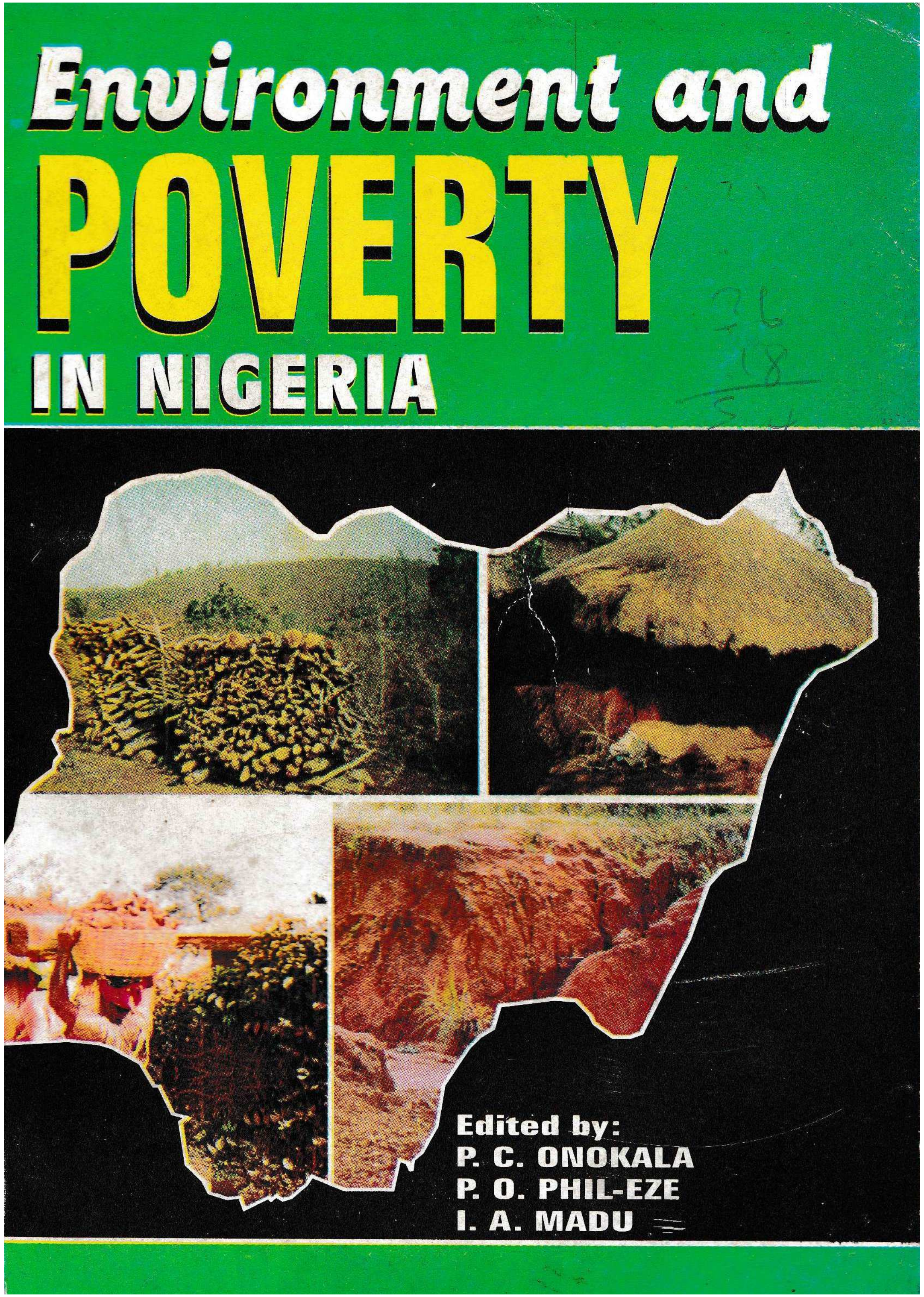

Chapter Five

PETROLEUM POLLUTION IN A PART OF NIGER DELTA: IMPLICATONS ON SUSTAINABLE AGRICULTURE, FISHING AND HEALTH

–IMOH UKPONG & EMMANUEL AKPABIO
Dept. of Geography and Regional Planning
University of Uyo

ABSTRACT

The fragile Niger Delta ecosystem started to deteriorate with the exploitation of crude oil in the late 1950's. For over Forty years now, environmental deterioration and poverty has increased proportional to the increase in crude oil and gas exploitation. Environmental Pollution had initiated an ecological disequilibrium, which replaced 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 viewpoint of sustainable agriculture, fishing and environmental quality. In an examination of soils contaminated by crude oil, total hydrocarbon content (THC) values were found to range 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. In the same areas edible plant samples contained THC ranging from 41.80pmm to 98.10ppm as a result of nutrient uptake from relatively uncontaminated soils. While THC in tidal creek 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

200,000.0ppm. An east west trend in soil and water abuse is reflected which correlate with increase in petroleum exploitation activities. In these polluted ecosystems, agriculture and fishing which are the means of livelihood of the people cannot be practiced on a sustainable basis. Air quality in the Delta area can be indexed by the atmospheric pollutants that cause acidification - both wet and dry acid pollution that falls to the surface consequent to the combustion of gases. In Iko, Akwa Ibom State, the mean concentration of acidic aerosols was observed to be 8. 64mg/L for H_2S, 0.50mg/L for CO and 7.6mg/L for SO_2, while air pH at 23^0C was 10.25. The effect here, is a dynamic threat to health as air is contaminated and water supplies polluted by the acid and other aerosols from the flared gases. For the sustainable development of the Niger Delta area, an integrated "bottom-up" management approach which recognizes the need for the preservation of the traditional socio-economic systems of the area is desired.

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 insult and abuse initiated an ecological disequilibrium which replaced the natural dynamic equilibrium situation that had hitherto sustained the Niger Delta ecosystem. The disequilibrium with serious environmental and socio-economic consequence occurs through hydrocarbon contamination of the ecosystem.

Sampling Methods

The sampling sites and techniques were described by Ukpong and Ojo-Ede (1999), Ukpong and Akpan (2000) Ukpong (1994), Udofia and Ikurekon (1998), Akpan and Inyang (1998) and need not to be elaborated here.

At each site along the coastal zone, soil, plant and water samples were collected for analysis. pH values of soils were measured in 1: 2 soil to water suspension using glass electrode (Jackson, 1962); exchange acidity was obtained by extraction with barium acetate and titration with NaOH (Jackson, 1962); organic matter/ Carbon was measured by the Walkley – Black method; total nitrogen, by the kjedahl method and available phosphorus by Bray p – 1 method, with P in the extract determined by Blue colorimetry (Jackson, 1962). Exchangeable Bases (K, Mg, Ca, and Na) were extracted in IN ammonium acetate and determined by atamic absorption (Ca, Mg) and flame spectrometry (K, Na). Effective action Exchange capacity (ECEC) was obtained as a summation of the exchangeable bases and exchange acidity. Base saturation was obtained as a ratio of the exchangeable bases to the ECEC expressed in percentage.

Plant and fish samples were analysed according to the methods outlined in A. O. A. C. (1975). Total hydrocarbon content in soil and water was determined by extraction with carbon tetrachloride and measured colorimetrically using a spectrophotometer. The absorbance values were matched against those of known crude oil (Ukpong and Ojo – Ede, 1999).

Water and air samples were analyzed using the following methods: (i) pH: was determined using a pH metre (Corning ion – analyzer model 255). (ii) NH_3 was determined Colorimetrically using the sauce 8700 UNICAM spectrophotometer at a wave – length of 400m. (iii) NO_2: was determined using 8700 UNICAM spectrophotometer at a wavelength of 520. (iv) SO_4 was determined by turbidimetric method at 420mm using UNICAM 8700 spectrophotometer and gelatinbarlum chloride as a reagent. (v) SO_2 (Sulphurdioxide gas) was oxidized to the sulphate using dilute Nitric acid and the resultant sulphate determined by the turbidimetric method at 420mm using UNICAM 8700 Spectrometer. (vi) CO^{2-}_3 was determined by titration against a standard hydrochloric acid solution using methyl orange as indicator.

Hydrocarbon Pollution of Soils

Study Areas and Data

The first location was in Warri at the locations of Ifie, Ogheye, Ekpan, Ekurede Itsekiri, Ugbori and Ajamimogha. The second location was adjacent to the Exxon/Mobil Tank farm in Akwa Ibom State. The third location the fishing settlements of Ibeno, Inuaeyet, 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 1-1 shows the concentration of hydrocarbons in the soils of these areas.

Table 1-1: Level of Total Hydrocarbon Content (THC) from selected locations in the Niger Delta

Location	THC	ppm)"Location	THC (ppm)
Ogbeye	150,000(HP)	Inuayet	30 (RU)
Ekpan	100,000(HP)	Mkpanak	60 (RU)
Ifie	200,000 (HP)	Upenekang	46 (RU)
Ekurede Itsekiri	50 (RU)	Tank Farm	
Ugbori	75 (RU)	Sample 1	721.3 (HP)
Ajamimogha	52 (RU)	Sample 2	1994.8 (HP)
Ibeno	98 (RU)	Sample 3	692.8 (HP)

Xppm = parts per Million; Hp = Highly polluted; RU = Relatively unpolluted.

Source: *Ukpong & Ojo – Ede (1999); Ukpong & Akpan (2000).*

Ukpong 1994

N/B = Emission Limits for Hydrocarbon Pollution of soils is 50 ppm (FEPA, 1991).

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 1-1 is due to dumping of oil by companies using petroleum products. The oil is carried by overland flow and seepage into the surrounding coastal plains. Severe soil pollution arises also due to over pressure and overflow of separators and storage tanks. This was the case in 11 – 13 (Table 1-1) 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 reaction would become anaerobic instead of aerobic as soil pores are blocked by hydrocarbon.
(v) The heavy metals e.g. lead could accumulate in levels that become toxic to organisms.
(vi) The water table becomes polluted.

A comparative analysis of soil nutrients from relatively unpolluted and polluted soils are given in Table 1-2 and Table 1-3.

Table 1-2: Mean values of total hydrocarbon Content (THC) and the corresponding soil nutrient values in four relatively unpolluted sites. Data for top soil (0 – 15cm) is reported.

Parameter x	**Sampling sites**			
	Ibeno	Inuaeyet	Mkpanak	Upenekang
THC (ppm)	98.10	30.00	60.70	41.80
PH	8.11	6.59	8.51	6.40
OM (%)	3.70	3.30	4.31	3.04
T. N! (%)	0.19	0. 17	0.22	0.13
Av. P (ppm)	18.08	41.06	15.40	25.46
Ca (meg/100g)	0.29	1.14	0.59	0.81
Mg (meg/100)	0.13	0.61	0.30	0.41
K (meg/100)	0.09	0.13	0.05	0.1
E. A (meg/100)	1.08	2.27	1.37	1.70
ECEC (meg/100g)	2.34	4.51	2.43	3.14
BS(%)	24.27	48.82	43.56	46.07

OM = Organic matter; T.N = Total nitrogen; Av. P = Available phosphorus;
E. A. = Exchangeable acidity; ECEC = Effective content exchange capacity
BS = Base saturation. N = 10;

Source*: *Ukpong & Akpan (2000).

Table 1-3: 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	502.8	693.4	1842.6	375.5
Sample 2	624.5	721.3	1292.5	692.8
Sample 3	304.7	605.8	1994.8	380.4
Field moisture (%)	28.4	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	5.9
Exchange acidity (meg/100g)	6.8	5.9	6.2	6.0
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
ECEC (me/100g)	38.5	42.3	34.2	44.5
Organic carbon	6.8	6.5	5.8	3.2

***Source*:** *Ukpong (1994)*

N/B: Emmission Limits For Thc of Soils is 50 (FEPA, 1991).

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

Hydrocarbon Pollution of Water

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 Upenekang 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 1-4.

Table 1-4: Total hydrocarbon values in water samples from selected sites

Location	THC (ppm)	Location	THC (ppm)
Warri River	150,000	Esisi River	51
Ugbodede Creek	18,000	Ibeno	18
Ogune Creekr	20,000	Inuayet	503
Edjeba River	60	Mkpanak	1,969
Itori Creek	40	Upenekang	1,667

Sources: *Ukpong & Ojo – Ede (1999); Ukpong & Akpan (2000)*

N/B: Thc Content Of Water Should Not Exceed 50 Ppm (FEPA, 1991)

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 shore – Line. The SW maritime trade winds could push the Atlantic storm waves 20km upstream. For instance, 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 other crustaceans) including Planktons degenerate in the toxic environment.

(iv) Fish, crustaceans and molluscs become carriers of toxic hydrocarbon substances along the food chain

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

(vi) Human health in these areas deteriorates Proportional to the level of water pollution. The high water table in the polluted Delta region often carry films of hydrocarbon due to sub-surface seepage and intrusion of contaminated water inland.

Hydrocarbon Pollution of Organisms

Study Areas and Data

One of the routine soil and water parameter in the Niger Delta region is hydrocarbon. Consequently, just as nitrogen and Phosphorus, for example, are essential to the performance of vegetation which helps to build up animal tissues, the effect of hydrocarbon though in most instances detrimental cannot be over-emphasized. 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 1-5). The plant samples consisted of cassava, pumpkin, maize, cocoyam, elephant grass and centrocema. The fish samples consisted of bonga, mud grab and periwinkle. These are staples food items that are obtained in the Niger Delta ecological zone. Samples were obtained from noticeably polluted areas at Ibeno, Inuaeyet, Mkpanak, Upenekang and off-shore locations.

Table 1-5: Mean values of THC and other chemical properties in plant and fish samples from polluted areas

Parameter	Plant	Fish	Crab	Periwinkle
THC (ppm)	77	108	211	240
Nitrogen %	2.1	1.8	2.0	2.4
Ca (meg/100g)	72	141	472	506
Mg (meg/100g)	104	182	150	144
K(meg/100g)	74	105	127	130
P (meg/100g)	553	94	94	111

Source: *Ukpong & Akpan (2000)*

N/B: The Contents Of Plant, Fish, Crab And Periwinkle Should Not Exceed 50 Ppm (FEPA, 1991)

Occurrence of hydrocarbon in edible organisms, mean that considerable portion of this substance passes into 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. Vegetable contaminated with THC through the soil can hardly be said to be nourishing.

Hydrocarbon Pollution of Air

Study Area and Data

The area of study was Iko, an oil producing community in Akwa Ibom State. Atmosperic pollution arising from gas flaring also effects 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 1-6a b, c)

Table 1-6(a): Acidity conditions of soils at Iko

Location	pH at 23^{0}C	SO_4^2 mg/100g	NO_3^2 mg/100g	$CaCO_3$ mg/100g
Near borehole	6.3	9.0	480	0.5
From Farm	5.8	2.0	460	2.0
Qua Iboe Church	5.4	1.0	420	0.5
Mean	5.8	4.0	453	1.0

Table 1-6 (b): Acidity conditions of water at Iko

Location	pH at 23^{0}C	SO_4^2 mg/L	NO_3^2 Mg/L	$CaCO_3$ mg/L
Borehole	6.0	10.0	0.32	1.0
River	6.3	109.0	0.12	0.5
Stream	6.5	3.0	0.05	0.5
Rain water	4.9	4.0	ND	0.5
FEPA (1991) Limits	6.5-7.2	30	0.006	ND

Tables 1-6 (c): Concentration of acid generating aerosols and gases in the atmosphere over Iko

Gas	Concentration	FEPA(1991) Limits
Hydrogen sulphide (H_2S)	8.6	5.1
Carbon monoxide (C0)	0.5	1.0
Sulphur dioxide ($S0_2$)	76.7	30
Nitrogen oxide ($N0_3$)	ND	
Air pH at 23^{0}C	10.8	6.0

***Sources:** of Tables a, b, c: Udofia & Ukurekong (1998).*

Table 1-6 (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 areas. Table 1-6 (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 1-6 (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.

Remediation of Impacted Ecosystems

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 remediation measures are often ignored or not given the attention it deserves. Data was collected near the Qua Iboe Terminal locality where Exxon/Mobil operates. The aims were to (i) asses the effects of weathered petroleum products on the physical and chemical characteristics of the aquatic ecosystem and (ii) estimate the extent of site recovery after clean up exercises (Tables 1-7).

Table 1-7: Mean values of physico-chemical parameters measured in impacted and post impacted water samples near OIT

Physico/Chemical Properties	Impacted Sample	Post Impact Sample	F – ratio
pH	5.40	6.82	NS
Turbidity	56	18	P = 0.01
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 ($mgdm^{-3}$)	1.5	8.0	P = 0.05
Do % saturation	20	105	P = 0.05
Chemicals oxygen demands ($mgdm^{-3}$)	62.5	38.0	P = 0.01
Biochemicals oxygen demand ($mgdm^{-3}$)	12.7	2.8	P = 0.01
Ammonium – nitrogen ($mgdm^{-3}$)	37.0	10.0	P = 0.01
Oil and grease content ($mgdm^{-3}$)	4.4	3.6	P = 0.01
Salinity 0/00	5.2	7.5	NS
Phosphate ($mgdm^{-3}$)	1.8	1.4	NS
Sulphide ($mgdm^{-3}$)	0.09	0.05	NS
Sulphate ($mgdm^{-3}$)	170	300	P = 0.01
N_2 ($mgdm^{-3}$)	12[illegible]0.8	1840.0	NS
K ($mgdm^{-3}$)	28.2	12.0	P = 0.01
Ca ($mgdm^{-3}$)	16.8	13.6	NS
Mg ($mgdm^{-3}$)	62.9	46.3	NS
Pl "	21.5	8.1	P = 0.01
Cd "	0.6	0.3	NS
Cu "	0.8	0.5	"
Zu "	0.4	0.7	"
Fe "	1.24	0.26	P = 0.5
NO_3^- "	3.3	8.6	P = 0.05

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

Table 1-7 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 the biochemical oxygen demand, chemical oxygen demand and turbidity improved 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 their than what is obtained now. Remediation implies attempts to restore by deliberate action, the natural equilibrium condition that had been destroyed.

Implication on Sustainable Agriculture, 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 sustained petroleum exploitation for decades while the individual's economic activity has become unsustained. The individuals' economic activity or means of sustenance has a relationship with resource exploitation. If the individual is the one doing the exploitation, the relationship is exponential – His well-being 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 recently.

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 Nigeria Government in this sense is helping to under develop itself. Under development is hereby defined as the process of NOT estimating and planning for the adverse future effects of present resource exploitation trends and development efforts. 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 crop 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) Environment 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 - iii) 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 has 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 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's concept is natural to man (defined as 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 sustainable development of the Niger Delta area lies in an intergrated 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 involve new styles of institutional organization 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.

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