Physico-Chemical Dynamics of Abandoned Oil Drilling Site in Bayelsa State, Nigeria

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Abstract
Presented in this study are the results of environmental impact assessment data of abandoned oil drilling site in Ogbia Local Government Area of Bayelsa State, in which unknown chemical wastes used for drilling were buried in the soils. Hence the assessment required to ascertain the site quality if it meets the Nigerian Environmental Laws and Standards. The study style entails field trips, sample collection and analysis as stipulated in the environmental study guidelines of water and soil parameters. The results obtained revealed presence of chemical wastes buried in the soils which has leached into the aquifer and may invariably contaminate the groundwater quality making it unsuitable for domestic uses. It is therefore, recommended that the area studied be decontaminated fast and treated to arrest further degradation and pollution of the groundwater which is the major source of livelihood in the community.

Keywords: *Physico-Chemical, Dynamics, Abandoned, Oil Drilling, Site*

Introduction

In the past few decades there has been an increased public awareness of environmental issues, particularly when contamination of soil, water and air is involved. Globally, scientists and environmentalists are faced with the challenge of overcoming the detrimental effects of such contamination. It is a known fact that industrial revolution gave birth to environmental pollution as it is today. Environmental pollution affects soil, water and air, presenting health dangers to humans, aquatic life, ecosystem and harmful threat to the natural environment (Hrvoje *et al.,* 2006). Hazardous waste such as inorganic metals (As, Ba, Cd, Cr, Hg, Pb, Zn), organic pollutants [herbicides (Atrazine), insecticides (DDT), polychlorinated biphenyls (PCB), volatile organic carbons (VOC), total petroleum hydrocarbons (TPH) including polycyclic aromatic hydrocarbons (PAH)], and radionuclides contaminate ecological communities and transform landscapes to ecologically degraded and unusable spaces in society (PilonSmits, 2005; Walker, 2009). Pollution of the natural environment by heavy metals is a universal problem because these metals are indestructible and most of them have toxic effects on living organisms, when permissible concentration levels are exceeded.
Soil is one of the most dynamic sites of biological and biochemical interactions concerned with the destruction of organic matter, weathering of rocks and nutrition of agricultural crops.

In the Niger Delta region, the soils are generally old and low in fertility. The decline in stability and productivity results from a complex and interrelated series of resources, degradation processes, majority of which results from oil pollution (Oyem and Oyem, 2013). Indeed, of all the environmental challenges facing the region of the Niger Delta, none is more challenging and have a larger potential impact than the declining soil activity and degradation. Often, though depending on the extent of spillage the soil area under spill becomes oil bathed. This means a total occupancy of the interstitial pores of the system by oil. In such situation, oil continues to permeate the upper part of the soil which forms the natural base of most organic interactions, percolating through the grains in different directions. The rate of percolation and the distance likely to be reached is dependent mainly on the soil texture, porosity and permeability of the soil. The determination of the total concentration of the metals in soils, especially those prone to metal contamination (Cd, Cr, Pb, Zn, Fe and Cu) is very important because of the variant effects of metal toxicity and accumulative behaviors (Akoto et al., 2008; Kasim, 2013).

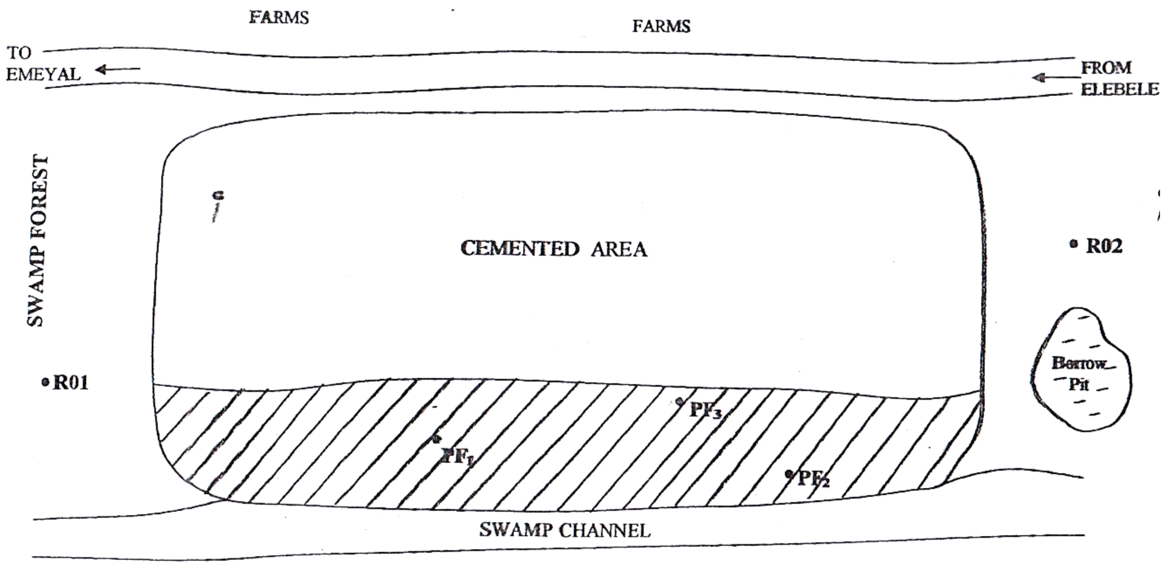
Health implications associated with environmental pollution by these metals include but are not limited to neurological damage, cancer, reproductive interference and birth defects. Chronic problems associated with long-term heavy metal exposures are mental lapses (lead); toxicological effects on kidney, liver and gastrointestinal tract (cadmium); skin poisoning and harmful effects on the central nervous system by Chromium, etc. (Adelekan and Abegunde, 2011). To a small extent trace metals enter the body system through food, air and water and bioaccumulate over a period of time. When agricultural soils are polluted, these metals are taken up by plants and consequently accumulate in their tissues (Trueby, 2003). Contaminants present in soils can enter the food chain and seriously affect animal and human health (Khan, 2005). Chromium enters the air, water and soil mostly in the Chromium (iii) and Chromium (iv) forms. In air, Chromium compounds are present mostly as fine dust particles which eventually settle over land and water. Chromium can strongly attach to soil and only a small amount can dissolve in water and move deeper in the soil to underground water. Fish do not accumulate much Chromium in their bodies from water. Most of the Cadmium entering the soil combines with the chemical complexes that are available and are assimilated by plants. Those entering fresh water, streams and seas are taken up and is concentrated by aquatic plants and animals.

The crux of this study is that there were some buried waste chemicals presumed to have been used in oil drilling operations around Elebele in Ogbia Local Government Area of Bayelsa State. The drilling chemical wastes are suspected to be buried at the site of operation without the knowledge of the host community. It is therefore suspected that the chemical wastes could be toxic to the biota, hence the need for this study to investigate the physico-chemical dynamics of the abandoned oil drilling sites. The study will equally, help to generate a baseline information of the soil quality, determine the background levels of pollutants and the ecological impact of the chemical waste buried in the area of operation.

Materials and Methods

The study area situated along Emeyal-Elebele road lies in the freshwater alluvial plain soils of Bayelsa State. The soils were deposited mainly by Taylor creek and other tributaries. The entire area is low-lying stretches of land bounded by levees. When flood waters rise, they pass through several creeks through the levees to fill the flood plain and drain away when the river water falls. The study site is located about 200m from the nearest building and about 50m to the burrow pit. By the study site is a swamp channel and beyond is a freshwater seasonal swamp forest dominated by freshwater vegetation (Fig. 1).

Sampling Method (field method)
The soils of the study area were examined by choosing sampling points as shown in figure 1, representing contaminated and uncontaminated sites. Each soil sampling station was marked, the position geo-located using geographical positioning system (Germin-12 GPS). At each station, a mini-pit was dug to reach the chemical waste and water table. Soil samples were collected from each horizon. Random soil samples were also collected from the surface (0-15cm) and sub-surface (15-30cm) with Dutchman hand soil auger. At each sampling site, composite soil samples were collected to give representative soils of the area. The soil samples were placed in a well labeled polyethylene bag for physico-chemical analysis. Those for total hydrocarbon (THC) analysis were in labeled 500ml amber glass bottles and sealed with aluminum foil. The samples were bagged separately according to the method of Hodgson (1983) and transported to the laboratory.



Seasonal Swamp Forest
Fig. 1: Sketch of the study area showing sampling stations.

Physico-Chemical and Heavy metals analysis
The analysis was performed on sub-samples of the air-dried soil samples using a 2 mm diameter mesh sieve. Concentrations are expressed on a dry weight basis. The following physico-chemical parameters were determined thus; soil pH, electrical conductivity, organic carbon, total and mineral nitrogen, exchangeable cations, chloride, sulphate and particle size analysis using Standard Methods for Soil, Plant and Water Analyses edited by Udo *et al., 2009*. Analysis for heavy metals like Mn, Pb, Cr, Cd, V, and Ni, were determined using Atomic Absorption Spectrophotometer, while those for oil content (THC) were analysed using toluene extract from fresh soil samples (AOAC, 2005).

Results and Discussion
The soils of the study area are typical fresh water alluvial plain soils. The soils` texture ranged between silty clay loam to silty clay surface and clay subsoil with clay minerals (38.5-66.6%) dominating the soil particles. Electrical conductivity values varied horizontally from 43.0us/cm at the reference station to 194.0us/cm at the chemical waste dumpsite and 1600.00us/cm vertically indicative of accumulation of salts in the subsoil. This was further

supported by the higher concentrations of chloride and sulphate observed around the chemical waste dumpsite. The soils are rich in exchangeable cations with calcium dominating, followed by sodium, magnesium, and potassium (Table 1).

High sodium contents than magnesium indicate the introduction of salts rich in Na which can contribute to adverse soil reaction (Bohn *et al.*, 1979). Soluble salts and sodium levels may limit plant growth by preventing hydrolytic reactions in the soils. The main hazard occurs during the high rainfall period and high-water table which will cause leaching of soluble salts rapidly into the aquifer thereby contaminating the groundwater quality and making the site acidic. These dynamics reduces the soil permeability or hydraulic conductivity, thus increasing surface ponding with subsequent effects on plant-water relations (Bohn *et al.*, 1979).

Table 1: Mean Physico-chemical Properties of Soils around Elebele Chemical Waste Dumpsite

S/N	Sample station	Cm depth	Coordinates N	Coordinates E	Ph	Mg/kg THC.	µS/cm E.C.	% Org. C	% TN	C/N ratio	kg/g Cl^-	kg/g SO_4^{2-}	kg/g NO^-_3	mg/kg K^+	mg/kg Na^+	mg/kg Ca^{2+}	mg/kg Mg^{2+}	% Sand	% Silt	% Clay	Texture
1.	ELE PF$_1$ A	0-10	$04^0$51.454	$006^0$20.899	6.0	222.51	194	1.82	0.12	15	35.56	20.5	0.20	58.7	103.3	32.1	114.3	17.4	44.1	38.5	Silty clay loam
2.	B	10-25			5.9	283.60	125	2.10	0.16	13	30.41	22.4	0.21	45.8	112.4	12.4	104.6	3.4	29.5	67.1	Clay
3.	C	25-45			7.2	1823.73	579	2.65	0.25	11	85.71	50.0	0.35	78.2	190.0	12.7	136.0	3.8	29.6	66.6	Clay
4.	D	25-30			7.6	680.62	1600	2.46	0.20	12	142.0	42.5	0.35	156.0	144.6	210.5	282.1	3.6	30.6	65.8	Clay
5.	ELE PF$_s$ A	0-10			6.1	868.24	90	2.20	0.16	14	42.81	27.5	0.20	89.0	153.2	172.8	190.4	10.4	31.1	58.5	Silty
6.	B	10-20			7.2	82.90	1200	2.35	0.18	13	106.30	65.0	0.55	78.2	231.6	204.3	174.1	3.5	31.2	65.3	Clay
7.	C	20-40			7.1	471.20	863	2.32	0.27	9	71.00	45.0	0.40	78.2	198.1	202.6	130.3	4.1	32.0	63.9	Clay
8.	D	40<			7.2	798.42	855	2.30	0.20	12	56.20	60.2	0.30	92.9	120.1	189.8	138.4	10.2	32.0	57.8	Silt clay
9.	ELE PF$_3$ A	0-20	$04^0$51.462	$006^0$20.893	6.6	554.10	145	1.90	0.18	10	45.8	27.3	0.21	88.4	110.4	201.4	180.4	3.5	31.2	65.3	Clay
10.	B	20-40			6.2	924.96	183	2.10	0.19	11	43.7	26.9	0.23	78.6	122.7	205.6	107.3	3.0	30.5	66.5	Clay
11.	C	40<			6.2	82.90	185	2.00	0.15	12	41.0	25.2	0.22	66.7	121.4	203.4	128.5	3.6	31.4	65	Clay
12.	ELE R. 01	0-15	$04^0$51.403	$006^0$20.931	5.8	340.31	55	2.30	0.20	12	54.20	25.0	0.32	68.6	179.0	206.0	103.4	9.8	48.0	4.2	Silty
13.		15-30			5.6	161.43	61	2.12	0.23	9	53.33	33.0	0.27	141.0	121.4	290.3	102.1	8.0	44.0	48.0	Silty
14.	ELE R O_2	0-15	$04^0$51.513	$006^0$20.831	5.5	1125.65	43	2.20	0.20	11	47.13	27.2	0.30	81.3	146.6	201.4	112.7	8.0	36.5	55.5	Silty
15.		15-30			6.1	191.97	65	2.10	0.22	10	42.80	31.1	0.26	138.6	119.4	210.3	104.6	11.4	30.1	58.5	Silty clay

Table 2: Mean Heavy Metal Concentration in the Related Soils

	mg/kg								
S/No	Sample Identity		Mn	Cr	Cd	Pb	Ni	V	Ni/V
1.	Ele PF_1	A	0.06	0.04	<0.001	<0.001	<0.001	<0.001	0
2.		B	0.10	0.06	<0.001	<0.001	<0.001	<0.001	0
3.	Ele PF_2 A		0.03	0.04	<0.001	<0.001	<0.001	<0.001	0
4.		C	0.05	0.06	<0.001	<0.001	<0.001	<0.001	0
5.	Ele PF_3 A		0.06	0.05	<0.001	<0.001	<0.001	<0.001	0
6.		C	0.03	0.06	<0.001	<0.001	<0.001	<0.001	0
7.	Ele R	01	0.04	0.02	<0.001	<0.001	<0.001	<0.001	0
8.		02	0.04	0.03	<0.001	<0.001	<0.001	<0.001	0

Pollution status

Total hydrocarbon concentration at the surface ranged between 222.51 to 868.24mg/kg and 82.9 to 1823.73mg/kg at the sub-surface, indicative of vertical oil movement underground. Hence, the hydrocarbon levels observed showed moderate to low degree of pollution indicating previous oil prospecting activities in the area. Heavy metals concentrations are very low, with Mn ranging from 0.03-0.10ppm, Cr ranged between 0.02 and 0.06ppm for both the surface and subsurface soils, while the other metals were below detectable limit of 0.001mg/kg, which could be attributed to decrease with the soil acidity. Hence, there may be no metal pollution in the ground water system.

Impact statement

The soils are fine-textured dominated by silt and clay fractions which may check vertical infiltration of pollutants into the subsoil. However, the water table being less than 50cm depth will quickly receive contaminants buried in the soil. Thus, the chemical waste leached out will affect the groundwater quality.

Conclusion

Soil quality studies showed moderately oil contamination in the soils. However, higher concentration of the cations and anions in the subsoil indicate presence of chemical waste that had leach out and this might affect the groundwater quality. Groundwater examinations may reveal hydrocarbon contamination and chemical waste leach which might cause very high dissolved solids and hardness of the groundwater system exceeding recommended limit for domestic use in Nigeria.

It is therefore recommended that it would be in the interest of the inhabitants of the community that the chemical wastes be evacuated and treated fast to arrest further degradation of the environment and attendant pollution of the groundwater which is their major source of livelihood.

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