Quest Journals
Journal of Research in Environmental and Earth Sciences
Volume 9 ~ Issue 7 (2023) pp: 33-38
ISSN(Online) :2348-2532
www.questjournals.org

Research Paper

Status of crude oil polluted soils in Bodo community, Gokana LGA, Rivers state, Nigeria

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Abstract
The study focused on analyzing the soil quality in crude oil polluted sites in Bodo community, Gokana LGA of Rivers state. Transect method of sampling was employed whereby two sets of soil samples (15 samples each) were collected randomly from crude oil polluted sites and unpolluted sites (control) for soil laboratory analysis for status of soils' physical, chemicals and heavy metals concentrations in the study area. Descriptive statistics in form of mean, standard deviation and Tables were employed for data presentation while ANOVA analysis and Excel work sheet 2010 were employed for data analysis. Findings of the study revealed that there were significant variations in soil physico-chemical and heavy metals properties between crude oil polluted soils and control soils (Bulk density ($F=14.338$; $p<0.05$); WHC ($F=239.226$; $p<0.05$); Av. Ph ($F=148.173$; $p<0.05$); Total N ($F=112.63$; $p<0.05$); calcium ($F=204.668$; $p<0.05$); THC ($F=986.621$; $p<0.05$); Fe ($F=272.469$; $p<0.05$); Pb ($F=41.272$; $p<0.05$). The study concluded that changes in soil physico-chemical and heavy metals properties were attributed to the response of the soil to crude oil hydrocarbon pollution. The study recommends that the activities of the oil multinationals should be monitored at all levels in order to reduce their environmental impacts especially as it has to do with occasional crude oil spills in the study area.
Keywords: *Crude oil polluted soil, Oil spill, Soil properties, Bodo community, Gokana LGA*

R*eceived 15 July, 2023;* ***R****evised 28 July, 2023;* ***A****ccepted 31 July, 2023*
P*ublished with open access at* ***www.questjournals.org***

I. Introduction

Conversely, goods and services such as food and shelter that are essential to human survival are provided by the environment as it naturally functions (Ohanmu et al., 2017). Carbon is stored in the ecosystem's plants and soils, where it plays a role in regulating water flow and water quality and helps to stabilize local climates (Abii and Nwosu, 2009). Although these services are not designed to be profitable, people nonetheless need them to survive. A rising number of environmental problems have been caused by human activity as it seeks to meet its demands and ambitions for improved living circumstances through resource exploitation (Harries, 1998). In spite of the 'blessings' from oil there are negative impacts on the human and ecological environment (Oyegun 1997, 1998; Pyagbara 2007; Mmom & Chukwuokeah 2011). Among the report's many dire predictions for the ecology of the Niger Delta is the statement that "there is a strong feeling in the region that the degree and rate of degradation are pushing the delta towards ecological disaster" (Ugbomeh and Atubi, 2010).

Crude oil spills from oil exploration activities affect the soil by deteriorating it and releasing liquid petroleum hydrocarbon into the environment. These spills are often caused by pipeline and storage tank neglect or oil well blowouts. When oil spills occur they contaminate nearby farmland, forests, rivers, streams, and other bodies of water. The soil and vegetation cover in tropical forests as well as the region's ability to regenerate are all destroyed by crude oil spills. The plant cover will show the effects of oil spill pollution on plants over time on any impacted surfaces (Oku, 2003; Nwokocha and Dienye, 2010; Tanee and Albert, 2015). According to Edokpolor et al. (2019), environmental contamination brought on by oil prospecting and exploration in Nigeria's Niger Delta has a detrimental effect on the biodiversity of the affected areas. The major stressors on freshwater ecosystems' soil, flora, and fauna are caused by crude oil leaks, gas flare-ups, and the escape of other production-related substances.

Additionally, Kadafa (2012) investigated the environmental effects of oil exploration and extraction in Nigeria's Niger Delta. According to the study, oil exploration and exploitation in the Niger Delta have been ongoing for decades, with detrimental effects on the region's environment and inhabitants. Similarly, the 18 February 2019 oil spill inflicted devastation on two oil-producing communities in the Gokana Local Government Area of Rivers State. Included among the affected communities are Bodo and the Goi. According to reports, the oil discharge was caused by a leak in the trans-Niger Delta pipeline operated by the oil colossus called Shell. The Ogoni people, who are still irritated by the federal government's indecision regarding the cleanup, are equally irritated by the divide-and-conquer strategies purportedly employed by the oil company to thwart the planned cleanup action which further deteriorates and degrades the environment.

Consequently, when a soil is polluted, the microbiota of the soil is affected as well as the plant community as a result of toxicity and indirect deleterious effects such as oxygen deprivation of land roots, generation of phytotoxic compounds such as hydrogen sulphide and death of herbaceous vegetation (Ojimba, 2012). Major inputs of petroleum may limit plant growth and animal activity which may in turn affect microbial activity. Studies have shown that surface soil contaminated by petroleum by-products with non- biodegradable additions are a potential source of ingestion by children. This may bioaccumulate, biomagnify and then lead to blood poisoning. In addition, explosion hazards may result from vapours of petroleum-contaminated soil, which migrates and later collects in underground utility vault, sewer lines and basements. Soils with a significant petroleum contamination can act as a source of contamination of ground water supplies.

The hydrocarbons in the crude oil spills tend to accumulate in the pores between soil particles, which result in reduced oxygen and water permeability through the soil. Viscous hydrocarbon mixtures may coat the surface of soil particles and significantly alter the binding properties of the clay minerals present and the water-holding capacity of the soil (Morgan & Watkinson, 1989). Migration is faster in clays than in loams due to the increased porosity of the former. Mobility is generally enhanced by microbial activity due to the production of biosurfactant and the relatively hydrophilic nature of most hydrocarbon metabolites (Adebusoye *et al*., 2007). Humid substances in soil may enhance mobility by emulsifying aliphatic molecules or may bind components depending on the local conditions. It is very important to clean up an environment that is polluted since in most cases it cannot be avoided so as to avoid the difficulties that may arise from the negligence of cleaning up. Thus, based on this background, the current study focused on the status of the crude oil polluted soils in Bodo community. The important research questions therefore guiding the study are: what is the status of the soil physico-chemical properties? Are there variations in the heavy metals and total hydrocarbon content between the polluted soils and control soils? Does the soil's physical, chemical and heavy metals concentrations vary between the polluted sites and control sites in the study area? The findings of the study shall therefore aid the government and environmental pollution managers in understanding the level of pollution of the soils even after the oil spill incident in year 2019; and promote ways of putting in place mitigation measures and procedures to effectively manage the pollution problems in the study area.

II. Materials and Methods

i. Description of the Study Area

The study area is Bodo community under Gokana LGA, Rivers state Nigeria. It lies geographically within latitude 4° 40′ 5″ N and 4° 43′ 19.5″ N and longitude 7° 22′ 53.7″ E and 7° 27′ 9.8″ E (Figure 1). Rainfall is present all year with an annual total of 200mm to 2300mm. However, a short spell of dry season usually occurs between the months of November and February. The vegetation of Gokana LGA falls within the rainforest vegetation belt. Trees found in this area are very tall, characteristics of the rainforest vegetation zone. These trees are about 30metres tall. These trees are evergreen with branches which interlace themselves to form canopies. The study area is predominated with sandy and loamy soil which is characteristic of coastal areas. The geology of the area and the adjourning areas is made up of the coastal plains due to the area's proximity to the Atlantic Ocean. Thus, the rivers surrounding the study area generally drains the area into the Atlantic Ocean. The area is generally underlain by the Benin formation, consisting of coarse sands interrupted by clay lenses of quaternary age. The types of crops cultivated mostly among residents in the study area include: yam, cassava, maize, cocoa, Oil palm etc.

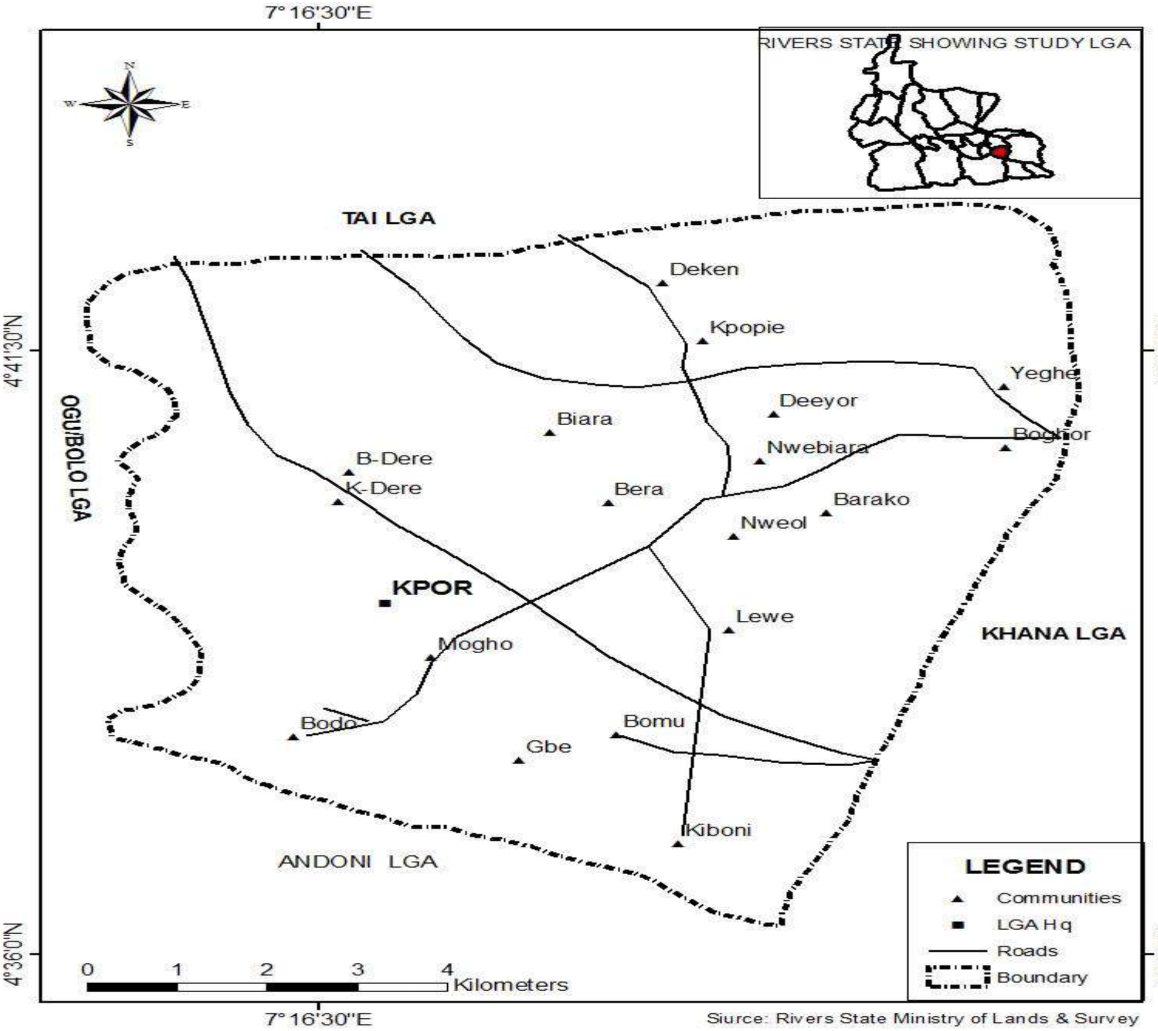

Figure 1. Gokana LGA showing its location in Rivers state (inset map)

ii. Data Acquisition

The primary data sources were employed for this study. The primary data sources included utilizing the point transect method whereby point samples were taken at random locations within the crude oil impacted soils and unpolluted soil samples for control purposes for the study. The soil samples were collected separately into two sets (one form the polluted sites and another from an unpolluted sites). The soil samples collected were for soil physical, chemical and heavy metals analysis. These soil samples were first sieved through a 2 mm mesh and then were air dried and pulverized. Soil samples weighing 200g each were collected from each sampling point making a total of 600g per transect plot (200g x 3 sampling points) (Figure 2). Thus, the sampling points established in the polluted soils and unpolluted soils were collected into polythene bags for laboratory analysis; and these are within each of the 5 transect plots (Figure 2) established for each study site (polluted and unpolluted) in the study area. The polythene bags containing soil samples were well labelled based on their individual sampling points. The polluted soil samples in polythene bags were separated from the unpolluted soil samples (control). The total soil samples collected in the study area were: 15 samples in polluted sites and another 15 soil samples in control sites, totaling 30 soil samples collected for the study.

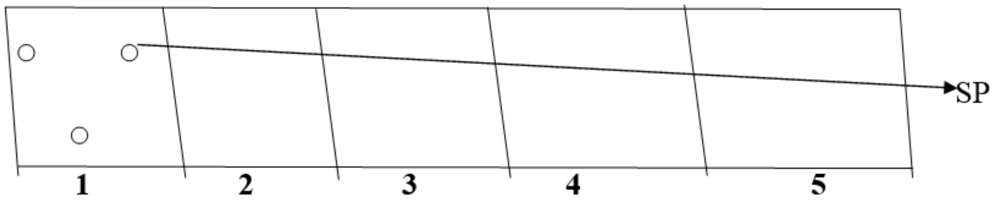

Figure 2: Point Transect Method for Collection of Soil samples
SP - Sampling Points of 0-30cm depths (3 soil samples x 5 transects = 15 soil samples)

iii. Data Collection Techniques

The instruments for collection of the soil samples included clean and sterilized auger, a clean plastic which was used to collect 200gramms of the soil samples at each point of collection (that is, 200g per sample point), hand gloves for protecting the hands. All the apparatus and glassware were washed, dried and sterilized by autoclaving for 15 minutes at 121ºC.

iv. Data Analysis

The descriptive and inferential statistics using mean, standard deviation, Tables and ANOVA tool were employed for data presentation and analysis. The Excel worksheet 2010 also aided the study in data arrangement and presentation. The mean and standard deviation of each point transect (three randomly selected points within each transect line from the five transect lines (Figure 2)) was determined while their overall means were presented on Table 1 alongside the F ratios and p-values for the analysis.

III. Results of the Analysis

The results displayed on Table 1 revealed the analyzed soil physico-chemical properties in crude oil polluted soils and unpolluted soils in Bodo community. The distribution revealed that there were significant changes in soil physico-chemical and heavy metals properties between the polluted soils and unpolluted (control) soils. For instance, the mean content of WHC (%) of the soils was higher in the control soils (29.4%) when compared with the crude oil polluted soils (20.6%). The study also discovered slight changes in the mean contents of soils physical properties (sand, silt, clay, and temperature and bulk density) between the crude oil polluted soils and control soils. The soil chemical analysis also showed significant variations between the polluted soils and control soils. Soils available phosphorus in crude oil polluted soils showed lower meant content of 4.9 mg/kg when compared with 7.8 mg/kg recorded for the mean content in the control soils. The mean contents of 3.4 mg/kg for magnesium (mg/kg) and 1.9 mg/kg for calcium (mg/kg) under the polluted soils were lower when compared with 6.5 mg/kg for magnesium (mg/kg) and 3.8 mg/kg for calcium (mg/kg) recorded under the control soils. The mean content of THC (mg/kg) of 285.7 mg/kg for crude oil polluted soils was higher than the mean content value of 24.6 mg/kg recorded for control soils. The results of the analysis further revealed that the mean concentrations of Fe, Cd, Cr and Pb (181.9 mg/kg, 1.9 mg/kg, 2.4 mg/kg and 4.2 mg/kg) have greatly increased in the crude oil polluted soils as against the mean concentration values (32.5 mg/kg, 0.7 mg/kg, 0.2 mg/kg and 0.1 mg/k) recorded for the control soils. The significant variations ($p<0.05$) observed in the soils physico-chemical and heavy metals properties between crude oil polluted soils and control soils are due to the response of the soil to the crude oil hydrocarbon pollutions. This has altered the physico-chemical and heavy metals properties of the soils in the polluted/crude oil affected soils in the study area. These have several implications on residents' livelihood and their socio-economic development.

Table 1: Analyzed Soil Physico-chemical and Heavy metals properties in Crude oil polluted soils and Unpolluted (Control) soils

Soil properties	Polluted Mean±SD	Control Mean±SD	F-ratio	p-value at 0.05	Remark
Sand (%)	56.5±3.4	63.1±2.0	28.374	0.00	S
Silt (%)	30.1±2.4	21.4±1.5	44.132	0.00	S
Clay (%)	13.4±2.8	15.6±2.5	5.421	0.03	S
Temperature (^{0}C)	32.8±1.9	29.9±0.5	33.638	0.00	S
WHC (%)	20.6 ±0.4	29.4±0.8	239.226	0.00	S
Bulk Density (Kg/m^3)	1.1±0.02	1.9±0.3	14.338	0.00	S
pH	5.0±0.2	6.3±0.3	68.213	0.00	S

Available Phosphorus (mg/kg)	4.9±0.2	7.8±0.4	148.173	0.00	S
Total Nitrogen (%)	4.6±0.4	5.7±0.4	112.63	0.00	S
Potassium (mg/kg)	0.3±0.03	0.8±0.04	76.148	0.00	S
Magnesium (mg/kg)	3.4±0.2	6.5±0.3	481.332	0.00	S
Calcium (mg/kg)	1.9±0.2	3.8±0.3	204.668	0.00	S
CEC (mg/kg)	3.6±0.2	9.1±0.2	84.542	0.00	S
THC (mg/kg)	285.7±18.1	24.6±0.5	986.621	0.00	S
Iron (Fe) (mg/kg)	181.9±4.0	32.5±6.6	272.469	0.00	S
Cadmium (Cd) (mg/kg)	1.9±0.06	0.7±0.3	5.869	0.03	S
Chromium (Cr) (mg/kg)	2.4±0.2	0.2±0.06	85.211	0.00	S
Lead (Pb) (mg/kg)	4.2±1.6	0.1±0.1	41.272	0.00	S

S – Significant; WHC – Water Holding Capacity; CEC – Cation Exchange Capacity; THC – Total Hydrocarbon Content

IV. Discussion

Findings of the study revealed that the concentrations of the soil physical, chemical and heavy metals properties differs between the crude oil polluted soils and control soils in the study area. The concentration of soil pH indicated a slightly acidic soil when compared with the pH content in the control unpolluted soils. The study discovered that crude oil have negatively impacted on the soils causing a decrease in soil physical and chemical properties in the polluted soils. The soil physical activities have been altered which have severe implications on water holding capacity (%) and bulk density (Kg/m^3). The study discovered that the content in soil chemical properties decreased considerably in the polluted soils when compared with the control unpolluted soils. The findings of the study further revealed that heavy metals concentration which is needed in trace amounts have increased significantly in the polluted soils. Thus, crude oil has directly impacted on the soil's physical, chemical and heavy metals properties in Bodo community which have several implications on residents' livelihood. This finding was earlier affirmed by Obire and Akinde (2006) that petroleum hydrocarbons directly impacts on the soil physical and chemical properties overtime. This finding also agrees with Wyszkowski and Zioikowska (2008) that crude oil decreases the content of soil chemical properties like carbon, calcium content and available phosphorus needed for plant growth and development. Similarly, Radulescu et al., (2012); Adesina and Adelasoye (2014); and Digha et al., (2017) also confirmed the adverse effects of crude oil impacts on soil physical and chemical properties. Their study further revealed the decrease in the content of soil chemical properties when compared with the control soil samples obtained for their study.

The findings of the study agrees with the findings of Aigberua and Okere (2019) on the impact of oil spills on the prevailing heavy metals in soils. Their findings stated that crude oil severely impacts on existing heavy metals in soils in B-Dere community in Ogoniland. It further stated that the presence of hydrocarbons as a result of the crude oil spills have direct impact on the soil by increasing the heavy metals contents in the soil. Also findings of Wang et al., (2007); and Adesina and Adelasoye, (2014) revealed that heavy metal pollution of the soil is caused by various metals especially copper, Nickel, Cadmium, Zinc, Chromium, and lead. This means that the concentration of heavy metals when it is high will affect the soil negatively.

V. Conclusion and Recommendation

The study focused on analyzing the soil quality status in crude oil polluted soils and control soils in Bodo community. Findings of the study revealed high concentration of petroleum hydrocarbon in the soils as well as high levels of toxic heavy metal contents in the soils as a result of the crude oil impacts on the soil. Thus, these recommendations were put forward for the study; and they are that: all activities leading to the addition of petroleum hydrocarbons to soil should be controlled at all cost because of its high toxicity levels capable of causing severe environmental damage and degradation to the people in the study area; the activities of the oil multinationals should be monitored at all levels in order to reduce their environmental impacts especially as it has to do with occasional crude oil spills in the study area.

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