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INCIPIENT ECOSYSTEM DAMAGE IN PARTS OF THE OIL FIELDS OF THE NIGER DELTA, NIGERIA: IMPLICATIONS ON SUSTENABLE AGRICULTURE, FISHING AND ENVIRONMENTAL QUALITY

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ABSTRACT

The damage to the fragile Niger Delta ecosystem started with the discovery of crude oil in its sub-stratum in the late 1950s. For over forty years now, environmental deterioration has increase proportional to the increase in crude oil and gas exploitation. Environmental abuse had initiated an ecological disequilibrium to replace the natural dynamic equilibrium situation that had hitherto sustained the Niger Delta ecosystem. In this report the Niger Delta ecosystem is investigated at various locations from the view point of sustainable agriculture, fishing and environmental quality. In soils contaminated by crude oil, total hydrocarbon content (THC) values ranged from 24.8ppm to 1994.8ppm near the Kwa Iboe River estuary, Akwa Ibom State, and from 50.9ppm to 150,000.00ppm at Warri, Delta state. Edible plant samples contained THC ranging from 41.80ppm to 98.10ppm as a result of root uptake from relatively uncontaminated soils. While THC in water samples near the Kwa Iboe River estuary, ranged from 503.0ppm to 1969.0ppm, values in

Warri were considerably higher, varying from 52.50ppm to 200,000.00ppm. There is a dynamic threat to health as air is contaminated and water supplies polluted by acid and other aerosols associated with gas flaring. In these polluted ecosystems, agriculture and fishing which are the means of livelihood of the people cannot be practised on a sustainable basis. For the sustainable development of the Niger Delta area, an integrated environmental management model approach which recognises the need for the preservation of the traditional socio-economic status of the area and the incorporation of the modern industrial production system is desired.

1.0 INTRODUCTION

Environmental disequilibrium occurs when the natural factors of the environment are modified by man directly or indirectly through human activities in the course of resource exploitation. Direct modification is usually positive or to the advantage of man (or sustenance of the ecosystem). For instance a stream flowing through rapids could be harnessed to produce hydro-electric power which might create reservoirs for fishing or water supply. On the other hand, indirect modification is a by-product of human activities. It is not intentional nor is the modification designed to achieve any purpose. Hence the disequilibrium created is often undesirable. Not being part of the resource exploitation process, it is often ignored until ecosystem damage sets in. Unfortunately, once there is incipient damage, the situation deteriorates through a chain of activity reactions to include human aspects hitherto unrecognized.

The damage to the fragile Niger Delta ecosystem occurs due to indirect modification being a by-product of petroleum exploitation. Since the late 1950's environmental deterioration has increased proportional to the increase in crude oil and gas exploitation. This environmental abuse initiated an ecological disquilibrium which replaced the natural dynamic equilibrium situation that had hitherto sustained the Niger Delta ecosystem. The disquilibrium with serious environmental and socio-economic consequences occur through hydrocarbon contamination of the ecosystem.

2.0 Hydrocarbon Pollution of Soils

2.1 Study Areas and Data

The first location was in Warri at the localities of Ifie Ekpan and Ogheye in Delta State. The second location was the vicinity of the Mobil Tank Farm in Akwa Ibom State. The third location was the fishing settlements of Ibeno, Inuyaeyet, Mkpanak and Ukpenekang along the Atlantic shoreline of Akwa Ibom State. The reason for selecting these locations was the continuous activities of oil exploiting companies which include Shell Exxon/Mobil, Agip and Elf. Table 1 shows the concentration of hydrocarbons in the soils of these areas.

Table 1: Levels of total hydrocarbon (THC) in soils from selected locations in the Niger Delta

Location	THC	Location	THC
1 Ogheye	150,000(HP)	7 Ibeno	98(RU)
2 Ekpan	100,000(HP)	8 Inuayet	30(RU)
3 Ifie	200,000(HP)	9 Mkpanak	60(RU)
4 Ekurede Itsekiri	50 (RU)	10 Ukenekang	46(RU)
5 [illegible]	75(RU)	11 Tank farm Sam[illegible] 1	72[illegible]
6 [illegible]mimogha	52(RU)	12 Tank farm Sample 2	1995.8(HP)
		13 Tanks farm Sample 3	692.8(HP)

ppm = Parts per million; HP = Highly polluted; RU = Relatively unpolluted.
Source: Ukpong & Ojo-Ede (1999); Ukpong & Akpan (2000); Ukpong 1994.

During exploration for crude, dynamite is shot into the ground and the explosions may cause crude oil deposit that lie close to the surface to gush out uncontrolled. The flow is usually along topographic gradients into creeks or basin wetlands where vegetation and other organisms are starved of air as aerobic conditions are created. The large THC values in the Warri samples (1-3) in Table 1 is due to dumpling of oil by companies using petroleum products. The oil is carried by over land flow and seepage into the surrounding coastal plains. Soil pollution arises also due to over pressure and overflow of separators and storage tanks. This was the case in 11-13 (Table 1) in relation to the Mobil Tank Farm samples. In the Warri area additional pollution sources are the refinery loading stations, filling stations and mechanic workshops. Pollution often occurs due to sabotage of oil installations e.g. theft or illegal bunkering during which pipes carrying crude are perforated to tap the crude oil illegally. When this happens to high pressure pipelines, spillage occurs.

Where the soil is polluted by hydrocarbon the following are likely to occur:

(i) Soil micro-organisms would be destroyed.
(ii) Decomposition of organic matter would be slowed down or terminated.
(iii) Consequent to (ii), the soils would be deficient in nutrients e.g. nitrogen calcium magnesium potassium and sodium etc.
(iv) Soil pores are blocked by hydrocarbon.
(v) The heavy metals e.g. lead could accumulate in levels that become toxic to organisms.

A comparative analysis of soil nutrient from relatively unpolluted and polluted soils are given in Table 2 and Table 3.

Table 2: Mean values of total hydrocarbon (THC) and the corresponding soil nutrient values in four relatively unpolluted sites. Data for top-soil (0-15cm) is reported.

Parameter	Sampling sites			
	Ibeno	Inuaeyet	Mkpanak	Upenekang
THC(ppm)	98.10	30.00	60.70	41.80
pH	8.11	6.59	8.71	6.40
OM(%)	3.70	3.30	4.32	3.04
Ca (mg/100g)	0.29	1.14	0.59	0.81
Mg (mg/100g)	0.13	0.61	0.30	0.41
K (mg/100g)	0.09	0.13	0.05	0.11
E.A. mg/100g)	1.08	2.27	1.37	1.70
ECEC (mg/100g)	2.34	4.51	2.43	3.14
BS(%)	14.27	48.82	43.56	46.07

OM = Organic matter; T.N = Total nitrogen; AV.P = Available phosphorus, E.A = Exchangeable acidity; ECEC = Effective cation exchange capacity; BS = Base saturation. N = 10.
Source: Ukpong & Akpan (2000)

Table 3: Mean values of total hydrocarbon content (THC) and the corresponding soil nutrient values from four highly polluted sites. Data for top-soil 0-15cm is reported

Parameters	Upenekang	Mkpanak	Tank Farm	Coastal Sands
THC (ppm)				
Sample 1	502.9	693.4	1842.6	375.5
Sample 2	627.5	721.3	1297.5	692.8
Sample 3	394.7	605.8	1994.8	380.4
Field moisture (%)	128.4	137.3	119.2	102.6
Bulk density (gcm^{-3})	92.8	88.5	80.9	90.5
pH	5.7	5.5	5.2	60
Exchange acidity (me/100g)	6.8	5.9	6.2	5.9
Phosphorus (ppm)	1.3	1.8	1.5	2.1
Sulphate (me/100g)	0.5	0.6	8.8	0.3
Aluminium (me/100g)	0.9	1.0	1.4	0.4
CEC (me/100g)	38.5	42.3	34.2	44.5
Organic carbon (%)	6.8	6.5	5.8	3.2

Source: Ukpong, (1994).

There tend to be a decrease in soil nutrient values as pollution becomes more severe. Apparent high levels of cations in the soil probably are associated with the THC/sea water sludge which cannot be used to define the nutrient status of the soils.

3.0 Hydrocarbon Pollution of Water

3.2 Study Areas and Data

The locations were Warri River, Ugbodede Creek, Ogunu Creek, Edjeba River, Itori Creek, and Esisi River, all in the Warri area of Delta State. Other areas were the coastal areas of Ibeno, Inuaeyet Mkpanak and Ukenekang in Akwa Ibom State. The reasons for selecting these areas are similar to those given in section 2.1 of the paper. The THC values in the water samples are given in Table 4.

Table 4: Total hydrocarbon values in water samples from selected sites.

Location	THC (ppm)	Location	THC
1. Warri River	150,000	5. Esisi River	50
2. Ugbodede Creek	18,000	6. Ibeno	38
3. Ogune Creek	20,000	7. Inuaeyet	47
4. Edjeba River	60	8. Mkpanak	62

Hydrocarbon pollution of water is fast in tidal areas. The spread can be phenomenal particularly if the source is offshore and the current is on-shore in direction as is usually the case along the Niger Delta shoreline. The SW maritime trade winds could push the Atlantic storm waves 20km upstream. For instances tidal influence is felt 20km up the Imo and Kwa Iboe River estuaries and 25km up the Calabar River at Creek Town. Hence, sediment and mangrove mud become impregnated with hydrocarbon far from the source of pollution. The effects are as follows:

(i) Spawning grounds become polluted.

(ii) Aquatic vegetation many of which have economic values degenerate in productivity. For e.g. die-backs in mangroves are more common in polluted areas than in relatively unpolluted areas.

(iii) Organisms (sea bottom/river bed) and crustaceans including planktons degenerate in the toxic environment.

(iv) Fishing as an economic activity is lost or threatened.

(v) Human health in these areas deteriorate proportional to the level of water pollution. The high water table in the polluted Delta region often carry films of hydrocarbon due to subsurface seepage and intrusion of contaminated water inland.

4.0 Hydrocarbon Pollution of Organisms

4.1 Study Areas and Data

One of the routine soil and water parameter in the Niger Delta region is hydrocarbon. Consequently, just as nitrogen an phosphorus, for example, are essential to the performance of vegetation which help to build up animal tissues, the effect of hydrocarbon though in most instances detrimental cannot be over-emphasised. As plants uptake food from the soil and fish feed in polluted water, these substances accumulate in their tissues and are eventually consumed by man (Table 5). The plant samples consisted of cassava, pumpkin, maize, cocoyam, elephant grass and centrocema. The fish samples consisted of bonga, mud crab and periwinkle. These are staple food items that are obtained in the Niger Delta ecological zone. Samples were obtained from noticeably polluted areas at Ibeno, Inuaeyet, Mkpanak, Ukenekang and off-shore locations.

Table 6: Mean values of THC and other chemical properties in plant and fish samples from polluted areas

Parameters	Plant	Fish	Crab	Periwinkle
THC (ppm)	77	108	211	240
Nitrogen %	2.1	1.8	2.0	2.4
Ca (meq/100g)	72	141	472	566
Mg (meq/100g)	104	182	150	144
K (meq/100g)	74	105	127	130
P (meq/100g)	553	94	94	111

Source: Ukpong & Akpan (2000)

Occurrence of hydrocarbon in edible organisms mean that considerate portion of this substance passes onto consumers. In the Warri River area, inhabitants have observed that brains of fish have the coloration of crude oil and the fish have the taste of crude when eaten. Where pollution is severe fish is paralysed and cannot swim properly, thereby becoming victim to predators. Vegetables contaminated with THC through the soil can hardly be said to be nourishing.

5.0 Hydrocarbon Pollution of Air

5.1 Study Areas and Data

The area of study was Iko, an oil producing community in Akwa Ibom State. Atmospheric pollution arising from gas flaring also affects the soil and water sources as rain passes through the atmosphere to the surface. Considerable volume of petroleum associated acids find their way into the soil and water channels and impact upon the ecosystem (tables 6a, b, c,)

Table 6(a): Acidity conditions of soils at Iko

Location	pH at 23°C	SO^{2}_{4} mg/100g	NO^{2}_{3} mg/100g	$CaCo_3$ mg/100g
Borehole	6.3	9.0	480	0.5
River	5.8	2.0	460	2.0
Stream	5.4	1.0	420	0.5
Rain water	5.8	4.0	453	1.0

Table 6(b): Acidity conditions of water at Iko

Location	pH at 23°C	SO^{2}_{4} mg/L	NO^{2}_{3} mg/L	$CaCo_3$ mg/L
Near borehole	6.0	10.0	0.32	1.0
From farm	6.3	109.0	0.12	0.5
Qua Iboe Church	6.5	3.0	0.05	0.5
Mean	4.9	4.0	ND	0.5

Table 6(c): Concentration of acid generating aerosols and gases in the atmosphere over Iko.

Location	Concentration (mg/L)
Hydrocarbon sulphide (H_2S)	8.6
Carbon monoxide (CO)	0.5
Sulphur dioxide (SO_2)	76.7
Nitrogen oxide (NO_3)	ND
Air pH at 23°C	ND

Table 6(a) shows that the soils at Iko which is typical of the Niger Delta oil producing areas, are concentrated with hydrogen ions. The soils are moderately acid with significant contents of sulphate and nitrates, an indication that wet and dry deposition processes are prevalent in the area. Table 6(b) shows that rain water is the main pathway of acid deposition. River water has the highest concentration of sulphate ions because of the discharge. The acidic ions are introduced into the groundwater by infiltrating rain water while rivers and stream also receive the ions directly from both wet and dry deposition processes.

Table 6(c) shows that hydrogen sulphide carbon monoxide and sulphur dioxide are the main acid generating gases in the air. They constitute the main sources of acid deposition in the Iko area. The effects of gas flaring resulting from petroleum exploitation are as follows:

(i) Excessive leaching of nutrients (especially aluminium and manganese) from plant foliage and soil thereby reducing the quality of soil and its productivity.

(ii) Disturbance of the balance of predators and prey in ecosystems by two major pathways: (a) direct damage through the deposition of acidic aerosols and gases on leaves and water bodies (b) soil acidification and disturbance of microbial processes in the soil.

(iii) Acidification of rivers streams and ponds, leading to increased mortality of fishes in the near coastal waters.

(iv) The corrosion of structures such as bridges, buildings and their roofs and the replacement of these over short periods of time.

(v) Subtle threat to health due to pollution of water supplies by acid and other aerosols from the flared gases. These can result in cancer and birth defects.

6.0 Remediation of Impacted Ecosystems

6.1 Study Area and Data

The most significant large-scale entry of crude oil and associated pollutants into the ecosystem is through accidental oil spill and gas flaring. However, because of the financial gains of compensation payment for loss of livelihood (which has been highly politicised and corrupt), ecosystem gains following proper redemption measures are often ignored or not given the attention it deserves.

Data was collected near the Qua Iboe oil terminal locality where Exxon/ Mobil operates. The aims were (i) assess the effects of weathered petroleum products on the physical and chemical characteristics of the aquatic ecosystems and (ii) estimate the extent of site recover after clean up exercise (Table 7).

Table 7: Mean values of physico-chemical parameters measured in impacted and post impacted water sample near QIT.

Physico/Chemical Properties	Impacted sample	Post impacted sample	F-ratio
1. pH	5.40	6.82	NS
2. Turbidity	56	18	P = 0.01
3. Free Co_2 ($mgdm^{-3}$)	0.85	4.00	P = 0.001
Total dissolved solids ($mgdm^{-3}$)	25.6	14.0	P = 0.001
Total alkalinity $CaCo_3$ ($mgdm^{-3}$)	18.8	40.0	P = 0.05
Dissolved oxygen demand ($mgdm^{-3}$)	1.5	8.0	P = 0.05
DO% saturation	20	105	P = 0.05
Chemical oxygen demand (mg/dm^{-3})	62.5	38.0	P = 0.01
Biochemical oxygen demand ($mgdm^{-3}$)	12.7	2.8	P = 0.01
Ammonium-nitrogen (mg/dm^{-3})	37.0	10.0	P 3 0.01
Oil and grease content(mg/dm^{-3})	4.4	3.6	P = 0.01
Salinity ‰	5.2	7.5	NS
Phosphate((mg/dm^{-3})	1.8	1.4	NS
Sulphide(mg/dm^{-3})	0.09	0.05	NS
Sulphate(mg/dm^{-3})	170	300	P = 0.01
N_2 (mg/dm^{-3})	1269.8	1840.0	NS
K (mg/dm^{-3})	28.2	12.0	P = 0.01
Ca (mg/dm^{-3})	16.8	13.6	NS
Mg (mg/dm^{-3})	62.9	46.3	NS
Pb (mg/dm^{-3})	21.5	8.1	P = 0.01
Cd (mg/dm^{-3})	0.6	3.3	NS
Cu (mg/dm^{-3})	0.8	0.5	NS
Zn (mg/dm^{-3})	0.4	0.7	NS
Fe (mg/dm^{-3})	1.24	0.26	P = 0.5
No_3 (mg/dm^{-3})	3.3	8.6	P = 0.5

Source: Akpan & Inyang (1998), NS = Not significant using F = test.

Table 7 shows that after appropriate remediation, an impacted ecosystem or site could be restored or improved upon. For example the pH (indicator of acid condition) of the post impacted sample was within the optimum range for the maintenance of a healthy aquatic environment. Likewise oxygen demand and turbudity improve considerably in the post impacted samples. It is clear that should sufficient attention be paid to remediation and prevention, the Niger Delta environment would be relatively healthier than what is obtained now. Remediation implies attempts to restore by deliberate action, the natural equilibrium condition that had been destroyed.

6.0 Implications on Sustenable Agriculture,
6.1 Fishing and Environmental Quality

A degraded environment is not sustainable except negatively. What is sustained in the oil producing communities of the Niger Delta is unsustainability. This is not tautology because the Delta environment has sustened petroleum exploitation for decades while the individuals economic activity has become unstained. The individuals econom activity or means of sustainance has a relationship with resource exploitation. If the individual is the one doing the exploitation, the relationship is exponential. His well-being increases with increase in exploitation (even if his environment deteriorates proportionally). However, in the Niger Delta, the relationship between resource exploitation and the individual is non-linear, has no reciprocal function nor adjustment mechanisms. That is to say, the individual has not been considered as a variable in the exploitation equation until recent.

The Nigerian Government and the operating oil companies may be partners in a repression trade. The observation being that the companies produce the oil, and split the revenue with the government which uses it to finance urban projects outside the exploitation zone. The Nigerian Government in this sense is helping to underdeveloped itself. Underdevelopment is hereby defined as the process of *NOT* estimating and planning for the adverse future effects. This is very apparent in the Niger Delta area where the inhabitants (individuals) and environment are of less importance than the resources taken out of it. Observably the following aspects have become of secondary importance:

(a) Agriculture (Food crops and market garden)
(b) Fishing (inland and off-shore)
(c) Environmental Quality (Aquatic, soil, air).

The relationship of man to the above aspects is traditional. They imply sustenance. Once separated from them, man becomes violent out of desperation. Separation is due to:

(i) Environmental insult (insult as defined in the lexicon). That is, the environment is not respected.
(ii) Environmental abuse (abuse as defined in the lexicon). That is, treated with violent disrespect.
(iii) Neglect of environmental cost (cost as translated by the trader, in relation to gain).

Once these later three aspects (i-ii) are recognized right from the onset of projects; budgets, loan negotiations, political campaigns and even chieftaincy awards, then the former three aspects (a-c) would be gradually addressed (the damage had been done, however).

Environment without man is a dangerous classification that has cost the Niger Delta its present problems. This concept (of the environment as the resources of the earth that man can use, which gives rise to various types of environments e.g., behavioural environment, business environment, school, hospital, social, physical, human environment) has led to the subtle decay of the Niger Delta through oil pollution. Alternatively, *environment including man* concept is natural to man (defined ad the totality of his living space, the constituent parts, interactions and relationships with the rest of the environment). Man would not in time of peace purposely destroy where he is living at present only to seek for a new habitat the next day.

Perhaps the solution to a sustenable development of the Niger Delta area lies in an integrated environmental management approach that looks backward into time and culture and progresses forward into science and technology. A *Sustainability Science* approach is desired which should evolve new styles of institutional organisation to support interdisciplinary research over the long term. It should involve a simplified participatory, non-refractory approach where the traditional means of livelihood of the people are respected, preserved and improved upon from the resources gotten from the community.

7.0 REFERENCE

Akpan, Anthony & Inyang Lary (1998) Comparative evaluation of water quality of sites impacted by petroleum hydrocarbon near Qua Iboe Terminal before and after remediation. IN Ukpong Imoh (editor) *Geography and the Nigerian Environment* pp. 177-183. The NGA, Nigeria

Udofia Emmanuel & Ikurekong Edet (1998) Acid deposition and the environmental quality of Iko, a Nigerian oil mineral producing community. IN Ukpong Imoh (editor) *Geography and the Nigerian Environment* pp. 203-209. The NGA, Nigeria

Ukpong Imoh (1994) Incipient soil damage in an oil field near the Qua Iboe River estuary, South-eastern Nigeria. *Ibom Journal of Social Issues 1*: 27-34.

Ukpong Imoh (editor) (1998) *Geography and the Nigerian Environment* The Nigerian Geographical Association, 309pp.

Ukpong Imoh & Ojo-Ede, Hector (1999) Hydrocarbon pollution of soils and water in Warri, Delta State: A Synopsis. *Transactions of the Nigerian Society for Biological Conservation* 8:37-40.

Ukpong Imoh & Akpan Emmanuel (2000). Effects of hydrocarbon pollution of the vegetation and soil resources of Ibeno, A Coastal town in Akwa Ibom State, Nigeria. *Environmental Analar* 6 (in print).

Mabogunji Akin (2001). The Sustainability Science Concept. *National Workshop on Sustainability Science*, Abuja June 5 - 6, 2001.

Ukpong Imo (2001). Incipient ecosystem damage in parts of the oil fields of the Niger Delta, Nigeria. Paper presented at the *1st International Conference/Symposium on Oil Pollution and Environmental Management*. Abuja Hilton Hotel, August 12-13, 2001.