International Journal of Development and Sustainability
ISSN: 2186-8662 – www.isdsnet.com/ijds
Volume 7 Number 4 (2018): Pages 1336-1354
ISDS Article ID: IJDS17082501

Assessment of petroleum products contamination of soil quality at selected truck parks in Calabar municipality, Nigeria

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Abstract

Soil samples were collected from three petroleum truck parks and a control located in Esuk Utan community in Calabar municipality of Cross River state. The three (3) truck parks had high human activities while the control had relatively lower human activities. Most of the petroleum handling facilities including jetties are located in this area. Sampling was carried out in the month of July, 2015. All investigations throughout the process followed standard analytical procedures. Assessment of contamination of soil quality, concentration of heavy metals in twelve (12) soil samples from three (3) truck parks and control were carried out and the results from these four areas compared. Heavy metals (Zn, Cu, Cr, Pb) were determined by FAAS. Soil samples were collected at the depths of 0-15 cm, 15 – 30 cm and 30 – 60 cm at each sampling point. Physicochemical parameters were obtained as follows: particle size distribution, sand 71.3 – 84.3 %; silt 7.0 – 16.0 %; clay 4.7 – 18.9 %. The soil showed evidence of severe hydrocarbon contamination which was established by high average extractable hydrocarbon contents (65,735 mg/kg, 59,327 mg/kg and 53,156 mg/kg) of the truck parks compared with 614 mg/kg of control. Soil texture was also affected. Although some heavy metals were within permissible limit, other indices investigated showed that the truck parks are affected with petroleum products spills. Therefore, it can be concluded that oil spills can negatively affect soil quality. This will result in low agricultural productivity and reduced source of livelihood in the affected areas.

Keywords: Assessment; Petroleum Products; Contamination; Soil Quality; Truck Parks; Calabar Municipality

Cite this article as: Ubong, I.U. and Edwin, J.D. (2018), “Assessment of petroleum products contamination of soil quality at selected truck parks in Calabar municipality, Nigeria”, *International Journal of Development and Sustainability*, Vol. 7 No. 4, pp. 1336-1354.

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1. Introduction

Petroleum truck parks are the least studied among other petroleum handling facilities. The parks in addition to the contamination which occurs naturally on the soil, also sustain activities that constitute risk to human health, soil quality and the ecosystem. This has made this study crucial because any contact with petroleum product causes damage to soil conditions of the land, which culminates in loss of soil fertility. It is worrisome that construction of Tank Farms and Depots are increasing day by day and large hectares of land are used for the construction of truck parks to accommodate the influx of trucks around Esuk Utan in Calabar municipality. However, there is a dearth of literature on the effect of these developments which this study seeks to evaluate the effects of these damages to soil quality and level of some heavy metals in selected truck parks and the control. Any study geared towards environmental management because of the elevated human and industrial activities is extremely valuable.

Human activities have always been a major cause of environmental pollution. These activities by man alter the environment in almost everything and consequently threaten man's own corporate existence. One of such alterations done to the environment is the constant spill of petroleum products on soil which changes the course of nature with attendant effects of environmental pollution and contamination. Soil pollution happens when the soil contamination exceed a certain threshold reaching amounts that could pose risk to human health and ecosystem. It is crucial to protect soil ecosystem, discharge of spills on land pollute the soil which renders it less useful for agricultural activities and affects soil dependent organism adversely (Lundstedt, 2003). Oil spills can cause various damages to marsh vegetation. It was found to reduce growth, photosynthetic rate, stem height, density and above ground biomass of *Spartina Alterniflora and Spartina Patens* and may cause their death (Krebs and Tamer, 1981).

A lot of investigations has been carried out by scholars, non-governmental organizations (NGOs) and professional bodies on environmental pollution generally and on spill related cases in particular**.** The negative impact of petroleum arises from its toxicity to many life-forms. Petroleum is strictly connected to nearly all facets of our contemporary society, particularly for transportation and heating in homes and for commercial as well as industrial activities. Oil spills take place in water and land. Odeyemi and Ogunseitan (1985), reported the growth and development of the oil and petrochemical industry in Nigeria with specific focus on the outstanding cases of pollution during the 25 years of its existence; He also highlighted causes and effects on the social, economic, agricultural and ecological characteristics on human and other biotic occupants of the region. When soil is polluted, the physicochemical properties are altered and this reduces the productive capacities (Osuji et al*.,* 2004).

In Nigeria, most of the terrestrial ecosystems and shoreline in oil-producing areas are important agricultural lands under cultivation (Egbo, 1994). Any contact with petroleum and/or refined petroleum products, causes damage to soil conditions of these agricultural lands, which culminates in loss of soil fertility (Sztompka, 1999). Pollution of agricultural soil has also greatly affected the development of plants. Agbogidi (2011), reported that the pollution of soil with crude oil had remarkably reduced biomass accumulation in *Jatropha curcas* when compared to seedlings grown in uncontaminated soils. He also observed a negative relationship between crude oil level in soil and weight gain in the plants. In an earlier study, Agbogidi (2010), reported that spent engine oil had impact on the rate of germination, in six cultivars of cowpea.

In maize, Okonokhua et al. (2007), observed that plant height, root number, root length and grain yield were adversely affected by soil crude oil contamination. Kekere et al. (2011), reported that crude oil pollution adversely affected leaf characteristics including total biomass as well as crop yield in *Vigna unguiculata*. They further reported low leaf chlorophyll content and elevated heavy metal uptake in the fruits. Ojimba and Iyagba (2012), observed that the yields of horticultural crops were much lower in crude oil-polluted farms than in non-polluted farms. They came to the conclusion that crude oil pollution had damaging and deleterious effects on horticultural crops. It is also reported that crude oil in soil renders it unacceptable for plant growth (Baek et al., 2005). Udo and Fayemi (1975) discovered that plants growing in an oil-polluted environment are mostly retarded with chlorosis of leaves, in addition to dryness of the plant. According to Badejo and Nwilo (2004), illegitimate fuel drain off as a result of the thriving black market for fuel products, has led to numerous oil pipeline bursts in recent years. This has also destroyed and polluted petroleum products truck parks. The effect of oil spills on land varies, depending upon the biota, geographical factors and the amount of spillage.

Nwanchukwu and Ugorji (1995), reported that pollution on soil is enormous, causing serious damage to vegetation and soil fertility. However, Reddy (2001), demonstrated that toxicity of the crude oil pollution varies depending on the type of oil and additive used during refining and also on the biota of spillage. Oil spills have caused great negative impact on food productivity. According to Oyefulu and Awobayo (1979), a good percentage of oil spills that occurred on dry land between 1978 and 1979 in Nigeria, affected farmlands in which crops such as rice, maize, yam, cassava and plantain were cultivated. Onwurah (1999), also reported that it affects germination and growth of some plants. It also affected soil fertility but, the scale of impact depended on the quantity and type of oil spilled.

Main crude oil spills have led to unfavourably effects on inorganic levels of soils. Metals present in petroleum depend on the geological source in which the crude is formed. Some metals in crude oil reflect the type of metals existing in the source rock. These heavy metals act as catalyst in the transformation of organic matter to petroleum (NNPC/PTI, 1987). Consequently, many metals in crude oil are basically a reflection of those carried over during movement of the source rock to the reservoir rock (NNPC/PTI, 1987). Metals in crude oil also come from the use of drilling mud during crude oil extraction. These substances, when further added to the crude oil, act as toxins in the soil (Stanisley, 2002). These heavy metals in the crude dispense themselves into the petroleum fractions after fractionation and refining thus giving rise to their presence in petroleum products. Elevated level of exposures to heavy metals contamination can be detrimental to the ecosystem and organisms by extension. Benka-Cooker and Ekundayo (1995), observed significant build-up of lead, iron and zinc in crude oil contaminated Niger Delta soil. Leschber et al. (1985), reported zinc having a positive correlation with pH and effective cation exchange capacity while clay and organic matter did not show any association with zinc in crude oil polluted soils. Chukwuma et al. (2010), reported that zinc distribution is more prevalent in an oil polluted site than non-oil polluted areas. He also added that zinc distribution depends on certain soil properties such as clay, organic matter and ρH. Hernberg (2002), reported in the 1920s the public health problem faced when tetraethyl lead was added to petroleum products to enhance its performance. The presence of lead in petroleum products poses a health threat to workers who face occupational exposures (Ankrah et al., 1996).

The aim of the study was to assess effects and nature of petroleum products contamination of soil quality at different depths and soil physico-chemical properties such as soil texture, pH, Organic Carbon, total nitrogen, average phosphorus, calcium, magnesium, potassium, sodium, aluminum, hydrogen, Cation exchange capacity and base saturation. Heavy metal concentrations covered (arsenic, copper, Zinc and lead) in the three truck parks and the control. The objectives of the study were set out to determine any changes on soil physico-chemical properties and concentrations of heavy metals (arsenic, copper, Zinc and lead) at the different soil depths at three (3) Petroleum Truck Parks: NNPC Truck Park, Dozzy Oil & Gas Truck Park and Export Processing Zone Truck Entrance Park and the control; all located in Calabar, Cross Rivers State.

1.1. Description of the study area

The study area was located in Esuk Utan Community, Calabar municipality, Cross River State, Nigeria. Its geographical Coordinates are on Latitude 5^0 1′0″ North and Longitude 8^0 20′0″ East (Fig.1). The community has a population of 1,141 based on 1991 population census (NPC, 1991). The area receives an annual average rainfall of about 254 mm within two distinct seasons; wet and dry. Mean annual temperature and relative humidity are 26.8 ^{0}C and 84 % respectively (FPDD, 1990). The state spans a total area of 21,481 sq. Km. The geology of Calabar area is built on the Tertiary and Quaternary sediment of the Niger Delta basin (Short and Stable, 1967). This basin consists of alternating sequence of gravel, sand, silt, clay and alluviums which are most likely derived from the adjoining Precambrian basement (Oban Massif) and Cretaceous rocks based on the Federal Department of Agricultural report (1990). The basement complex is made up of gneisses, Granites, schists, pegmatites and host of ultra-mafic suites (Ekwueme, 2003), while the Cretaceous sedimentary unit (Calabar Flank) is built up of limestone, sandstones, shales and marls (Reijers, 1996).

Access road to the study area (Esuk Utan) is through harbor road and Zone six (6). Esuk Utan being a relatively small town settlement in Calabar, is sparsely populated with clustered housing pattern typical of the southern rural region settlement (Figure 1). By virtue of its location along water front and hinterlands, the residents are known for their farming and fishing activities. However, beside the tank farm, the area has other activities including fuel dealers/distribution, repairing of vehicles, car washing, panel beating and small scale motor mechanics. These activities contribute to the total load of spill to the area.

2. Materials and methods

2.1. Sampling sites

The study involved both fieldwork and laboratory analyses of collected soil samples from three (3) truck parks and a control. The parks were selected based on site of high petroleum truck activities. The sampling sites located at Esuk Utan community in Cross River State of Nigeria were as follows:

- Site I: (Dozzy Truck Park) was picked closed to Dozzy and Ibafon Depot (within Longitude 008^0 19.665" E and Latitude 05^0 01.107" N) with elevation of 69m.
- Site II: (EPZ Truck Entrance Park) was selected close to Fyne field and Simon Depot (within Longitude $008^0$19.860"E and Latitude 05^0 01.350" N) with elevation of 83 m.
- Site III: (NNPC Truck Park) also located closed to NNPC Depot, Calabar (within Longitude 008^0 19.477" E and Latitude $05^0$00.930"N) with elevation of 50m.
- Site IV: (Control) with no industrial activities (situated between Longitude 008^0 19.440" E and Latitude 05^0 00.911"N) with elevation of 51 m. Sampling sites are shown in Plate 1.

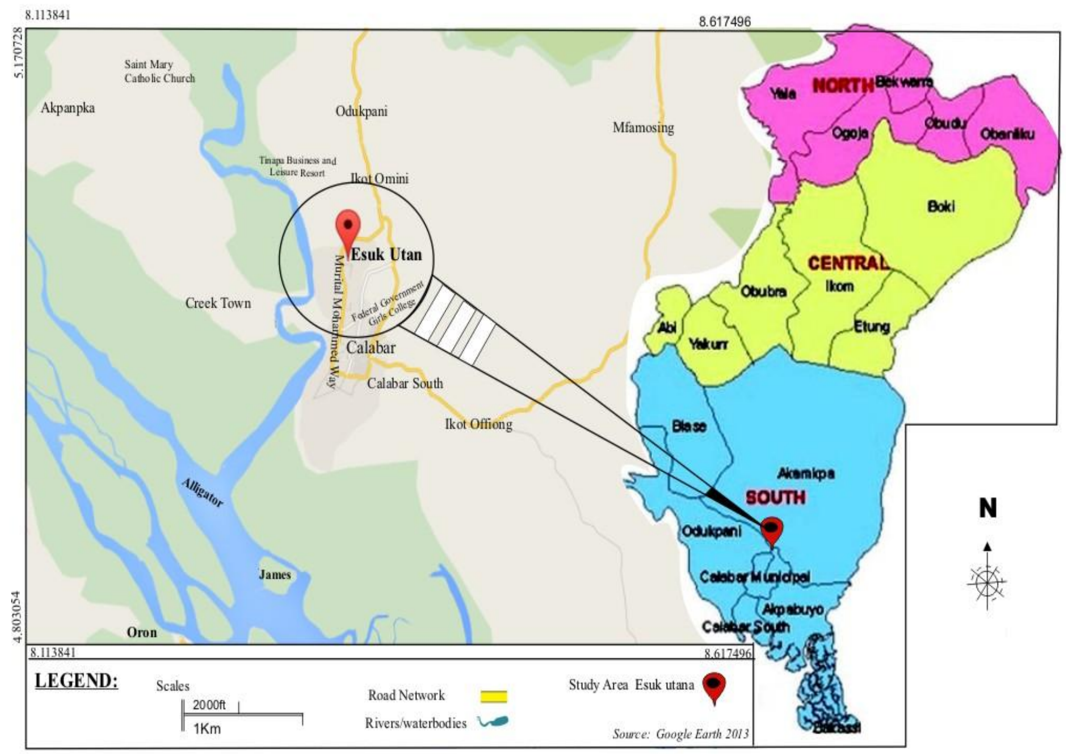

Figure 1. Map of Nigeria, Cross River State, showing Esuk Utan, the study area in Calabar Municipality

2.2. Sample collection, preparation and analysis

The sample collection was carried out randomly at the various sampling sites (Parks and Control) and samples were labelled accordingly. Standard methods were used during sample collection. The parks were functional and operational at the time. Selection of sampling site was based on Truck parks of high activities. Soils from various depths at the sampling locations were selected to represent the study areas. A hand soil auger was used to collect soil samples at the depths of 0 to 15 cm, 15 to 30 cm and 30 to 60 cm respectively. The auger was cleaned properly after each sampling point and the collected samples were wrapped in aluminum foil, transferred into pre-washed glass bottles and labelled before taking to the laboratory for processing and determination. In the laboratory, the soil samples were air-dried, gently crushed and sieved using 2 mm sieve. The sieved samples were properly stored and sub-sampled for the determination of particle size distribution (mechanical analysis and chemical) properties of the soil. All solvents/chemicals were of analytical grade. Standard procedures were followed to avoid contamination during analysis and standard protocols were followed [Day, 1965; Hesse, 1972; Walkley and Black, 1934; Bray and Kurtz, 1945; Juo, 1979; Murphy and Rily, 1962; Heald, 1965; Knudsen et al., 1982].

Plate 1. Location of the four Sampling Sites

2.3. Heavy metal analyses

Heavy Metals were determined using wet digestion method after finely grinding the soil sample to facilitate extraction and digesting. 5 gm of the finely ground sample with HNO_3/Perchloric acid were used in a ratio of 3:1. The digest was diluted to a desired volume. The absorbance of each sample was read with Atomic Absorption Spectrophotometer and result calculated according to Standard methods.

3. Results

3.1. Particle size distribution

The results of the soil physicochemical properties of Truck Parks are presented for the depths of 0-15; 15-30 and 30-60 cm respectively in Tables 1 and 2. The particle size distribution (Sand, Silt and Clay) are presented in Table 1 for the three (3) Petroleum Truck Parks and the control at various depths studied. The particle size distributions were: Sand (71.3 – 84.3 %); Silt (7.0 – 16.0 %) and Clay (4.7 – 18.9 %) for the three (3) parks and the control. The averages were: sand (78.1) %; silt (12.8) % and clay (9.1) % in the study sites (Table 1).

3.2. Other physiochemical parameters

The pH varied thus: Dozzy Park (5.7-5.8) averaging 5.7; EPZ Park (5.9-6.2) averaging 6.1; NNPC Park (5.7-6.0) averaging 5.8; and Control (4.8-5.1) averaging 5.03. The lowest value was obtained at the control, while the highest was obtained from EPZ (Table 2). Organic Carbon: Dozzy Park (2.7-3.5) % with an average of 3.2 %; EPZ (2.8-3.9) % with 3.2 % average; NNPC (2.6-2.9) % with an average of 4.2 % and control (1.0-1.2) % with 1.1 % average (Fig. 2). NNPC had the highest value while control had the lowest value (Table 2). Total Nitrogen results: Dozzy Park (0.15-0.29) % with 0.2 % average; EPZ (0.2-0.3) % with 0.7 % average; NNPC (0.16-0.19) % with 0.5% average and control (0.10-0.90) % with 1.1 % average. Dozzy had the least while control had the highest value (Table 2). Available Phosphorus: Dozzy Park (73.7-75.3) Cmol/kg with 74.6Cmol/kg average; EPZ (62.5-67.4) Cmol/kg with 65.4 Cmol/kg average; NNPC (65.7-69.2) Cmol/kg with 67.6 Cmol/kg average and control (43.8-44.1) Cmol/kg with 43.9 Cmol/kg average. The least value was from the control while Dozzy had the highest (Table 2).

Effective Cation Exchange Capacity (ECEC): Dozzy (5.06-6.62) Cmol/kg with 5.6 Cmol/kg average; EPZ (6.8-8.4) Cmol/kg with 7.5 Cmol/kg average; NNPC (6.87-10.54) Cmol/kg with 8.3 Cmol/kg average and Control (5.36-6.02) Cmol/kg with 5.6 Cmol/kg average. The control and Dozzy had the least while NNPC had the highest (Table 2). Base Saturation was: Dozzy (69-85) % with 74.3 %; EPZ (84-87) % with 84.7 % average; NNPC (87-91) % with 88.3 % average and Control (83-86) % with 84.7 % average. Dozzy had the least while NNPC had the highest (Table 2).

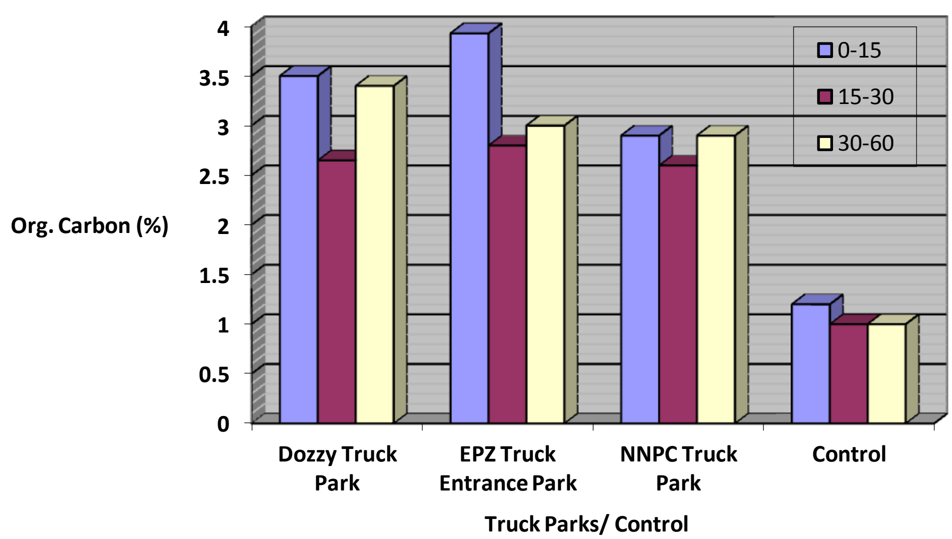

Figure 2. Organic Carbon Concentrations at the Study Areas

3.3. Total hydrocarbon contents

Total hydrocarbon contents were: Dozzy (50,153-87,712) mg/kg; EPZ (48,663-76,425) mg/kg; NNPC (41,295-69,947) mg/kg and Control (498-829) mg/kg. The lowest value was obtained from the control while Dozzy had the highest (Table 3). The result also showed that the total hydrocarbon content decreased with increase in soil depth (15-30) cm and increased again within (30-60) cm. Concentrations at 0-15 cm were the highest followed by 30-60cm (Table 3).

3.4. Heavy metal contents

The results of heavy metals for the soil samples are presented in Table 3 for the various depths of 0-15; 15-30 and 30-60 cm. The concentrations of Cadmium were: Dozzy Park (0.35-0.70) mg/kg; EPZ Park (0.40-0.70) mg/kg; NNPC Park (0.40-0.45) mg/kg; and Control (0.30-0.35) mg/kg. The Lowest concentration of Cadmium, measuring 0.35 mg/kg was obtained in the control while the highest was from EPZ with 0.70 mg/kg (Table 3). Copper concentrations were: Dozzy Park (26.0-30.90) mg/kg; EPZ (26.80-27.50) mg/kg; NNPC (20.85-21.5) mg/kg and control (20.10-20.18) mg/kg. The least value was obtained from the control while Dozzy Park had the highest (Table 3). Lead: Dozzy Park (1.04-3.25) mg/kg; EPZ (2.70-3.25) mg/kg; NNPC (2.95-3.50) mg/kg and control (1.04-1.93) mg/kg. The lowest was from the control while NNPC had the highest value (Table 3). Zinc: Dozzy Park (10.50-14.40) mg/kg; EPZ (5.75-15.05) mg/kg; NNPC (9.05-12.50) mg/kg and control (5.07-6.35) mg/kg. The highest value was obtained from EPZ while control had the least (Table 3).

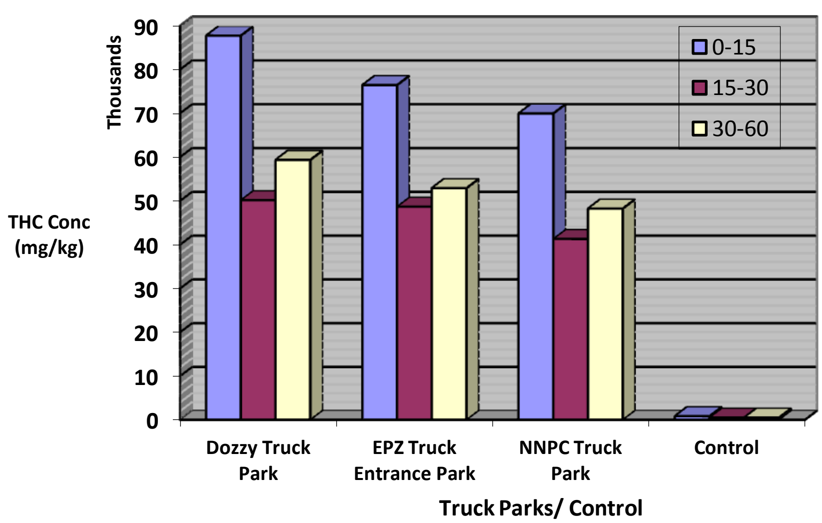

Figure 3. Concentration of Total Hydrocarbon Contents at the study sites

Table 1. Soil Textures for the four study Truck Parks/ Control in July, 2015

Sample location	**Sampling points**	**Depths (cm)**	**Sand (%)**	***Silt* (%)**	**Clay (%)**
Dozzy Truck Park	A1	0-15	84.3	11.0	4.7
	A2	15-30	79.3	13.0	7.7
	A3	30-60	83.3	12.0	4.7
EPZ Truck Entrance Park	B1	0-15	77.3	16.0	6.7
	B2	15-30	77.3	14.0	8.7
	B3	30-60	76.3	16.0	7.7
NNPC Truck Park	C1	0-15	80.3	15.0	4.7
	C2	15-30	79.3	15.0	5.7
	C3	30-60	79.3	13.0	7.7
Control (Farmland)	D1	0-15	78.3	7.0	14.7
	D2	15-30	71.3	12.0	16.7
	D3	30-60	71.3	10.0	18.9
Range			71.3-84.3	7.0-16.0	4.7-18.9
Average (%)			78.1	12.8	9.1

Table 2. Other Physiochemical Parameters

Sample location	Sampling points	Depths	pH	Org. C (%)	T. N (%)	Av. P mg/ kg	Ca	Mg Cmol/ Kg	K Cmol/ Kg	Na Cmol/ Kg	ECEC Cmol/ Kg	B/S (%)
Dozzy Truck Park	A1	0-15	5.8	3.5	0.29	74.8	4.8	0.2	0.6	.06	6.62	85
	A2	15-30	5.8	2.65	0.15	75.28	3.6	1.4	0.15	0.09	5.06	69
	A3	30-60	5.7	3.40	0.29	73.65	3.6	1.40	0.12	0.06	5.06	69
EPZ Truck Entrance park	B1	0-15	6.2	3.93	0.31	66.30	6.0	0.8	0.19	0.05	8.4	83
	B2	15-30	5.9	2.8	0.2	62.5	5.0	0.8	0.19	.05	6.84	84
	B3	30-60	5.9	3.0	0.2	67.4	5.2	0.8	0.12	.09	7.11	87

Table 2. *Cont.*

Sample location	Sampling points	Depths	pH	Org. C (%)	T. N (%)	Av. P mg/kg	Ca	Mg Cmol/Kg	K Cmol/Kg	Na Cmol/Kg	ECEC Cmol/Kg	B/S (%)
NNPC Truck Park	C1	0-15	6.0	2.9	0.19	65.7	5.8	3.6	0.14	.08	10.58	91
	C2	15-30	5.7	2.6	0.16	69.20	5.0	0.8	0.17	0.05	6.87	87
	C3	30-60	5.8	2.9	0.16	66.10	5.0	1.2	0,12	.06	7.34	87
Control	D1	0-15	5.2	1.2	0.10	43.75	3.1	0.9	0.10	0.07	6.02	86
	D2	15-30	4.8	1.0	0.10	43.82	3.2	0.5	0.11	0.08	5.44	85
	D3	30-60	5.1	1.0	0.9	44.10	3.1	0.7	0.10	0.14	5.36	83

Table 3. Heavy Metal and Total Hydrocarbon Contents of Truck Parks/ Control in July, 2015

Sample Location	Sample Points	Depths (cm)	Cadmium (Cd) mg/kg	Copper (Cu) mg/kg	Lead (Pb) mg/kg	Zinc (Zn) mg/kg	THC
Dozzy Truck Park	A1	0-15	0.60	26.0	3.25	10.8	87,712
	A2	15-30	0.50	30.60	2.70	14.40	50,153
	A3	30-60	0.55	30.90	3.05	13.80	59,341
EPZ Truck Entrance Park	B1	0-15	0.70	27.50	1.40	10.45	76,425
	B2	15-30	0.40	27.50	1.70	15.05	48,663
	B3	30-60	0.65	26.80	2.25	5.75	52,894
NNPC Truck park	C1	0-15	0.45	20.85	2.95	9.05	69,947
	C2	15-30	0.4	21.05	3.00	11.00	41,295
	C3	30-60	0.45	21.0	3.5	12.50	48,226
Control	D1	0-15	0.30	20.18	1.93	6.35	829.0
	D2	15-30	0.35	20.12	1.07	5.25	516.0
	D3	30-60	0.35	20.10	1.04	5.07	498.0
WHO (1984) Permissible Limits			0.3	150	40	500	

THC= Total Hydrocarbon Content

3.5. Exchangeable Cations

Calcium concentrations were: Dozzy (3.6-4.8) Cmol/kg with 4.0 Cmol/kg average; EPZ (5.0-6.0) Cmol/kg with 5.4 Cmol/kg average; NNPC (5.0-5.8) Cmol/kg with 5.3 Cmol/kg average and Control (3.1-3.2) Cmol/kg with 3.1 Cmol/kg average. The highest value was EPZ while control had the least (Table 2). Magnesium: Dozzy Park (0.2-1.4) Cmol/kg with 1 Cmol/kg average; EPZ (0.8-0.8) Cmol/kg with 0.8 Cmol/kg average; NNPC (0.8-3.6) Cmol/kg with 1.9 Cmol/kg average and control (0.5-1.1) Cmol/kg with 0.7 Cmol/kg an average. NNPC had the highest while control had the least (Table 2). Potassium: Dozzy (0.1- 0.6) Cmol/kg with 0.3 Cmol/kg average; EPZ (0.1-0.6) Cmol/kg with 0.3 Cmol/kg average; NNPC (0.1-0.2) Cmol/kg with 0.2 average; control (0.1-0.1) Cmol/kg with 0.1 Cmol/kg average. The highest value was obtained from Dozzy and EPZ while control had the least (Table 2). Sodium: Dozzy Park (0.06-0.09) Cmol/kg with 0.07 Cmol/kg average; EPZ Park (0.05-0.09) Cmol/kg with 0.06 Cmol/kg average; NNPC (0.05-0.08) Cmol/kg with 0.06 Cmol/kg average and control (0.07-0.14) Cmol/kg with 0.096 Cmol/kg average. The least value was obtained at EPZ and NNPC while the control had the highest (Table 2).

4. Discussion

4.1. Particle size distribution and physicochemical properties

The particle size distributions indicated Sand predominance of 78.1 %, followed by Silt (12.8) % and Clay (9.1) % (Table 1). The sandy nature of the soil suggests that ground water at the truck park is susceptible to contamination by surface pollution. Texture is an indication of the relative content of particles of various sizes, such as sand, silt and clay in the soil. Texture influences the ease with which soil can be worked, the amount of water and air it holds, and the rate at which water can enter and move through the soil. The pH values from the truck Parks (5.7 – 6.2) were moderately acidic while those of the control (4.8- 5.2) were also acidic. The result indicated that, Dozzy and NNPC Parks have acidic soils while EPZ (pH of 6.0) though acidic, can be considered optimum for growth of many plants. The control with a pH of 5.03 also shows very acidic soil. Soil pH is an expression of the acidic, neutral or alkaline condition of the soil. The pH range of 4.8-6.2 is in agreement with that of Niger Delta soils (Isirimah, 1987; Odu et al., 1985). Itanna (1998) reported that the availability of heavy metals increases with decreasing pH.

pH affects plants growth primarily through its effects on nutrients availability. High or low pH causes deficiency in essential nutrients that plants need to grow with. Furthermore, soil pH affects the behavior of soil microbes encouraging or inhibiting the growth of pathogens and affecting how well helpful microbes are able to break down organic materials, free the nutrients it contains for the plants use (Thumma, 2000). The importance of pH arises from its influence of the availability of vital nutrients. Most garden crops will grow reasonably in soils with a pH between 6 (slightly acid) and 7.5 (slightly alkaline). For most plants, a soil pH below 6.0 is objectionable (Jauron, 2002). Most crops grow well if pH is close to neutral (pH 6 to 7.5) but a few crops prefer acid or alkaline soils. Phosphorus, iron, copper, zinc, and boron are often lacking in very high pH soils (Michelle, 2017).

Higher organic carbon in the truck Park soils than in the control soil may be due to gasoline fuel, which is composed of Hydrocarbon and Polycyclic Aromatic Hydrocarbons as observed and reported by Atlas (1981). Total organic carbon (TOC) was highest at EPZ Truck Entrance Park (3.93 %) followed by Dozzy Truck Park (3.5 %). Organic carbon (TOC) concentration also decreased with depth and increased again at the depth of 30-60 cm. The lowest organic carbon was at the control station (1.0-1.2 %). Total organic carbon (TOC) with highest at EPZ Truck Entrance Park (3.93 %) exceeded the limit of 3.5 % recommended for 0-15 cm depth by Brady (1974). The organic matter content of soils depends on the rate of production and decay of waste and is a function of temperature, rainfall and nutrient status (Smith and Atkinson, 1975). Total organic carbon (TOC) is the carbon (C) stored in soil organic matter (SOM). About 58 % of the mass of organic matter exists as carbon. Organic carbon (OC) enters the soil through the decomposition of plant and animal residues, root exudates, living and dead microorganisms, and soil biota (Edwards et al*.,* 1999). Change in soil organic carbon is an indicator of soil quality.

Total Nitrogen showed no remarkable difference in the truck parks and control. Total Nitrogen of soil is an indication of the organic nitrogen present in the soil which must undergo mineralization for it to be available for plant use in the form of NH_4^+ and NO_3^- (Miller and Donahue, 1992). The Total Nitrogen values are consistent with those reported by Baker and Herson (1994), who observed that high levels of Total Nitrogen suggest active mineralization of organic nitrogen in the soil. The concentration of extractable macro-nutrients, Phosphorous in the truck parks (62.5 -75.28) mg/kg were higher than in the Control (43.75-44.10) mg/kg. This could be as a result of the utilization of resident micro flora. These observations were in agreement with the report that organic matter increases phosphorous retention in soils (Ozanne, 1962). Available Phosphorous is one critical essential nutrient in soil fertility, because of its fixation and transformation in the soil system. Inadequate supply of P can have detrimental effects on plants (Miller and Donahue, 1992). According to Black (1982), the level of available phosphorous in the soils at the study sites were very high. The concentrations of K, Ca, Na and Mg showed no remarkable variation. The average effective cation exchange capacity (ECEC) of Dozzy was 5.87cmol/kg, EPZ was 7.45Cmol/kg and NNPC, 8.26 Cmol/kg while 5.31 Cmol/kg was for the control. Effective cation exchange capacity of soil is the sum total of cations (acid and basic) which the soil can hold on its exchange complex (Miller and Donahue, 1992). It is an important indicator of soil fertility, soil acidity and basicity. Effective cation exchange capacity (ECEC) of both surface horizon (6.62 to 10.58 cmol/kg) and subsoil horizons (5.06 to 7.34 cmol/kg) of samples was less than 12 cmol/kg, indicating low content in the soil.

Percentage Base Saturation from the truck parks and control showed that the values were greater than 60 % which indicated the availability of cations in soil solution for plant absorption in the soil (Enwezor et al., 1990). Base saturation is an indication of the concentration of basic cations (Ca^{2+}, Mg^{2+}, K^+ and Na^+) in the adsorption complex by the soil compared to acidic cations (H^+, Al^{3+}) (Miller and Donahue, 1992). Base saturation percentage was high in both surface and subsoil in the study area.

The concentrations of heavy metals in the truck parks (Dozzy, EPZ, and NNPC) were higher for all analyzed heavy metals (Cd, Zn, Cu and Pb) in comparison to the control. The average concentration of Cd in the three truck parks were 0.55 mg/kg for Dozzy, 0.58 mg/kg for EPZ and 0.43 mg/kg for NNPC while 0.35 mg/kg was for the Control. These were above the permissible limits of 0.3 mg/kg (WHO, 1984). Cadmium was the only metal that exceeded the WHO limit of 0.3 mg/kg (1984). However, the highest concentration of Cd came from EPZ. High concentrations can be detrimental to health. The levels of Cd, Cu, Pb and Zn (in the three (3) Truck Parks and Control at 0-15 cm) showed differences in concentrations but the control had the least concentration in terms of Cd, Cu, and Zn at 0-15 cm depth (Fig. 5). Copper showed increases over the control amount but was below the WHO limit of 150.0 mg/kg. Similarly, Lead and Zinc showed increases over the control values but were generally below their permissible values of 40.0 and 500.0 mg/kg respectively.

The levels of total hydrocarbons represented a high level of hydrocarbon contamination on the truck sites (Fig. 4). Osuji and others (2004), affirmed that such high hydrocarbon levels affect both above-ground and underground flora and fauna. These conditions usually suggest low soil fertility, which in turn infer low agricultural output and reduced source of income in the affected areas. The load may have been influenced by the activities of fuel dealers/distributors, repairing of vehicles, car washing, panel beating, motor mechanics and vehicle overhaul. The study also revealed that there is the potential of these activities to increase overtime which could cause bioaccumulation of pollutants. There is need for monitoring and regular sensitization and examination of soil quality since the bioaccumulation through oil spill can affect soil fertility.

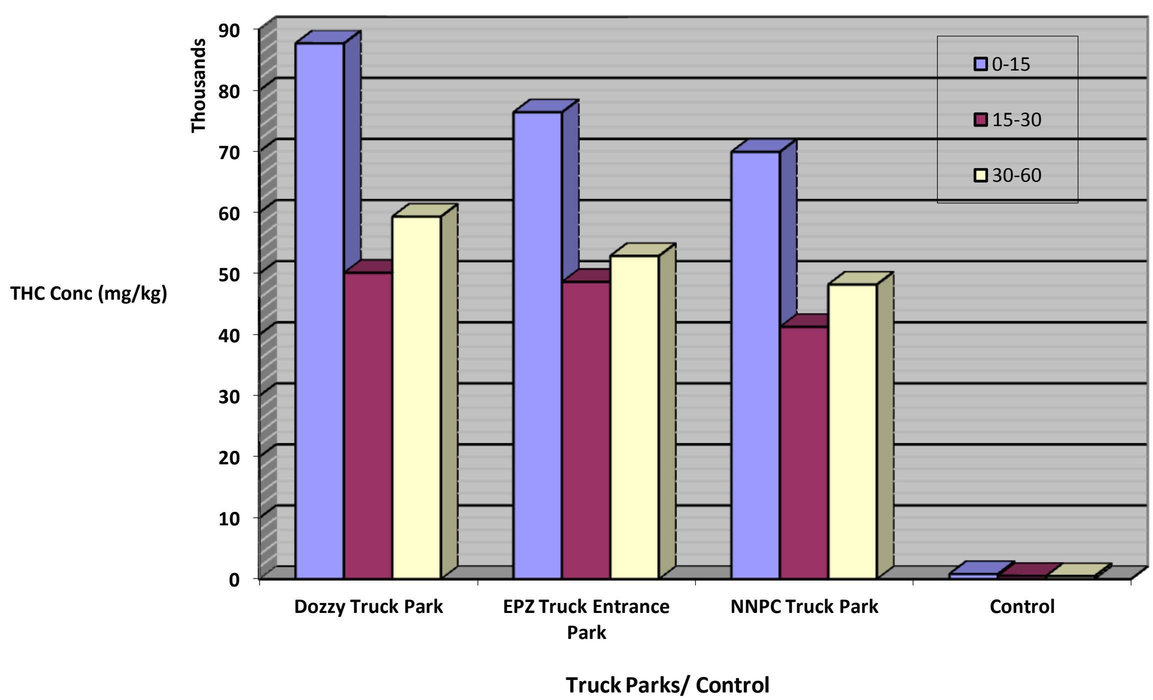

Figure 4. Concentration of Total Hydrocarbon Contents at the study sites

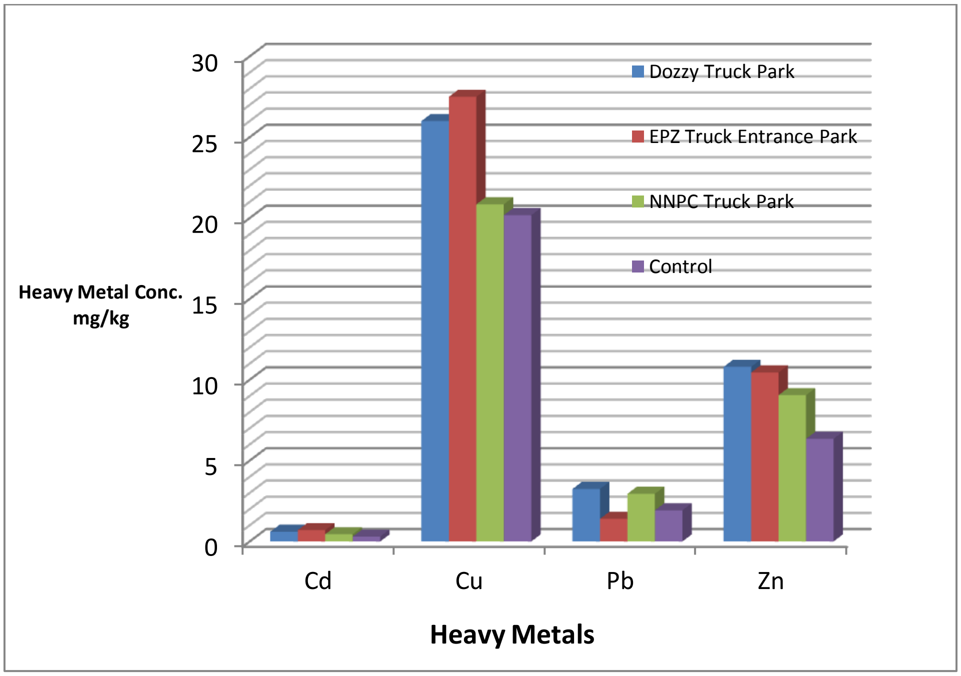

Figure 5. Heavy Metals in the three (3) truck parks and control at 0-15 cm only

5. Conclusion

Having analyzed the soil samples from the four locations of study, it can be concluded that samples from Dozzy, EPZ and NNPC truck parks were heavily contaminated with petroleum hydrocarbons. The findings when compared with the control are consistent with other findings. The result indicated that, the total hydrocarbon levels observed from the three truck parks have provided evidence of severe hydrocarbon contamination of the sites. These conditions generally imply low soil fertility, which in turn implies low agricultural productivity and reduced source of livelihood in the affected areas. In order to minimize the rate of spills by way of illegal siphoning, trans-loading and leakages from the trucks in these areas, there should be a time frame for the existence of truck parks, after which the soil of the affected truck parks can be treated to get back the soil quality. Bioremediation in truck parks should be encouraged in line with international best practices. Loaded trucks and other unguided human activities should be disallowed in truck parks. Above all, updating and revising the legislations, reviewing the licence of the oil companies and reviewing the fines will go a long way to ensuring compliance.

Acknowledgements

The authors are grateful to the Institute of Geosciences and Space Technology (IGST), Rivers State University, Port Harcourt, Nigeria, for providing the platform for this study.

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