ASSESSMENT ON THE IMPACT OF GAS FLARING ON THE PHYSICOCHEMICAL QUALITIES OF GARDEN SOILS IN BONNY ISLAND

Ejiogu, C.C[1]., Halliday, K[1], Opara, K.D[2], Ude, A.D[3] and **Anyanwu, G.C[2]**

[1]Department of Environmental Technology.[2]Department of Geology, [3]Department of Urban and Regional Planning, Federal University of Technology, Owerri, Nigeria.

Correspondence e-mail: chrisejiacada@yahoo.com, kelechiopara81@gmail.com

ABSTRACT

Soil samples from 3 communities in Bonny Island were evaluated to assess the impact of gas flaring on the physicochemical qualities of garden soils**.** The result of the physicochemical properties of soils under study showed that the soil pH values ranged from 4.5 to 5.1 with soil samples from Macauley community having the lowest (4.5). The control site (FUTO garden) has a value of 5.1 which means that the soil in the impacted area were acidic. The electrical conductivities of the three study areas were higher than the control site. The soil available phosphorus value was higher in the control site (FUTO Garden with value of 3.28mg/kg). The three flare sites had an average value of 1.95mg/kg. Moreso, the nitrate-nitrogen level was higher in the control site than the other three flare sites with a value of 2.1mg/kg. The average value for the other three sites was 1.43mg/kg. The Total Organic Carbon (TOC) value ranged from 9.18% in Abalamabie, 17.6% around Berger road to 10.14% in Macauley community with an average of 12.31%. The FUTO Garden Control site showed a value of 19.6%. These values indicated that there were more organic carbons in soils where there were no gas flare and low organic carbon in the soil that is affected by gas flare. The observed slight acidity level of soils could have been responsible for the poor utilization of the nutrients in the growth medium. The Total Petroleum Hydrocarbon (TPH) values for the study area ranged from 3760.8 µg/g for Abalamabie, 3063.62 µg/g around Berger road to 394,362.9 µg/g for Macauley community. The Control site (FUTO Garden) showed a value of 52,907.3 µg/g. The very high value recorded in Macauley community had been associated with spilled petroleum contaminant from oil tankers in the sea which finds its way into the community lands during high tide.

***Keywords**: Gas flaring, Physicochemical qualities, Garden soils, Nigeria.*

1.0 Introduction

Gas flaring and venting has being an issue of concern since the discovery and exploration of oil in commercial quantity in Nigeria. Environmental issues of gas flaring are generally described in terms of efficiency and emission (Panayotou, 2000).

Gas flaring and venting of petroleum-associated gas is a significant source of greenhouse gas emission and airborne contaminants that has proven difficult to mitigate over the years (Ndebio, 2000). In the petroleum industry, poor efficiency in the flare systems often result in incomplete combustion (VOCs), polycyclic Aromatic Hydrocarbons (PAHs) and inorganic contaminants (Sojinu *et al*., 2010). Over the past fifty years, gas flaring and venting associated with petroleum exploration and production in Nigeria's Niger Delta has continued to generate complex consequences in terms of energy, human health, natural environment, socio-economic environment and sustainable development (Ite and Udo, 2013).

Gas flaring and venting has negative effects on the immediate, particularly on the plant growth and wildlife (Ana *et al*., 2009). Odjugo and osemwenkhae (2009) concluded that further studies were necessary to determine the effects of the flares on the yield of crop plants grown in Niger Delta but the present result indicates that flares effects doubtfully extend beyond a distance greater than 110 meters from the sacks, except in the case of suppression of the flowering of short-day plants. Soils of the study area are fast losing their fertility and capacity for sustainable agriculture due to acidification of the soils by the various pollutants associated with gas flaring in the area (Odjugo and Osemwenkhae, 2009).

Apart from thermal pollution associated with gas dispersion and emissions from the flare systems discharge various organic and inorganic contaminants into the atmosphere (Julius, 2011). It has been suggested that increase in temperature associated with gas flare contributed to low agricultural productivity and cause changes in the natural ecosystem (Brady and Weil, 2002). The modified microenvironment in terms of air and temperature of the flare site, relative humidity, soil moisture and other soil chemical properties affected not only maize germination but also the growth and agricultural (Odjugo and Osewenkhae, 2009).

It is known that pollution from gas flares affects the microbial populations which participate in inorganic matter decomposition and nitrogen formation process resulting in a decline in organic matter and total nitrogen as well as microbial populations, humid (topsoil) formation, nutrient availability and soil fertility (Ite and Udo, 2013). Ite and Udo (2013) also explained that gas flaring and venting impact adversely on the negative effects on physical and chemical properties of the soil subsequently impact on some crops due to modification of the microclimate in the area.

Gas flaring and venting systems in the petroleum exploration and production operations are stationary sources of atmospheric contaminants that have several consequences on the regional and global environment (Ugochukwu and Ertel, 2008). Some of the effects of petroleum associated gas flaring and venting system in the oil producing Niger Delta region include greenhouse effect, increase in temperature or thermal gradient (Oseji, 2007), human health problems (Gobo *et al*., 2010), poor agricultural yield (Dung *et al*., 2008), acid rain/acidification of aquatic ecosystem (Efe, 2010). In the Niger Delta, there are widespread perceptions that gas flaring and venting practices in the petroleum industry contribute to several human health, environmental and socio-economic problems in the region (Edino *et al*., 2010).

Studies show that gas flaring significantly affects not only the microclimate but also the phyico-chemical properties of the flare sites (Ite and Sample, 2012). In some oil-producing communities, most flaring and venting systems are located in close proximity to residential area and farmlands and the resultant emissions potentially contribute to global warming as well as some local and regional adverse environmental impacts (Buzcu-Guven and Harriss, 2012). Flaring and venting during oil production operations emit carbon dioxide (CO_2), methane (C_4H_{10})0 and other forms of gases which contribute to global warming causing climate change, and this affects the agricultural, social, environmental qualities and health of the vicinity of the flares (Ejiofoh, 2011).

From an operational perspective, some 45.8 billion kilowatts of heat are discharged into the atmosphere of the Niger Delta from combustion of 1.8million cubic feet of gas everyday (Agbola and Olurin, 2003). These emissions increase the concentration of greenhouse gases in the atmosphere which in turn contributes to global warming. In a study, Ayansina *et al*, (2010) assessed the adverse effect of gas flaring on the environmental and the potential benefits of its reduction on the local economy and the environment at large. The data from the study suggested that gas flaring contributes to global climate change and has significant negative impacts on the environment (Ayansina *et al*., 2010). It is evident that gas flaring has contributed significantly to poor environmental and human health quality around the vicinity of the flares and overall environmental degradation in the area.

Nigeria has had regulations on the books banning gas flaring for more than a quarter of century; however they are yet to effectively implement their policies. In 1969, the Nigerian government legislated a requirement that oil companies set up facilities to use the associated gas within five (5) years of the commencement of oil production (Ikeze, 1999). However, the companies preferred to pay the fine imposed as penalty for gas flaring by the government rather than stopping the flaring.

The magnitude of these problems necessitates the need to determine the essence of soil properties around gas flaring and venting site of the area.

1.1 Location and Geomorphology of the study area

The study area falls within the Cartesian coordinates of latitude: 4° 27' 8" N and 4^{0}.45’51”, longitude: 7° 10' 5" E and 7^{0}16’8”. The geology of the area is predominantly composed of coastal plain sand. The study area falls within the sub-equatorial climate region of Nigeria with a total rainfall of more than 3,050mm (170 inches). The area under study experiences two major seasons; the rainy of wet and the dry seasons.

The seasonal occurrence of rainfall accounts for the variability in river flows. This implies that, a river may have virtually no discharge in the late dry season, but in the rainy season or early dry season may experience severe flooding. Drainage depends on the soil type, vegetation, relief, topography etc. Bonny drainage pattern is controlled by rivers like: St Bathlomew River, St Gallabor, Andoni River, Imo River and Bonny River depositing large amount of sand sediments (alluvium) because of the decrease in intensity, capacity and velocity of the river. This simply classifies the study area into an area with a dendritic drainage pattern. .

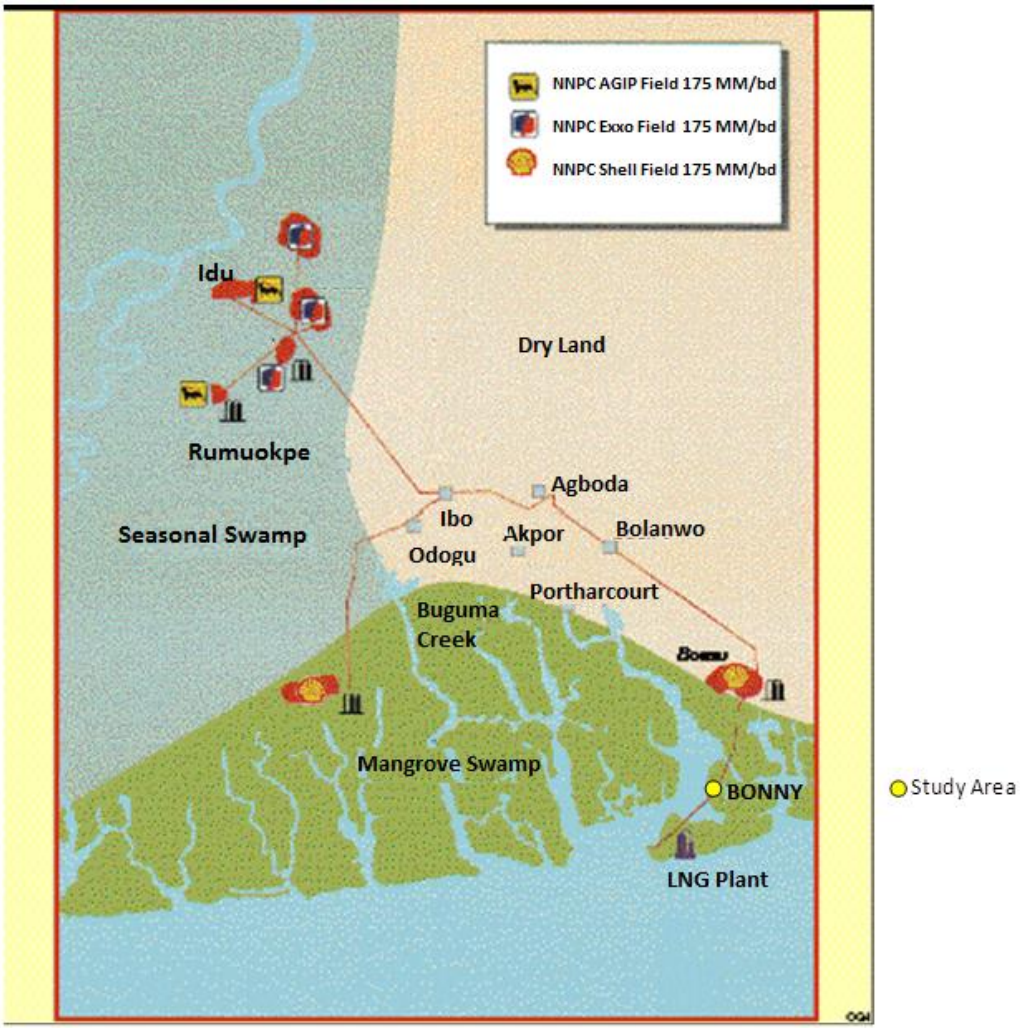

Fig 1.: Location map of the study area

2.0 Methodology

The pH of the sample was determined using a digital pH meter. The organic carbon was determined by the Walkey Black method. Sulphate level in the soil sample and is determined using the multi-parameter photometer.

Phosphate is extracted using sodium bicarbonate at soil water ratio of 1:25. The extracted phosphate is reacted with phosphate reagent, Amrnonium molybdate under reducing conditions in acidic solution to form a blue cultured complex. The intensity of the blue coloration is proportional to the phosphate level in the soil determined by Amino acid method. The phosphate is then determined in the sample by using multi-parameter photometer.

Exchangeable calcium and magnesium were determined by EDTA titration; and potassium and sodium by flame photometry.

TPH were determined using Ultraviolet visible spectrophotometer. 5g of the soil sample was poured into a conical flask containing 20mls of hexane and 5g of dried sodium sulphate. The mixture was shaken vigorously for 30mins. The solvent extracted was allowed to settle before decanting carefully into the UV/visible spectrometer cell and the absorbance of the extract water measured at 420nm. The heavy metals were analysed using Atomic Absorption Spectrophotometer (AAS).

3.0 Results

Table 1 shows the physico-chemical properties of soils from the study area namely: Abalamabie, Berger Road and Macauley Community with FUTO garden as the control site, while fig 2-5 shows the various plots using the parameters measured in the study area.

From hand specimen analysis, the basic soil type in the study area is sand-dominated. The soil pH ranges from 4.5 in Macauley community, 4.9 around Berger Road to 5.0 in Abalamabie with average value of 4.8. The FUTO Garden Control site has a pH of 5.1.

The electrical conductivities of the study areas ranged from 71µs/cm to 80µs/cm with Macauley community recording the highest 83µs/cm, berger Road has 82µs/cm, Abalamabie has 81µs/cm and FUTO garden, 71.0µ/cm.

The extractable phosphorus values recorded 0.82mg/kg for Abalamabie, 3.2mg/kg around Berger road and 1.84mg/kg for Macauley community with an average of 1.95mg/kg. The Control site (FUTO Garden) showed a value of 3.28mg/kg.

The nitrate-nitrogen value had 2.1mg/kg for the control site, 1.2mg/kg around Berger road, 1.5mg/kg in Macauley community to 1.6mg/kg in Abalamabie with an average value of 1.43mg/kg for the three study areas.

The Total Organic Carbon (TOC) value range from 9.18% in Abalamabie, 17.6% I around Berger road to 10.14% in Macauley community with an average of 12.31%. the FUTO Garden Control site showed a value of 19.6%.

The Total Petroleum Hydrocarbon (TPH) value for the study area ranges from 3760.8 µg/g for Abalamabie, 3063.62 µg/g around Berger road to 394,362.9 µg/g for Macauley community. The Control site (FUTO Garden) showed a value of 52,907.3 µg/g.

Heavy mineral occurrence in the study is limited to arsenic and cadmium with Lead totally absent. An average value of 0.096mg/kg and 0.033mg/kg respectively for cadmium and arsenic was recorded.

Table 1: Physicochemical parameters recorded in the soils from the study area and the control site

S/N	**WHO**	**PARAMETER STANDARD**	**ABALAMABIE**	**BERGER ROAD**	**MACAULEY COMMUNITY**	**FUTO**
1	PH	6.5—8.5	5.0	4.9	4.5	5.1
2	Conductivity, µs/cm	100	81	82	83	71
3	Nitrate($N0_3$), mg/kg	20	7.1	5.3	6.4	5.6
4	Nitrate-Nitrogen(NO^-_3-N), mg/kg	-	1.6	1.2	1.5	2.1
5	Sulphate(SO_2), mg/kg	100	64	31	15	52
6	Phosphate(P034),mg/kg	>100	2.52	9.84	5.60	10.08
7	Phosphorus(P), mg/kg	-	0.82	3.20	1.84	3.28
8	Phosphate(P_2O_5), mg/kg	-	1.89	7.36	4.20	7.52
9	Lead,_mg/kg	0.05	0.00	0.00	0.00	0.00
10	Cadmium mg/kg	0.10	0.122	0,106	0.061	0.054
11	Arsenic, mg/kg	0.01	002	008	000	6.06
12	Total Organic Carbon, %	-	9.18	17.60	10.14	19.6
13	Total Petroleum Hydrocarbon, µg/g	-	3760.8333	3063.6191	394362.9339	52907.3469

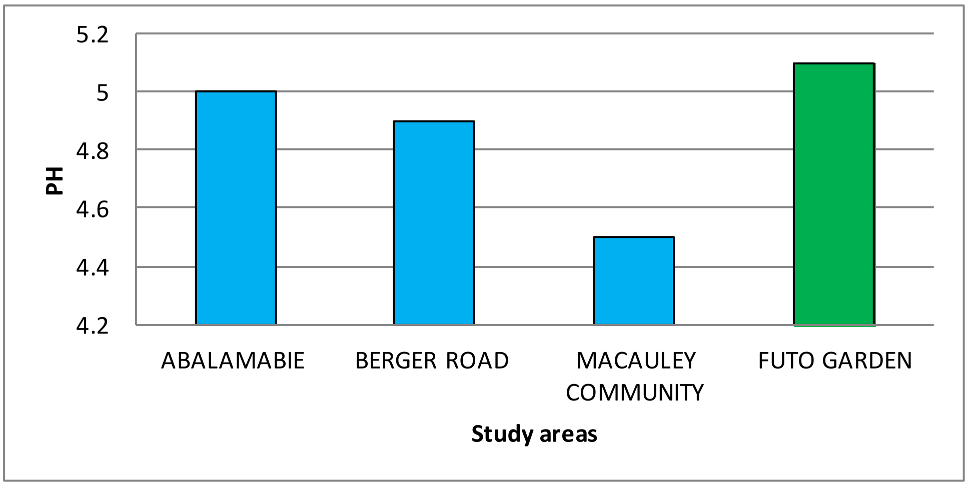

Fig 2: A plot showing the PH range for the study area

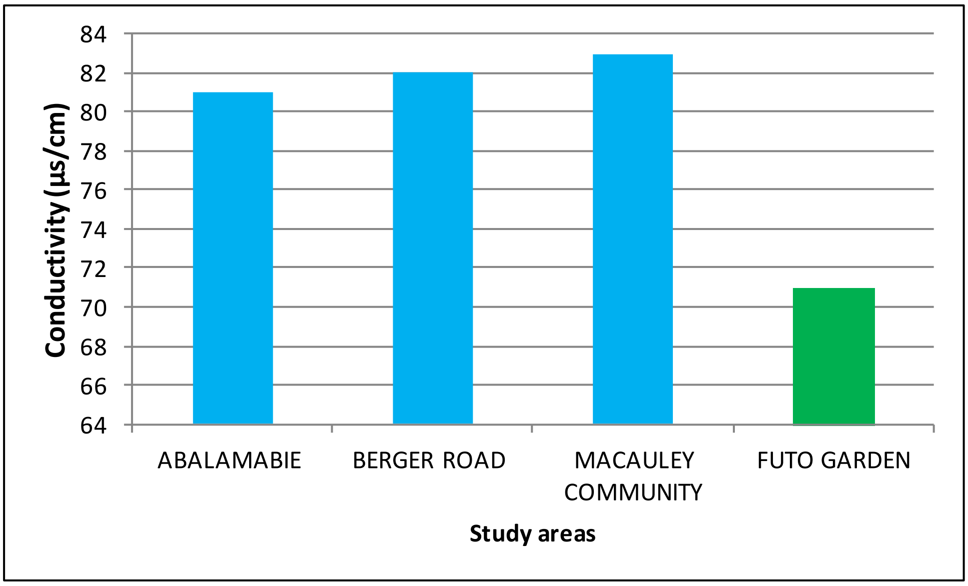

Fig 3: A plot of the Electrical Conductivities in the study area

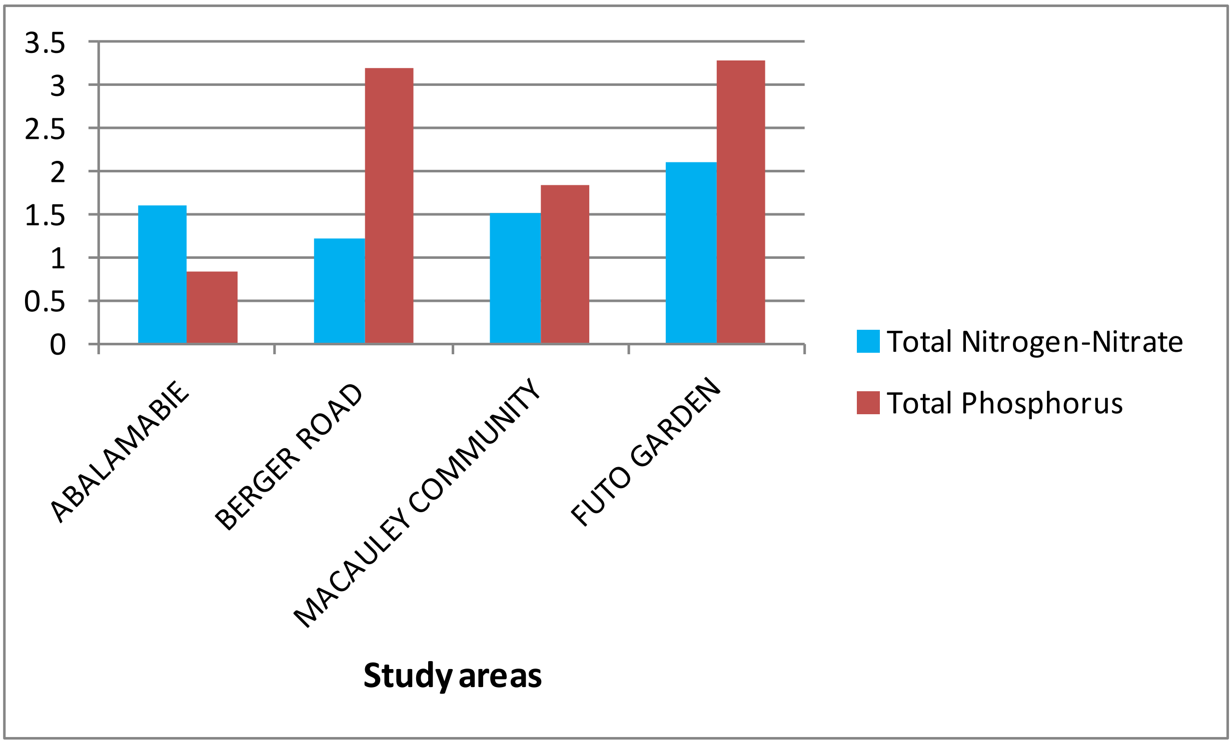

Fig 4: A Combined plot of Total Nitrogen-Nitrate and Phosphorus values in the study area

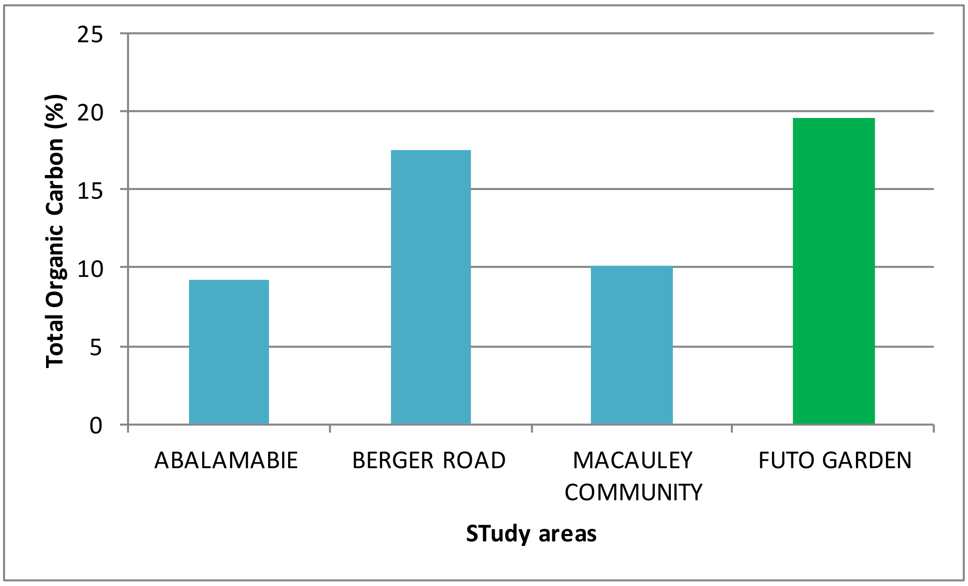

Fig 5: Percentage occurrence of Total Organic Carbon in the study area

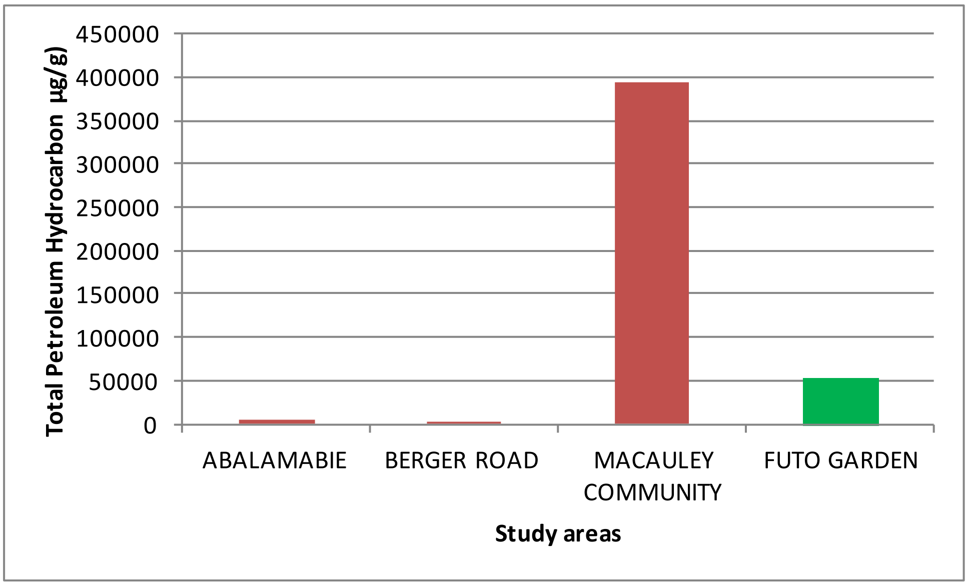

Fig 6: A plot of available Total Petroleum Hydrocarbon in the study area

4.0 Discussion

The results of the physicochemical properties of soils from the study area namely: Abalamabie, Berger Road and Macauley Community with FUTO Garden as the control site were shown in table 1 and the various parameters were plotted in statistical charts to show their distribution. From hand specimen analysis of the soil samples, the basic soil type in the study area was sand-dominated especially from the FUTO Garden. This might be due to the effect of a nearby stream and land filling by relatively coarser materials.

The soil pH values ranged from 4.5 in Macauley community, 4.9 around Berger Road to 5.0 in Abalamabie. The FUTO Garden Control site showed a pH of 5.1.

The soil pH measures the level of soil acidity or alkalinity in a solution or substance. Thus, the soils found in the study area were slightly acidic with the three study communities slightly more acidic than the control site. The observed slight acidity level of soils could have been responsible for the poor utilization of the nutrients in the growth medium. The low pH around the flare sites could be attributed to acidic precipitation (Botkin and Keller, 1995). The slightly acidic pH of the control site could be attributed to fertilizer application around the FUTO farm. In particular ammonium fertilizers such as urea and ammonium phosphates, such as monoammonium and diammonium phosphate are converted rapidly into nitrate through a nitrification process, releasing acids in the process and thus increasing the acidity of the topsoil (Lavelle and Spain, 2001).

Soil acidity affects microbial activities which results in reduction of organic decomposition and the recycling of basic plant nutrients. In addition, at low pH (below 5.5) aluminium (Al^{3+}) is abundant and will react more readily with phosphates to form aluminium phosphate which has low water solubility. The lack of water solubility of this compound means that the compounds are not readily available for plant use. In other words, in strongly acidic soils, most of the phosphates is bound and not released. Consequently, the fertility of the soils decreases with decreasing pH (Lavelle and Spain, 2001).

The pH of a soil is a fundamental chemical property controlling soil biology and chemical processes such as biological nitrogen fixation, root growth and the mineralization of organic matter (Paustian, 2002). The soil pH has a direct effect on the ability of plant root cells to absorb both nutrients and water from the soil. The soil pH greatly affects the solubility of minerals. Most crops will produce satisfactory yield with pH range of about 5.5-7.5 while a pH of about 6.3 being ideal for most crops (Akinbola *et al*., 2009).

The electrical conductivity values of the three study areas are higher than the control site. (83µs/cm in Macauley community, 82 µs/cm around Berger Road and 81 s/cm in Abalamabie, 68.7 µs/cm in the FUTO Control site). This implies that the electrical conductivity in the flare areas is greater than that of the non-flared site (FUTO Garden).

The soil available phosphorus value is higher in the control site (FUTO Garden with value of 3.28mg/kg). The three flare sites have an average value of 1.95mg/kg. Moreso, The nitrate-nitrogen level is higher in the control site than the other three flare sites with a value of 2.1mg/kg. The average value for the other three sites is 1.43mg/kg.

The Total Organic Carbon (TOC) values ranged from 9.18% in Abalamabie, 17.6% around Berger road to 10.14% in Macauley community with an average of 12.31%. The FUTO Garden Control site showed a value of 19.6%. These values indicate that there is more organic carbon in soils where there is no gas flare and low organic carbon in the soil that is affected by gas flare.

Soil organic matter affects both the chemical and physical properties of the soil and its overall health (FAO, 2005). Soil organic matter also influences the effect of chemical amendment, fertilizer, pesticides and herbicides. Many important chemical properties of soil organic matter result from the weak acid nature of humus (Mrabet *et al*., 2001a).

The ability of organic matter to retain cations from plant use while protecting them from leaching i.e. the cation exchange capacity (CEC) of the organic matter is due to the negative charges created as hydrogen is removed from weak acids during neutralization (Blair and Crocker, 2000)

The Total Petroleum Hydrocarbon (TPH) value for the study areas ranged from 3760.8 µg/g for Abalamabie, 3063.62 µg/g around Berger road to 394,362.9 µg/g for Macauley community. The Control site (FUTO Garden) showed a value of 52,907.3 µg/g. The very high value recorded in Macauley community has been associated with spilled petroleum contaminant from oil tankers in the sea which somehow finds its way into the soils in the community possibly during high tide or by artificial tides created by sea vessels and speed boats plying the route around the community.

5.0 Conclusion

From the study, it is seen that gas flaring has some notable effects in the environment especially in the area of study, which ranges from its effect on the soil to its effect in the entire environment. Apart from affecting the chemical properties of the soil, it also resulted to poor soil fertility or nutrient, leading to poor crop productivity in the area. Because gas flaring seems to affect agricultural and economic activities of oil host communities in Nigeria, both the government and the oil companies should therefore keep up to the challenges of monitoring, evaluating and managing the oil drilling environment for a sustainable environmental development.

In the light of the above findings, the following recommendations are made with respect to the impact of gas flaring on soil around Bonny Island:

1) Federal Government through the Federal Ministry of Environmental Protection Agency (FEPA), Niger Delta Affairs Ministry, Policy Makers and stakeholders in environment and oil sector should revisit and review existing environmental and oil drilling laws in Nigeria.
2) The Federal Government policy on zero flare by July, 2008 should be put to place and not a mere policy statement. This could be done by the utilization of the gas being flared through re-injection process during oil production, and construction of gas plants for electricity generation and harness the flared gas for both private and commercial uses.
3) There should be a constant environmental monitoring, assessment and evaluation to determine the level of damage that is done by gas flaring and other oil pollutions on the environment as a whole.
4) Stakeholders which include Governments, oil companies and most scientists should explore ways of re-using of the excess gas into veritable use instead of flaring them. They can be channeled into the running of gas-turbine to generate electricity etc.
5) Advocation of Sequestration as an alternative to gas flaring as a way to slow the atmospheric and marine accumulation of greenhouse gases, which are released by burning fossil fuels especially gas flaring and venting.

REFERENCES

Agbola, T., and T. Olurin (2003). "Landuse and Landcover Change in the Niger Delta," Excerpts from a Research Report presented to the Centre for Democracy and Development.

Akinbola, G.E., Anozie, H.I. and Obi, J.C. (2009)."Classification and characterization of some pedon son basement complex in the forest environment of south-western Nigeria" *Nigeria J.Soil.Sci*, Vol 19, No 1, pp 109-117.

Ana, G. R., M. K. Sridhar, and E. A. Bamgboye (2009), "Environmental risk factors and health outcomes in selected communities of the Niger delta area, Nigeria, "Perspectives in Public Health, 129 (4). 183- 191.

Ayansina, A., O. Orimoogunje, T. Akinkuolie, and Odiong, A (2010), "Perception on Effect of Gas Flaring on the Environment," *Research Journal of Environmental and Earth Sciences*, 2 (4). 188-193.

Blair, N. and Crocker, G.J. (2000). Crop rotation effects on soil carbon and physical fertility of two Australian soils. *Aust. J. Soil Res.*, 38:72-84.

Botkin, D. B. and Keller, E. A. (1998). Environmental Science, Earth as a Living Planet, 2nd ed., John Wiley and Sons, Canada

Brady, N.C and Weil, R.R (2002). The Nature and properties of soils. (13th ed). Prentice Hall International Editions, upper Saddle river, new Jersey.

Buzcu-Guven, B., and Harriss, R. (2012). "Extent, impacts and remedies of global gas flaring and venting," Carbon Management, 3 (1). 95-108.

Dung, E., L. Bombom, and Agusomu, T. (2008). "The effects of gas flaring on crops in the Niger Delta, Nigeria," *Geojournal,* 73 (4). 297-305.

Edino, M., G. Nsofor, and Bombom, L (2010)., "Perceptions and attitudes towards gas flaring in the Niger Delta, Nigeria," *The Environmentalist,* 30 (1). 67-75.

Efe, S. I.,(2010). "Spatial variation in acid and some heavy metal composition of rainwater harvesting in the oil-producing region of Nigeria," *Natural Hazards*, 55 (2). 307-3 19.

Ejiofoh, B.T. (2011). Gas flaring, climate change and livelihood in Nigeria. M.Sc thesis submitted to centre for energy law and management policy, University of Dundee, UK.

Ejiofoh, B.T. (2011). Gas flaring, climate change and livelihood in Nigeria. A M.sc thesis submitted to Centre for Energy law and management Policy, University of Dundee, United Kingdom.

FAO, (2005). The importance of soil organic matter. Food and Agriculture Organization of the United Nations, Rome, Italy.

Ite, A. E and Udo, J. I. (2013). "Gas flaring and venting Associated with petroleum Exploration and protection in the Nigeria's Niger Delta". *Amer. J. Environ*. Protection 1:4, 70-77.

Ite, A. E., and Semple, K.T (2012). "Biodegradation of petroleum hydrocarbons in contaminated soils," Microbial Biotechnology: Energy and Environment, R. Arora, ed., pp. 250-278, Wallingford, Oxfordshire: CAB International.

Julius, O.O (2011). "Environmental impact of gas flaring within Umutu-Ebedei gas plant in Delta State, Nigeria," *Archives of Applied Science Research,* 3 (6). 272-279.

Lavelle, P. and Spain, A. (2001). Soil ecology. Dordrecht, The Netherlands, Kluwer Academic Publishers.

Mrabet, R. Ibno-Namr K., Bessam F. and Saber N. (2001a). Soil chemical quality and implications for fertilizer management after 11 years of non-tillage wheat production systems in semi-arid Morocco. Land Deg. Dev, 12:505-517.

Ndebio, J.E.U. (2000). "The Role of Multinational Companies in the Economic backwardness of Niger Delta" *Nigeria Journal of Social and development issues* 291): 14-35

Odjugo, P. A. O., and Osemwenkhae, E. J. (2009) "Natural gas flaring affects microclimate and reduces maize (Zea mays) yield," *International Journal of Agriculture & Biology,* 11(4). 408-412,

Ologunorisa, T. E. (2001). "A review of the effects of gas flaring on the Niger Delta environment," *International Journal of Sustainable Development & World Ecology,* 8 (3). 249-255.

Oseji, J. O (2007). "Thermal gradient in the vicinity of Kwale/Okpai gas plant, Delta state, Nigeria: Preliminary observations," *Environmentalist,* 27 (2). 311-314, 2007.

Panayotou, T (2000) Globalization and the Environment. Environment and Development, 1:148.

Paustian, K. (2002). Organic matter and global cycle. In: Encyclopedia of soil science, pp 895-898. New York, USA, Marcel Dekker Inc.

Sojinu, O. S. S., Wang, J.Z, Sonibare, O.Oand Zeng, E.Y (2010) "Polycyclic aromatic hydrocarbons in sediments and soils from oil exploration areas of the Niger Delta, Nigeria," *Journal of Hazardous Materials,* 174 (1-3). 641-647.

Ugochukwu, C. N. C., and Ertel, J (2008). "Negative impacts of oil exploration on biodiversity management in the Niger Delta area of Nigeria," Impact Assessment and Project Appraisal, 26 (2). 139- 147.