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OIL PRODUCING AND AGRO-ECOLOGICAL AREA IN THE NIGER DELTA, NIGERIA: CASE OF OIL SPILLAGE.

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ABSTRACT: *Environmental evaluation review (EER) is considered useful indicator of post mortem analysis of oil polluted soils. This research hypothesized that crude oil spillage has strongly influenced on soil properties dynamics of some Ultisols. The study was conducted on soil samples collected from crude oil spilled sites (n= 46), between two months and five years after spillage. The soil texture ranged from sand to loam, while the colour varied from dark brown (7.5 YR 3/2) to dark yellow grayish brown (10 YR 5/2) and was generally dark brown within two month of the spillage. Soils in some locations on the surface appeared to be fertile. However, this colour only occur to a depth of a few centimetres and then change to a mottled yellow-grey indicating that anaerobic conditions may exist for part of the years. Total heterotrophic bacterial counts (THBC) during 2012 varied from nil to 40.0 X 10^4 cfu/g soil with a mean value of 6.85 X 10^4 cfu/g on the surface soil and from nil to 35.0 X 10^4 cfu/g soils averaging 6.35 X 10^4 cfu/g in the subsurface layer. But in the control sites, THBC ranged from 10 to 15.0 X 10^4 cfu/g (20.0 X 10^4 cfu/g) and 8.0 to 30.0 X 10^4 cfu/g (22.67 X 10^4 cfu/g) in the respective layers of surface and subsurface soil. . Based on the relationship of these components, careful management of land is required to create an ideal condition for optimum plant growth and healthy soil.*

KEYWORDS: Oil spill, Pollution, Bacterial counts, Land management environment, Evaluation

INTRODUCTION

Either by design or an accident of nature, it is an incontrovertible fact that Nigeria is a nation richly endowed with oil (Odu, 2000). Crude oil is made up of petroleum hydrocarbons. They include natural deposits of crude oil, refined oil and oil waxes of biological origin. Nigeria's good luck in having an abundance of petroleum hydrocarbons has in the case of prospecting activities been a disaster for the environment, particularly the ecologically highly sensitive Niger Delta ecosystem where most of Nigeria's oil is produced. According to Edem et al., (2012), the science and technology of pipelining have progressed to a stage where the possibilities of small insidious linkages have been reduces to practical minimum. Accidents on the other hand still do happen which results in significant spillages and pollution.

Oil is something foreign to the soil and the apparent long-standing adverse effects of oil spillage on crops and soils. Oil by itself in polluting the soil is not toxic to plants, but it exerts its adverse effects on plants indirectly by creating certain conditions which make essential nutrients like NH_4 and NO_3 unavailable to the plants while the adverse conditions it create in the soil make some nutrient that are toxic to plant more abundant and available (SPDC, 1996). From the agricultural and scientific points of view, oil pollution is just a temporary setback to farming processes and just how temporary is determined by the level of pollution. Therefore this research aimed at assessing the effects of oil spillage on soil and biological properties during the first two and seven years of spillage.

MATERIALS AND METHODS

The vegetation of the area is rainforest. The important crops grown in the areas include; maize, cassava, yam, cocoyam, fluted pumpkin, banana and plantain. Between August and November 2007, a large volume of oil spilled from the corked well located in the area (Fig 1). Analysis of 16 and 46 Soil samples were collected from surface and subsurface layers during 2007 and 2012 respectively for EER on physical, chemical and biological properties of oil spilled soils near the Apara flow stations. A total of 40 Bulk, core and aggregate samples were collected at two depths of 15cm interval (0-l5 and 15-30cm). The core samples were obtained for saturated hydraulic conductivity and bulk density determinations. The soil samples were secured in a core and one end of the core was covered with a piece of calico cloth fastened with a rubber band and properly labeled while the bulk samples were collected and secured in a properly labeled polythene bags before it was conveyed to the University of Uyo Soil Science laboratory for physical, chemical and structural parameters determinations. Particle-size distribution was determined by the hydrometer meter (Day, 1965) chemical analyses were carried out on soil samples with a particle size < 2.0 mm using standard methods and procedures as outlined by Hinga et al., (1980). Soil samples were analysed for organic C using the Walkley and Black method (Black, 1965), total N by Kjeldahl digestion method, soil pH (1:2.5) soil-water suspension), available P by the molybdenum blue/ascorbic acid method (Mehlich et al., 1962), Na and K by flame photometer and Mg and Ca by the atomic absorption spectrophotometer method. Statistical analysis of the data was conducted on MegaStat 9.1 statistical package. The analysis was conducted to determine if there is significant difference between soil properties at soil near the flow stations during these periods after spillage. A one way ANOVA t-test was performed to show the mean of each variable and any significant difference. The significant difference is determined by Prob>F, if < 0.05 there is a significant difference.

RESULTS AND DISCUSSION

Soil texture and colour

The proportions of sand, silt and clay particles in the soil determine soil texture. The colour of a soil is perhaps its most obvious characteristic. Along with texture and structure, it forms the basis for soil classification. Usually colours seen in the field result from the mixing of colours formed by mineral and organic matter. A red-brown colour may be formed from a mixture of red iron oxide and brown organic matter. Organic matter build up in sand can be seen by a greying in the top 20 cm. In this study area, colour was objectively assessed by comparing the colour of a freshly broken surface of moist soil with the standard Munsell Soil Colour Charts.

During 2012 soil study at Apara flow stations (Table 1), on the surface and subsurface soil layers, the soil texture ranged from sand to loam, while the colour varied from dark brown (7.5 YR 3/2) to dark yellow grayish brown (10 YR 5/2) and was generally dark brown during 2007 sampling exercise. Soils in locations 3,7,12,17 and 20 on the surface appeared to be fertile. However, this colour only occur to a depth of a few centimetres and then change to a mottled yellow-grey indicating that anaerobic conditions may exist for part of the year. Growth on these soils would be poor. (David and Janssen, 2006). Generally, in the entire site studied nutrient contents are high, but some may be fixed due to immobilization.

Soil pH (soil reaction)

Soil pH is one of the most common and important measurements in standard soil analyses. Many soil chemical and biological reactions are controlled by the pH of soil solution in equilibrium with the soil particle surfaces (Taylor, 1955). Soil acidity is a major problem in the production of arable crops in the humid tropical soil of which Apara community is one. Yields of many crops are high reduced when the pH values are low (strongly acidic < 5.0) (NSPS, 2005). The results of soil reaction(Table 1) revealed only slight differences in pH from the two layers and control examined during 2007, it varied from slightly acidic to moderately acidic. But in 2012 assessment, great variances from slightly acidic to strongly acidic on the surface soil (4.5-6.7, 6.0), on the subsurface soil (4.0-6.8, 5.5) and control (4.6-5.6, 5.2). Obviously, the acidic level of the soils at locations 10, 15, 16, 31, 32, 42, 43 and 44 is very high and requires liming in order to support optimum plant growth.

Electrical conductivity (EC)

The estimate of solute concentration as a measure of Electrical conductivity (EC) of the soils (Table 1) indicates the amount of dissolved salt content in the soil. It is directly proportional to soluble salt. In 2007, Electrical conductivity values of soils of Apara flow station ranged from 167.2 µs/cm (sample station 3) to 470.0 µs/cm (sample station 6) at the surface level and from 147.2 µs/cm (sample station 5) to 394 µs/cm (sample station 6) at the sub surface level. The electrical conductivity value of the soil of the Apara flow station and the control station (362 and 107 for surface and sub surface soil levels respectively) are moderate. Whereas in 2012, EC varied from 188 – 420 µS/cm with a mean value of 284.85 (surface soil) and between185-476 µS/cm averaging 258.20 (subsurface soil) and the control stations, 188-280 µS/cm and 140-190 µS/cm for surface and subsurface layers respectively. However, the period between 200-2012 resulted in 5.6 % decrease in EC for surface layer, .34.7 % for control and no change for subsurface layer, while 34.39 % increase was observed in the subsurface control. These values are within the tolerance levels for plant growth. Electrical conductivity tolerance levels for plants growing on soils according to Tel (1984) have been set at 4000 µs/cm in the saturated soil extract.

Salinity

Salinity determined as chloride is a monovalent stable oxidation state of halogen in soils. It is essential for plant growth in trace amounts. Excessive amount of chloride in soils increase the osmotic pressure of the soil water thereby reducing the availability of water to plants (Isirimah *et al* 2003). The concentration of chloride of soils of Apara flow station (Table 1) in 2007 ranged from 40.18mg/kg (station 2) to 143.35 mg/kg (station 6) at the surface soil level, and from 36.80mg/kg (station 5) to 99.0 mg/kg (station 7) at the subsurface soil level. The chloride concentration at the control point was 30.12 mg/kg both at the surface and the subsurface soil level. Whereas in 2012, the range for salinity of the samples taken varied from 38.2 to 96.3 mg/kg averaging 69.35 mg/kg and 37.8 to 93.0 mg/kg averaging 60.60 mg/kg for surface layer and control respectively compared to the subsurface layer with salinity range of 29.8 to 103.4 mg/kg averaging 62.27 mg/kg and 33.0 to 82.10 mg/kg (52.37 mg/kg) for control. The salinity content of these soils was more in 2007 than 2012, except in control. These could partly be due to the sampling size of the earlier year and this measure of concentration may also be due to human activity which was more on soil then, than now.

Total Nitrogen

As shown in (Table 1), Total Nitrogen content of a soil gives an indication of the organic nitrogen present in the soil. Most of the Nitrogen in soils is in the organic form as only relatively small quantities occur in NH_4^+, and NH_3; the more available forms. The amount of available nitrogen in the soil is an indication of how suitable conditions in the soils are. A value below 0.1% total Nitrogen is considered low for soils (Bohn et al, 1984 and Isirimah et al 2003). Between the periods of 2007 to 2012, the concentration of Total Nitrogen in the soil of the Apara Flow station is high. In 2007, Total N values ranged from 62.2 mg/kg to 162.9 mg/kg at the surface soil level and from 121.8 mg/kg to 198.2 mg/kg at the sub surface soil level. The values for the control point were 97.4 mg/kg, and 137.3 mg/kg for the surface and subsurface soil levels respectively. While in 2012, Total N varied from 11.2 to 132.0 % with a mean value of 95.81 % on the surface soil layer and from 40.7 to 114.0 % with a mean of 81.54 % for subsurface soil layer. Surface layer of control ranged from 59.0 % to 83.0 % averaging 70.69 % when the subsurface control varied from 52.3-467.0 % with a mean value of 195.27. The Total Nitrogen values of 0.15%, 0.15% - 0.20%, and >2.0% are classified as low, medium, and high respectively (Enwezor et al, 1988). Therefore, the results indicated high concentration of total N for these periods.

Phosphorus

Phosphorus occurs naturally in the environment and is also a by product of many human activities. Phosphorus helps plants grow, but having too much of it on soil leads to excessive plant growth and blooms. Phosphorus is one of the nutrients that is very essential for plant growth. However not all the total phosphorus in the soil is available for plant uptake. This is because phosphorus occurs in soil matrix either in the occluded or solution form. Only the solution form of phosphorus is available for plant uptake. Most of the phosphorus in tropical soils that are available for plant uptake is induced by microbial activities in the soil. Thus phosphorus availability is also affected by soil environmental factors that affect microbial activities. The Phosphorus contents of the soils of the Apara flow station area in 2007 (Table 1) ranged from 1.34 mg/kg (sample station 4) to 2.13 mg/kg (sample station 6) at the surface soil level and from 1.26 mg/kg (sample station 3) to 5.07 mg/kg (sample station 6) at the subsurface soil level. In 2012, phosphorus content on the surface soil ranged from 0.75 to 1.18 mg/kg with a mean of 1.27 mg/kg, while the subsurface soil layer varied from 0.45 to

1.23 mg/kg with a mean of 0.88 mg/kg. Surprisingly, P content at the adjacent soils were very high. It ranged from 0.95 to 120 mg/kg with a mean of 40.72 mg/kg (surface soil) and 0.41 to 98.0 mg/kg with a mean of 33.03 mg/kg (subsurface soil layer). The phosphorus content of the soils at the flow stations are considered low as available phosphorus content of <3 mg/kg, 7 -20 mg/kg, and >20 mg/kg are classified as low, moderate, and high respectively (NPSPS, 2005).

Potassium

Potassium is an essential and major soil nutrient that occurs in mineral, exchangeable, and solution (available form plant uptake) forms. The primary source of potassium is the weathering of minerals while fertilizer application and mineralization of soil organics are lesser sources of potassium into the soil. The concentration of potassium in the soil of the Apara flow station area in 2007 (Table 1), ranged from 126.9 mg/kg (sample station 1) to 606 mg/kg (sample station 2) at the surface level, and from 155.9 mg/kg to 339.3 mg/kg at the subsurface soil level. The potassium concentration at the control station was 440 mg/kg and 374.9 mg/kg for the surface and subsurface soil levels respectively. In 2012, large quantity of K averaging 117.59 mg/kg (surface soil), 126.42 mg/kg (subsurface soil) and for surface and subsurface control, 87.93 mg/kg and 83.77 mg/kg respectively. These results are comparable to the extremely high of K of 2007 report. Even though there were apparent differences in surface and subsurface control concentration of K between 2007 and 2012, K concentrations in 2012 control soils are high.

Calcium

Ca is an essential nutrient element require by crop in large amount for sustainable growth and development. During 2007 soil study of the Apara flowstation area, it was assessed as $CaCO_3$ concentration of the soil and was rated low (Table 1). It ranged from 8.0 meq/100g to 16.0 meq/100g at both the surface and sub surface soil levels respectively. The control station concentration was slightly higher at 12.00meq/100g and 10.0 meq/100g at the surface and subsurface soil levels respectively. But in 2012 assessment, the content further drastically reduced to 3.33 meq/100g (2.16 to 5.13 meq/100g), 3.34 meq/100g (2.00 to 5.11 meq/100g) for surface and subsurface soils respectively. The difference was not significant in control soils as it varied from 2.49-3.87 meq/100g (averaging 3.17 meq/100g) and 2.14 to 3.78 meq/100g (averaging 2.73 meq/100g) for surface and subsurface control soil. This drastic reduction in Ca could be traceable to increase in soil acidity as the sorption site of the soil is saturated with acidic radicals instead of basic cation (Effiong *et al.*, 2006).

Magnesium

One of the most important plant nutrients but least researched in Nigerian soil may be because it poses least problem among major plant nutrients (NPK). Investigation of Apara flow stations revealed generally low availability of Mg, ranging from 0.23 to 2.48 meq/100g (averaging 1.64 meq/100g) and 0.11 to 2.48 meq/100g (averaging 1.37 meq/100g) on surface and subsurface soil layers respectively. But on the adjacent control soils, Mg varied from 1.04 to 2.77 meq/100g with a mean of 2.09 meq/100g on the surface soil and then increased down the layer to 2.26 meq/100g (2.12 to 2.49 meq/100g).

Heavy metals (Traced elements)

The mineral element originates from soil and dissolved in water for plant roots' absorption but those required in small quantity for optimum performance are regarded as traced elements The concentration of these metals can however be increased to become potential pollutants if heavy metals – containing waste products from industrial or domestic activities are introduced into the environment (Bohn et al, 1984). Concern over the presence of heavy metals in an environment arises from the fact that they cannot be broken down into non toxic forms. Thus once aquatic ecosystems are contaminated by heavy metals, they remain a potential threat for many years (Isirimah *et al* 2003).

Copper

Copper is important for the reproductive growth and root metabolism. A major property affecting the availability is soil pH, a measure of soil acidity or alkalinity. Cu tend to be less available in soils with high pH (Akinrinde, 2006). In the study of Apara flow station in 2007 (Table 2), Copper concentrations range from 4.7 mg/kg (sample station 1) to 16.06 mg/kg (sample station 7) at the surface soil level, and from 4.12 mg/kg (sample station 2) to 10.88 mg/kg (sample Station 7) at the subsurface soil level. The concentrations of copper at the control point are equally low with values at 6.73mg/kg at surface soil level and 5.08 mg/kg at the subsurface level. Zinc concentration ranged from 15.29 mg/kg (sample Station 2) to 103.27 mg/kg (sample station 6) at the surface soil level, and from 14.3 mg/kg (sample station 2) to 83.7 mg/kg (sample Station 6) at the subsurface soil level. The control point concentration was 23.21 mg/kg at surface soil level and 13.99 mg/kg at the subsurface level. But the concentration of Cu during 2012 study showed that, on the soil surface layer, Cu varied from 0.15 to 8.63 mg/kg (averaging,1.78mg/kg) and 0.06 to 2.13 mg/kg (0.81mg/kg) on the subsurface. Whereas in the control area, it ranged from 0.18 to 1.82 mg/kg (0.96 mg/kg) and 0.14 to 0.44 mg/kg (0.30 mg/kg) on surface and subsurface soil respectively. The concentration was significantly low in the control soils. Surface control soil layer ranged from 0.18 to 1.82 mg/kg (0.96 mg/kg) and 0.14 to 0.44 mg/kg (0.30 mg/kg) for subsurface soil. This suggests a large amount of copper in the previous study and may remain relatively unstable in the subsequence years.

Lead (Pb)

In 2007, Lead concentrations range from below detectable limit to 2.60 mg/kg at the surface soil level, and from below detectable limit to 1.46 mg/kg at the subsurface level. The control point concentrations are less than 0.001 mg/kg at both the surface and subsurface levels. While in 2012, Pb averagely made up to 0.143 mg/kg (0.01 to 1.04 mg/kg) and 0.108 mg/kg (0.01 to 0.63 mg/kg) in surface and subsurface soils respectively. In the control of same year, it ranged from 0.00 to 0.08 with a mean of 0.04 mg/kg (surface) and < 0.001 to 0.03 mg/kg.

Zinc

In 2007, Zn concentrations range from 15.29 to 103.4 mg/kg at the surface soil level, and from 14.3 to 83.70 mg/kg at the subsurface level. The control point concentrations averaged 23.21 mg/kg and 13.9 mg/kg at the surface and subsurface soil levels respectively. Whereas in 2012 soil study, Zn on the surface soil significantly dropped to concentration range of

10.0 mg/kg to 30.40mg/kg averaging 6.36 mg/kg, but increased from 5.29 to 110.88mg/kg with an average of 22.58mg/kg on the subsurface layer. For control soil, it ranged from10.33 to19.81 mg/kg (15.15 mg/kg) and 6.31 to 9.31 mg/kg (7.91 mg/kg) for surface and subsurface layers respectively. Generally, there was significant reduction in Zn concentration at Apara flow stations in 2012 when compared with earlier study.

Cadmium

Cadmium concentrations in 2007 study, ranged from 0.04 mg/kg (sample Station 1) to 0.36mg/kg at the surface soil level, and from below detectable limit to 0.57mg/kg (sample Station 3) at the subsurface level. The control point concentrations are 0.12 mg/kg and 0.14 mg/kg at the surface and subsurface soil levels respectively. While in 2012 soil study, Cd concentration on the surface soil range of 0.01 mg/kg to 0.53 mg/kg averaging 0.16 mg/kg, and from 0.03 to 0.08 mg/kg with an average of 0.08 mg/kg on the subsurface layer. For control soil, it ranged from 0.11 to 0.18 mg/kg (0.14 mg/kg) and 0.03 to 0.08 mg/kg (0.06 mg/kg) for surface and subsurface layers respectively.

Barium

Compare with 2012, Barium concentration during 2007 soil study, ranged from 0.53 mg/kg (sample station 3) to 1.56 mg/kg (sample Station 6) at the surface soil level, and from 0.44 mg/kg (sample Station 3) to 1.30 mg/kg (sample station 5) at the subsurface level. The control point concentrations are 0.72 mg/kg and 0.91 mg/kg at the surface and subsurface soil levels, respectively. But in 2012, concentration on the soil surface ranged from 0.11 to 1.51 mg/kg with a mean value of 0.79 mg/kg and 0.31 to 1.33mg/kg with a mean of 0.57 mg/kg on the subsurface layer. 0.25 to 0.53 mg/kg (0.14 mg/kg) and 0.11 to 0.93 mg/kg (0.57 mg/kg) were Barium respective concentration for surface and subsurface control sites

Iron

In 2007 soil study, Iron concentration ranged from 4220 mg/kg (sample station 1) to 11419 mg/kg (sample station 4) at the surface soil level, and from 5289 mg/kg (sample station 3) to 8426 mg/kg (sample station 5) at the subsurface soil level. The concentration of iron at the control point is equally high with values at 12291 mg/kg at surface soil level and 9106 mg/kg at the subsurface level. High concentration persisted in 2012 soil study. It varied from104.30 to 5106.00 mg/kg with a mean value of 1877 mg/kg and from122.42 to 4210.00 mg/kg averaging 1577.99mg/kg on the surface and subsurface soil layers. Control sites ranged from 810 to 1134 mg/kg (958.66 mg/kg) and from 588.90 to 1110.00 mg/kg (807.31mg/kg) on surface and subsurface layers respectively.

Organic compounds

Organic carbons are complex and valuable mixture of compounds which is alien to soil and their presence affects exchange of oxygen and stain surface soil. The concentration of Total organic C varied from 16.3 to 26. 1% with a mean of 19.93 % on the surface, but generally reduce in the sub surface soils to 14.4 to 20.6 % (averaging 17.75%). The reverse range was true for control sites. It varied from10.6 to 16.3% (19.93%) and 15.9 to 18.8 %(17.33%) in the respective layers.

Total hydrocarbon values are presented in Table 3a&b. Concentrations on the surface soil layer varied from 18.1 to 40.8 mg/kg (31.55 mg/kg) and 16.5 to 41.5 mg/kg with a mean value of 27.95mg/kg on the subsurface layer. The concentration in control site ranged from 27.5 to 31.2 mg/kg (29.13 mg/kg) on the surface layer and 20.9 to 29.70mg/kg (24.07 mg/kg) subsurface layer. The concentration of these organic compounds was relatively more on the soil surface. Also it could be accounted for manly from biogenic sources of wax and suberins from decay plants and animals. The area therefore is not contaminated by petroleum hydrocarbon.

Total Petroleum Hydrocarbon (TPH)

A crude oil or petroleum hydrocarbon as it is often called is predominantly make-up of carbon and hydrogen is not a specific single mineral substance. The study area (Apara flow station) was used for petroleum hydrocarbon production activities thus necessitating the need for evaluating the total petroleum hydrocarbon content of the soil. In 2007 (Table 2), Total Petroleum Hydrocarbon concentrations of the soil of the Apara flow station area ranged from 28.72 mg/kg (sample station 4) to 43.9 mg/kg (sample station 5) at the surface level, and from 30.03mg/kg (sample station 3) to 41.10 mg/kg (sample station 5) at the subsurface soil level. The control station concentration was 440 mg/kg and 374.9 mg/kg for the surface and subsurface soil levels respectively. But in 2012, significant concentration reductions were noticed. It varied from 16.30 to 39.10 mg/kg averaging 29.85 mg/kg and 16.50 to 41.30 mg/kg with a mean value of 27.05 mg/kg on the surface and subsurface soils respectively. The ranges were slightly higher than the control soils especially at the upper limit. It varied from 18.40 to 32.00mg/kg (25.10 mg/kg) and 15.10 to 28.50 mg/kg (21.07 mg/kg) on the respective surfaces.

Biological studies

The microbial community in soil is important because of its relationship to soil fertility and the biochemical cycling of elements. Thus the need to enumerate and isolate major and minor members of the microbial community in soils. Micro organisms are predictable of the first component of biota in an ecosystem to demonstrate the effect of environmental pollution resulting from any contamination. As shown in Tables 2, the soil microbes consisting mainly of fungi and bacteria substantially to the recycling of nutrients within the system. Total heterotrophic bacterial counts (THBC) during 2012 varied from nil to 40.0 X 10^4 cfu/g soil with a mean value of 6.85 X 10^4 cfu/g on the surface soil and from nil to 35.0 X 10^4 cfu/g soil averaging 6.35 X 10^4 cfu/g in the subsurface layer. But in the control sites, THBC ranged from 10 to 15.0 X 10^4 cfu/g (20.0 X 10^4 cfu/g) and 8.0 to 30.0 X 10^4 cfu/g (22.67 X 10^4 cfu/g) in the respective layers of surface and subsurface soil. Similarly, the heterotrophic fungi count in the soil did not change. It varied from zero to 2.0 X 10^4 cfu/g soil with mean values of 0.45 X 10^4 cfu/g and 0.30 X 10^4 cfu/g in both surface and subsurface soil layers. Surprisingly, no THFC was found on the control sites up to subsurface layer. Counts for the Hydrocarbon utilizing fungi (HUF) were equally low at both soil surfaces. Both ranged from zero to 2.0 10^4 cfu/g with means of 0.35 X 10^4 cfu/g and 0.00 to 1.0 X 10^4 cfu/g averaging 0.25 X 10^4 cfu/g in the respective layers of surface and subsurface soil. Counts for the Hydrocarbon utilizing bacteria (HUB) varied from zero to 18 X 10^4 cfu/g with an average of 4.28 X 10^4 cfu/g and zero to 7.0 X 10^4 cfu/g averaging 2.35 X 10^4 cfu/g in the surface and subsurface soil respectively. HUB was significantly ($p<0.05$) high in both surface and subsurface layers of the control sites. it ranged from 4.0 to 18.0 X 10^4 cfu/g (9.0 X 10^4 cfu/g) and 3.0 to 10.0 X 10^4 cfu/g (7.67 X 10^4 cfu/g) respectively. The high bacteria and fungal populations indicate that they have the potential to biodegrade petroleum hydrocarbons when they are inadvertently released into the environment. From the results, HUB are more prevalent at the surface of locations 27, 29, and 45 also 2, 28, 40 and 46 in the subsurface soil layer of the flow stations.

Coliform

The presence of fecal bacteria on soil increases the risk of transport of fecal bacteria to surface water (Nunez-Delgado et al., 2002). In addition, some fecal bacteria can be hazardous to human or animal health if the bacteria are ingested (Jones, 1999). Therefore understanding of the length of time fecal Coliform and *Escherichia coli* can survive in soil environments is an important factor in evaluating the risks associated with petroleum facility in an environment. When water is removed from this natural environment and used for drinking water as is the case with well water of Apara community, it is important that the water is free from organisms that can cause illness. One of the most common drinking water contaminants especially in rural water supplies is Coliform bacteria. As shown in Table 2, On the surface soil of the study area, it ranged from zero to 28.0 log(10) cfu/g with a mean value of 5.10 log(10) cfu/g, while on the surface soil, it varied from zero to 11.0 log(10) cfu/g averaging 2.55 log(10) cfu/g. But in the control soils, it ranged from 4.00 to 25.00 log(10) cfu/g (11.67 log(10) cfu/g) and 5.00 to 20.00 log(10) cfu/g (15.00 log(10) cfu/g) on the respective surfaces. On average, soil fecal Coliform concentrations in Apara study area declined from 15 cm soil depth at the flow station area but increases with depth at the adjacent control soils.

FINDINGS AND RECOMMENDATIONS

The following are the findings of these investigations. Recommendations, buttressed by the soil analytical investigations and experience in land use and management of soils of similar nature and environment are also prescribed. Oil by itself on polluting the soil is not toxic to plants but it exerts its adverse effects on plant indirectly by creating certain conditions which make nutrients essential for plant growth unavailable, while the adverse conditions creates in the soil makes some nutrient like Zn and Fe more available and toxic to plant . The significant reductions in total petroleum hydrocarbon during 2012 could be attributed to lighter nature of Nigeria crude oil which is easily decomposed by microorganisms and volatilizes under our humid tropical condition. Also the action of rainfall in the area aided downward seepage of oil. However, the multiplication of bacteria was a short-lived occurrence, with declines in fecal Coliform concentrations down the depth at the flow stations may be due to environmental changes (oil wells), thus causes the increase in fecal bacteria concentrations detected in the control soils.

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APPENDIX

Table 1. Means and Standard Deviation of Physico-Chemical Parameters of polluted soils naer Flow Stations (Between 2007 &2012)

Soil component	Parameters /units	Depth	Akpo/Apara EER, 2007-2012		STD	Control	
			2007 Range	2012 Range		2007* Range	2012 Range
Physical properties	Sand %	Surface		51.00 - 81.22	8.66		89.20 - 92.00
		Subsurface		55.00 - 93.26	8.90		89.86 - 94.54
	Silt %	Surface		2.74 - 16.80	4.10		4.00 - 5.40
		Subsurface		3.37 - 12.80	3.15		2.73 - 6.07
	Clay %	Surface		10.20 -32.20	7.73		4.0-5.4
		Subsurface		3.37- 32.20	7.98		2.73-6.07
	Texture	Surface		Sand –loamy sand			Sand –loamy sand
		Subsurface		Sand - loam			Sand - loam
Morphological characteristics	Colour	Surface	Brown	Dark brown-Yellowish brown		Brown	Dark brown
		Subsurface	Brown	Dark brown- dark yellow grayish brown		Brown	Dark brown
Chemical properties	pH	Surface	5.3-6.9	4.5-6.7	0.62		4.7-5.7
		Subsurface	5.2-6.8	4.0-6.8	0.78		4.5-5.0
	EC_{25} uS/cm	Surface	167-470	188-420	64.14		188-280
		Subsurface	147-394	185-476	80.28		140-192
	Nitrogen	Surface	62.2-162.9	11.20-132.00	37.31		59.0-83.0
		Subsurface	121.8-198.2	11.40- 40.70	21.34		52.3-467
	Phosphorus	Surface	1.34-2.13	0.75 - 1.18	0.27		0.95-120
		Subsurface	1.26-5.07	0.45-1.23	0.26		0.41-98.0
	Potassium	Surface	126.9-606	85.10-194.00	29.65		78.1-98.7
		Subsurface	155.9-339.3	58.40-645.00	122.9		62.5-103.1
	Calcium	Surface		1.12-5.13	088		2.49-3.87
		Subsurface		2.00-5.11	0.93		2.14-3.78
	Magnesium	Surface		0.12-2.45	0.66		1.04-2.77
		Subsurface		0.11-2.48	0.62		2.12-2.49
	Salinity	Surface	40.18-143.4	38.20-96.30	17.43		37.8-93.0
		Subsurface	36.8-99	29.80-103.40	20.54		33.0-82.1

Table 2. Means and Standard Deviation of Heavy Metals, Organics and Microbial Counts at oil spill soil (Between 2007 &2012)

Soil component	Parameters /units	Depth	**Akpo/Apara EER, 2007-2012**		**STD**	**Control**	
			2007 Range	**2012 Range**		**2007* Range**	**2012 Range**
Heavy Metals	Copper	Surface	4.7-16.06	0.15-8.63	1.858		0.18-1.82
		Subsurface	4.12-10.88	0.06-2.13	0.668		0.14-0.44
	Lead	Surface	<0.001-2.6	0.01-1.04	0.275		0.00-0.08
		Subsurface	<0.001-1.46	0.01-0.63	0.178		<0.001-0.03
	Zinc	Surface	15.29-103.4	10-30.4	6.36		10.33-19.81
		Subsurface	14.3-83.7	5.29-110.88	22.58		6.31-9.31
	Cadmium	Surface	0.04-0.36	0.01-0.53	0.125		0.11-0.18
		Subsurface	<0.001-0.57	0.01-0.36	0.083		0.03-0.08
	Barium	Surface	0.53-1.56	0.11-1.51	0.347		0.25-0.53
		Subsurface	0.44-1.30	0.31-1.33	0.345		0.11-0.93
	Iron	Surface	4220-11419	104.3-5106	1459.06		810-1134
		Subsurface	5289-8426	122.42-4210	1163.71		588.9-1110
Organic compounds	TOC	Surface		16.3-26.1	2.43		10.6-16.3
		Subsurface		14.4-20.6	2.03		15.9-18.8
	THC	Surface		18.1-40.8	5.64		27.5-31.2
		Subsurface		16.5-41.3	7.13		20.9-29.7
	TPH	Surface	28.72-43.93	16.3-39.1	4.48		18.4-32.0
		Subsurface	30.03-41.1	16.5-41.3	6.12		15.0-28.5
Microbial Counts	THBC	Surface		0-40	9.82		10-40
		Subsurface		0-35	7.55		8-30
	THFC	Surface		0-2	9.82		0-0
		Subsurface		0-2	0.57		0-0
	HUB	Surface		0-18	4.29		4-18
		Subsurface		0-7	2.03		3-10
	HUF	Surface		0-1	0.48		0-2
		Subsurface		0-1	0.44		0-28
	Coliform	Surface		0-28	68.09		4-25
		Subsurface		0-11	3.49		0-11

*There were no values for the affected parameters in the respective period(s)