollover anticline and listric growth faults provide the traps. The integrity of a trap depends on the juxtaposition of a shale seal across the fault plane. The density controlled occurrence of ground hydrocarbon is such that the least dense gaseous hydrocarbon (CH_4) is above the solid hydrocarbon, while the solid hydrocarbon lies above the basinal water in a trap. This stratigraphic occurrence of hydrocarbon is a major reason why exploitation of hydrocarbon is not without flares to flame. Fire accidents during hydrocarbon transportation processes also account for a high degree of pollution in the region. Currently, 56.6 million m^3 of associated gas is flared daily in the Niger Delta, Nigeria, and an amount equivalent to about 16% of the total world gas that is flared daily. The major impact of gas flaring is on the climate, which result to: global warming as a result of ozone layer depletion; extinction of flora and fauna; sea level rise due to melting of the polar ice. Nigerian oil companies in the Niger Delta, are yet to comply 100% to the global best practices of, liquefying the flared gas (methane) for domestic and other purposes.

Keywords: Anaerobic, Trap, Stratigraphic, Flaring, Digester, CH_4, Co_2.

INTRODUCTION

Oil exploration in Nigeria has had several environmental and human consequences for the indigenous people who inhabit the area surrounding oil exploitation. The environmental impacts of oil production has been extensive with the destruction of wildlife and biodiversity, loss of fertile soil, pollution and damage to aquatic ecosystem, all of which have caused serious health problems for the inhabitants of the people around oil production (Kadafa, 2012). Oil was first discovered in the region in 1958, and since early 1970s, oil has dominated the Nigeria's economy, accounting for about 97% of the country's total export; and due to these oil exploitation activities, the region is highly susceptible to environmental changes occasioned by climate change, making the area one of the most ecologically sensitive areas (Uyigue and Ogbeibu, 2015). According to Akpotor (2019) crude oil exploration and exploitation activities are the major causes of environmental degradation within the oil bearing communities of the Niger Delta.

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Crude oil is a mixture of comparatively volatile hydrocarbons (compounds composed mainly of hydrogen and carbon), though it also contains some nitrogen, Sulfur and oxygen. And it occurs underground at various pressure depending on depth, and can contain considerable natural gas kept in solution by pressure (Augustyn, *et al.,* 1998). There is no doubt that the Nigerian oil industry has affected the country in a variety of ways at the same time. On the one hand it has fashioned a remarkable economic landscape for the country, however on the negative side, petroleum exploration and production has been very glaring with adverse effect on fishing and farming which are the traditional means of livelihood of the people of the oil producing communities in the Niger Delta, Nigeria, and has left a balance sheet of ecological and socio-physical disaster (Celestine, 2003). Most oil and gas exploration activities take place in the Niger Delta region of the country where there is high rate of gas flaring from oil and gas production. Although the Federal Government of Nigeria has directed all oil and gas producing companies to reduce gas flare to a minimum by 2008 and stop total gas flaring by 2010 due to its effects on the environment and climate, oil and gas companies are yet to implement these directives, making the country suffer intense climate change, environmental

degradation, etc (Bisong, 2014). Despite longstanding laws against gas flaring – the burning of natural gas during oil extraction in Nigeria and shifting deadlines to end the practice, the activity continues, with serious health consequences for people living nearby (The New Humanitarian, 2012). Oil exploration activities have resulted to a high rate of gas flaring due to weak enforcement of the anti-gas flaring laws by the regulatory authorities (Olujobi, 2020). Climate change is the periodic modification of the earth's climate brought about as a result of changes in the atmosphere as well as interactions between the atmosphere and various other geologic, chemical, biological, and geographic factors within the earth system (Jackson, 2021). The Flared gas is a burnt off unusable waste gas or flammable gas, which is released by pressure relief valves during over pressuring of plant equipment. It burns through a gas flare on oil wells, in refineries, or in chemical plants. Flaring is a high temperature oxidation process used to burn combustible components, mostly hydrocarbons, of waste gases from industrial operation. Natural gas, Propane, ethylene, propylene, budadiene and budane constitute 95% of the waste gases flared (Gervet, 2007). While the exploitation of hydrocarbon affects the climate negatively, the use of biogas is more friendly to the environment. The environmental be benefits of biogas technology are often highlighted as valid and sustainable alternatives to fossil fuels. A main objective of biogas industry is the reduction of fossil fuel consumption, with the final goal of mitigating global warming (Cecchi and Cavinato, 2015 in Paolini *et al.,* 2018; Paolini *et al.,* 2018). Biogas is a gas produced by anaerobic (in the absence of oxygen) digestion of organic material, and it is enhanced by bacteria. Similarly, a biodigester is a tank that produces biogas, and can be manufactured in different shapes and sizes, depending on the need of the people (Schwarz, 2007). Biogas is a renewable energy source for cooking, lighting and heating purposes. It is mixture of gases that is composed mainly of CH4 (40 -70%), CO_2 (30 – 60%) and other gases such as H_2S and NH_3 (1 – 5%). The main objectives of the paper is to: to study the climatic impact of ground hydrocarbon exploitation and the production of biogas (methane) from the anaerobic biodigester; to examine the challenges in hydrocarbon exploitation in the region; to highlight the climatic benefits of biogas production from the anaerobic digester; to highlight some of the activities in the region that contribute to climate change; and to proffer solutions that will drastically reduce the damaging impact of climate change.

METHODOLOGY

Information on exploitation of the hydrocarbon in the Niger Delta, Nigeria, was gotten through direct observation of the gas flare at the exploitation site (Figure 2 below), analysis of the seismic attributes of density controlled stratigraphic occurrence of hydrocarbon in the Niger Delta as analyzed by (Philip A. Allen and John R. Allen, 2006, in Basin Analysis: Principles and Application, second Edition), and also interactions with the oil workers in the Niger Delta. The result showed that the gravity controlled rollover anticline and listric growth fault provide the traps. The integrity of a trap depends on the juxtaposition of a shale seal across the fault plane. However, the structural and stratigraphic occurrence of hydrocarbon is such that, the gaseous hydrocarbon is above the solid oily hydrocarbon, the oily hydrocarbon is above the basinal water. It is this stratigraphic occurrence of gaseous hydrocarbon that makes it difficult for exploitation of hydrocarbon without gas flare to flame, thus producing excess co and co_2 into the atmosphere, the major gases responsible for climate change, due to their impact on the ozone layer. The ozone layer is known to reduce the direct heat of the sun into the environment, and when the ozone layer is depleted the direct heat result to global warming and melting of the polar ice with it consequent see level rise.

The 150 litres capacity biodigester (Figure 1 below), is made up of internally plastic coated steal with the following characteristics:

1. Temperature stabilizing system
2. Agitating system
3. Mouth (for feeding the digester)
4. Exhaust point
5. PH meter
6. Gas pressure gauge
7. Dual scrubbers:
    - The first scrubber is to remove H_2S and NH_3 gases from the biogas (Methane)
    - The second is to remove Co_2 that will hinder the combusting quality of the biogas.

100kg of food waste from restaurant was used as feed stock, inoculated with the rumen content of cow and allowed for 60 days to digest anaerobically under temperature range of 20^oc – 35^oc, PH between 7-8, substrate and water ratio 1:1. The result showed that 4.5kg of methane was recorded after scrubbing, 1.5kg of $Naco_3$ crystals, 0.5g of NH_3 and H_2S were trapped in the scrubber. The digestion is done in a closed system and as a result, near 100% friendly with the climate. There is no escape of $C0_2$ into the environment. This is a major advantage of the biodigester over hydrocarbon exploitation in the Niger Delta. The crystals of $Naco_3$ are useful in saponification. The methane gas can be used for cooking and generation of electricity. It provides an alternative to deforestation activities as a result of the search for fire wood, and also an efficient organic waste management system.

DISCUSSION

The Niger Delta is in the South Eastern part of Nigeria, the basin occupies the Gulf of Guinea continental margin in equatorial West Africa, between Latitude 3^o and 6^oN, and longitude 5^o and 8^oE; and the region occupies the coastal and ocean ward part of a much larger and older tectonic feature, i.e. the Benue Trough, which is a NE – SW folded rift basin that runs diagonally across Nigeria (Reijers and Nwajide, 1997). Geologic Settings of the Niger Delta Niger covers an area of about 75,000 Km^2 from the Calabar Flank and Abakaliki Trough in Eastern Nigeria to the Benin Flank in the West, and it opens to the Atlantic ocean in the South where it protrudes into the Gulf of Guinea as an extension from the Benue Trough and Anambra Basin provinces (Burke and Whiteman, 1970; Burke *et al.,* 1972; Tuttle *et al.,* 1999; IHS, 2010 in Chiadikobi *et al.,* 2012). A look at the map (figure 3 above) shows many gas flaring points, each of the flaring points indicates hydrocarbon exploitation activities in the Delta. The hydrocarbon occurrence in the Niger Delta is density controlled such that the gaseous hydrocarbon is above the solid oil hydrocarbon, bellow the oil hydrocarbon is basinal water (Allen and Allen, 2006). It is this stratigraphic occurrence that makes exploitation difficult, because as soon as a hydrocarbon trap is exposed, the first emissions are the highly flammable gaseous hydrocarbon.

Figure 1. 150 Litres Anaerobic Biodigester, designed and constructed by Hilili Johnson & Dandy Onurah (2013)

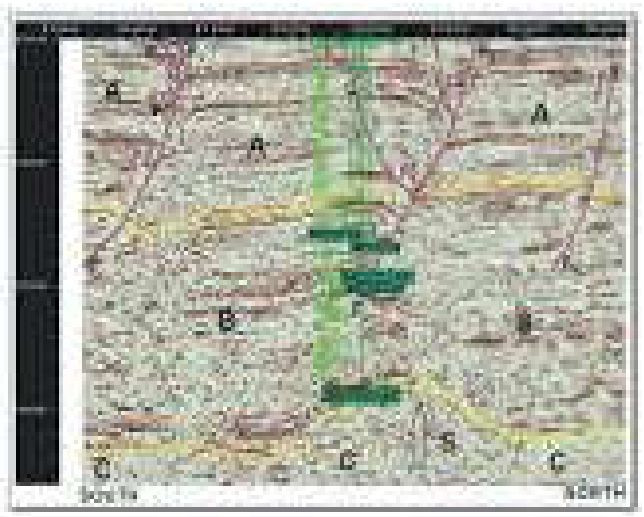

Figure 2. Siesmic Attributes in the Niger Delta by Chiadikobi, *et al.* (2012)

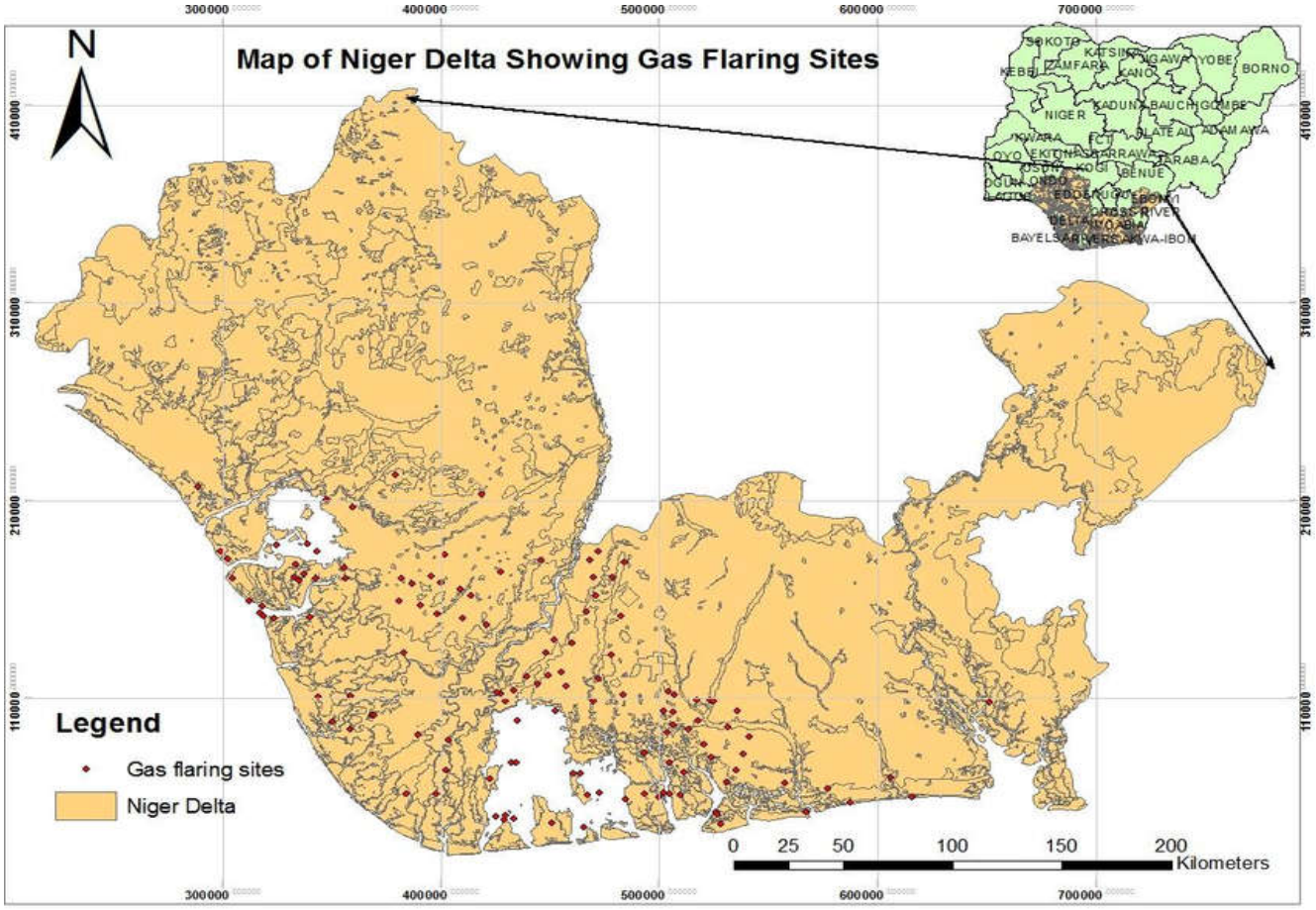

Figure 3. Map of Niger Delta Showing Gas flaring Sites (Source: NASRDA, 2005, in Tracy adole 2011)[1], "A GIS Bases Assess of the Impact of Gas Flaring on Vegetation Cover in Delta State, Nigeria. A Masters Thesis submitted to the University of East Anglia, Worwich. Available in https://www.researchgate.net.Assessed 30/01/2021)

Some of the traps occur as a result of shallow crustal density discontuities which reflect a range of geological structures associated with rift zones, share zones and cratonic margins (Fairhed and Okereke, 2010). Although the "International Best Practices" is that all flared gases should be collected and Liquefied, as liquefied Natural Gas (LNG), but the oil companies in the region are yet to 100% implement this practice. Interactions with most oil workers reveal that, their challenges in the LNG process is attributed to implementation cost compare to the profit of the LNG.

Hydrocarbon in the Niger Delta exists in 2 types of trapping system:

1. Stratigraphic traps, which are due faulting between units of shale, sand shale intervals such that the shale's are juxtaposed as seals along the fault plane, resulting to" a 4 – way closure", of the sands. Sands are god reservoir rocks. They are listrick growth fault with roll over anticline structures that help in the hydrocarbon trapping system.

2. Structural traps: These are mostly as a result of sedimentary pinch out of sand unit and porosities created by limestone structures controlled by dissolution (Allen and Allen).

During exploitation, the flaring methane in the form of flame emits excess carbondioxide (Co_2) and Carbon Monoxide into the environment. The Co_2 destroys the ozone layer that serves as umbrella to the biosphere, when the ozone layer is depleted, the direct heat from the sun gets to the environment resulting to climate change, global warming, the consequences of this is that the polar ice are melted, in which case it result to global seal level rise (flooding). Climate change has been responsible for the extinction of flora and fauna in the region. Excess environmental heat can trigger mutation in man, animals and plants. Currently 56.6 million m^3 of associated gas is flared daily in Niger Delta, Nigeria, and an amount equivalent to about 16% of the total world gas that is flared daily. Also, the physical and chemical properties of the methane gas produced anaerobically in the biodigester is the same with the Liquefied Natural Gas (LNG) during hydrocarbon exploitation, but the biodigester is limited to the production of gaseous hydrocarbon alone. Natural ground hydrocarbon gas occurs alongside solid oil hydrocarbon. Due to the non-profit (as complained by the oil workers) in the LNG processes, the oil companies are sluggish in the 100% implementation of zero gas flair. The impact of gas flare in the environment is a build-up process and the consequences are not only regional but global. Government must put necessary measures in place to enable the implementation of zero gas flare policy. Due to the knocking properties of most purely refined fuels, most companies result to using lead fuels as antiknocks. Lead destroys road side vegetation and indirectly contributes to excess Co_2 concentration. Since plants need $C0_2$ for their growth and in exchange produce the useful O_2 which we all need. Several accident cases resulting from the transportation of fuel has led to disappearance of large mass vegetation's along the roads, and the emission of large scale carbon monoxide and carbon dioxide into the atmosphere with their destructive potentials on the climate in this region. Deforestation resulting from the search for fire woods for domestic energy can be avoided. Agricultural waste and other forms of biodegradable waste can be managed in a biodigester to produce biogas for domestic use.

SOLUTIONS TO CLIMATE CHANGE

(a) Adaptive Solutions

- Aggressive reforestation programmers should be put in place by the government and relevant authorities, as acarbon capture strategy.
- Climate change seminars and conferences should be organized regularly to educate the people on the causes of climate change and its consequences on health and the environment.
- Carbon capture technologies like the use of anaerobic bio digesters in the production of domestic fuels be encouraged.

(b) Preventive/Mitigative Solutions

- Stringent measures by the government, that will encourage the oil companies to implement the zero gas flair policy
- Efficient and environmentally save strategies (such as transportation of fuels from one location to the other with the use of sub surface piping) be adopted.
- Deforestation and bush burning should by all means be prevented.
- Efficient and save waste recycling system (such as the use of bio digester) be practiced, rather than incineration
- Bioremediation technologies (example, phytoremediation) be used to reclaimed oil contaminated areas.

RECOMMENDATIONS

- Environmentally friendly geophysical tools (such as seismics) should be used during exploration and exploitation of hydrocarbon.
- Government must put stringent measures in place that will mandate the oil companies to comply to zero gas flair policy.
- The use of anaerobic biodigester as domestic source of gas should be encouraged to prevent deforestation for domestic energy.
- The use of lead fuels as antiknocks should be discouraged.
- Proactive afforestation/reforestation programs should be implemented and monitored by government and relevant organizations.

CONCLUSION

Exploitation activities in the Niger Delta Nigeria, contributes greatly to climate change, as gas flaring challenges are yet to be overcome, including other activities such as bush burning, deforestation, either for fire wood or during oil accident in the region. The stratigraphic occurrence of gaseous hydrocarbon above the solid oily hydrocarbon, and solid oily hydrocarbon above the basinal water, account for the difficulties in exploitation without gas flare. The cost of liquefying the flared gas is more than the profit associated with it, as explained by the oil workers. Thus, government must put stringent measures that will mandate the companies comply with zero gas flare policy. Also, aggressive afforestation and reforestation programs must be put in place to serve as a carbon capture strategy and reduce ozone layer depletion. Regular education programs should be made available to the companies and the people in this region, on the causes and dangers of climate change. The use of anaerobic biodigesters for the provision of domestic energy for cooking and electricity generationbe encouraged, as the end products are also good sources of organic fertilizer which is far better than the inorganic fertilizer. Finally, bioremediation technologies such as phytoremediation, indigenous bacteria bioremediation are adopted to reclaim damage ecological zones.

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