



Effect of Oil Spill on Physicochemical Properties of Soil Spilled Sites in Kokori, Ethiope East Local Government Area, Delta State, Nigeria

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ABSTRACT: Oil pollution might affect soil physicochemical properties. Pore spaces might be clogged, which could reduce soil aeration, water infiltration and increase bulk density, subsequently affecting plant growth. This study investigated the effect of oil spill sites at Kokori, Delta State, Nigeria, analyzing physicochemical properties, total petroleum hydrocarbon, polyaromatic hydrocarbon, benzene, anions and selected heavy metal concentrations using standard methods. Data obtained revealed that the physicochemical properties of the assessed soils were insignificantly altered when compared with their respective DPR intervention values. PH values were in the range of 4.80-5.60 which is considered to be strongly acidic. The electrical conductivity ranged from 122 μ S/cm to 185 μ S/cm indicating that the soil is saline. Chloride ion values were between 32.50mg/kg to 82.10mg/kg. Nitrate ranged from 0.85mg/kg to 1.04mg/kg, while phosphate was between 0.34mg/kg and 0.96mg/kg. Total petroleum hydrocarbon varied from 7.12-45.66mg/kg for topsoil and 7.12-37.82mg/kg for bottom soil. It is lowest at 7.12mg/kg, mean at 18.1mg/kg. These values were within the DPR permissible limits. Benzene and Polyaromatic Hydrocarbon (PAH) had a constant value of 0.001mg/kg in all locations. Iron, arsenic, lead, mercury, cadmium, nickel and copper were the heavy metals detected. Their concentrations at spill sites were moderate and generally did not exceed their respective target limits. However, level of lead was as high as 11.6mg/kg in location 3. The soil should be monitored so that it does not exceed the threshold values of the studied parameters.

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Keywords: Soil; oil spill site; heavy metals; total petroleum hydrocarbon.

Crude oil is a complex mixture of aliphatic and aromatic hydrocarbons, containing low percentages of sulfur and trace amounts of nitrogen and oxygen compounds (Hawkey, 1981). Oil exploration and production activities have huge negative impacts on soils, water bodies, human health and the ecosystem (Ite *et al.* 2013). In Delta State, south-south Nigeria; oil spill has been termed as the major cause of environmental pollution. Production of conventional oil and gas is often accompanied by production of large volumes of waste which are released into the environment (DPR, 2002). Contamination of soil can occur through spills of fluids during drilling, fracturing processes, during transport by truck or through wastewater pipelines, failure of well casings, well blow-out, equipment failures and corrosion of

pipes and tanks. Oil spills also result from the activities of bunkers and illegal oil refining in creeks across Delta State. The effluents discharged by oil and gas companies onto land contain many toxic chemicals, heavy metals, mineral acids, bases and total petroleum hydrocarbon which over a period of time get deposited in the soil due to their retention and adsorption on the soil particles. Heavy metals such as cadmium, lead, zinc, copper, nickel and chromium are major components of Nigeria's crude oil (Dickson and Udoessien, 2012). These metals make their way into the soil during oil spills and when taken up by plants, they become toxic (Ekundayo and Obuekwe, 2000). In the same vein, anions such as chloride, nitrate and phosphates are acidic and can alter the acid-base load level of the body when taken in high concentrations

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(Berardi, 2003). Therefore, the objective of this paper was to evaluate the effect of oil spill sites at Kokori in Ethiope East Local Government Area of Delta State, Nigeria by analyzing physicochemical properties, total petroleum hydrocarbon, polyaromatic hydrocarbon, benzene, anions and heavy metal concentrations.

MATERIALS AND METHODS

Study Location: Kokori has a land area of 196 square kilometers. It is a hinterland bounded by many communities. Kokori is accessible via network of

roads, including the Obajere-Orokpor road in the northwest, Isiokolo-Egume road in the southwest and the Anaka road in the southeast (Figure 1). The cottage hospital, Kokori Grammar school and Kokori Girls' Secondary School are situated towards the northern, eastern and southwestern sections of the community. The major occupation of the people of Kokori is Agriculture. There are many oil wells, flow stations, oil pipelines and gas flare sites in Kokori (Agbogidi *et al.* 2005). Network of streams and creeks cut across different parts of Kokori territory. The soils at the spill sites were generally muddy.

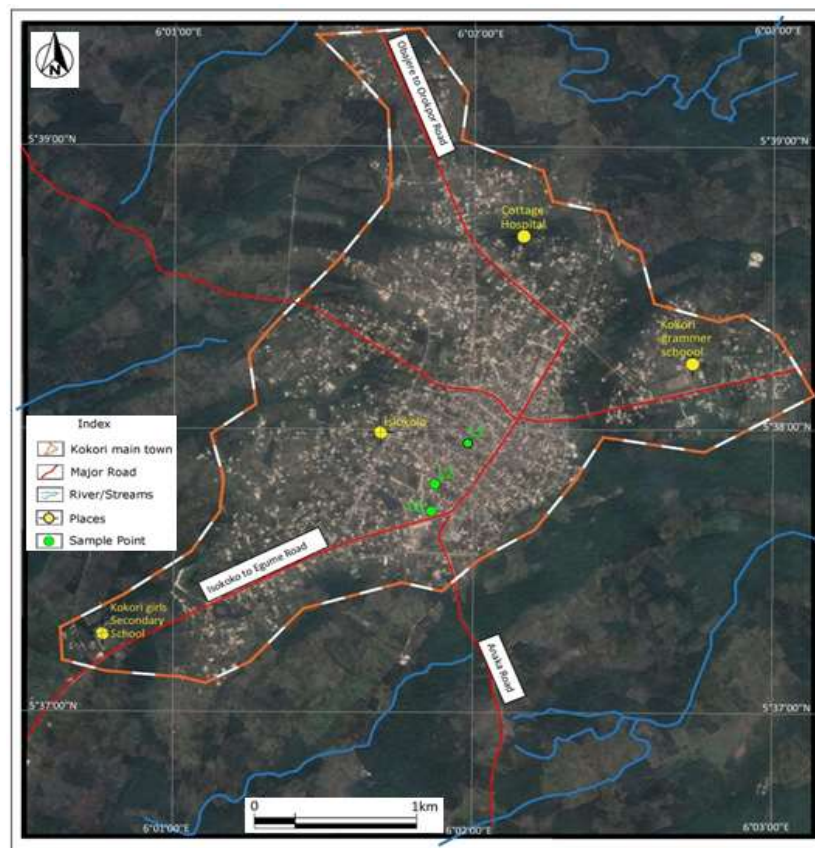


Fig 1. Map of Kokori showing sample locations

MATERIALS AND METHODS

Soils were collected from spill sites within the oil producing areas of Kokori. Soil samples were taken from depths range of 0-30cm at each sampling point. The samples were collected into sampling bags and transported to the laboratory for analysis.

Procedures for Sample Analysis: The collected soil samples were analyzed to determine their physicochemical characteristics such as pH, electrical conductivity (EC), cations exchange capacity (CEC), sodium, chloride, phosphate and selected heavy metals. Standard procedures as prescribed by the

Department of Petroleum Resources (DPR) were employed.

pH: was analysed using the pH meter with a 1:2 soil to solution ratio.

Electrical Conductivity (EC): EC was determined using the conductivity meter, deionized water and KCl solution.

Cations Exchange Capacity (CEC): CEC was determined by summation of the exchangeable cations with ammonium acetate buffer.

Sodium: was determined with the conductivity meter and a slurry soil paste prepared by adding deionized water to the soil.

Chloride: The water-extract method was used in determining chloride from dried soil samples using nitric acid solution, measuring cylinder and conical flask

Phosphate: This was determined using distilled water and sodium bicarbonate

Total Petroleum Hydrocarbon (TPH: Total Petroleum Hydrocarbon was determined according to American Standard for Testing Materials (ASTM) method as approved by the Department of Petroleum Resources (DPR, 2002).

Heavy metals: Selected heavy metals such as iron (Fe), copper (Cu), lead (Pb), zinc (Zn), cadmium (Cd), mercury (Hg), arsenic (As) and nickel (Ni) were determined using the atomic absorption spectrophotometer.

RESULTS AND DISCUSSION

Physical and chemical characteristics of soil: Presented in Table 1 below are some physico-chemical and bacteriological characteristics of the soil collected from the study area. Soil reaction, in terms of pH values were in the range of 4.80- 5.60 and 5.00- 5.50 respectively at both the impacted and control site, while the sediment is 5.70. According to Anon (1986), soil with pH range of 4.5-.5.0 is classified as very strongly acidic, pH 5.1 - 5.9 as strongly acidic while those within the range of pH 5.6 - 6.5 as slightly acidic.

Table 1. Physicochemical properties of soil from Kokori

Parameters	Samples		
	L1	L2	L3
pH	5.30	5.11	4.68
Electrical conductivity (microsecs/cm)	122.00	172.00	185.00
Cation Exchange Capacity, CEC (meg/100g)	8.49	7.50	9.03
Chloride (mg/kg)	32.50	82.10	65.99
Nitrate (mg/kg)	0.85	1.04	0.96
Phosphate (mg/kg)	0.96	0.34	0.54

Table 2. Total organic and petroleum hydrocarbon content

	L1	L2	L3
Total organic content, TOC (%)	1.009	1.142	0.082
Total Petroleum Hydrocarbon, TPH (mg/kg)	30.08	11.14	8.33
Polycyclic aromatic hydrocarbon, PAH (mg/kg)	0.001	0.001	0.001
Benzene (mg/kg)	0.001	0.001	0.001

Considering this classification, the soil and sediment within the area can be categorized as strongly acidic, while the control soils can be said to be very strongly acidic. This indicates that the pH of the soils and sediment were not noticeably different from the control. The electrical conductivity ranged from 122 μ S/cm to 185 μ S/cm. The soil can be described as saline since the electrical conductivity levels were above 120 μ S/cm as prescribed by DPR. Chloride was between 32.50mg/kg to 82.10mg/kg. The high concentrations of chloride can be linked to the salinity of the salt. Nitrate ranged from 0.85mg/kg to 1.04mg/kg, while phosphate had a lowest concentration of 0.34mg/kg and peaked at 0.96mg/kg. The nitrate and phosphate levels were below the DPR permissible limits.

Total Petroleum Hydrocarbon and Heavy metal concentration: Total Petroleum Hydrocarbon levels gives varied from 7.12-45.66mg/kg (mean 25.06mg/kg) and 7.12-37.82mg/kg (mean 18.11mg/kg) for top soil and bottom soil respectively while 10.83mg/kg for sediment, which is below the

DPR intervention limit (5000mg/kg). Benzene and Polyaromatic Hydrocarbon (PAH) had a constant value of 0.001mg/kg in all locations.

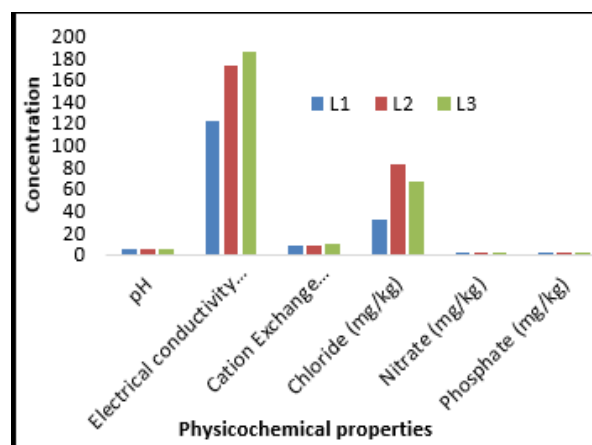


Fig 2. Physicochemical properties and their corresponding values

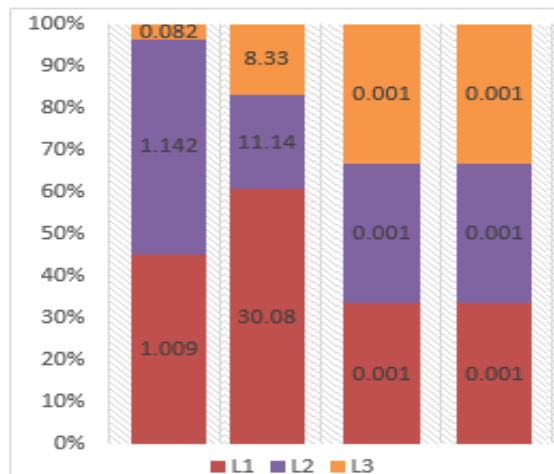


Fig 3. Value of organics in soil

Table 3. Heavy metal contents of the soils from Kokori

	L1	L2	L3
Iron	1548	2369	2600
Arsenic	0.001	0.001	0.001
Lead	3.15	2.49	11.06
Mercury	0.001	0.001	0.001
Cadmium	0.58	0.260	0.216
Nickel	2.509	7.601	5.102
Copper	3.104	6.185	4.018
Zinc	27.158	13.750	25.103

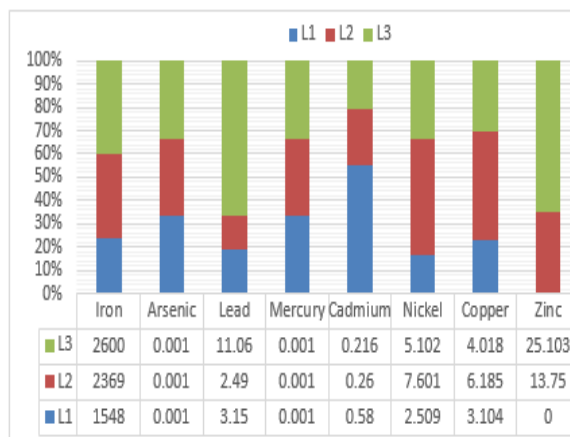


Fig 4. Heavy metal content of soil taken from Kokori

The levels of heavy metals in the soil samples were low. Heavy metals levels, nutrients and other physicochemical properties of the soil were not at significant variance with the control value and DPR Target value. The recorded values for Polynuclear Aromatic Hydrocarbon and benzene were within the DPR permissible limits.

Conclusion: Soils collected from spill sites in Kokori were sampled for physicochemical, total petroleum hydrocarbon and heavy metal analyses in Kokori. Physicochemical properties of the assessed soils were insignificantly altered when compared with their respective DPR permissible limits. The moderate

concentrations notwithstanding, since farming is the major occupation of the locals in the study area. It is therefore important to investigate uptake of heavy metals by crops in the study area

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