International Research Journal of Advanced Engineering and Science
ISSN (Online): 2455-9024

Effect of Oil Spillage on the Soil Properties

Anyadiegwu C.I.C[1], Ohia N.P.[2]
[1, 2]Department of Petroleum Engineering, Federal University of Technology, Owerri
Email address: [1]drcicanyadiegwu@yahoo.com

***Abstract*— *The effect of oil spillage on the properties of soil are studied in this work. The study site is around the vicinity of Imo River-2 flow station at Owaza in Abia State of Nigeria, located East of Nkali and North of Isimiri flow stations in the Niger Delta Basin. Soil samples were taken from three oil-impacted areas and an unimpacted (control) area. The contaminated areas considered are at the wellhead, far from the wellhead (100 metres from the wellhead) and very far from the wellhead (within the flow station). Soil samples were collected at surface (0-15 cm) depths. The soil properties considered were total hydrocarbon content, moisture content, soil pH, electrical conductivity, total organic carbon content, organic matter content, phosphorus content, potassium availability and nitrate-nitrogen content. The study shows that oil spillage affects the site where they occur by the reduction of the nutrients in the site (land or water).*

***Keywords*— *Oil spillage, wellhead, control, flow station, soil*.

I. INTRODUCTION

Crude oil is a mixture-not only of hydrocarbons, but of suspended salts and of sulphur compounds. The toxicity of some of the hydrocarbons and some of the sulphur compounds is discussed, as is the toxicity of salt. Consideration is also given to the complexity of the hydrocarbon components and the influence of refining methods on toxicity (Shaw, 1976).

According to Duru et al (2009), crude oil spillage is one major means of environmental pollution in oil and gas producing areas. It has far reaching effects in the soil and water where it distorts their structures and affects the biota. Since 1976, about 5334 case of crude oil spillage releasing an estimated 2.8 million barrels of oil into the land, swamps, estuaries and coastal waters have been reported in Nigeria. It is noteworthy that the devastating consequences of spill of crude oil with its eventual hazards to both aerial and terrestrial environs is tantamount to irreversible chain effect on both bio-diversity and human safety.

II. EFFECTS OF OIL SPILLAGE

Exploitation of hydrocarbons has led to oil spills, which have impacted on the Niger Delta environment in both positive and negative ways. The impact of environmental degradation caused by oil pollution has been a subject of several litigations, politically induced violence and other behaviours but little attention has been paid to the positive effects of oil spillage (Ozumba et al., 2005).

The impacts of oil spills are not limited to the direct effect on the ecosystem; it goes a long way to affect the social welfare, aggravates poverty, population displacement, social conflict, production reduction and also affects the profit margin of the companies involved. This study is aimed at providing a review and comparison of the remediation techniques currently in use and suggest the most suitable methods of oil spill clean-up and remediation in Nigeria Niger Delta region based on certain criteria and to also suggest ways of mitigating oil spill occurrences in this region. In the course of this research study, data collection was on primary and secondary data (Olayinka et al., 2013).

Generally, oil spills in water may lead to surface floating oil, oil components in the atmosphere due to the evaporation and oil droplets in the water column entrained by breaking waves. Submerged floating or sunk semi-solid oil lumps and tar balls in the seawater may happen after severe weathering of surface slick and the uptake of seawater and emulsification process leading to density of oil mass that is very close or even greater than seawater density (Mohamed et al., 2005).

Onshore oil spillages can cause a range of pervasive impacts over the environment, human health and society. Impacts can be immediate or long term, which depends upon variables such as soil properties, ground surface permeability, water flow characteristics, etc. Immediate impacts include inhalation of toxic vapours, impoverishment of air quality by evaporation and risks of explosion. Long term consequences include water sources contamination, bioaccumulation of toxins, change in soil properties and physical damage to biota, which moreover could affect fish farming and crop growing (Sanchez-Thorin et al., 2008).

According to Hinson (1972), with increasing use of offshore and estuarine facilities for production, handling, and transportation of refined and crude oil products, the potential for ecological destructive spillage is greatly enhanced. Restoration of damaged habitats previously has been limited to mechanical and chemical clean-up, with biological devastation left to natural recovery. However, the long time periods necessary to achieve successful ecological recovery must be shortened to allow for maximum utilization of local sport are commercial fisheries, wildlife and waterfowl resources, and water-oriented recreation. Estuarine habitats may be greatly impaired by large quantities of spilled oi1 due to the toxic aromatics and water-soluble fractions, emulsification of oil, and adsorption of oil into sediments. High initial mortality may completely eliminate sensitive benthic and intertidal faunas, or, if incomplete, drastically alter the existing species diversity and community stability. Repopulation will be hindered by lack of adequate food resources, residual sediment toxicity, lack of clean substrate for larval attachment, and the seasonal abundance of immigrating juvenile and larval forms. Restoration in this discussion includes those post-clean-up activities which aid in the ecological recovery of an oil-disrupted area. Ecological recovery responds direct to the success of oil clean-up activities, particularly the degree of environmental detoxification achieved. However, specific clean-up practices, especially the extensive use of surfactants or emulsifiers, can increase overall spill toxicity and further hinder reputation of the resultant biological wasteland. Mechanical and chemical removal techniques for removal of crude and refined oils may not be technically or economically feasible under some conditions. Biological methods using oil-degrading bacteria prove beneficial in facilitating recovery after these "uncleaned" spills. In all these cases, artificial repopulation techniques should be able to accelerate natural recovery.

According to Ritchie et al (1972), if we are to develop an effective means of preventing spills of oil, we must first understand the nature and causes of such spills. How do they occur? Why do they occur? Where do they occur? How frequent? How big? What kind? A part of this historical spill data is already available at several federal agencies, state offices, and industries. Spill data have improved considerably since September 1970 when notification of a harmful discharge of oil became a mandatory requirement. A review of state and federal oil spill reports reveals four major causes of spills: (1) human error related to inadequate operational procedures or handling; (2) poorly designed, inadequate, non-existent, or faulty equipment; (3) acts of God; and (4) acts of third parties. To prevent spills from occurring we must examine not only the reported causes, but also the corrective actions taken and preventive measures applied which might eliminate these potential failures at other facilities.

Oil spillage can be resultant from pipeline failures. Petroleum pipelines are generally subject to different degrees of failure and degradation during operation and in their entire life cycle. Failure reduces the integrity of an operating pipeline, and consequently lowers its service life (Dawotola, 2012).

III. MATERIALS AND METHODS

3.1 Sampling Design and Site Description

3.1.1 Site description

The study site is around the vicinity of Imo River-2 flow station at Owaza in Abia State of Nigeria, located East of Nkali and North of Isimiri flow stations in the Niger Delta Basin. The release was caused by valve failure at the relief pit behind the flow station and covered over five hectares of arable land. An estimated 30,000 barrels (approximately 4.8 million litres) of crude oil was released.

3.1.2 Historical antecedence and geo-characteristics of soils

About 4 soil types from various soil zones of the Niger Delta have been identified. The study site soils fall within the Agbada-1 and Agbada-2 prospect areas of the Niger Delta Basin and are believed to have been derived from the quartenary Warri-Sombreiro plains; the major underlying bedrock of the area. This plain appears on either side of the recent alluvial plain and was deposited in the Late Pleistocene to Early Holocene time. It occupies an area similar to the present day Delta but was mostly eroded away during the ice ages when the sea level was lower. The sediments occur as grey to dark grey/brown clayey-silty sands. These sediments likely retard vertical infiltration to a shallow aquifer around the Agbada flow station thereby limiting contamination to the near surface horizon.

3.1.3 Climate

The study area lies in the wet equatorial climate region, with high cloud cover characterized by limited sunshine, extended high cloud cover, low sunshine hours and very high relative humidity most of the year. The study area records a mean daily temperature of 26^0C and monthly rainfall of 180 mm respectively; rain falls every month of the year with a short dry spell in the months of January to March (NDES, 1999).

3.1.4 Sampling design and soil collection

Soil samples were taken from three oil-impacted areas and an unimpacted (control) area. The contaminated areas considered are at the wellhead, far from the wellhead (100 metres from the wellhead) and very far from the wellhead (within the flow station). Soil samples were collected at surface (0-15 cm) depths. The soil samples were put in aluminium foil paper bags, labelled and taken to the laboratory.

3.2 Laboratory Analyses

3.2.1 Oil extraction and estimation of total hydrocarbon content

Five grams (5g) of each soil sample was weighed out and transferred into a 500ml volumetric flask. Into this was added 50ml of xylene. The xylene/soil mixture was shaken vigorously for five minutes and filtered into 400 ml cylinder. The volumetric flask and soil materials were rinsed properly with 500ml xylene and filtered again into the cylinder. The xylene-oil extract was thereafter placed in cuvette wells and its absorbance was determined using Hack DR/2010 Particle Data Logging Spectophotometer. A calibration curve was obtained by measuring the absorbance of dilute standard solutions of lease oil (Bonny Light/Bonny Medium Crude Oils), prepared by diluting 2.5, 5.0, 10.0, 20.0, 25.0 and 30.0 microlitres of the lease oil with 50 ml xylene solution. Total hydrocarbon content (THC) was calculated after reading the absorbance of the extract from the spectrophotometer at a wavelength of 425 nm. The process was repeated two extra times and the data values were noted for the three trials.

3.2.2 Determination of moisture content

A constant weight of watch glass was obtained and thereafter, 20g of sample was weighed into the watch glass, and transferred into the oven for 1hr at 110^0C. The sample was cooled inside desiccators for 30 min before a constant weight of the sample and watch glass after heating and cooling was recorded. The process was repeated two extra times and the moisture contents were noted for the three trials.

3.2.3 Determination of soil pH and electrical conductivity (EC)

To five grams (5.0g) of each soil sample (in a sample cell) was added 50 ml of distilled water. The lump of the soil was stirred to form homogenous slurry, then pH-meter (Jenway 4010 model) probes were immersed respectively into the sample and allowed to stabilize at 25^0C and pH of sample was recorded. The process was repeated two extra times and the pH were noted for the three trials.

3.2.4 Total organic carbon (TOC) and Total organic matter (TOM) contents

Half a gram (0.5g) of each air-dried soil sample was put into a conical flask and 2.5 ml of 1N potassium dichromate solution $K_2Cr_2O_7$ was added and swirled gently to disperse the sample in the solution. 5 ml of concentrated tetraoxosulphate(VI) acid was added rapidly, into the flask and swirled gently until sample and reagents were mixed and finally swirled vigorously for about a minute. The flask was allowed to stand in a fume cupboard for 30 minutes. Five to ten (5 to 10) drops of the indicator were added and the solution titrated with 0.5N F_eSO_4 to maroon colour. A blank determination was carried out to standardize the dichromate (Nelson and Summers, 1982). TOC and TOM contents were calculated as follows:

$$\text{TOC (\%)} = [(\text{meq } K_2Cr_2O_7 - \text{meq } F_eSO_4) * 0.003*100*1.3]/\text{wt of sample (g)} \quad 3.1$$

$$\text{TOM (\%)} = \text{TOC (\%)} * 1.724 \quad 3.2$$

3.2.5 Extractable phosphorus

Bray-1 Method

The soil phosphorus measured was that which is extracted by a solution consisting of 0.025 normal HCl and 0.03 normal NH_4F, referred to as Bray-1 extractant. A 1 gram scoop of air-dried soil and 10 milliliters of extractant were shaken for 5 minutes. The amount of phosphorus extracted was determined by measuring the intensity of the blue color developed in the filtrate when treated with molybadate-ascorbic acid reagent. The color is measured by a Brinkman PC 900 probe colorimeter at 880 nm. The result is reported in parts per million (ppm) phosphorus (P) in the soil and they were converted to mg/kg. The phosphorus measured does not represent all of the phosphorus that may be available for plant growth; e.g., some fraction of the organic phosphorus not measured may become available upon mineralization. The upper reporting limit for this test is 100 ppm. The process was repeated two extra times and the values were noted for the three trials.

3.2.6 Available potassium

Potassium was extracted from the soil by mixing 10 milliliters of 1 normal ammonium acetate, pH7 with a 1 gram scoop of air-dried soil and shaken for 5 minutes. The available potassium was measured by analyzing the filtered extract on an atomic absorption spectrometer set on emission mode at 776 nm. The results are reported as parts per million (ppm) of potassium (K) in the soil and they were converted to mg/kg. The process was repeated two extra times and the values were noted for the three trials.

3.2.7 Nitrate-nitrogen

Nitrate-nitrogen was determined by adding 60 milliliters of KCl extracting solution to a 2 gram scoop of soil and shaken for 15 minutes. The nitrate level in the filtered extract is measured on a Lachat QuickChem 8500 Flow Injection Analyzer by the cadmium reduction method. The results are reported as parts per million (ppm) nitrate-nitrogen (NO_3-N) in the soil and they were converted to mg/kg. The process was repeated two extra times and the values were noted for the three trials.

IV. Results

4.1 Results of the Soil Properties Analyses at the Wellhead

4.1.1 Nitrogen content

The concentrations of extractable nitrogen in the soil at the wellhead were gotten from the analyses for the three trials. The result of the amount of nitrogen at the first trial was gotten as 2.06mg/kg. At the second trial, the result was 2.13mg/kg while the result at the third trial was 2.11mg/kg.

4.1.2 Phosphorous content

The concentrations of phosphorous and compounds of phosphorous in the soil at the wellhead were gotten from the analyses for the three trials. The result of the amount of phosphorous at the first trial was gotten as 0.23mg/kg. At the second trial, the result was 0.24mg/kg while the result at the third trial was 0.24mg/kg.

4.1.3 Potassium ions and compounds

The concentrations of metallic ions and compounds in the soil at the wellhead were gotten from the analyses for the three trials. The result of the amount of potassium ions and compounds at the first trial was gotten as 7.64mg/kg. At the second trial, the result was 7.91mg/kg while the result at the third trial was 7.83mg/kg.

4.1.4 Total organic carbon content

The amounts of organic carbon present in the soil at the wellhead were gotten from the analyses for the three trials. The result of the amount of carbon at the first trial was gotten as 1.08mg/kg. At the second trial, the result was 1.12mg/kg while the result at the third trial was 1.1mg/kg.

4.1.5 Total organic matter content

Total organic matter in the soil at the wellhead were gotten from the analyses for the three trials. The result of the amount of organic matter at the first trial was gotten as 1.86mg/kg. At the second trial, the result was 1.92mg/kg while the result at the third trial was 1.90mg/kg.

4.1.6 Total hydrocarbon content

The concentrations of hydrocarbon compounds in the soil at the wellhead were gotten from the analyses for the three trials. The result of the hydrocarbon volumes at the first trial was gotten as 29400mg/kg. At the second trial, the result was 30450mg/kg while the result at the third trial was 30150mg/kg.

4.1.7 Moisture content

The percentages of moisture in the soil at the wellhead were gotten from the analyses for the three trials. The rate of moisture at the first trial was gotten as 44.1%. At the second trial, the result was 45.67% while the result at the third trial was 45.2%.

4.1.8 pH

The values of the pH of the soil at the wellhead were gotten from the analyses for the three trials. The pH at the first trial was gotten as 2.4. At the second trial, the result was 2.5 while the result at the third trial was 2.5.

4.1.9 Electric conductivity

The conductivity of the soil at the wellhead were gotten from the analyses for the three trials. The conductivity at the first trial was gotten as 150µS/cm. At the second trial, the result was 155µS/cm while the result at the third trial was 153µS/cm.

4.2 Results of the Soil Properties Analyses Far (100metres) From Wellhead

4.2.1 Nitrogen content

The concentrations of extractable nitrogen in the soil far from the wellhead were gotten from the analyses for the three trials. The result of the amount of nitrogen at the first trial was gotten as 10.6mg/kg. At the second trial, the result was 11.06mg/kg while the result at the third trial was 10.95mg/kg.

4.2.2 Phosphorous content

The concentrations of phosphorous and compounds of phosphorous in the soil far from the wellhead were gotten from the analyses for the three trials. The result of the amount of phosphorous at the first trial was gotten as 1.17mg/kg. At the second trial, the result was 1.21mg/kg while the result at the third trial was 1.2mg/kg.

4.2.3 Potassium ions and compounds

The concentrations of metallic ions and compounds in the soil far from the wellhead were gotten from the analyses for the three trials. The result of the amount of potassium ions and compounds at the first trial was gotten as 12.9mg/kg. At the second trial, the result was 13.4mg/kg while the result at the third trial was 13.2mg/kg.

4.2.4 Total organic carbon content

The amounts of organic carbon present in the soil far from the wellhead were gotten from the analyses for the three trials. The result of the amount of carbon at the first trial was gotten as 3.04mg/kg. At the second trial, the result was 3.14mg/kg while the result at the third trial was 3.11mg/kg.

4.2.5 Total organic matter content

Total organic matter in the soil far from the wellhead were gotten from the analyses for the three trials. The result of the amount of organic matter at the first trial was gotten as 5.19mg/kg. At the second trial, the result was 5.37mg/kg while the result at the third trial was 5.32mg/kg.

4.2.6 Total hydrocarbon content

The concentrations of hydrocarbon compounds in the soil far from the wellhead were gotten from the analyses for the three trials. The result of the hydrocarbon volumes at the first trial was gotten as 14700mg/kg. At the second trial, the result was 15225mg/kg while the result at the third trial was 15075mg/kg.

4.2.7 Moisture content

The percentages of moisture in the soil far from the wellhead were gotten from the analyses for the three trials. The rate of moisture at the first trial was gotten as 30.38%. At the second trial, the result was 31.46% while the result at the third trial was 31.15%.

4.2.8 pH

The values of the pH of the soil far from the wellhead were gotten from the analyses for the three trials. The pH at the first trial was gotten as 3.6. At the second trial, the result was 3.7 while the result at the third trial was 3.7.

4.2.9 Electric conductivity

The conductivity of the soil far from the wellhead were gotten from the analyses for the three trials. The conductivity at the first trial was gotten as 416µS/cm. At the second trial, the result was 431µS/cm while the result at the third trial was 427µS/cm.

4.3 Results of the Soil Properties Analyses Very Far From Wellhead (Within the Flow Station)

4.3.1 Nitrogen content

The concentrations of extractable nitrogen in the soil very far from the wellhead were gotten from the analyses for the three trials. The result of the amount of nitrogen at the first trial was gotten as 15.09mg/kg. At the second trial, the result was 15.63mg/kg while the result at the third trial was 15.47mg/kg.

4.3.2 Phosphorous content

The concentrations of phosphorous and compounds of phosphorous in the soil very far from the wellhead were gotten from the analyses for the three trials. The result of the amount of phosphorous at the first trial was gotten as 2.28mg/kg. At the second trial, the result was 2.36mg/kg while the result at the third trial was 2.34mg/kg.

4.3.3 Potassium ions and compounds

The concentrations of metallic ions and compounds in the soil very far from the wellhead were gotten from the analyses for the three trials. The result of the amount of potassium ions and compounds at the first trial was gotten as 21.69mg/kg. At the second trial, the result was 22.4mg/kg while the result at the third trial was 22.25mg/kg.

4.3.4 Total organic carbon content

The amounts of organic carbon present in the soil very far from the wellhead were gotten from the analyses for the three trials. The result of the amount of carbon at the first trial was gotten as 3.64mg/kg. At the second trial, the result was 3.77mg/kg while the result at the third trial was 3.73mg/kg.

4.3.5 Total organic matter content

Total organic matter in the soil very far from the wellhead were gotten from the analyses for the three trials. The result of the amount of organic matter at the first trial was gotten as 6.66mg/kg. At the second trial, the result was 6.9mg/kg while the result at the third trial was 6.8mg/kg.

4.3.6 Total hydrocarbon content

The concentrations of hydrocarbon compounds in the soil very far from the wellhead were gotten from the analyses for the three trials. The result of the hydrocarbon volumes at the first trial was gotten as 3430mg/kg. At the second trial, the result was 3552mg/kg while the result at the third trial was 3517mg/kg.

4.3.7 Moisture content

The percentages of moisture in the soil very far from the wellhead were gotten from the analyses for the three trials. The rate of moisture at the first trial was gotten as 29.4%. At the second trial, the result was 30.4% while the result at the third trial was 30.1%.

4.3.8 pH

The values of the pH of the soil very far from the wellhead were gotten from the analyses for the three trials. The pH at the first trial was gotten as 4.7. At the second trial, the result was 4.9 while the result at the third trial was 4.8.

Anyadiegwu C.I.C and Ohia N.P., "Effect of oil spillage on the soil properties," *International Research Journal of Advanced Engineering and Science*, Volume 3, Issue 4, pp. 238-245, 2018.

4.3.9 Electric conductivity

The conductivity of the soil very far from the wellhead were gotten from the analyses for the three trials. The conductivity at the first trial was gotten as 978µS/cm. At the second trial, the result was 1012µS/cm while the result at the third trial was 1002µS/cm.

4.4 Results of the Soil Properties Analyses at the Control Area

4.4.1 Nitrogen content

The concentrations of extractable nitrogen in the soil at the control area were gotten from the analyses for the three trials. The result of the amount of nitrogen at the first trial was gotten as 35.47mg/kg. At the second trial, the result was 36.74mg/kg while the result at the third trial was 36.38mg/kg.

4.4.2 Phosphorous content

The concentrations of phosphorous and compounds of phosphorous in the soil at the control area were gotten from the analyses for the three trials. The result of the amount of phosphorous at the first trial was gotten as 4.5mg/kg. At the second trial, the result was 4.67mg/kg while the result at the third trial was 4.62mg/kg.

4.4.3 Potassium ions and compounds

The concentrations of metallic ions and compounds in the soil at the control area were gotten from the analyses for the three trials. The result of the amount of potassium ions and compounds at the first trial was gotten as 40.57mg/kg. At the second trial, the result was 42.02mg/kg while the result at the third trial was 41.6mg/kg.

4.4.4 Total organic carbon content

The amounts of organic carbon present in the soil at the control area were gotten from the analyses for the three trials. The result of the amount of carbon at the first trial was gotten as 4.41mg/kg. At the second trial, the result was 4.56mg/kg while the result at the third trial was 4.52mg/kg.

4.4.5 Total organic matter content

Total organic matter in the soil at the control area were gotten from the analyses for the three trials. The result of the amount of organic matter at the first trial was gotten as 7.44mg/kg. At the second trial, the result was 7.71mg/kg while the result at the third trial was 7.64mg/kg.

4.4.6 Total hydrocarbon content

The concentrations of hydrocarbon compounds in the soil at the control area were gotten from the analyses for the three trials. The result of the hydrocarbon volumes at the first trial was gotten as 0.196mg/kg. At the second trial, the result was 0.203mg/kg while the result at the third trial was 0.201mg/kg.

4.4.7 Moisture content

The percentages of moisture in the soil at the control area were gotten from the analyses for the three trials. The rate of moisture at the first trial was gotten as 9.2%. At the second trial, the result was 9.54% while the result at the third trial was 9.44%.

4.4.8 pH

The values of the pH of the soil at the control area were gotten from the analyses for the three trials. The pH at the first trial was gotten as 5.39. At the second trial, the result was 5.58 while the result at the third trial was 5.52.

4.4.9 Electric conductivity

The conductivity of the soil at the control area were gotten from the analyses for the three trials. The conductivity at the first trial was gotten as 1784µS/cm. At the second trial, the result was 1848µS/cm while the result at the third trial was 1830µS/cm.

4.5 Evaluation of the Mean Values of the Soil Parameters and their Deviation Percentages from the Control Area Mean Values

The mean values of the soil parameters refer to the average values of the soil parameters gotten in the three trials for the cases of soil collected at the wellhead, soil collected far from the wellhead, soil collected very far from the wellhead and soil collected at the un-impacted or control area. The deviation percentage of each mean value from the control area mean values refers to the extent to which the value of that parameter at that case deviates from what it would have been if the soil in the area was not impacted by spillage. The deviation percentage is computed using Equation 4.1 shown below:

$$D = (|E|/C)*100 \qquad 4.1$$

Where, D = Deviation percentage, %.

E = Difference in the mean value of the soil parameter at the wellhead, far from the wellhead or very far from the wellhead and the mean value of the soil parameter at the control area.

|E| = Absolute value of E.

C = Mean value of the soil parameters at the control area.

4.5.1 Case 1: At the Wellhead

The mean values of the various parameters are presented in Table 4.1.

TABLE 4.1: Mean Values and Deviation Percentages of Soil Parameters at the Wellhead

Parameters	Wellhead	Control Area	Deviation Percentage
Nitrogen	2.1	36.2	94.20
Phosphorous	0.24	4.6	94.78
Potassium	7.8	41.4	81.16
TOC	1.1	4.5	75.56
TOM	1.9	7.6	75.00
THC	30000	0.2	14999900.00
Moisture	45	9.4	378.72
pH	2.5	5.5	54.55
Conductivity	153	1821	91.60

4.5.2 Case 2: Far (100metres) from the wellhead

The mean values of the various parameters are presented in Table 4.2.

TABLE 4.2: Mean Values and Deviation Percentages of Soil Parameters Far From the Wellhead

Parameters	Far From Wellhead	Control Area	Deviation Percentage
Nitrogen	10.9	36.2	69.89
Phosphorous	1.2	4.6	73.91
Potassium	13.2	41.4	68.12
TOC	3.1	4.5	31.11
TOM	5.3	7.6	30.26
THC	15000	0.2	7499900
Moisture	31	9.4	229.79
pH	3.7	5.5	32.73
Conductivity	425	1821	76.66

4.5.3 Case 3: Very far from the wellhead (Within the flow station)

The mean values of the various parameters are presented in Table 4.3.

TABLE 4.3: Mean Values and Deviation Percentages of Soil Parameters Very Far From the Wellhead

Parameters	Very Far From Wellhead	Control Area	Deviation %
Nitrogen	15.4	36.2	57.46
Phosphorous	2.33	4.6	49.35
Potassium	22.14	41.4	46.52
TOC	3.72	4.5	17.33
TOM	6.8	7.6	10.53
THC	3500	0.2	1749900
Moisture	30	9.4	219.15
pH	4.8	5.5	12.73
Conductivity	998	1821	45.19

4.6 Plots of the Mean Values of the Soil Parameters at the Four Cases

4.6.1 Nitrogen

The plot of the mean values of the nitrogen and nitrogen compounds concentrations at the four cases are as shown in Fig. 4.1.

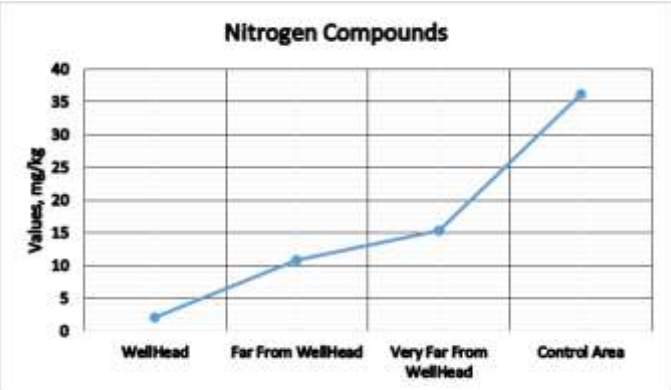

Fig. 4.1: Mean Values of the Nitrogen Concentrations for the Four Cases

4.6.2 Phosphorous

The plot of the mean values of the phosphorous compounds concentrations at the four cases are as shown in Fig. 4.2.

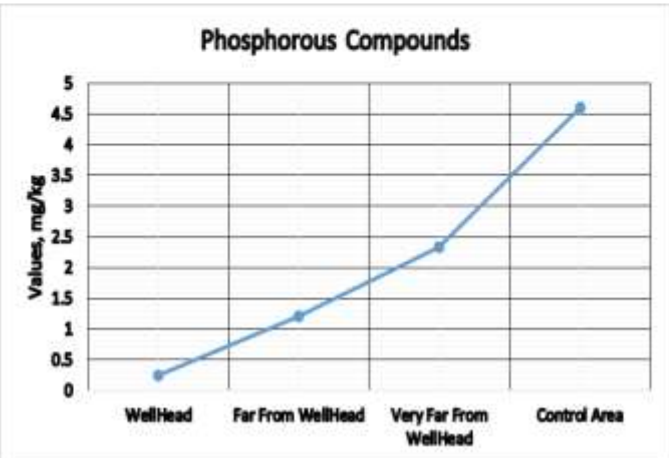

Fig. 4.2: Mean Values of the Phosphorous Concentrations for the Four Cases

4.6.3 Potassium

The plot of the mean values of the potassium ions and compounds concentrations at the four cases are as shown in Fig. 4.3.

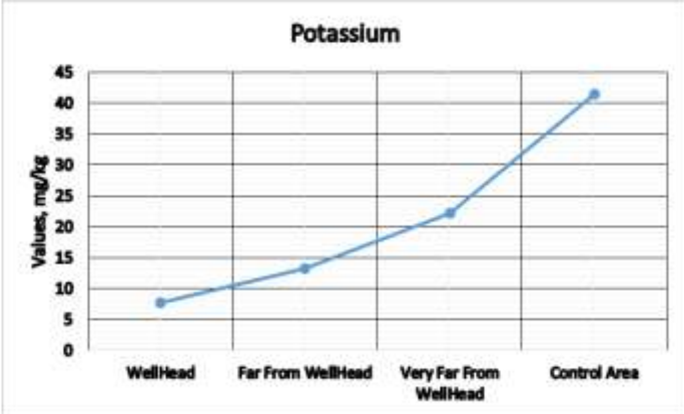

Fig. 4.3: Mean Values of the Potassium Ions and Compounds Concentrations for the Four Cases

4.6.4 Total organic carbon

The plot of the mean values of the total organic carbon concentrations at the four cases are as shown in Fig. 4.4.

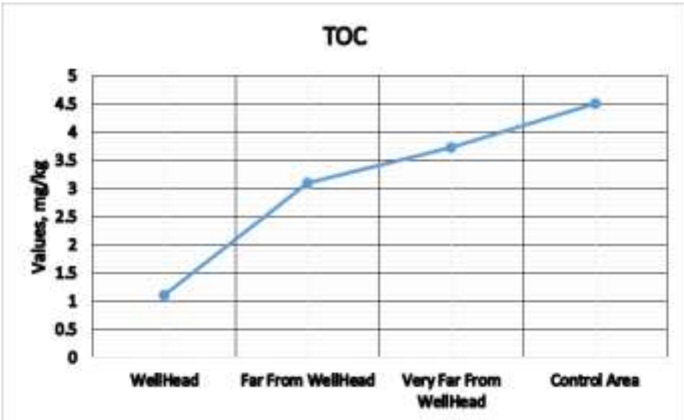

Fig. 4.4: Mean Values of the Total Organic Carbon Concentrations for the Four Cases

4.6.5 Total organic matter

The plot of the mean values of the total organic matter at the four cases are as shown in Fig. 4.5.

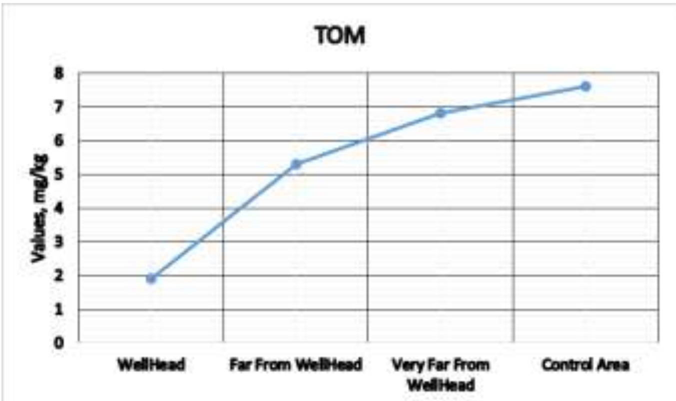

Fig. 4.5: Mean Values of the Total Organic Matter for the Four Cases

4.6.6 Total hydrocarbon content

The plot of the mean values of the total hydrocarbon content at the four cases are as shown in Fig. 4.6.

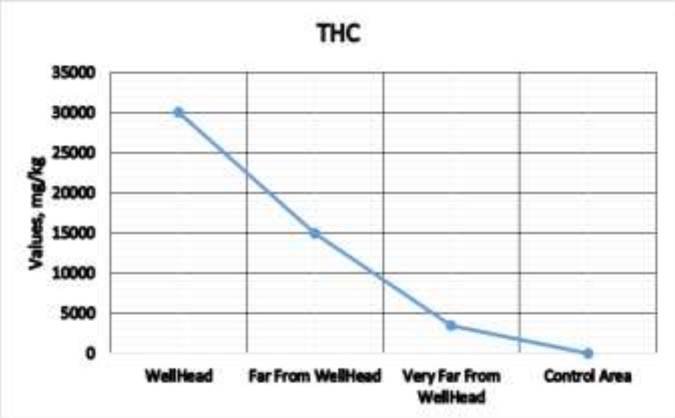

Fig. 4.6: Mean Values of the Total Hydrocarbon Content for the Four Cases

4.6.7 Moisture content

The plot of the mean values of the moisture content at the four cases are as shown in Fig. 4.7.

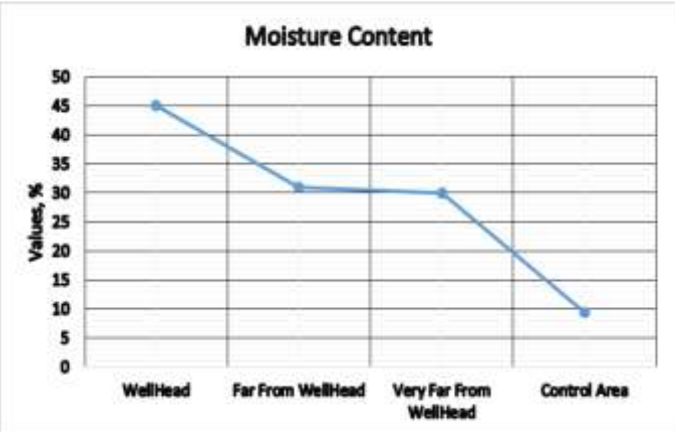

Fig. 4.7: Mean Values of the Moisture Content for the Four Cases

4.6.8 pH

The plot of the mean values of the pH at the four cases are as shown in Fig. 4.8.

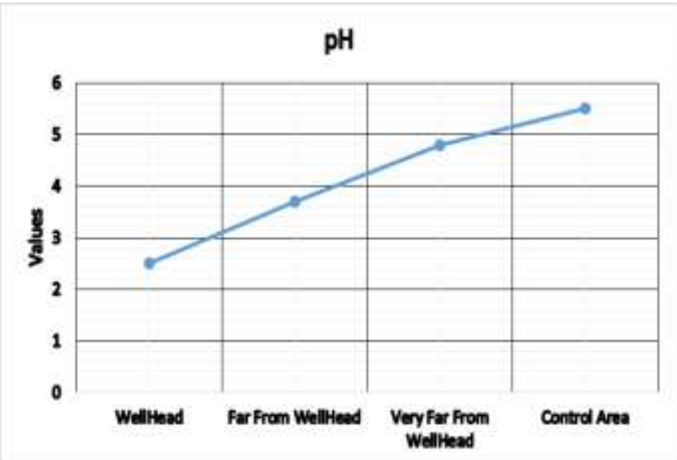

Fig. 4.8: Mean Values of the pH for the Four Cases

4.6.9 Electrical conductivity

The plot of the mean values of the conductivity at the four cases are as shown in Fig 4.9.

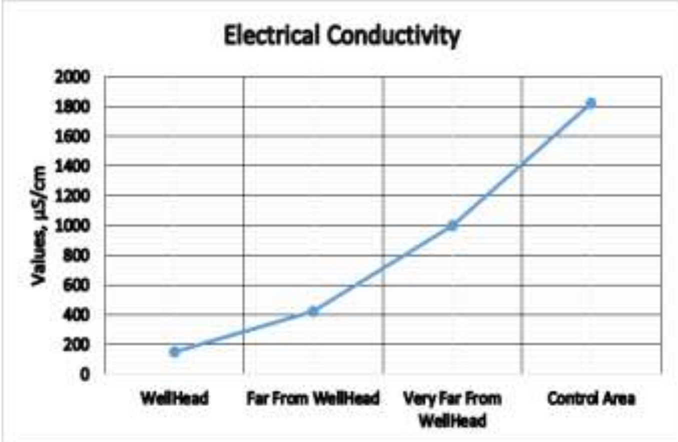

Fig. 4.9: Mean Values of the Conductivity for the Four Cases

V. CONCLUSION

From the evaluations conducted in this work, the following conclusions may be drawn:

1. Oil spillage affects the site where they occur by the reduction of the nutrients in the site (land or water).
2. Oil spillage decreases the soil pH and electrical conductivity of the site it occurs.

REFERENCES

[1] Dawotola A. (2012). Quantitative Risk Analysis of Oil Spillage In A Petroleum Pipeline. SPE-161487-MS. Abu Dhabi International Petroleum Conference and Exhibition, 11-14 November, Abu Dhabi, UAE.

[2] Duru U.I., Ossai C.I., Ossai I.C., Ossai I.A. and Arubi T.I.M. (2009). The After Effect of Crude Oil Spillage on Some Associated Heavy Metals in the Soil. IPTC-13415-MS. International Petroleum Technology Conference, 7-9 December, Doha, Qatar.

[3] Hinson M.O.Jr. (1972). Aspects of Restoration for Estuarine Habitats Following Spills of Oil and Petroleum-Derived Substances. OTC-1678-MS. Offshore Technology Conference, 1-3 May, Houston, Texas.

[4] Mohamed K.A., Odeh M. and Areiqat A. (2005). The Risk of Oil Spillage At Mirfa Power And Desalination Plant. ISOPE-I-05-094. The Fifteenth International Offshore and Polar Engineering Conference, 19-24 June, Seoul, Korea.

[5] NDES (1999): Niger Delta Environmental Survey Phase 1 Report, Vol.1 Environmental and Socio-Economic Characteristics (Revised Edition). Technical Report Submitted by Environmental Resource Managers Limited, Lagos, pp. 101 – 116.

[6] Olayinka E.D. and Ogbonna F.J. (2013). Environmental Remediation of Oil Spillage in Niger Delta Region. SPE-167585-MS. SPE Nigeria Annual International Conference and Exhibition, 5-7 August, Lagos, Nigeria.

[7] Ozumba C. and Udonsi J.K. (2005). Impact of Oil Spills on Mosquito Biology In the Utorogu Field of the Western Niger Delta. WPC-18-0980. 18th World Petroleum Congress, 25-29 September, Johannesburg, South Africa.

[8] Ritchie J.E.Jr. and Cleave H.D.V. (1972). A Reliability Study of Petroleum Systems And Prevention of Offshore OiI Spillage. OTC-1521-MS. Offshore Technology Conference, 1-3 May, Houston, Texas.

[9] Sanchez-Thorin A., Garcia-Perdomo G. and Perez-Velasco E. (2008). The Science Behind a Spillage Reduction Success. SPE-111828-MS. SPE International Conference on Health, Safety, and Environment in Oil and Gas Exploration and Production, 15-17 April, Nice, France.

[10] Shaw D.R. (1976). The Toxicity of Some Formation Fluids And Methods of Rehabilitation Subsequent to Their Spillage. PETSOC-76-03-04. Journal of Canadian Petroleum Technology, Volume 15 Issue 03.

NOMENCLATURE

F_eSO_4 = Iron(II)tetraoxosulphate(VI)
g = Grams
GAB = General Aerobic Bacteria
HCl = Hydrogen chloride
Hr = Hour
H_2SO_4 = Tetraoxosulphate(VI) acid
K = Potassium
KCl = Potassium chloride
$K_2Cr_2O_7$ = Potassium dichromate
mg/kg = Milligram per kilogram
Min = Minute
ml = Millilitre
NDES = Niger Delta Environmental Survey
NH_4F = Ammonium chloride
nm = nanometre
NOAA = National Oceanic and Atmospheric Administration
NO_3-N = Nitrate-nitrogen
P = Phosphorus
ppm = Parts per million
SRB = Sulfate-reducing bacteria
THC = Total hydrocarbon content
TOC = Total Organic Carbon Content
TOM = Total Organic Matter Content
^{0}C = Degree Celsius