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Petroleum Hydrocarbon Contamination of Soil at a Commercial Trailer Truck Parking Facility at Alesa Eleme, Rivers State, Nigeria.

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Abstract: Soil quality, Petroleum Hydrocarbons and selected heavy metals were determined at the trailer truck park at Alesa community, Eleme, Rivers State. Soil samples were collected from three diffèrent locations including a control at 0-15cm depths. The control was collected away from the contaminated soil and the following parameters were determined: pH value, parcticle size, total nitrogen, potassium, avalable phosphorus. conductivity, organic carbon, organic matter, total organic carbon, total hydrocarbon, total petroleum hydrocarbon, textural content, magnesium, calcium, cadmium, chromium, vanadium, Nickel, zinc, and lead using standard method of Flame Atomic Absorption Spectrophotometry. The result showed that the Trailer park contributed to high level of nutrients, hydrocarbons and heavy metals. The concentrations of the samples were: pH (7.64-8.10), Conductivity (54-107) µS/cm, phosphorus (0.11-0.53) mg/kg, Sodium (56.82-104.49 mg/kg), calcium (1403.99-1540.96) mg/kg magnesium (614.94-711.33,) mg/kg ; potassium (85.24-193.81) mg/kg, THC (28.5-9214.1) mg/kg, TPH (21.44-160.6,) mg/kg, TOC (0.897-3.276) %, Organic Carbon (0.54- 3.43)%, cadmium (0<0.001-0.21) mg/kg, Chromium (8.08-9.96) mg/kg, vanadium (0.01-0.54) mg/kg, Nickel (0.22-8.08,) mg/kg, zinc (14 .03-59.17) mg/kg and lead (6.62-21.58) mg/kg. The result showed that, total hydrocarbon and total petroleum hydrocarbon levels observed at the truck park,have provided evidence of severe petroleum hydrocarbon contamination of the Alesa trailer park sites and this has led to an increase in the levels of heavy metals in the truck soil. The study recommends that more studies be done at trailer parks and that, the trailer parks should be located far from homes and farms. These conditions of soil contamination generally imply low soil fertility, which in turn implies low agricultural productivity and reduced sources of livelihood in the affected areas. 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.

Key Words: Petroleum hydrocarbons, contamination, truck parks, Heavy Metals, Soil Quality, Eleme, Rivers State.

1.0 INTRODUCTION

Shortages of truck parking facilities are a national as well as international safety concern. An inadequate supply of truck parking spaces can result in two negative consequences: first, tired truck drivers may continue to drive because they have difficulty finding a place to park for rest and, second, truck drivers may choose to park at unsafe locations, such as on the shoulder of the road, exit ramps, or vacant lots, if they are unable to locate official, available parking. Numerous public, private, academic and non-profit studies have been carried out on the adequacy of truck parking and these studies have some common findings, including an expected growth in truck activity, severe shortages of parking for trucks, lack of information on truck parking opportunities, and challenges due to limited delivery windows and specific rest requirements (USDOT, 2017). The primary issues of concern were the safety aspects of fatigued truck drivers when trucks are parked on shoulders and ramps along highway segments due to insufficient parking capacity and overflowing rest facilities, and the personal safety of truck drivers who must park for rest or stop over but are often unable to find a suitable parking when and where they need it. However, there is a dearth of information on the environmental quality of these truck parks which this study seeks to address.

There is growing public concern as a wide variety of toxic chemicals are introduced into the environment. Petroleum hydrocarbons for instance, come into the environment through accidents, spills or leaks, urban input include trucking park activities, industrial releases, commercial and domestic uses (Wang and Stout, 2007). The site of oil pollution is not necessarily the site of use; hence oil is transported several kilometres to reach its various destinations (Onyeagba and Isu, 2006). In Nigeria, the mode of transportation has been through pipelines, barges, oil tankers and road tankers. The losses are mainly as a result of lack of regular maintenance of the pipelines as most of the pipelines are obsolete (Walkle and Black, 1934). Other causes of petroleum pollution include oil-well blow-out, corrosion of oil pipelines, pipeline vandalization and human errors, etc; all resulting in petroleum pollution (Sakari *et al.*, 2008).

Petroleum Pollution of the natural environment like soil is a universal problem because of the effect on soil ecosystem (Akoto *et al.*, 2008). Petroleum pollution exerts adverse effects on plants indirectly by making toxic minerals in the soil available to plants (Adams and Ellis, 1960). Crude oil pollution also leads to deterioration of soil structure, loss of organic matter contents, loss of soil minerals nutrients such as potassium, sodium, sulphate, phosphate, and nitrate, etc (Akubugwo *et al.*, 2009). It also exposes soil to leaching and erosion (Palese *et al.*, 2003). The environmental significance of the enhanced levels of these pollutants is judged in terms of the degree of toxicity, the extent of exploitation of the pollutants, their application, concentration and consequent mobilization into the soil (Udechukwu, 1972). The presence of these pollutants obviously has resulted in loss of soil fertility, poor crop yield and harmful implications on humans and the entire ecosystem. With the high degree of ecological degradation resulting from petroleum pollution, there is need for continuous monitoring and evaluation in order to cope with new strategies and policies that will aid in protecting and preserving the environment. The truck park is a typical example of an area with suspected soil contamination. The common chemicals involved in soil contamination are petroleum hydrocarbons, solvents, pesticides, lead and other metals. The occurrence of this phenomenon is correlated with the degree of industrialization and intensity of chemical usage (Stegmann, 2001).

Oil spill has been described as release of a liquid petroleum hydrocarbon into the environment due to human activity (Ayininuola and Kwashima, 2015). The Niger Delta in Nigeria has been the attention of many environmentalists as far as oil spill is concerned (Sposito and lund, 1982). Various researches have been carried out by various scientists across the country to analyse the extent of contamination by petrochemical hydrocarbons on the quality of soils in the Niger Delta region of the country. This work was aimed

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at assessing the impact of trailer park activities on soil physico-chemical properties at Alesa Community, Eleme, Rivers State. The objectives were todetermine the extent of pollution of soil at the trailer park and to determine the effect of the trailer park on soil physicochemical properties. There is a great concern on the rate of pollution in the environment and agricultural sectors by the activities at trailer park, thus the need to access the effect of these activities and proffer possible solution to that effect.

Study Area Description

Alesa is a community in Eleme Local Government of Nigeria (LGA) of Rivers State, Nigeria. It is located along high pressure oil pipelines used for the distribution of petroleum products from Port Harcourt refinery, a subsidiary of the Nigeria National Petroleum Corporation (NNPC), River State, to other parts of the country. Being a developing economy, the community has a trucking park where trailers and trucks carrying petroleum products are parked.

2.0 MATERIALS AND METHODS

2.1 Collection of Soil Samples

The sampling area was Alesa Eleme and the collection points were referenced (Table 1). An unpolluted farmland was chosen as a control in the community. Soil samples were collected at different distances at a depth of 0-15cm using a soil auger and kept in sterile plastic bags. The samples were then transported to the Soil Science laboratory for analysis, in the Rivers State University, Port Harcourt.

Soil samples were air-dried and sieved with a 2 mm mesh size according to Allen *et al.* (1974). The temperature of each sample was taken at site with a thermometer and the reading taken after one minute in ^{o}C.

Analytical Methods

Organic Carbon was determined by the Walkley-Black Wet-Oxidation Method. Percentage Organic Matter was by the method ofIbitoye (2008). Percentage Organic Carbon was converted to percentage organic matter by multiplying the results by 1.724 and answers reported in gKg^{-1}. pH determination was done by (Electronic pH Meter Method): Soil pH In H_20 1:2.5 (Ibitoye, 2008). Particle Size Determination was by the Hydrometer Method while the Dry Matter and Moisture Contents were done by standard methods.

Total Hydrocarbons (THC), were done by the Spectrophotometric Method by Concade (1972). The oil content of the soil was detemined by shaking 5g of a representative fresh soil sample contained in 100 ml conical flash with 10 ml of toluene. The extract was filtered into the test tube through a funnel and oil extracted determined by absorbance of the extract at 420 nm in a spectronic 21D spectrometer. Oil concentration was then calculated with a reference to the standard curve, moisture content and multiplication by the appropriate dilution factor. All solvents/chemicals were of analytical grade**.** Standard procedures were followed to avoid contamination during collection and analysis [Day, 1965; Hesse, 1972; Walkley and Black, 1934; Bray and Kurtz, 1945; Juo, 1979; Murphy and Rily, 1962; Heald, 1965; Knudsen *et al*., 1982].

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 (APHA, 1998).

Table 1: Geographical Location of Sampling Stations

Station No.	Station Name/Code	Geographical Locations	
		East (Long.)	North (Lat.)
1	Location 1	7^0 618.11	4^0 46'11.38
2	Location 2	7^0 619.11	4^0 46'12.18
3	Control Location 3	7^0 620.11	4^0 46'14.05

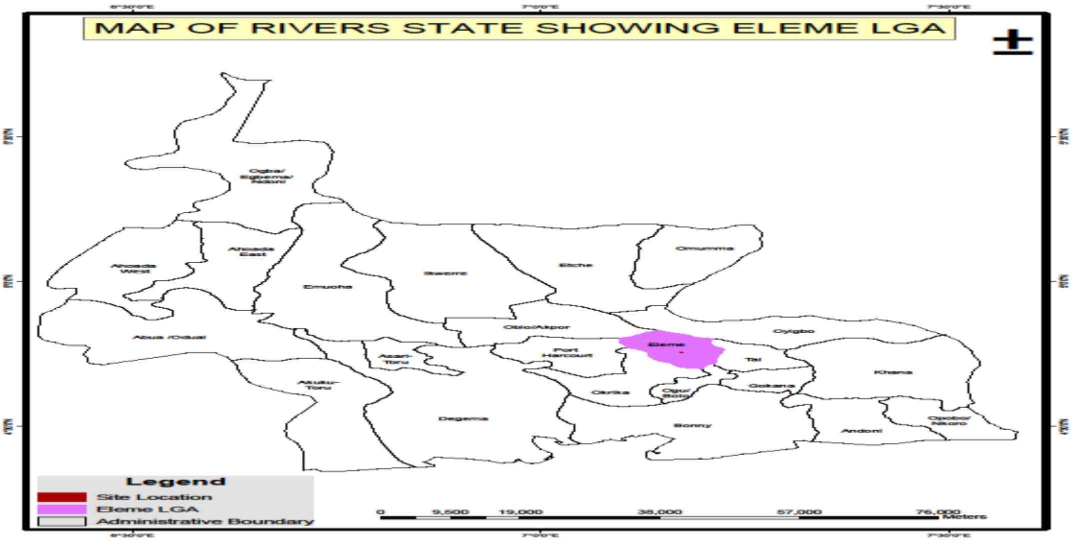

Fig. 1: The Map of Rivers State showing the Area of Sample Collection

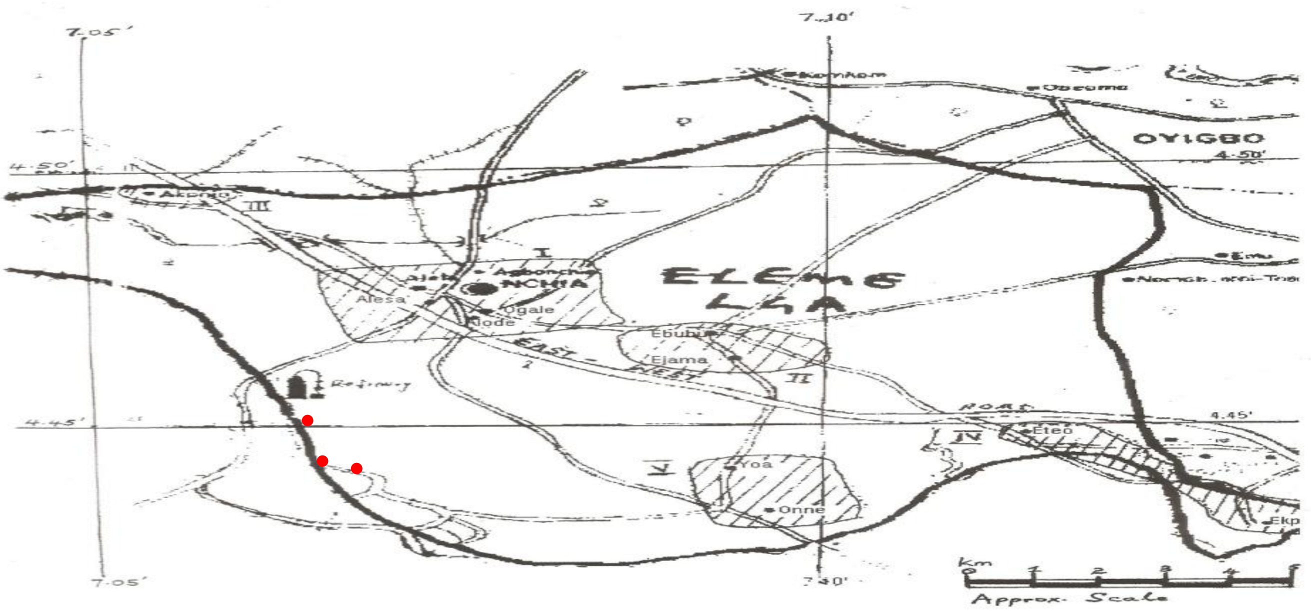

Fig. 2 : Sample Collection Stations

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3.0 RESULTS AND DISCUSSION

The results of the soil physico-chemical properties of the Truck Park are presented for the sub surface depth of 0-15 cm in Table 2. The particle size distributions were: Sand (70.23 – 74.4 %); Silt (4.32 – 14.36 %) and Clay (19.24 – 35.32 %) for the park stations and the control respectively. The averages were: sand (78.1) %; silt (12.8) % and clay (9.1) % in the study sites (Table 2). The textural classification ranged from sandy loam to sandy clay loam and sandy clay at the control. The moisture content ranged from (23.9 – 27.4) %, with a mean of 25.65±2.5 % while the control was 32.1 % (Table 2).

The pH ranged from 7.64 –8.04 with a mean of 7.84±0.28 while the control pH was 8.10. Other parameters were: Conductivity (54 – 58) µS/cm, with a mean of 56±2.83 (µS/cm) while the control was 107 (µS/cm). Phosphorus (0.32 – 0.53) mg/kg with a mean of 0.43±0.15 mg/kg while the control was 0.11 mg/kg. Total Organic Carbon (TOC)(2.57–3.28) %, with a mean of 2.93±0.5 % ; with a control value of 0.90 %. Organic Carbon was (2.43–3.43) % with a mean of 2.93±0.71 % and a control value of 0.54 %. Organic Matter was (4.19–5.91) g/kg with a mean of 5.05±1.22 g/kg and a control value of 9.31g/kg.

The exchangeable cations were: Calcium (1403.94–1409.10) mg/kg with a mean of 1406.52±3.65 mg/kg; and control value of 1540.96 mg/kg; Magnesium (697.18– 711.33) mg/kg with a mean of 704.26±10.01 mg/kg and control value of 614.71 mg/kg. Potassium (185.24 – 193.81) mg/kg, with a mean of 189.53±6.06 mg/kg and control value of 96.54 mg/kg and Sodium (104.49 – 102.04) mg/kg with a mean of 103.27±1.73mg/kg and control value of 56.82 mg/kg) (Table 3).

Total Hydrocarbons, THC (191.6 – 214.1) mg/kg; with a mean of 202.85±15.9 mg/kg and a control value of 28.59 mg/kg. Similarly, Total Petroleum Hydrocarbons, TPH was (143.7–160.6) mg/kg with a mean of 152.15±12.0 mg/kg and a control value of 21.44 mg/kg. The lowest value was obtained at the control while the truck park had the highest (Table 2).

The heavy metal results were: Cadmium (0.16–0.21) mg/kg with a mean of 0.19±0.04 mg/kg while the control was not detectable (<0.00) 1mg /kg. Chromium (8.08–9.96) mg/kg with a mean of 9.020± mg/kg while the control was 9.52 mg/kg. Vanadium (0.38–0.54) mg/kg with a mean of 0.46±.11 mg/kg while the control was 0.01 mg/kg. Nickel was (5.73–8.08) mg/kg with a mean of 6.91±1.7 mg/kg while the Control was 0.22 mg/kg; Zinc was (51.84 –59.17) mg/kg with a mean of 55.51±1.70 mg/kg, while the control had 14.03 mg/kg. Similarly, lead was (16.12– 21.58) mg/kg with a mean of 18.85±3.9 mg/kg, while the control was 6.62 mg/kg (Table 3). Metal concentrations were in this order: Zinc > lead >Nickel > Chromium > Vanadium >Cadmium (Fig. 5).

Table 2: The physicochemical parameters measured at the different sampling stations, Alesa Eleme

Parameters	Location 1	Location 2	Mean	Std.	Control
pH	7.64	8.04	7.84	0.28	8.10
Conductivity (µS/cm)	54	58	56	2.83	107
Phosphorus (mg/kg)	0.32	0.53	0.425	0.15	0.11
Sodium (mg/kg)	104.49	102.04	103.265	1.73	56.82
Calcium (mg/kg)	1403.94	1409.10	1406.52	3.65	1540.96

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Magnesium (mg/kg)	711.33	697.18	704.255	10.01	614.71
Potassium (mg/kg)	185.24	193.81	189.525	6.06	96.54
THC (mg/kg)	191.6	214.1	202.85	15.90	28.59
TPH (mg/kg)	143.7	160.6	152.15	11.95	21.44
TOC (%)	2.57	3.28	2.93	0.50	0.90
Organic Carbon (%)	2.43	3.43	2.93	0.71	0.54
Organic Matter (g/kg)	4.19	5.91	5.05	1.22	0.93
Textural Classification	Sandy Loam	Sandy Clay Loam			Sandy Clay
Sand (%)	70.32	74.44	72.38	2.91	50.32
Silt (%)	10.44	4.32	7.38	4.33	14.36
Clay (%)	19.24	21.24	20.24	1.43	35.32
Moisture Content (%)	23.9	27.4	25.65	2.48	32.1

THC=Total Hydrocarbon, TPH=Total Petroleum Hydrocarbon, TOC=Total Organic Carbon

Table 3: Concentrations of heavy metals in soils at the Alesa Study Area

Metals (mg/kg)	Location 1	Location 2	Mean	STd.	Control	WHO (1984) Permissible Limits
Cadmium	0.21	0.16	0.19	0.04	<0.001	0.3
Chromium	9.96	8.08	9.02	1.33	9.52	-
Vanadium	0.38	0.54	0.46	0.11	0.01	-
Nickel	5.73	8.08	6.91	1.66	0.22	-
Zinc	59.17	51.84	55.51	1.70	14.03	500
Lead	21.58	16.12	18.85	3.86	6.62	40

3.1 Discussion

The textural classification ranged from sandy loam to sandy clay loam at the truck park and sandy clay at the control (Table 2). The particle size distributions indicated predominance of sand (78.1) %; silt (12.8) % and clay (9.1) % in the study sites (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 moisture content ranged from (23.9 – 27.4) %, with a mean of 25.65±2.5 % while the control was 32.1 % (Table 2).

The pH values from the truck Parks (7.64 – 8.04) were alkaline while that of the control (8.10) was also alkaline. The result indicated that, Soil pH is an expression of the acidic, neutral or alkaline condition of the soil. The pH range of 7.64 – 8.04 is higher than the acidic range reported for Niger Delta soils (Isirimah, 1987; Odu *et al.*, 1985. The alkaline nature of the pH may be due to the presence of alkaline materials or liming materials such as wood ash, palm products, plantain leaves, and peels, formation of CaO and $Ca(OH)_2$, and the activities of micro-organism on wastes generated in the park (Ideriah *et al.*, 2006). pH correlated positively and significantly with TOC (r=0.67) and (r=0.54) with organic matter and organic carbon.

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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 pH is important because it influences the availability of essential nutrients. Most horticultural crops will grow satisfactorily in soils having a pH between 6 (slightly acid) and 7.5 (slightly alkaline). For most plants, however, a soil pH below 6.0 is undesirable (Jauron, 2002). Under acidic conditions, many soil minerals dissolve and increase the concentration of metal ions to toxic levels. The primary toxic metal is aluminum, but high levels of manganese and iron can also inhibit plant growth under these conditions.

Available phosphorous was more in truck parks than the control. Correlation with pH was not significant (r=0.48). The concentration of extractable macro-nutrient, Phosphorous in the truck parks (0.32-0.52) mg/kg were slightly higher than in the Control (0.11) mg/kg. This could be as a result of the utilization of residentmicro flora. 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 lower.

Higher Total organic carbon in the truck Park soils (2.57-3.28 %) than in the control (0.90 %) and organic carbon in soil (2.43-3.43 %) 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 higher at the truck parks than control (Table 2). The lowest organic carbon was at the control station (0.54 %). Total organic carbon (TOC) (3.28 %) was below even though very close to 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).

The concentrations of K, Ca, Na and Mg were in the order of Ca>K >Mg >Na and they all correlated strongly and positively with pH (r=0.86). Conductivity (µS/cm) at the truck park was lower (54.0- 58.0) (µS/cm) while the control was 107.0 (µS/cm) (Fig. 3).

The total hydrocarbon level represented a high level of hydrocarbon contamination on the truck sites (Fig. 4) when compared to that of the control of 28.0 mg/kg. Total petroleum Hydrocarbon (TPH) levels of 143.7-160.6 confirms contamination arising from petroleum activities of the tanker trucks at the park (Fig. 4). Osuji and others (2004), affirmed that such high hydrocarbon levels affect both above-ground and subterranean flora and fauna, which are essential adjuncts in the biogeochemical cycle that affect availability of plant nutrients. The intense infusion of degradable hydrocarbon likely stimulates aerobic microbial metabolism as oxygen becomes limiting utilization of alternate electron. In general, the essential elements required for plant growth, will be inherently low due to the high concentration of

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degradable hydrocarbons. These conditions generally imply low soil fertility, which in turn implies low agricultural productivity and reduced source of livelihood 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.

The concentrations of heavy metals in the truck parks were in the order of Zn > Pb >Cr > Ni > V > Cd (Fig. 5). These were higher (Cd, Zn, Cu and Pb) in comparison to the control. Zinc was the highest metal obtained (51.84-59.17) mg/kg at the truck park and 14.0 mg/kg at the control. Zinc levels though remarkably higher than the control value, were much below 500.0 mg/kg being WHO (1984) limit for zinc in surface soil. Zinc levels were in agreement with that reported by Ideriah *et al.* (2006) for soil in wet season. This was followed by lead (16.12 -21.58) mg/kg which also showed enhanced concentrations over the control value. However, concentrations were below the 40.0 mg/kg WHO (1984) limit for lead in surface soil. Chromium levels were similar both in the truck parks and the control, probably showing uniformity of chromium concentration in the area. Nickel concentrations at the parks were very pronounced with very low levels in the control. It is possible nickel is contained in the petroleum products. Vanadium was the least of the metals measured and it had enhanced concentrations at the truck parks than the control. The non detection of cadmium at the control showed contamination of the truck park with heavy metals. However, cadmium at truck park sites was below the permissible limits of 0.3 mg/kg (WHO, 1984) (Fig. 5). The concentrations of heavy metals were higher in the polluted soils thanthe control.

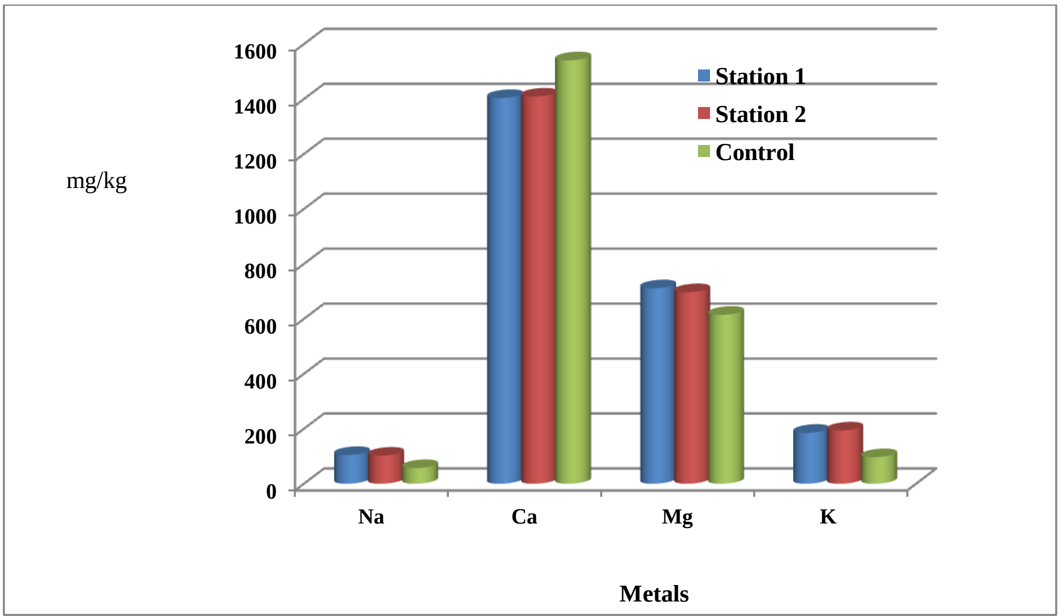

Fig. 3: Concentrations of Exchangeable Cations in truck soils at Alesa Eleme

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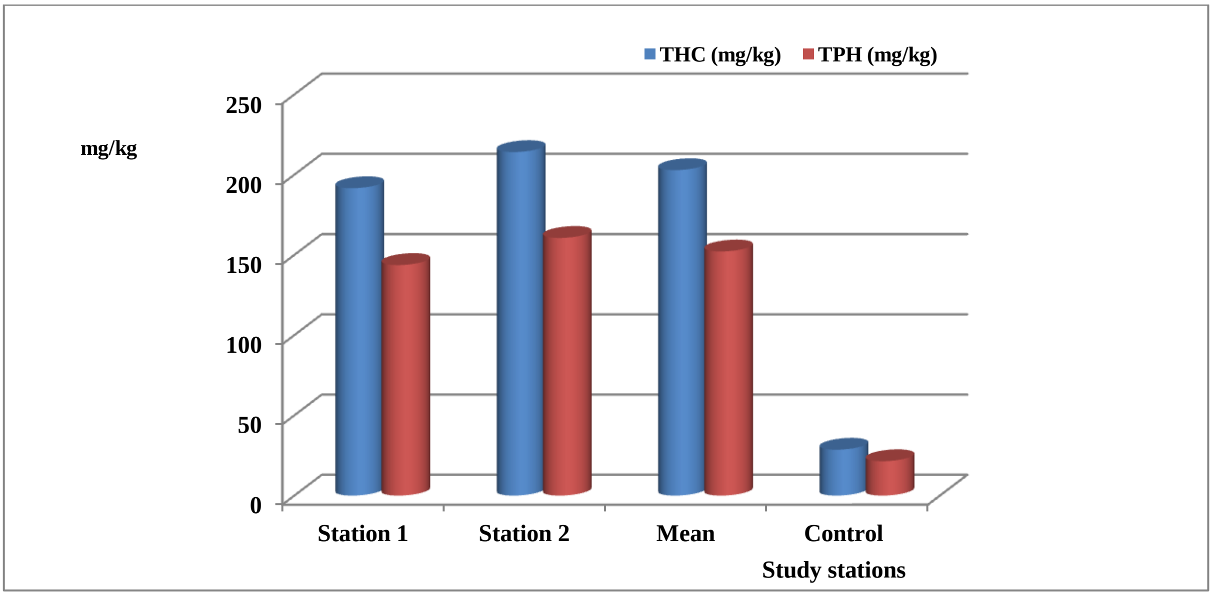

Fig. 4: Total Hydrocarbon/ Petroleum Hydrocarbon Concentrations in Alesa Truck Park Soil

Table 3: Heavy Metal content of Alesa Truck Park Soil

Metals (mg/kg)	Location 1	Location 2	Mean	Std.	Control
Cadmium	0.21	0.16	0.19	0.04	<0.001
Chromium	9.96	8.08	9.02	1.33	9.52
Vanadium	0.38	0.54	0.46	0.11	0.01
Nickel	5.73	8.08	6.91	1.66	0.22
Zinc	59.17	51.84	55.51	1.70	14.03
Lead	21.58	16.12	18.85	3.86	6.62

Std. =Standard Deviation

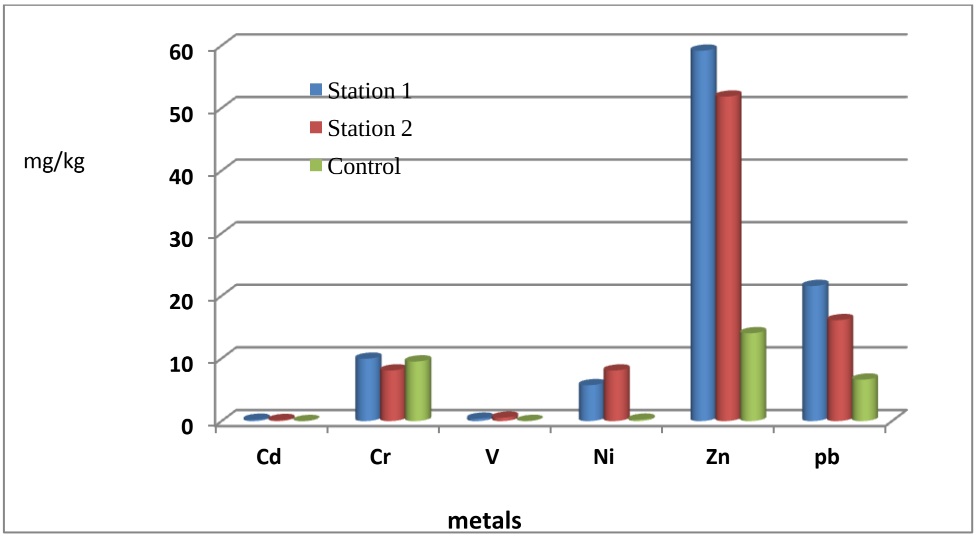

Fig. 5: Concentrations of heavy metals in truck soils at Alesa Eleme

4.0 CONCLUSION

The result showed that, total petroleum hydrocarbon levels observed have provided evidence of severe petroleum hydrocarbon contamination of the Alesa trailer park sites and this has led to an increase in the levels of heavy metals in the truck soil. The study recommends that more studies be done at trailer parks and meanwhile, the trailer parks should be located far from homes and farms. These conditions of soil contamination generally imply low soil fertility, which in turn implies low agricultural productivity and reduced source of livelihood in the affected areas. 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.

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