Effects of Crude Oil Spillage on Soil Physico-Chemical Properties in Ugborodo Community

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ABSTRACT: *An oil prone community were identified as the study area, and this community has three quarters which are Orgonoko, Kana and Arunton. Soil samples were collected at the depths of 0-15 cm and 15-30cm at each sampling point. Four (4) samples each were collected from each quarters. These soil samples were analysed for physico-chemical properties that reflect soil nutrient content and fertility status in the laboratory using standard methods and the results from these three areas compared. Evidence of severe hydrocarbon contamination was established by high average extractable hydrocarbon content of 66,034mg/kg in Orgonoko and 31,328mg/kg in Kana and was compared to that of Arunton having total hydrocarbon content of 882mg/kg. High electrical conductivity as well as high moisture content all provided evidence of reduced metabolic activities on the affected sites (Orgonoko and Kana) explains the relatively high total organic carbon values obtained. Also, there were increase in the salinity levels of 24ppm and 13ppm for Orgonoko and Kana quarters respectively when compared to 6ppm in Arunton quarter. From the data obtained, the average pH value in samples analysed in Orgonoko area was 5.3 and that obtained in Kana was 5.7. Both values shows that the soils in these areas are acidic compared to the pH in Arunton which has the average value of 6.1. A pH value between 6.5 and 7.5 is considered optimum for the growth of many plants.*

These high values means that Orgonoko and Kana soils (areas) are affected with oil spillage, therefore, it implies low soil fertility, which in turn implies low agricultural productivity and reduced source of livelihood in the affected areas.

Keywords: *Oil spills, Contamination, Soil properties, Soil Fertility, Soil moisture,*

I. INTRODUCTION

Oil production has continued to play a dominant role in the Nigerian economy, ranging from generation of foreign exchange to serving as a source of energy to run the nation‘s Economy. Industries cannot function effectively with the use of refined petroleum products Easy and faster means of transportation would have been impossible without pipelines. Production of other necessary needs of man derived from crude oil would not have been possible if crude oil was not discovered and exploited. The above-mentioned benefits and lots of others have shown that crude oil has been a blessing to man and the nation as a whole.

On the other hand, the process of employing modern technology in the exploration, production, processing and storage of this God- given resources has resulted in the abuse of man's environment directly or indirectly.

Bodies of water are polluted, leading to the destruction of useful aquatic lives. Cultivable lands are rendered uncultivable due to loss of soil fertility. Diseases due to polluted lands, water and air are on the increases. There are reports from the various communication media about community disturbances by youth in the host communities who feel cheated by these oil companies 'harvesting gold' in their land and leaving nothing in return. Large sums of money are lost daily due to shut down in oil production. Some of the oil company staffs have lost their lives to irate youths, who want to enjoy from the boom and not to be left in the doom. All these problems of pollution, fertility loss, rampant spread of diseases, loss of aquatic lives, killings, money loss, fire outbreaks, shut down in the oil production and community disturbances are traced to crude oil spillage.

Contamination of soil by oil spills is a wide spread environmental problem that often requires cleaning up of the contaminated sites. These petroleum hydrocarbons adversely affect the germination and growth of plants in soils (Samina and others, 2002). Oil spills affect plants by creating conditions which make essential nutrients like nitrogen and oxygen needed for plant growth unavailable to them (Adam and others, 2002). Phytoremediation is an alternative to more expensive remediation technologies because it is a feasible, effective and non-intrusive technology that utilizes natural plant processes to enhance degradation and removal of oil contaminants from the environment (Marmiroli and others, 2003). All stages of oil exploitation impact negatively on the environment, and the greatest single intractable environmental problem caused by crude oil exploration in the Niger Delta region is oil spillage. Over 6000 spills had been recorded in the 40 years of oil exploitation in Nigeria, with an average of 150 spills per annum. In the period 1976 –1996, 647 incidents occurred resulting in the spillage of 2,369,407.04 barrels of crude oil. With only 549,060.38 barrels recovered, 1,820,410.50 barrels of oil were lost to the ecosystem. The environmental consequences of oil pollution on the inhabitants of Delta State are enormous. Oil spills have degraded most agricultural lands in the State and have turned hitherto productive areas into wastelands. With increasing soil infertility due to the destruction of soil micro-organisms, and dwindling agricultural productivity, farmers have been forced to abandon their land, to seek non-existent alternative means of livelihood. Aquatic lives have also been destroyed with the pollution of traditional fishing grounds, exacerbating hunger and poverty in fishing communities. Many authors have reported a lower rate of germination in petroleum or its derivatives contaminated soil (Adam and others, 2002; Vavrek and Campbell, 2002; Méndez-Nateraand others., 2004; Achuba, 2006; Smith *and others*, 2006, Sharifi *and others*, 2007; Korade and Fulekar, 2009; Ogbo, 2009). Petroleum hydrocarbons may form a film on the seed, preventing the entry of oxygen and water (Adam and others, 2002) and toxic hydrocarbon molecules could inhibit the activities of amylase and starch phosphorylase and thereby affecting the assimilation of starch (Achuba, 2006). Henner *and others.* (1999) reported that petroleum hydrocarbons consisting of small molecules and those that are water soluble are more phytotoxic for the germination.

The most common and important symptoms observed in the plants contaminated with oil and its by products include the degradation of chlorophyll (Malallah *and others.,* 1998).

Types of Oil Spillage

Oil spill is categorized into groups namely:

- Minor spill occurs when the volume of the spilled oil is less than 25 barrels in inland water or less than 250 barrels on land; offshore or coastal water that does not pose a threat to public health or welfare
- Medium spill takes place when the volume of the spill is 250 barrels or less in inland waters or 250 to 2500 barrels on offshore and coastal waters
- Major spill occur when the oil discharged to inland water is in excess of 250 barrels in offshore or coastal waters.
- Catastrophic spill refers to any uncontrolled well blowout, pipeline rupture or storage tank failure which poses an imminent threat to the public health or welfare.(Egbe, R.E and others,2010)

Oil lake types

Oil lakes vary in their type, area, volume, and depth of penetration. They differ in type due to the different formation condition. Studies categorized them into four types

1) *Wet oil lakes contamination* which is formed in areas of shallow depression and drainage channels. It's described as black, highly weathered and viscous liquid or semi-solid oil sludge over a thickness of oil contaminated soil that in turn overlies clean soil.

2) *Dry oil lakes contamination:* occurs in shallow depression and flat areas and it is comprised of a black, moderately hard, tar-like dry surface layer overlying dark brown oil contaminated soil that in turn overlies clean soil.

3) *Oil-Contaminated piles:* occurs when earthmoving equipment has been used to consolidate oil contaminated and/or liquid oil into mound. These piles were made to stop the flow of oil from wells, to clean areas of heavy oil contamination to facilitate fire fighting or subsequent KOC field operation.

4) *Oil trenches and associated oil spill* which consist primarily of oil-contaminated soil from back-filled trenches. Including in this category are oil contaminated soils associated with oil spills from Nigeria constructed pipelines.

Soil pH

The pH value determines to what degree the soil environment is acidic or alkaline. The pH of a solution is the logarithm of the reciprocal of the hydrogen ion concentration where pH = log 1/H+ and H_2O is ionized as an H+ cation (acid) and an OH- anion (base).

A pH value between 6.5 and 7.5 is considered optimum for the growth of many plants. Although many plants respond to an optimum pH, this value usually covers a range from 0.5 units below to 0.5 units above the optimum level. It should be noted one pH unit is a factor of 10. Therefore, plants have a fairly broad pH tolerance.

The pH of soil influences the absorption and availability of nutrients to plants. There are two general sources of soil nutrients. Some nutrients are absorbed on colloids and some are available to plants as ions in solution. In both cases the various nutrients are present as ions. In most cases the cations (positively charged ions) are absorbed on colloids and the anions (negatively charged ions) are in solution.

Soil is a highly buffered ecosystem. Hydrogen ions in the soil solution are in equilibrium with negative exchange sites on the soil particles. In cation exchange, hydrogen acts as a reserve pool which continuously supplies hydrogen ions to the soil.

In areas of high rainfall, soil tends to be acidic due to the leaching effect on the exchange sites. In arid and semi-arid regions, soils tend to be basic. Basic soils have higher concentrations of calcium, magnesium, and sodium carbonates. The pH of soil varies significantly in thin soil zones. These variations in pH are due to differences in both macro and micro ecosystems. The microbial population near root surfaces is an example of such an ecosystem. The rhizosphere bacteria population significantly impacts pH this microsystem and thus affects plant growth and the progress of soil remediation. Restoring the rhizosphere bacteria population and activity significantly increases available nutrients to the soil.

Since most soils in Niger Delta are basic, the addition of sulphur with fertilizer is an important part of the remediation. As pH approaches 8.7, the addition of sulphur can be justified. To lower the pH of an 8 inch deep loam soil 0.5 pH units, 1,000 lbs of sulphur per acre is required. Sulphur lowers the pH thus increases the solubility of gypsum.

Soil Moisture

The volume and movement of water in the soil is the single most important factor determining plant growth. Depending on the plant, water comprises 50% to 90% of the plant tissue.

Photosynthesis and nutrient availability depend on water. Water is the solvent in which all chemical reactions take place.

Similarly, water is the most important factor determining remediation of salt water and hydrocarbon spills. Approximately 12-14 inches of rain are required to remediate 10,000 uS/cm of electrical conductivity per year, depending on soil type.

Gravitational force pulls water down through the soil matrix and is the predominant influence on water movement in soil.

Water can also move by capillary action due to hydrogen bonding and the subsequent magnetic attraction of water molecules to one another. Capillary forces can overcome gravitational forces and move water in a direction other than straight down into the soil. Both gravitational and capillary water movement is influenced by soil particle type and distribution in the soil.
Water around soil particles is controlled by adhesive and cohesive forces. "Adhesion water" is held tightly and does not move. In contrast, "cohesion water" is held more loosely on soil particles and can be utilized by plants. Cohesive forces and capillary forces move water against gravitational forces in the root zone to increase water utilization by plants.
The osmotic potential of water becomes important in a saline soil. At high salt concentrations, a higher osmotic potential decreases the movement of water into plants. Additionally, more energy is required to move water into the root at higher osmotic potentials.

Following a rain event, the soil is saturated as soil pores fill with water. Gravitational forces drain water from the root zone. Depending on the soil and amount of rain, the draining process is completed in 48 to 72 hours. As the soil drains, the soil reaches a "field capacity" state. At this point, air will fill the large pores and each soil particle will have a thick film of moisture (cohesion water). Plant uptake and evaporation will continue to deplete the cohesion water and shrink the soil-water film. As the film becomes thinner it is more difficult for the root to absorb water. As this process continues and capillary water and additional rain fall does not replenish the root zone, a "wilt point" will develop.
During this process of saturation and drainage, calcium ions can replace the sodium ions and remediation can occur. It is important that water move evenly though the soil as it drains out of the root zone. Therefore, pre-work of the soil to produce a "remediation seed bed" to facilitate water drainage out of the root zone is helpful to the total remediation process. Soil texture will determine the "water retention" capacity of a soil. A loamy soil will remediate at a faster rate than a sandy or heavy clay soil.(Gawel,2003)

Soil Texture

The relative proportions of sand, silt and clay particles in a mass of soil (material less than 2mm in size). Soil characteristic is influence by texture. Structure modifies the influence of texture in regard to moisture and air relationships, availability of plant nutrients, action of microorganisms and root growth.
Silt, the intermediate size, feels smooth when dry, and slippery but not sticky when moist. Because the smaller particle size promotes smaller pore spaces between particles, silty soils have a slower water intake rate but a higher water holding capacity than sandy soils.. These are difficult for storage because they often lack aggregation. This results in high density and a pore size too small for suitable water percolation and aeration. Nevertheless, silt is an essential component of the medium textured, versatile soil called loam.
Clay, the finest size fraction, gives the soils a sticky or plastic feel. Clay exhibits some unusual properties, unexpected if it were merely composed of smaller particles or the same minerals that make up sand and silt. Clay is largely composed of a different set of minerals, called secondary minerals. These are weathering products of the primary minerals -- quartz, feldspar, and mica -- of which sand and silt are largely composed.
Soil with large diameter particles (coarse texture) can contain less water than soil with small diameter particles. . Loamy soil has about 30-50% silt and 20% less than clay particles.
Sand contains rock particles with diameter in range 0.125-2.0mm.
Clay has soil particles whose size is less than 2-4mm in diameter.
Silt soil is composed of particles whose diameter ranges from 1/256-1/16mm.
Soil texture relates primarily to particles smaller than 2 millimetres (.080 inches) in diameter - sand, silt, and clay - since these are the particles most active in soil processes which support plant growth. Coarser particles, gravel and stones, are either inert or detrimental to plant cultivation.

LOCATION

This study is limited to Ugborodo community situated between the Escravos River and the Atlantic Ocean of latitude 5°34'60N and longitude 5°10'0E, in Warri South-West Local Government Area of Delta State of Nigeria. The community of Ugborodo consists of three quarters namely Orgonoko, Kana and Arunton.

PURPOSE AND JUSTIFICATION

Oil spillage in the Niger-Delta area of Southern Nigeria has become a public concern as a result of its frequent occurrence which has been linked with Petroleum exploration and development activities. Crude oil spill affects plants negatively by creating conditions which makes essential nutrients like nitrogen , Oxygen etc needs for plant growth unavailable to them from the spilled affected soil. Therefore, the purpose of this study is to evaluate the effects of oil spillage on soil properties in these areas. The result will give an insight to the level of damage that oil spill has done to the fertility and nutrient status of the community farmland.

II. MATERIALS AND METHODS

2.1 MATERIALS/ PREPARATION

The Four (4) suspected soil samples were collected from each three different places (quarters) or locations (12 samples in all) –Orgonoko, Kana and Arunton about one kilometre apart by taking 5-10 auger boring at random. Soil samples from each sampling locations was put in a sterile polyethylene bag, flamed sealed, labelled and taken to the laboratory. The suspected soil samples were subjected to drying under atmospheric condition for several days and sieved with 2mm sieves before analysis of various parameters.

METHODOLOGY

A series of tests were performed to evaluate the physiochemical effect of crude oil spill on soil. Properties like C/N ratio, Electrical conductivity, bulk density, moisture content, pH, Salinity, THC and other physiochemical properties. All the tests were conducted in line with the API specification.

RESULTS.

Soil samples	Sample point	Depths (cm)	C/N ratio	Electrical conductivity(µs/cm)	Bulk Density(g/cm^2)	Carbonate (%)	Bicarbonate (%)	Moisture content (%)	pH	Nickek (mg/kg)	THC (mg/ Kg)	Salinity (ppm)
Orgonoko	A1	0-15	8:1	101	1.00	2.27	0.11	0.78	5.28	0.90	86715	21
		15-30	4:1	89	1.00	1.94	0.11	0.54	5.24	1.45	50242	14
	A2	0-15	6:1	145	1.66	3.65	0.16	1.22	5.33	0.95	77413	33
		15-30	6:1	121	1.59	3.22	0.14	0.67	5.31	1.33	49766	28
Kana	B1	0-15	12:1	58.6	2.65	0.47	0.18	1.17	5.88	0.30	46408	12
		15-30	10:1	55.4	3.78	0.41	0.14	0.75	5.74	0.21	30266	12
	B2	0-15	10:1	66.4	4.55	0.64	0.25	1.77	5.67	0.15	28766	14
		15-30	8:1	59.8	5.67	0.60	0.21	0.73	5.66	0.09	19873	13
Arunton	C1	0-15	14:1	36.3	1.33	0.49	0.09	0.63	6.04	0.30	1200	8
		15-30	10:1	24.2	1.33	0.33	0.04	0.43	6.11	0.30	920	6
	C2	0-15	10:1	19.6	1.23	0..30	0.02	0.54	6.06	0.23	876	4
		15-30	10:1	20.4	1.20	0.30	0.02	0.46	6.11	0.15	532	5

Table 2.2 UGBORODO SOIL TEXTURE

Soil sample	Sample Point	Depths (cm)	Sand (%)	Clay (%)	Silt (%)
Orgonoko	A1	0-15	60	32	8
		15-30	58	34	8
	A2	0-15	56	28	16
		15-30	54	37	9
Kana	B1	0-15	77	21	2
		15-30	69	20	11
	B2	0-15	79	17	4
		15-30	70	22	8
Arunton	C1	0-15	51	43	6
		15-30	56	42	2
	C2	0-15	51	44	5
		15-30	57	41	2

III. DISCUSSION OF RESULTS

Total Hydrocarbon Content (THC)

From the data obtained (table 2.1) shows a significant difference between the two impacted locations of Orgonoko and Kana and the area of Arunton. The total hydrocarbon content at the depth of 0-15cm was 86715 mg/kg and at the depth of 15-30 cm was 50242 mg/kg in one of the sample point, and then 77413 and 49766 mg/kg at the depths of 0-15cm and 15-30cm respectively in the second sampling point in Orgonoko quarters. This result shows that the total hydrocarbon content decreases with increases in depth. The average total hydrocarbon content in Orgonoko quarters was 66034 mg/kg.

The same trend was followed in the case of four samples collected at the depths of 0-15cm and 15-30cm respectively in Kana and Arunton quarters. The average total hydrocarbon content was 31,328 mg/kg in Kana and 882mg/kg in Arunton.

The hydrocarbon content of 66034 mg/kg and 31,328 mg/kg for Orgonoko and Kana respectively compared to total hydrocarbon content value of 882mg/kg in Arunton represents a high level of hydrocarbon contamination on the impacted sites. A review of such existing data on the Niger Delta Environment Survey-NDES (1999), Osuji and others,2004), affirms that such high hydrocarbon levels affect both above–ground and subterranean flora and fauna, which are essential adjuncts in the biogeochemical cycle that affects availability of plant nutrients.

The intense infusion of degradable hydrocarbon likely stimulates aerobic and anaerobic microbial metabolism. As oxygen becomes limiting utilization of alternate electron acceptors produces an increasing reducing environment. In general, the essential elements required for plant growth, will be inherently low due to the high concentration of the degradable hydrocarbon.

The significant difference between Orgonoko sample and that of Kana sample may be attributed to the differences in volume of the spilled crude (hydrocarbon) on each location.

Electrical Conductivity (EC)

Electrical conductivity (EC) is a measure of ionic concentration in the soils and is therefore related to dissolve solutes. As salt content increases, so does Electrical conductivity. The significantly higher electrical conductivity values obtained for Orgonoko samples and Kana samples could be as a result of the high concentration of charged ions (cations and anions) in the oil impacted sites. Anions, metallic ions and carbonic acids contribute to electrical conductivity of tropical soils. However, the generally low electrical conductivity values of the soils of the study area is an indication of the high degree of leaching of nitrate salt taking place as a result of high rainfall in the Niger Delta. (Ekundayo, 1997).

Moisture Content

It was found from table 2.1 that the moisture content in the Arunton location (un-impacted by oil spill from the data obtained) was 0.63% at the depth of 0-15cm and 0.43% at the depth of 15-30cm. And on the second sampling point on Arunton quarter, was 0.54% and 0.46% at the depths of 0-15 and 15-30 cm respectively. Compared to the values obtained from Orgonoko and Kana quarters, which has the values of 0.78%, 0.54% and 1.22%, 0.67% at the depths of 0-15cm and 15-30cm at the two sampling points in Orgonoko quarters and 1.17%, 0.75% and 1.77% , 0.73% in Kana quarters. It can therefore be concluded that the spilled affected soils (Orgonoko and Kana) retained more water especially in Kana soil samples than the soil in Arunton. The higher moisture content of 0.78% for Orgonoko and 1.17% for Kana can be attributed to insufficient aeration of the soil that might have arisen from the displacement of air in the oil-spilled soils, this probably encouraged water logging and reduced rate of evaporation.

High moisture content may reduce microbial activities not as a result of the water itself but rather by the indirect hindrance to the movement of air which would reduce oxygen supply to plants

Salinity

From the data obtained (table 2.1) shows a significant difference in the salinity values between the value samples obtained at sampling points in Arunton and that of Orgonoko and Kana quarters. The average values for Orgonoko was 24ppm and that of Kana was 13ppm which were quite higher than that of Arunton with an average value of 6ppm.

Soil salinity is a soil condition when water soluble salts in the crop rooting zones impede crop growth. High salt content increases the osmotic potential of the soil solution and prevents crop uptake of water. Crops are generally most sensitive to salinity during germination and emergence. As soil salinity level increases, the stress on germinating seedlings also increases. This clearly shows that the crude oil spillage actually increased the soil salinity of the impacted locations-Orgonoko and Kana. Symptoms of salt damage include, brown stunted roots, dead and sections on the margins, burning and die-back of young growth and slow or no growth.

Carbon- Nitrogen Ratio

If the C/N ratio is affected by nitrogen-coating pollutants undesirable effects may occur. More so, very low C/N ratio values as in Orgonoko sample may lead to organic matter soil losses and to desertification problems. That is why a C/N ratio of around 25: 1 is considered optimal for soil fertility. As C/N ratio < 10:1 then problem arises.

If the organic material has a less amount of nitrogen in relation to the carbon then the micro organism will utilize the soil nitrogen for further decomposition and the soil nitrogen will be immobilized and will not be available for plant use.

Soil fertility in terms soil nitrogen content and total carbon showed apparent and significant increases for Orgonoko and Kana samples compared to Arunton (control). These increases confirmed the relationship between soil pH and soil nitrogen that the increase in pH with the oil spill contributed to the higher nitrogen value recorded in the crude oil contaminated soil (Orgonoko and Kana soil samples).

Soil pH

pH acts indirectly on plant growth by affecting availability of nutrients, the presence of toxins and the growth of soil microorganisms. . pH stands for "potential hydrogen" and measures the acidity of your soil using a scale from 0 to 14. A pH of 7 is neutral. If the pH is lower than 7, people refer to it as acidic, sour or low pH, while a pH over 7 is termed alkaline, basic, sweet or high pH.

From the data obtained, the average pH value in samples analysed in Orgonoko area was 5.3 and that obtained in Kana was 5.7. Both values showing that the soils in these areas are acidic compared to the pH in Arunton which has the average value of 6.1. A pH value between 6.5 and 7.5 is considered optimum for the growth of many plants. Even though, Arunton's pH is little short of that.

pH affects plant growth primarily through its effects on nutrient availability. High or low pH cause deficiencies in essential nutrients that plants need to grow. According to the Clemson Cooperative Extension, acidic soils frequently experience deficiencies in calcium, phosphorus and magnesium. Alkaline soils demonstrate deficiencies in phosphorus and many micronutrients. The availability of aluminium and manganese can also approach toxic levels in acidic soils and impair plant growth. Furthermore, soil pH affects the behaviour of soil microbes, encouraging or inhibiting the growth of pathogens and affecting how well helpful microbes are able to break down organic material, freeing the nutrients it contains for plant use. (Thumma, 2000)

Acidic soil often causes the stunting and yellowing of leaves, resulting in the decrease in growth and yield of crops as the pH levels falls. Additionally, plants grown in adverse pH conditions may be more prone to disease and fungal attack. The availability of plant nutrients is considerably affected by soil pH. Calcium, potassium, magnesium and sodium are alkaline elements, which are lost with increasing acidity whereas phosphorous is more available in acidic soil conditions.

Soil Bulk Density

Bulk density is used to measure compaction. In general, the greater the bulk density the less the pore space for water movement, root growth, penetration and seedling germination. It reflects the soil ability to function for structural support, water and solute movement and soil aeration. Bulk densities above thresholds indicate impaired function.

From the table (2.1), the values of the average bulk density obtained from Orgonoko and Arunton (control) areas were $1.31g/cm^3$ and $1.27g/cm^3$ respectively shows that soil can actually support plant growth. But the oil impacted sample (Kana) has the value of $4.16g/cm^3$ shows that plant growth was severely restricted. Oil spillage really impacted significantly on the bulk density of Kana soil samples, and this adversely affected agricultural practice in this location. The average bulk density for Kana in particular, shows that the viscous crude oil settled into the pores to increase both the soils wet weight and the liquid content, this in turn cause increase in bulk density as compared to Arunton soil samples (control).

Soil Texture

The average soil texture at the first sampling point in Orgonoko quarters was 59% sand, 33% Clay, and 8.0% silt and at the second sampling point in Orgonoko, the average soil texture was 55% sand, 32.5% Clay and 12.5% silt at the depths of 0-30cm respectively. Therefore, the total average soil texture ii Orgonoko at the depth of 0-30cm was **57**% sand, **32.75**% Clay and **10.25**% respectively.

At Kana quarter, the soil texture was 73% sand, 20.5 Clay, and 6.5% silt at site 1 and 74.5% sand, 19.5% Clay, and 6.0% silt at site 2. For Kana, the average soil textures at these locations were **73.75**% sand, **20**% and **6.25**% for Sand, Clay and Silt respectively.

In Arunton areas, sand content was 53.5%, clay was 42.5% and 4.0% silt at sampling site 1 and 54% sand, 42.5% clay and 3.5% silt at sampling point 2. For Arunton, which serves as control, has the following values as the average soil texture **53.75**%, **42.5**% and **3.75**% for sand, clay and silt respectively.(Table 2.2)

Kana quarter has the highest sand content, so, have the highest rapid water/ hydrocarbon infiltration and lowest water / hydrocarbon holding and very low nutrient storage capacity resulting in high C/N ratio .Arunton has almost balanced values of sand and clay soil with lowest amount of silt content.

Orgonoko has the highest amount of silt content which may result in slower hydrocarbon and water intake and higher water and holding capacity.

IV. CONCLUSION

It can be concluded that the test results obtained from the soil analysis of the oil-spilled impacted sites (Orgonoko and Kana) compared to the result of the un-impacted site (Arunton) shows that the total hydrocarbon levels observed from both the oil spilled locations have provided evidence of severe hydrocarbon contamination of the sites. These conditions generally imply low soil fertility, which in turns implies low agricultural productivity and reduce source of .livelihood in the affected areas. There was significant difference in electrical conductivity values between the impacted and un-impacted sites. More also, the salinity values for the oil spilled affected areas increased significantly when compares to Arunton (control).

However, there was no significant change or difference in values for properties like nickel, carbonates and Bicarbonate content in both affected and un- affected sites or locations.

V. RECOMMENDATION

Having successfully analysed the soil samples from the three quarters involved in community, it has shown that the soil samples from Orgonoko and Kana are contaminated. Therefore, in order to minimize the rate of spills in these areas (community), the following recommendations are suggested.

The government of Nigeria should muster the political will to exact stricter respect for environmental laws and regulations by oil companies and a penalty plan established that require oil companies whose activities cause excessive pollution or are ill-equipped to forfeit their licenses.

Multinational and indigenous oil companies should ensure regular and constant inspection and maintenance of oil facilities to avoid accidental discharge or spillage of oil and other petroleum products.

The current compensation regime in Nigeria has to be reviewed for it to be fair and adequate to meet the emergency needs and concern of those affected by pollution.

Adequate security personnel should provided to guard oil installation and such security arrangement should involve people from the host communities to work-in collaboration with government security forces to improve monitoring of oil facilities to avoid vandalisation.

Constant seminar, training workshop, public enlightenment campaign should be organized for host communities and other stakeholders in the oil industry to educate them on the negative impact of oil spillage on the soil properties.

Application of appropriate and sufficient inorganic NPK fertilizer to restore the Carbon to Nitrogen ratio to the optimum required to stimulate and sustain microbial activity.

Stimulating of the indigenous microbial growth by cultivating the soil to distribute the nutrient and lime and to aerate the treatment zone.

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