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Evaluation of the effect of Total Hydrocarbonlevels on growth anddistributionof *Rhizophora racemosa*and *Nypafruticans* in selected Niger Delta mangrove forest, Nigeria.

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Abstract
The effect of total hydrocarbon content (THC) levels on the growth and distribution of R. racemosa and N. fruticans in selected Niger Delta mangrove forest soil was evaluated in this study. Seasonal soil samples were collected from study plants growth dominated and non-growth stations, and analyzed for THC using the distillation method after extraction with soxhlet extraction apparatus. Findings showed the THC levels at R. racemosa (7.20±1.26-16.97±7.51mgkg^{-}) and (11.06±0.45 - 24.70±8.50mgkg^{-}), N fruticans (6.37±1.55-10.95±0.62 mgkg^{-}) and (9.87 ± 1.28-15.17±2.76 mgkg^{-}) growth dominated soils, while the non- growth soils showed (6.77±0.86-6126.33±195.59mgkg^{-}) and (15.47± 4.37-8600.00±1038.58mgkg^{-}) for wet and dry seasons respectively. The study also showed non-growth soil THC level >R. racemosa soil THC level >N. fruticans soil THC level. Findings on stations THC levels showed Bomu as the most impacted mangrove soil >Borokiri>Ogu>Kono study stations. Remediation of the impacted forest is recommended for healthy mangrove growth.

Key words*: Evaluation, Hydrocarbon, Growth, Distribution, Mangrove forest, Niger Delta.*

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I. Introduction

The red mangrove (*Rhizophora racemosa* G.F.W Meyer) and Nypa palm (*Nypafruticans*Wurmb (Arecaceae) belong to the mangroves, which are assemblage of salt-tolerant trees and shrubs that grow in the intertidal regions of tropical and subtropical coastlines (FAO, 2007). According to Giri*et al.* (2011) mangrove forest are distributed in the intertidal zone between the sea and the terrestrial area in the tropical and subtropical regions of the world and are located between approximately latitude 30˚N and 30˚S of the equator.

The Niger Delta mangrove ecosystem is globally ranked among the most important ten wetland and marine ecosystems (FME *et al*., 2006; ANEEJ, 2004), with well distributed native mangrove species in the coastline of which *Rhizophora racemosa* is the dominant species occupying the boundary of the alluvial salt swamp, (Ohimain, 2006). They constitute a major source of sea food such as crabs, oyster, cockles and periwinkles that are usually found around mangrove roots (Ejituwu, 2003).Other functions include the provision of quality environment for spawning, nurseries, nutrients and fishing ground for several species of fisheries including crustaceans and molluscs (Lay *et al*., 2002; Marshall, 2004).*Nypafruticans*was introduced to Nigeria for purposes of stabilizing coastline against erosion (Udoidiong and Ekwu, 2011). The species strives well in calm mangrove ecosystem with high inflow of fresh water (Tomlinson, 1986).

Mangrove soils are characteristically observed to possess a natural ability to act as a sink for anthropogenic pollutants. Many studies have attributed the high status of pollution in the Niger Delta region to oil related activities (Kinigorna, 2001; Amusan and Adeniyi, 2005; Wogu and Okeke, 2011). Among the known causes of soil and water pollutants is the release of hydrocarbons into the environment following accidental discharge or by human and other activities (Holliger*et al*., 1997). This discharge results in the accumulation of total petroleum hydrocarbon in soils, with resultant drastic environmental health problems (Denys *et al*., 2006).Oil spillage in mangrove ecosystem has been reported to causes adverse effects (Marmiroli*et al*., 2006). These effects are attributed bythe types of oil, level of spill, the area covered, oil composition and the season of occurrence (Pezeshki*et al*., 2000). In some cases, it results to changes in the colour of foliage, low quality in canopy formation, low productivity and mortality of plants (Akwiwu*et al*., 2002, Nkwocha and Duru, 2010). Other effects include inhibition of germination, growth and development of plants (Ekundaro 2007, Ekpo*et al*., 2012, Eze *et al*., 2013), poor growth in terms of stem diameter and height, reduction in the rate of photosynthesis and death of plants (Pezeshki, 2000, Tanee and Anyanwu, 2007, Anyanwu and Tanee, 2008). Oil

pollution also negatively impacts on the environment, resulting to loss of biodiversity (Phil-Eze and Okoro, 2009), mortality of several hectares with the inhibition of plant survival in the environment (Obilo and Ogungemi, 2002, Ufot*et al*., 2003). The impact also results in the reduction in population and growth rate of mangrove trees (Zhu *et al*., 2004)

The study area was chosen based on its outstanding role in oil exploration and exploitation activities, with characteristic exposures to the negative impacts of crude oil pollution such as degradation and deforestation of mangrove forest. The area is among the mangrove cover in Nigeria that is reported to have been degraded from 9,900 Km^2 to 7, 386 Km^2 between 1980 and 2006 (World Rainforest Movement, 2009).Kono and Bomu (the study area) in Ogonilandis among the identified mangrove devastated coastline due to oil related pollution (UNEP, 2011). This study was thus designed to evaluate the inundation of total hydrocarbon on the growth, distribution of *Rhizophora racemosa*(native mangrove) and *Nypafruticans* (aggressive invasive mangrove) which are the predominant mangrove species in the area.

II. Materials And Methods

Description of Study Area

Four study stations namely Kono (station 1), Bomu (station 2), Ogu (station 3) and Port Harcourt (station 4) in Khana, Gokana, Ogu/Bolo and Port Hacourt local government area of Rivers State, stretching from Longitude 7^0 05' 00'' E through Longitude 7^0 30' 30'' E and latitude 4^0 45' 30'' Nthrough Latitude 4^0 55' 00'' with an insert of Rivers State showing study Local Government Area and Nigeria showing Rivers State(Fig. 1), (Gbosidom*et al*., 2017).

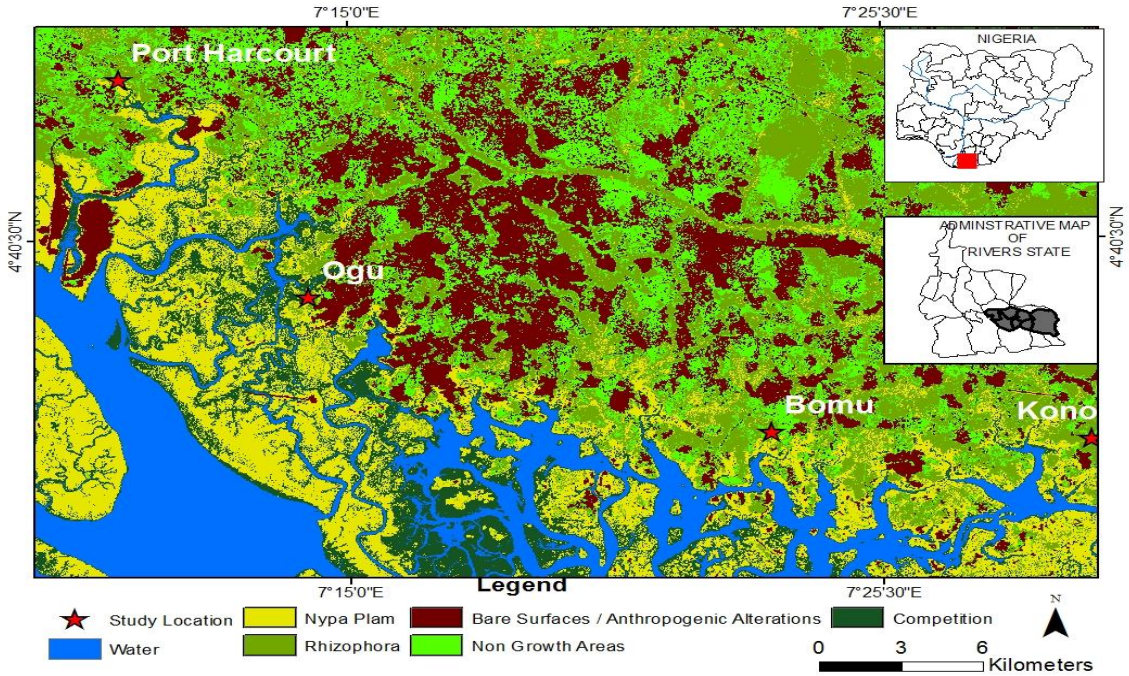

Fig. 1: Study area showing sampling location/stations

Research Design

The Randomized Complete Block Design (RCBD) method consisting of 4 stations and 3 growth *(Rhizophora*,*Nypa*, non-growth) areas was used for the study.

Sampling

Various soil samples were collected in the months of July and August 2015,and the months of January and February 2016, for wet and dry seasons respectively. Top soils were randomly collected at 0 - 30 cm closer to the roots of *Rhizophora racemosa* and *Nypafruticans* at their respective growth sites, and the non-growth sites of both plant species and bulked together as representative samples in three replications each from the four established stations in the study area, using soil auger.Soil samples were stored in sterile cellophane bags, tied and labelled using masking tape and marker pen. Samples were preserved in a plastic cooler and transported to the laboratory for total hydrocarbon analyses. Samples for deferred analysis were stored in the refrigerator and regulated at 4˚C (Gbosidom*et al*., 2017).

Sample preparation and determination of soil Total Hydrocarbon content

Soil samples were air dried and sieved through a 2mm mesh sieve prior to extraction and stored in cellophane bags, labeled with sample identity.

The respective samples were weighed at 10 g each and blended with 10 g of anhydrous Sodium Sulphate. The harmonized samples were transferred to an extraction thimble of SOXHLET apparatus and covered with glass wool. Samples were extracted using the Soxhlet extraction apparatus model ASTMD9071B-7.N-hexane was prepared and 90 ml was transferred into a 250 ml boiling flask which was connected to the soxhlet apparatus containing an extraction thimble with the various samples as a set up. Sample extraction was done in 4hours duration.The organic extract was filtered through grease-free cotton into a pre-weighed boiling flask. The flask and the wool were rinsed with n-hexane into the 250 ml boiling flask. Distillation of solvent was achieved by connecting the boiling flask to a distilling head apparatus and distilled using a heating mantle, model MY 6403. At the end of distillation, the distillation head was disengaged from the boiling flask which was allowed to cool in a desiccator for 30 minutes and weighed.The gain in weight of the boiling flask was determined by subtracting the initial weight from the final weight of the flask. The concentration of THC in soil was calculated as follows:

$$\text{THC (mg/kg)} = \frac{\text{gain in weight of flask (mg)} \times 1000}{\text{Weight of dry solid (g)}}$$

III. Results

Total hydrocarbon content of soilsand plant distribution

The wet season result of total hydrocarbon content (THC) of soilsat the respective study stations showed the concentrations atKono (station 1)with non-growth soil recording the highest concentration of THC level, followed by *N. fruticans*growth soil, while*R racemosa*growth soil recordedlower concentration of THC. At Bomu (station 2), theresult showed that non-growth soil also recorded the highest concentration of THC, followed by*R. racemosa*growth soil, while*N. fruticans*growth soil recorded the lowest concentration of THC. At Ogu (station 3), the result showed *N. fruticans*growth soil having the highest concentration of THC, followed by non-growth soil, while *R. racemosa*growth soil recorded the lowest concentration of THC. At Borokiri (station 4), the result showed that*R. racemosa*growth soil recorded the highest concentration of THC, followed by non-growth soil, while *N. fruticans*growth soil recorded lower concentration of THC (Table 1). Statistical differences were established at Kono (station 1) and Bomu (station 2)between the concentrations of THC at*R. racemosa*growth soil and non-growth soil, and between *N. fruticans*growth soil and non-growth soil at $p = 0.05$ respectively (Table 1).

The dry season result of concentration of THC levels at the respective study stations showed that at Kono (station 1), non-growth soil recorded the highest concentration of THC, followed by *R. racemosa*growth soil, while*N. fruticans*growth soil recorded the lowest concentration of THC.At Bomu (station 2), the result showed that non-growth soil recorded the highest concentration of THC, followed by*R. racemosa*growth soil, while *N. fruticans*growth soil recorded lower concentration of THC. Ogu (station 3) result showed that Non-growth soil recorded the highest concentration of THC, followed by *R. racemosa*growth soil, while*N. fruticans*growth soil recorded the lower concentration of THC.Borokiri (station 4)result showed that non-growth soil recorded the highest concentration of THC, followed by *R. racemosa*growth soil, while N. *fruticans*growth soil recorded lower concentration of THC. The result further showed that at the four study stations, the non-growth soil was highly concentrated with THC, followed *R. racemosa*growth soil, while *N. fruticans* growth soil showed the lowest THC concentration (Table 1).Statistical differences in concentration of THC were established at Kono (station 1)between *R. racemosa*growth soil and non-growth soil, and between *N. fruticans*growth soil and non-growth soil at $p = 0.05$ respectively. At Bomu (station 2), statistical differences in concentration of THC were established between *R. racemosa*growth soil and non-growth soil, and between *N. fruticans*growth soil and non-growth soil at $p = 0.05$ respectively. At Ogu (station 3), statistical difference in concentration ofTHC were established between *R. racemosa*growth soil and *N. fruticans*growth soil, between *R. racemosa*growth soil and non-growth soil, and between *N. fruticans*growth soil and non-growth soil at $p = 0.05$ respectively. At Borokiri (station 4), no statistical difference in concentration ofTHC was establishedat $p = 0.05$ (Table 1).

Table 1: Total hydrocarbon content (mg kg^{-}) of soil at plant growth stations

	Wet Season THC Distribution			
Variable	**STA 1**	**STA 2**	**STA 3**	**STA4**
R. racemosa	7.20±1.36^{a}	16.97±7.51^{b}	7.71±1.05^{a}	7.96±1.13^{a}
N. fruticans	8.07±0.21^{a}	10.95±0.62^{b}	6.73±2.52^{a}	6.37±1.55^{a}
Non-growth	15.20±0.70^{a}	6126.33±195.59^{b}	6.77±0.86^{a}	7.14±0.41^{a}
	Dry Season THC Distribution			
R. racemosa	11.10±0.26^{a}	21.57±4.01^{bc}	11.06±0.45^{a}	24.70±8.50^{c}
N. fruticans	10.75±0.55^{a}	15.17±2.76^{b}	9.87±1.28^{c}	13.73±2.29^{d}
Non-growth	19.91±1.20^{a}	8600.00±1038.58^{b}	15.47±4.37^{a}	27.27±6.41^{a}

STA 1 = Kono study station, STA 2 = Bomu study station, STA 3 = Ogu study station, STA 4 = Borokiri study station

Stations comparison of total hydrocarbon content distribution

Wet season result for the comparisonof concentrations of THC between stations showed the trend at *R. racemosa*growth stations, with highest concentration of THC at Bomu (station 2), followed by Borokiri (station 4) and Ogu (station 3), while Kono(station 1) showed the lowestconcentration of THC in soil. The result further showed statistical differences at *R. racemosa* growth stations between station 1 and 2, station 2 and 3, and between station 2 and 4 at p = 0.05 respectively (Table 2).

The results at*N. fruticans*growth stations showed Bomu (station 2) as the station with the highest concentration of THC in the soil, followed by Kono(station 1) andOgu (station 3), while Borokiri (station 4) showed the lowest concentration of THC. The above result further showed statistical differences in the concentration of THC at *N. fruticans* growth stations, between stations 1 and 2, 2 and 3 and between station 3 and 4 at p = 0.05 respectively (Table 2).

The non-growth stations result showed Bomu (station 2) as the station with the highest concentration of THC, followed by Kono (station 1) and Borokiri(station 4), while Ogu (station 3) showed the lowest concentration of THC. Theseresults non-growth further showed significant differences in the concentration of THC between stations 1 and 2, 2 and 3, and between station 2 and 4 at p = 0.05 respectively.

Furthermore,the mean concentration result of THC at the four study stations showed that the non-growth stations recorded the highest concentration of THC, followed by *R. racemosa* growth stations, while *N. fruticans*growth stations showed the lowest THC level (Table 2).

The dry season result of THClevels in soilsat *R. racemosa*growth stations showed a trend of Borokiri (station 4)>Bomu (station 2)>Kono (station 1)>Ogu (station 3), while*N. fruticans*growth stations showed the trend of Bomu (station 2)>Borokiri (station 4)>Kono (station 1)>Ogu (station 3). At the non-growth soil, Bomu (station 2)showed very high concentrationof THC in the study area, followed by Borokiri (station 4) and Kono (station 1), whileOgu (station 3) showed the lowest THCconcentration in the study area (Table 2). The result further showed mean level of THC at the four study stations with station Bomu (station 2)showing the highest concentration ofTHC, followed by Borokiri (station 4) and Kono(station 1), while Ogu(station 3)showed the lowest level of THC level. The result of THC comparison between stations showed that at *R. racemosa*growth stations,significant differenceswere observed between stations 1 and 2, 2 and 3, and between 2 and 4 at p < 0.05 respectively, while *N. fruticans*growth stations showed significant differences in THC levels between stations 1 and 2, 1 and 3, 1 and 4, 2 and 3, 2 and 4, and between station 3 and 4 at p <0.05 respectively (Table 2). The result at non-growth stations showed significant differences in THC levels between station 1 and 2, station 2 and 3, and between station 2 and 4 at p < 0.05 respectively (Table 2).

Table 2: Distribution of THC (mgk^{-}) at study stations

Wet Season THC Distribution			
Stations	***R. racemosa***	***N. fruticans***	**Non-growth**
STA 1	7.20±1.36^{a}	8.07±0.21^{a}	15.20±0.70^{a}
STA 2	16.97±7.51^{b}	10.95±0.62^{b}	6126.33±195.59^{b}
STA 3	7.71±1.05^{a}	6.73±2.52^{a}	6.77±0.86^{a}
STA 4	7.96±1.13^{a}	6.37±1.55^{a}	7.14±0.41^{a}
	Dry Season THC Distribution		
STA 1	11.10±0.26^{a}	10.75±0.55^{a}	19.91±1.20^{a}
STA 2	21.57±4.01^{bc}	15.17±2.76^{b}	8600.00±1038.58^{b}
STA 3	11.06±0.45^{a}	9.87±1.28^{c}	15.47±4.37^{a}
STA 4	24.70-±8.50^{c}	13.73±2.29^{d}	27.27±6.41^{a}

STA 1 = Kono study station, STA 2 = Bomu study station,
STA 3 = Ogu study station, STA 4 = Borokiri study station

IV. Discussion

The result of soil total hydrocarbon (THC) levels at *R. racemosa*, *N.fruticans* and Non-growth stations showed variability and a trend of Non-growth THC level>*R. racemosa* THC level >*N. frutican*s THC level.The comparison of THC levels at *R. racemosa, N. fruticans* and Non-growth soils at the respective stations showed significant difference between *R. racemosa* and Non-growth THC levels and between *N. fruticans* and Non-growth THC leves. The above findings showed that soil THC levels negatively influenced the distribution of *R. racemosa* and *N. fruticans* mangrove species. These findings are in tandem with earlier findings that showed that oil pollution has negative impact on the environment, resulting to loss of biodiversity (Phil-Eze and Okoro, 2009).

Study on the levels of THC in soils showed that the study plants were distributed based on their tolerance ability, a finding which corroborates an earlier finding by Subodh and Abhiroop (2013) who observed the dominance of *Avicinnia marina* in different mangrove patches due to pollution.

The study showed non-growth of *R. racemosa* and *N. fruticans* at stations having high levels of total hydrocarbon content. This observation may be attributed to the toxicity caused by the high levels of THC on both study plants and this may have affected the structure of the forest, in line with earlier findings of(Ekundaro 2007, Ekpo*et al*., 2012; Eze *et al*., 2013) who reported inhibition of germination, growth and development of plants, and Kairo *et al*, (2001) who reported that the loss of larger mangroves due to pollution affects the structure of the forest which may not naturally recover. The above observation also corroborates the findings of the United Nations Environmental Programme report on Ogoni environment, which stated that oil impact on mangrove vegetation was disastrous and vary from extreme stress to total destruction of leaves and stems, leaving roots which were completely coated with oil up to 1cm or thicker layer of bituminous substances (UNEP, 2011).

Findings on stations comparison of mean levels of THC showedBomu (station 2) >Borokiri (station 4) >Kono (station 1) >Ogu (station 3). Consequently, stations with high concentration of THC may have experienced high mortality of mangrove species, in line with the report of Obilo and Ogungemi (2002) and Ufot*et al.* (2003), who observed that pollution from oil spill resulted in the mortality of several hectares of mangrove forest, with the inhibition of plant survival in the environment. This finding further confirms UNEP (2011), who reported the pollution and accumulation of oil in Ogoni mangrove for a period estimated to be over decades.

V. Conclusion

The impact of total hydrocarbon content levels on the growth and distribution of *R. racemosa* and *N. fruticans* in the study area has established that THC levels has negative impact on the growth and distribution of the referenced mangrove species, as stations with high impact of THC showed non-growth of plants due to the toxicity associated with THC in the soil. The study further established the variability of THC levels at the study stations.

References

[1]. Akwiwu, C. D., Nwajiuba, C.U. andNnadi, F. N. (2002).Pollution and agro-forestry practices of farming in Imo State. Implications for house hold livelihood. Paper presented at 36th Annual Conference of the Agricultural Society of Nigeria held at Federal University of Technology,October 20-24, 2002 Owerri.

[2]. Amusan, A. A. and Adeniyi, I. F. (2005). Genetic classification and heavy metal retention potential of soils in mangrove forest, Niger Delta, Nigeria. *Journal of Human Ecology*,17(4): 255-261.

[3]. ANEEJ, (2004).*Oil of poverty in the Niger Delta.*A publication of African Network for Environment and Economic Justice.

[4]. Anyanwu, D. I. andTanee, F. B. G. (2008).Tolerance of cassava (Var. TMS 30572) to different concentrations of post- planting crude oil pollution.*Nigerian Journal of Botany*, 21:203-207.

[5]. Denys, S., Rollin, C., Guillot, F. and Baroudi, H. (2006). In-situ phytoremediation of PAHS Contaminated soils following a bioremediation treatment. *Water, Air and soil pollution*, 6: 299-315.

[6]. Ejituwu,N. C. (2003). *Andoni women in time perspective*. In: Ejituwa, N.C and A.O.I Gabriel, Women in Nigeria History. The Rivers and Bayelsa States Experience, Choba, OnyomaResearch Publications

[7]. Ekpo, I. A., Agbor, R. B., Okpako, E. C. andEkanem, E. B. (2012). Effect of crude oil polluted soil on germination and growth of soybean (Glucine max). *Annals of Biological Research*., 3:3049-3054.

[8]. Ekundayo, L. O. (2007). The impact of Shell Petroleum Development Company on socio-economic development of Port Harcourt.*International Journal on Environmental Issues*, 9:5-6.

[9]. Eze, C. N., Maduka, J. N., Ogbonna, J. C. and Eze, E. A. (2013). Effect of Bonny light crude oilcontamination on the germination, shoot growth and Rhizobacterial flora of *Vignaunguiculata* and*Arachis hypogea* grown in sandy loam soil. *Scientific Research and Essays*, 8:99-107.

[10]. FAO (Food and Agricultural Organization of the United Nations) (2007). "The world's mangroves 1980-2005" FAO forestry paper 153:75.

[11]. Federal Ministry of Environment Abuja, Nigeria Conservation foundation Lagos, WWF UK and LEESP- IUCN commission on Environmental, Economic and Social policy, May 31 (2006). Niger Delta Resource Damage Assessment and Restoration project.

[12]. Gbosidom, V. L., Obute, G. C., and Tanee, F. B. G. Evaluation of heavy metal levels and the distribution of *Rhizophora racemose* and *Nypafruticans* in the Niger Delta mangrove forest, Nigeria

[13]. Giri, C., Ochieng, E., Tieszen, L. L., Zhu, Z., Singh, A., Loveland, Masek, J. and Duke, N. (2011).Status and distribution of mangrove forest of the world using earth observation satellite data. *Global Ecology Biogeography*, 20: 154-159.
[14]. Holliger, C., Gaspard, S., Glod, G., Heijman, C., Schumacher, W., Schwarzenbach, R. P. and Vazquez, F.(1997). Contaminated environment in the subsurface and bioremediation:organic contaminants. *FEMS Microbiology Reviews*, 20 (3-4): 517-523.
[15]. Kairo, J.G., Dahdouh-Guebas, F., Bosire, J., Koadam, N (2001). Restoration and management of mangrove systems-a lesson for and from the East African region. *South African Journal of Botany*, 67: 383-389.
[16]. Kinigorna, B. S. (2001). Effect of drilling fluid additives on the Niger Delta environment: A case study of the Soku oil fields. *Journal of Applied Science and Environmental Management*, 5(1): 57-61.
[17]. Lay, J. A., Halliday, I. A., Tobin, A. J., Garrett, R. N. and Gribble, N. A. (2002). Ecosystem effects of fishing closures in mangrove estuaries of tropical Australia. *Marine Ecology Progress Series*, 245:223-238.
[18]. Marmiroli, N., Marmiroli, M. andMaestri, E (2006). Phytoremediation and phytotechnologies: A review for the present and the future. In: Twardowska, I., Allen H.E and Hagglom M. H (ed), *Soil and Water Pollution Monitoring, Protection and Remediation*.*Springer*, Netherland.
[19]. Marshall, N. (2004). Mangrove conservation in relation to overall environmental consideration.*Hydrobiologia*, 285:303-309.
[20]. Nkwocha, E. E. andDuru, P. O. (2010).Micro-analytic study on the effect of oil pollution on local plant species and food crops.*Advances in Bioresearch*, 1: 89-198.
[21]. Obilo, O. P. andOgunyemi, S. (2002). The use of maize as an indicator crop and in the reclamation offarmland laden with heavy metals as a result of crude oil pollution. Paper presented at 36th Annual Conf. of Agric. Society of Nigeria held at the federal Univ. of Tech. (Fut)Owerri Oct. 20-24, Owerri.
[22]. Ohimain, E. I. (2006). Oil and Gas exploration poverty and environmental unsuitability in the Niger Delta.A paper presented at the International Association for Impact Assessment Conference in Stavanger, Norway (May 2006).
[23]. Pezeshki, S. R., Hester, M. W., Lin, Q. and Nyman, J. A. (2000).The effect of oil spill and clean-upon dominant US Gulf coast marsh macrophytes. *Environmental Pollution*, 108:129-139.
[24]. Phil-Eze, P. O. and Okoro, I. C. ((2009). Sustainable biodiversity conservation in the Niger Delta: A practical approach to conservation site selection. *Biodiversity and Conservation*, 8 (5): 1247-1257.
[25]. Tanee, F. B. G. and Anyanwu, D. I. (2007). Comparative studies of the growth and yield of two cassavalines (TMS 30572 and TMS 30555) in a crude oil polluted habitat. *Scientia Africa*, 6:81-84.
[26]. Tomlinson, P. B. (1986).*The Botany of Mangroves*.Cambridge University press.
[27]. Udoidiong, O.M andEkwu, A.O (2011).Nypa Palm (*Nypafruticans*Wurmb) and the intertidalepibenthic macrofauna east of the Imo River Estuary, Nigeria. *World Applied Sciences Journal*, 14(9): 1320-1330.
[28]. Ufot, O., Uwakwe, V.C., Akande, O. andLekwa, G. (2003).The effect of oil expiration on the soil of Izombe in Imo State, Nigeria. Paper presented at 28th annual conference of the soil science soc. ofNigeria at National Root Crops Research Inst. Umudike, Abia State, 4-7Nov. 2003.
[29]. UNEP, (2011).*Environmental assessment of Ogoniland report*.United National EnvironmentalProgramme, Nairobi, Kenya.
[30]. Wogu, M. D. andOkaka, C.E. (2011). Pollution studies of Nigerian Rivers: Heavy metals in surface water of Warri River, Delta State. *Journal of Biodiversity and Environmental Sciences*, 1(3):7-12.
[31]. World Rainforest Movement (2009). Niger Delta mangrove communities threatened by continued gas flaring, Map Alert Action in Africa, in mangrove and disappearing and with them, Livelihood, *WRM bulletin*, No. 14.
[32]. Zhu, X., Venosa, A. D., Suidan, M. T. and Lee, K. (2004). Guidelines for the bioremediation of oil contaminated salt marshes. EPA/600/R-04/074.;36pp.

Gbosidom, V. L, et. al. "Evaluation of the effect of Total Hydrocarbonlevels on growth anddistributionof Rhizophora racemosaand Nypafruticans in selected Niger Delta mangrove forest, Nigeria." *IOSR Journal of Environmental Science, Toxicology and Food Technology (IOSR-JESTFT)*, 14(03), (2020): pp 58-63.