Environmental Effect of Oil Spillage in Bomu Community, Rivers State, Nigeria.

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Abstract

This study was carried out to determine the Environmental effects of oil spillage on Bomu community of Rivers State, Nigeria. In other to achieve this, the following methods were adopted: oral interview, physical observation and field sampling of soil and water. Heavy metals in the soil and water samples were determined using Atomic Adsorption Spectrometer (AAS). The findings showed that environmental characteristic (social distortion, soil and water) has significant effect on the inhabitant of Bomu community and that has been severely distorted, the chemical analysis result of soil and water samples shows that they contained high level of heavy metals when compared with Food and Agricultural Organization (FAO) and World Health Organization (WHO). The soil sample showed high level depletion of vital nutrients that are necessary for plant growth, for instance, Iron content is 4.68mg/kg and Phosphorus 4.48mg/kg. These values are below the FAO standard also water quality parameter such as pH is 5.1 and copper 0.3mg/l do not conform to WHO standards. The concentration of lead in water samples A, B, C, D and E are 0.17, 0.15, 0.24, 0.16 and 0.21 respectively. These concentrations are above the WHO standard of 0.10mg/l most especially in A and E were the impact of oil spillage is frequent, this might be responsible for the recurrent report of toxic biochemical effect in the water of the study area. It is recommended that best practices are adhered to in oil exploration, transportation and storage as this would minimise the occurrence of oil spillage in future. Meanwhile, the cleaning up of the area should be carried out as soon as possible and some compensation should be paid to the people who have suffered for a long time from the damaging spill. Since Ghana is planning to commence Oil exploitation, Ghanaian Government should borrow a leaf from the Nigerian experience.

Keywords

Oil, Spillage

1   Introduction

In the history of oil production in Nigeria, Gokana Local Government Area in Rivers State is very important. While oil was first struck in commercial quantity in 1956 at Oloibiri town in the present day Bayelsa State, the second discovery of oil in commercial volume was at Bomu in 1958 – the Bomu oil field contributed major supply to the first shipment of oil from Nigeria in 1958. Bomu is an Ogoni town administratively located in Gokana Local Government Area of Rivers State (Figure1). There are 96 oil wells connected to 5 flow stations in Ogoni operated by the Shell Petroleum Development Company of Nigeria (SPDC – a subsidiary of the Royal Dutch Shell). Two of the Ogoni flow stations code-named Bomu and Bodo West are situated in Gokana. Presence of these facilities including numerous Trans-Niger pipelines that criss-cross Gokana land and seascape render the area highly vulnerable to oil spills. Generally, oil spillages occur almost daily in Nigeria's Niger Delta- the country's hub of oil and gas production. Between 1979 – 1997, the Nigerian Petroleum Industry experienced 5334 cases of oil spillage resulting in the discharge of 2.8 million barrels of oil into the land, swamps, estuaries and coastal waters (Dublin-Green *et al*, 1988).

The area is low lying with height of not more than 3.0 meter above sea level and is generally covered by fresh water swamp, tidal channels, beach ridges and sand bars. The region basically lies in the wet equatorial climate, with high cloud cover, low sunshine hours and damp air for most of the year. The area experiences rainfall every month of the year with a short dry spell in the month of January to march. The area is blessed with natural resources which include; oil and gas, reservoirs, extensive forest, good agricultural land with extensive palm trees and abundant aquatic culture (Dublin- Green *et al*, 1997).
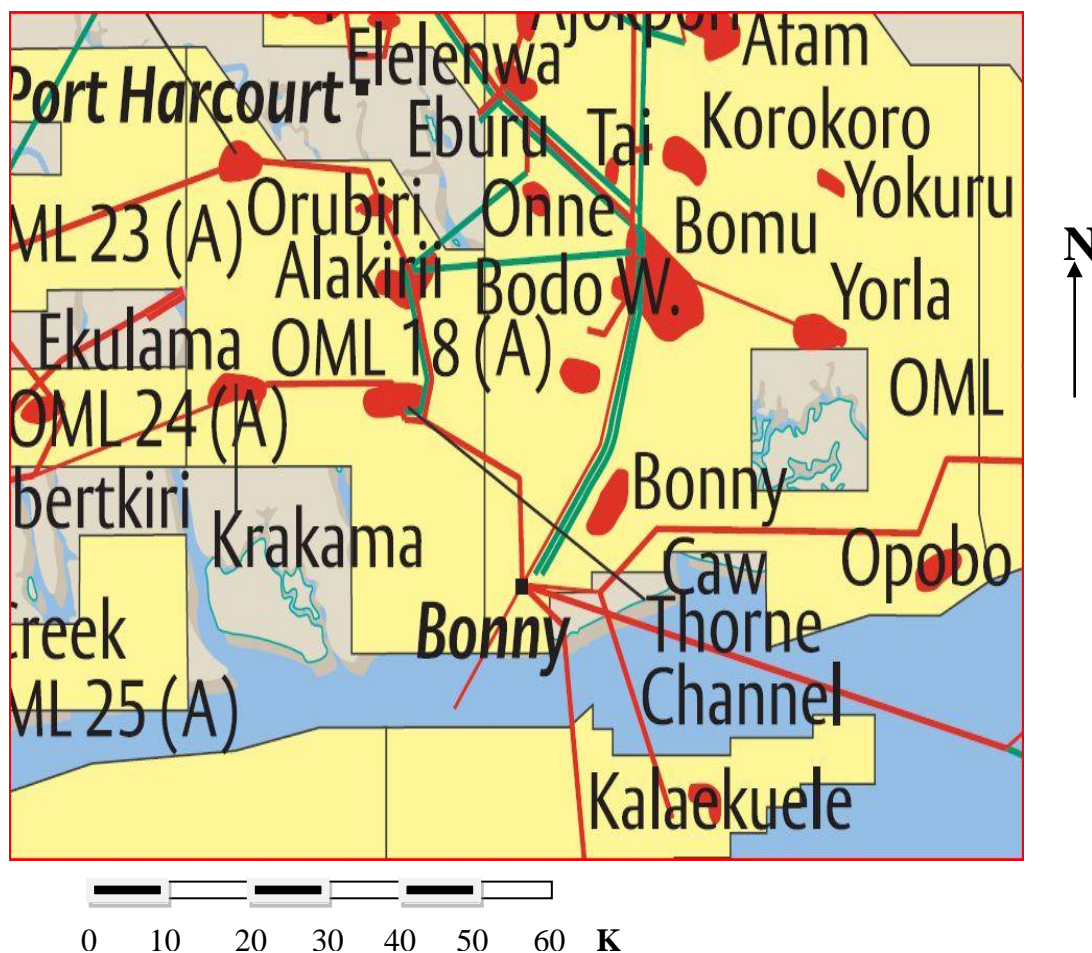
Figure 1: Map Showing Bomu Community and Neighbouring Communities

According to Egberongbe *et al*, 2006, fifty percent (50%) of oil spills in Nigeria is due to corrosion, twenty eight percent (28%) to sabotage and twenty one percent (21%) to oil production operations. One percent (1%) of oil spills is due to engineering drills, inability to effectively control oil wells, failure of machines, and inadequate care in loading and unloading oil vessels.

Of the people residing in the Niger Delta region, 75 per cent rely on natural endowments for a living. But air, water, soil and forest resources have been devastated by the exploitation of oil and gas resources. Particular problems result from gas flares and oil spills. Local people suffer harm to their health, productivity, incomes and welfare (UNDP report, 2006a). For decades, oil has been the main export product of Nigeria, number eight of the world's oil producing countries. Oil revenues have not brought about prosperity for Nigerians, on the contrary. According to the World Bank, the portion of the population living in poverty grew from 28 percent in 1980 to 66 percent by 2000. Sectors of the non-oil economy have almost disappeared (World Bank Report, 2006)

1.1   Oil Spills

For decades now, oil spills have devastated the environment of the fertile Niger Delta. According to available statistics, in the last 30 years more than 400,000 tons of oil has spilled into the creeks and soils of southern Nigeria. Some 70 per cent of the oil has not been recovered (UNDP report, 2006b). The vast majority of the spills are a consequence of aging facilities and human errors. In January 2008, the Nigerian National Oil Spill Detection and Response Agency (NOSDRA) declared it had so far located more than 1,150 oil spill sites abandoned by various oil companies within the Niger-delta (Anon, 2008a).The Niger-delta still looks green from above. On the surface the damage is big: fish have died; some agricultural lands have become infertile; drinking water has become polluted.

1.2   Nigerian Law on Oil Spills

Nigerian law concerning oil spills is fairly clear. The Nigerian Federal Environmental Protection Agency Act of 1988 orders that following oil spill, oil companies should "begin immediate clean-up operations following the best available clean-up practice and removal methods." The Oil Pipeline Act of 1990 states that oil companies should pay compensation to any person suffering damage as a consequence of any breakage of or leakage from the pipeline or an ancillary installation (except when the spill is the result of the malicious act of a third person). The Nigerian Petroleum Act of 1969 states that oil and gas production shall conform to good oilfield practice, according to American standards (Anon, 2008b).

1.3   Materials

The materials basically used were soil and water samples from different positions within the oil spillage area, which were later analysed in the laboratory for quantity and quality of various parameters, other materials used are the picture evidence of different location for the collection of the sample, beaker, pipette, shaker box, filter, pH meter, electrical conductivity meter, volumetric flask, photo tube, Whatman paper, distillation flask, Erlenmeyer flask, photometer, atomic absorption meter.

2   Methods

The following methods were adopted in this study; Physical observation, oral interview and field sampling of water and soil.

2.1   Physical observation

Thorough investigation was carried out in the study area to determine the likely factors responsible to the natural changes in the environment also physical observation of the soil, water, agricultural products (plant/animal) and infrastructures were made to determine the physical effect of oil spillage on them.

2.1   Field sampling

Water and soil samples of the study area were collected to determine the levels of the degradation of soil and water and their effects on human, farming and fishing sites in the community.

2.3   Soil Sample

The following soil qualities were determined; pH, Electrical conductivity, Total Organic matter, Phosphorus, Nitrogen Potassium, and extractable micronutrients such as Zinc and Iron. The result was compared with FAO (1990) standard as shown in Table 1.0

2.4   Determination of Soil pH and Electrical Conductivity

20.0g of air dried soil sample was put into 50ml beaker and 20 ml of distilled water was added. The lump of the soil was stirred to form homogenous slurry, the pH meter (Jenway3015 model) and Electrical Conductivity (Jenway4010 model) probes were immersed respectively into the sample and allowed to stabilize at 25˚C. pH and Electrical Conductivity were taken and recorded as shown in Table 1.0

2.5   Determination of Total Organic Matter

Total organic matter (TOM) were determined by the chromic acid titrimetric method of Walkey and Black (1992) as follows: One gram (1g) of soil sample was weighed into a 500ml flask and 10ml of $K_2Cr_2O_7$ 20ml of concentrated H_2SO_4 were added. To the mixture was further added 200ml of distilled water, 10ml H_3PO_4 and five drops of diphenylamine indicator before titrating with 0.5N $(NH_4)_2SO_4Fe$. A blank titration (without 1g of soil) was thereafter carried out and percentage total of organic carbon (TOC) was calculated as:

$$\%TOC = \frac{\text{Blank Titre} - \text{Sample Titre x 0.003 x 100}}{\text{Sample Weight}}$$

$$\%TOM = TOC (\%) \times 1.724$$

Where: 1.724 = Conversion factor;

2.6 Determination of Soil Phosphorus

10.0g of air dried sieved soil was weighed into a beaker and 40ml phosphorus extracting solution of ammonium chloride (NH4Cl) was added. The mixture was been shocked in the shaker box for 15minutes at high speed and filtered using whatman paper. 20 ml of the filtrate was pipetted into 50ml volumetric flask and 10ml of ascorbic acid in Murphy and Rally reagent was added and made up to 50ml with distilled water. The mixture was allowed to stand for 30 minutes for blue colour development. The mixture was then shocked and then poured into phototube where the absorbance was taken as 400nm visible spectrometer. Standard was prepared for 0, 0.2, 0.4, 0.8 and 1.0mg/l. the graph of standards was plotted against absorbance and the soil phosphorus in mg/kg was calculated and the values obtained were recorded.

$$P \ (mg/kg) = \frac{R \times V \times D}{W}$$

Where, R = Reading from the graph

V = Volume of extracting solution

D = Dilution factor

W = Weight of sample used

2.7 Determination of Nitrogen in the Soil

Nitrogen was measured using ASTM D6187-97 procedure. 10g of soil sample weighed into a dry 500ml flask and 30ml distilled of distilled water was added. The flask was swirled for some minutes and allowed to stand for 30 minutes. 10.0g 0f potassium sulphate (K2SO4) and 30 ml of concentrated sulphuric acid (H2SO4) were added through an automatic pipette. The flask was cautiously heated at low heat on the digestion stand when the water as been removed and frothing as ceased. The heat was increased until the digest was cleared. The mixture as boiled for 5hours. The flask was allowed to cool and 100ml of water was slowly added to the flask. The digest was carefully transferred into another clean macro-kjeldahl flask (750ml). All sand particles were retained in the original digestion flask. The sand residue was washed with 50mal distilled water four times and the aliquots were transferred into the the same flask. 50ml of trioxoboric (III) acid (H3BO3) indicator solution was added

into a 500ml Erlenmeyer flask. Which was then placed under the condenser of the distillation apparatus about 150ml of 10ml NaOH was poured through the distillation flask by opening the funnel stop cork.

The distillation was commenced immediately, the condenser was kept cool below 30˚C and the heat was regulated. About 150ml distillate was collected and the distillation was stopped. The Nitrogen in the distillate was determined by titrating with 0.01M standard hydrochloric acid (HCl) using a 25ml burette.

Percentage Nitrogen content in the soil was calculated in the formula below and the values obtained were recorded

$$.\%N = \frac{T \times M \times 14100}{\text{Weight of sample}}$$

Where T = Titre value

M = Molarity of HCl

2.8 Determination of Potassium in the Soil

Potassium (K) was determined on a flame photometer. 10.0g of soil sample was weighed into a beaker and 10ml of neutral ammonium acetate solution was added. The mixture was stirred and allowed to stay for one hour. The mixture was then filtered and the filtrate was collected. 10ml of the filtrate was pipetted into 100ml volumetric flask and poured into a test tube. Standard solutions within the range of 0, 2, 4, 6, 8 and 10ppm were prepared. The appropriate filter was selected and the photometer was set up and calibrated using the standard solutions. Emission intensities for the standard and the unknown samples were then measured.

2.9 Determination of Zinc and Iron Extract

Atomic absorption spectrometry (AAS) method was used. Atomic absorption is based on the intensity of a spectral line absorbed by the element under study. A series of standard solution of the element were made by dissolving known weights of the element into a known volume solution. The absorption of each solution was measured in an atomic absorption spectrometer and plotted to provide a calibration curve. The instrument was set up according to the instruction provided for the 370 Potential Exponential (PE) model of atomic absorption spectrometer. The concentration obtained was standardized using the standard solution. The readings of the sample solution were taken, the element contents in the sample were

determined by adopting similar method of that of flame photometry and values obtained were recorded for Zinc content and iron content in the soil.

Table 1: Values of Chemical Analysis of the Soil in the Study Area

SOIL PROPERTY	SSA	SSB	SSC	SSD	SSE	FAO, 1990 STANDARD
PH	5.8	6.1	5.3	5.0	5.8	6-7
Electrical conductivity(μs/cm)	1180	1050	1160	1140	1070	0-750
Total Organic matter (%)	5.52	4.76	5.47	5.32	4.50	1.5-3
Phosphorus (mg/kg)	7.80	8.41	9.22	8.64	9.15	7.20
Nitrogen (%)	0.60	0.26	0.51	0.46	0.54	0.08-3
Potassium (Cmol/mg)	0.50	0.24	0.38	0.35	0.30	0.15-0.44
Zinc(mg/kg)	5.46	6.90	6.00	5.80	6.40	2.0-4.8
Iron(mg/kg)	4.68	3.41	4.07	4.00	3.65	8.4

2.10   Water Sample

The following water qualities were determined: pH, Electrical conductivity, Total dissolved oxygen (TDS) and some metal which include; Lead, copper and cadmium. The results obtained were compared with World Health Organisation (WHO, 1998) standard as shown in table 2.0

2.11   Determination of Water pH

The PH tester was standardized with buffers of pH 4 and 7 prior to usage. This was subsequently dipped into the water sample to take the pH reading of the sample.

2.12   Determination of Electrical Conductivity of Water

Water conductivity was determined with conductivity meter. The reading portion of the conductivity meter was adjusted and the electrode was dipped into the water sample. The appropriate reading was taken and recorded.

2.13   Determination of Dissolved Oxygen

Dissolved oxygen in the water sample was determined by iodometric test (Winkler's method) procedure. 300ml of water sample was added to manganese ions manganese (IV) oxide was precipitated. The precipitate was treated with ions until the amount iodine liberated was chemically equivalent to the original dissolved oxygen and recorded; the liberated iodine was determined by titrating it with sodium thiosulphate. The presence of nitrite and iron was removed by using dissolved oxygen analyzers with membrane electrode.

2.14   Determination of Heavy Metals in Water

50ml of water samples was subjected to fixing by using concentrated nitric acid and hydrochloric acid in a ratio of 1:10, which was meant to digest the particulate matter inside the sample by heating carefully in a water bath to obtain thick yellow solution and later was cooled and made up to 100ml with distilled water. After the fixing, the samples were directly analyzed using atomic absorption spectrometer (AAS). For each heavy metal, specific concentration standard was made and a calibration curve was prepared were the concentration of the metals was read directly from the AAS Visual Display System (VDU) system and the values obtained were recorded.

Table 2: Values of Chemical Analysis of the Water in the Study Area

WATER PROPERTY	WSA	WSB	WSC	WSD	WSE	WHO,1998 STANDARD
PH	5.6	6.9	5.1	5.4	6.6	6.5-7.5
Electrical Conductivity(μs/cm)	820	930	967	780	950	400
Dissolved Oxygen (mg/l)	3.0	3.4	2.9	2.4	2.8	6.00
Lead (mg/l)	0.17	0.15	0.24	0.16	0.21	0.01
Copper (mg/l)	0.13	0.33	0.40	0.10	0.37	1.0
Cadmium(mg/l)	0.27	0.20	0.30	0.22	0.29	0.005

3   Results and Discussion

3.1   Results and Discussion for Soil Samples

3.1.1   pH Values in Soil

pH measures the acidic and alkaline condition of soil and availability of micro and macronutrient to plants. The soil data analysis in Table 1 indicated that the pH of SSA, SSB, SSC, SSD and SSE are 5.8, 6.1, 5.3, 5.0, and 5.8 respectively.
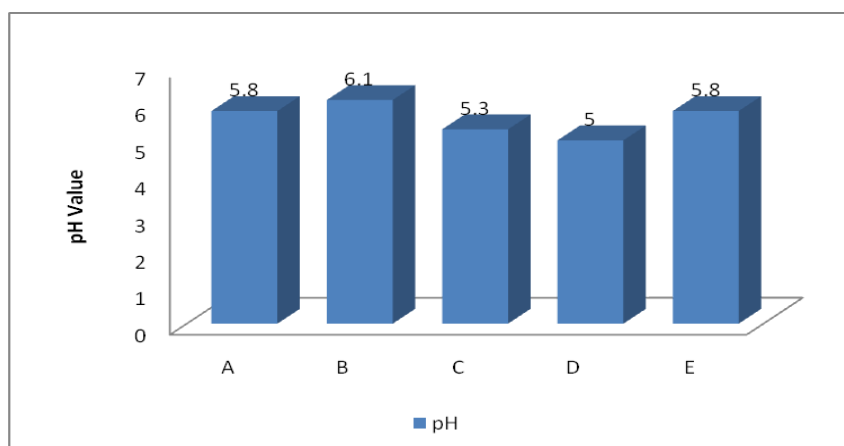

Figure 2: Chemical Analysis of Soil pH Value in the Study Area

The FAO pH standard is within 6-7 for crops and plants, Figure 2 indicate pH values which clearly depicted that SSA, SSC, SSD and SSE are acidic and are below FAO standard. This could be attributed to the frequent oil spillage in the area that had prevent the leaching of basic salts responsible for pH rising. The binding of the oil with soil particulate matter in these samples posed a major resistance to the removal of such basic ions. The pH of the soil is to be adjusted by aeration to complete the microbial oxidation of organic acid while agricultural lime must be added to provide some buffering capacity to the soil (Amadi and Dickson, 1993).

3.1.2   Electrical Conductivity in soil

Electrical conductivity measures the exchangeable elements that are present in the soil matrix. The most common quality of soil measured in terms of its salinity. Table 1 indicates that the electrical conductivity in SSA is 1180μs/cm, SSB is 1050 μs/cm, SSC is 1160 μs/cm, SSD is 1140 μs/cm and SSE is 1070 μs/cm.
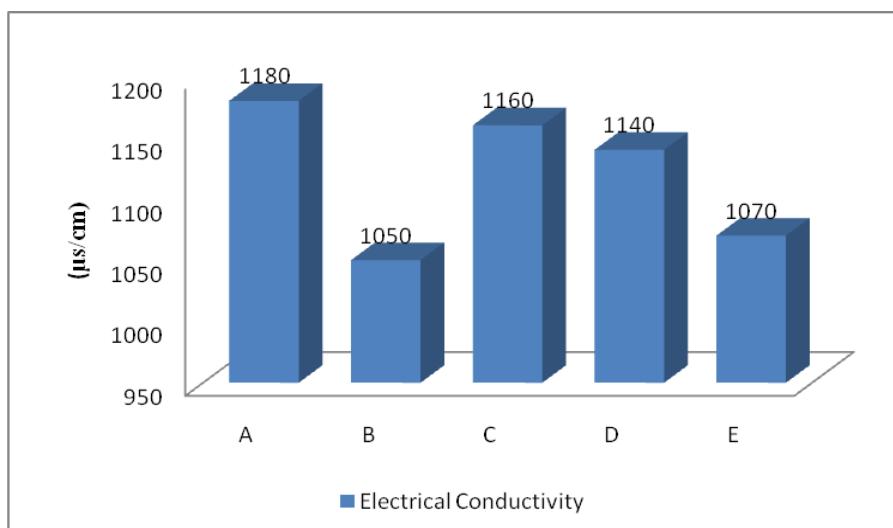
Figure 3: Chemical Analysis of Electrical Conductivity Value of the Soil in the Study Area

If electrical conductivity is checked on the basis of tolerance capacities of Food and Agricultural Organisation (FAO) standard of (0-750) µs/cm for plants, Figure 3 shows that none of the samples is suitable for plant growth. This is as a result of the various mineral salts in the spilled oil that covered the soil which might have dissolved into the soil and increased soil salinity beyond acceptable level.

3.1.3 Organic Matter and Nitrogen in Soil

The organic matter in all the soil samples was expected to be very high following the addition of carbonaceous substance.
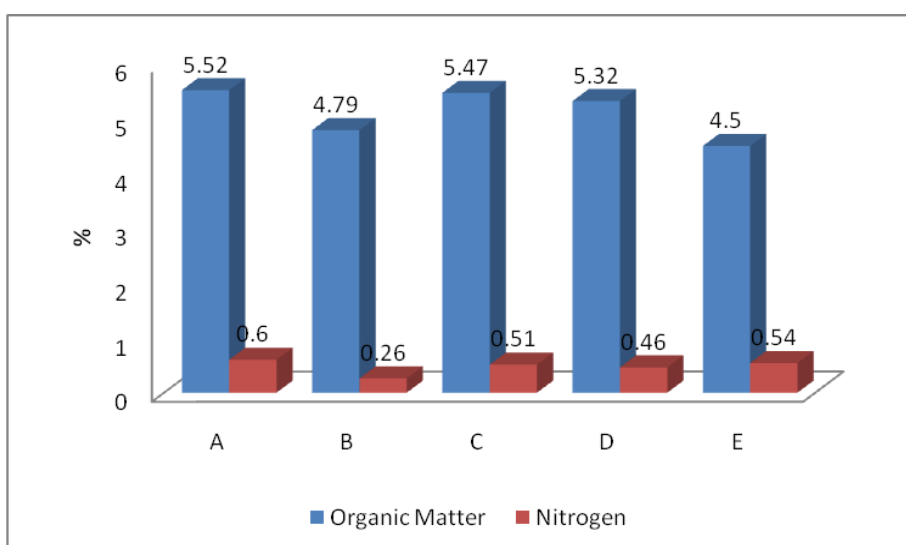
Figure 4: Chemical Analyses of Total Organic Matter and Nitrogen in the Soil of the Study Area

Figure 4 shows this when compared with FAO standard of (1.5-3) %. This is because the spilled oil had impaired the metabolic processes that would have facilitated the agronomic addition of organic carbon from the petroleum hydrocarbons by reducing the carbon mineralizing capacity of the micro flora. Figure 4 shows that total nitrogen content in the soil is moderate and it falls between the FAO standard of (0.08-3) %. This could be attributed to high organic matter in the area. Addition of inorganic NPK fertilizer may improve the soil nitrogen of the area.

3.1.4   Potassium in Soil

Figure 5 shows the level of potassium in the soil samples, were sample B, C, D and E are within FAO standard of (0.15-0.44) Cmol/mg, while sample A has the highest concentration of potassium content of 0.5Cmol/mg
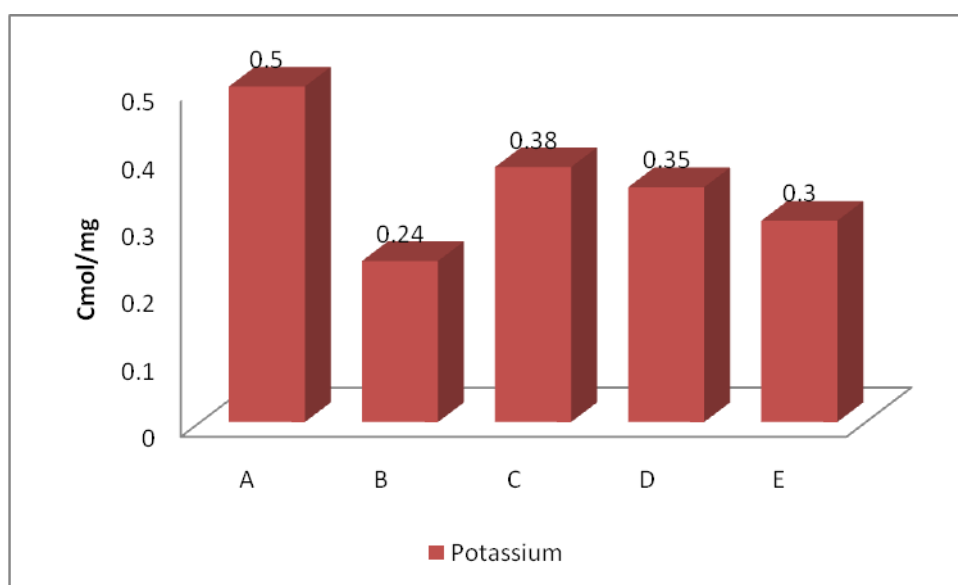

Figure 5: Chemical Analysis of Potassium in Soil Sample in the Study Area

3.1.5   Phosphorus and Extractable Micronutrients in the Soil

Table 1 shows that the phosphorus concentrations in the soil samples were higher than FAO standard of 7.20mg/kg. This is because oil spillage had allowed the fixing of weather minerals in the area, making less phosphorus available for plants.
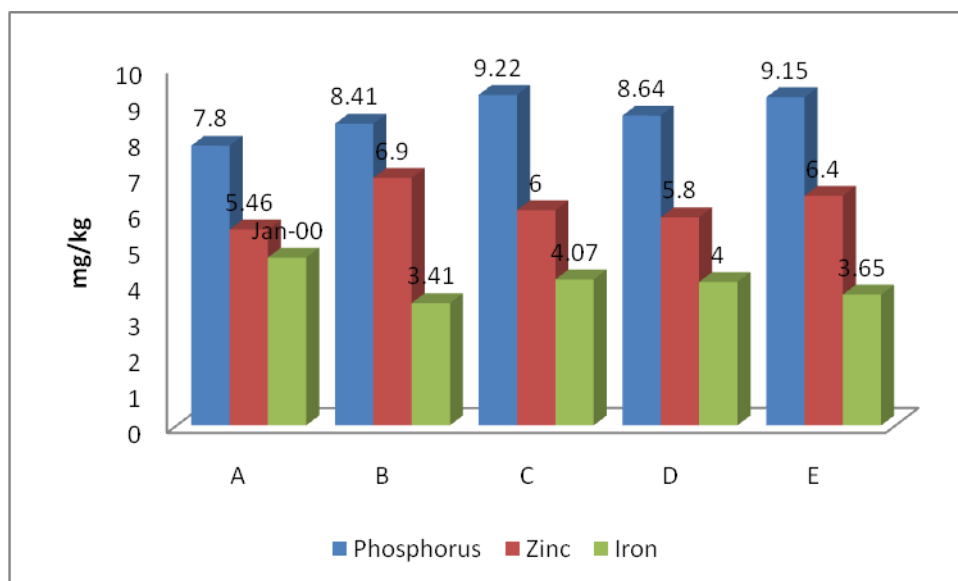
Figure 6: Chemical Analysis of Phosphorus and Extractable Micronutrients in the Soil of the Study Area

Figure 6 also shows the concentrations of micronutrients within the study area e.g. the concentrations of zinc in soil sample were above FAO standards of (2.0-4.8) mg/kg. This has prevented the activity of microorganism and earthworms in the soil and slowdown the breakdown of organic matter. Figure 6 also shows the concentrations of iron falls within FAO standard of 8.4mg/kg.

3.2   Analysis of Result for Water Samples

3.2.1   pH Value of Water

The intensity of acidity or alkalinity of a sample at a given temperature is measured on the pH scale, which determines the concentration of hydrogen ions present.
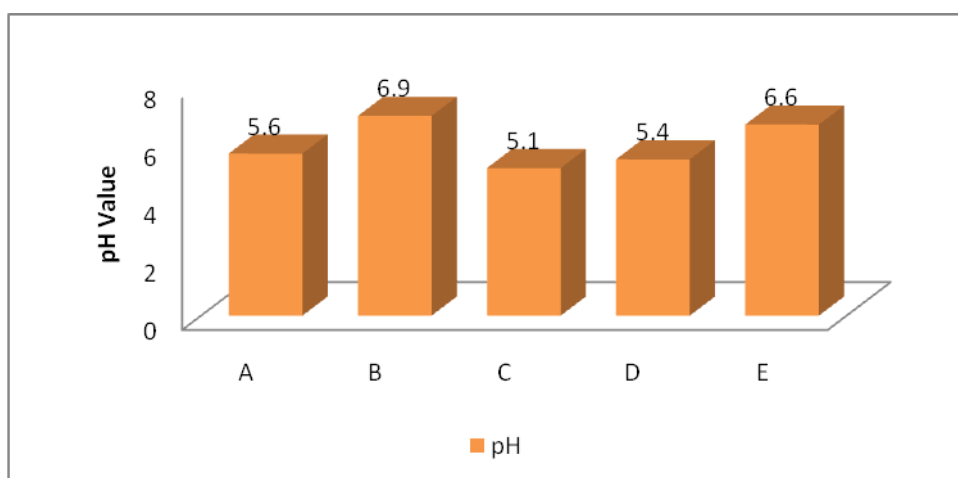

Figure 7: Chemical Analysis of pH Value of Water in the Study Area

The mean concentration of water analysis in Figure 7 indicates that the pH of sample B, sample E, falls within the WHO standard for pH in drinking water, which is in the range of 6.5-7.5 while sample A, C, and D are below WHO standard, and as such acidic in nature. This could be attributed to the high level of organic carbon content and free carbon dioxide in water resulting from oil spillage in the area. This had encouraged high levels of toxic metals such as Pb and Cu in the water which resulted to the sour taste of the water and other aesthetic problems.

3.2.2   Electrical conductivity of water

Electrical conductivity measures the exchangeable element that is present in water body. The common quality in water measured in terms of electrical conductivity is salinity.
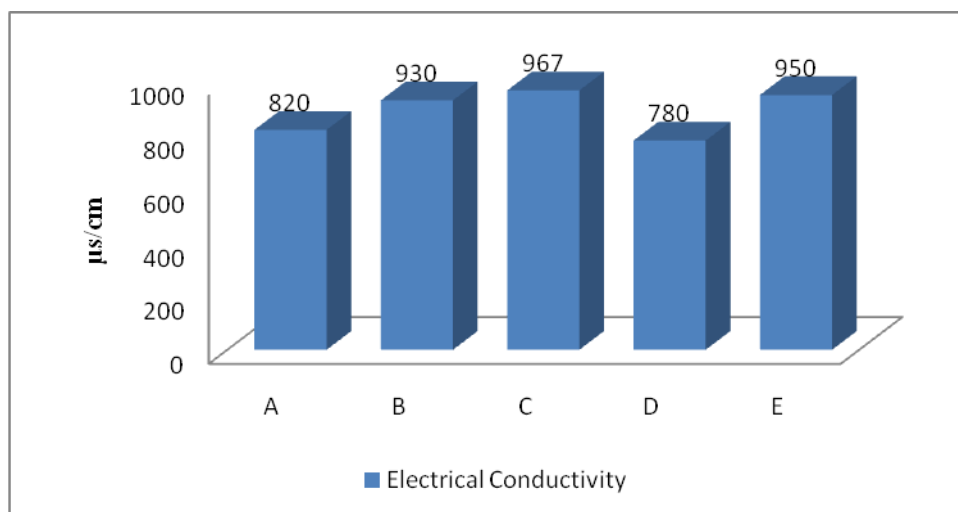

Figure 8: Chemical Analysis of Electrical Conductivity Value of Water in the Study Area

Table 2 and Figure 8 show the high values of electrical conductivity obtained in all of the samples which is above WHO standard of 400µs/cm for drinking water is as a result of oil spillage.

3.2.3   Dissolved Oxygen in Water of Study Area

Figure 9 shows that the dissolved oxygen content in the water samples is of low range which is between (2.4-3.4)mg/l obtained during the study, which is an indication that that the water in the study area is not suitable for aquatic life. This is because under favourable environmental conditions a minimum constant value of 6mg/l of dissolved oxygen is recommended by WHO, as this is satisfactory for the sustenance of aquatic biota including

fishes. This is one of the reasons responsible for the rapid reduction of fish stock in the water of the study area.
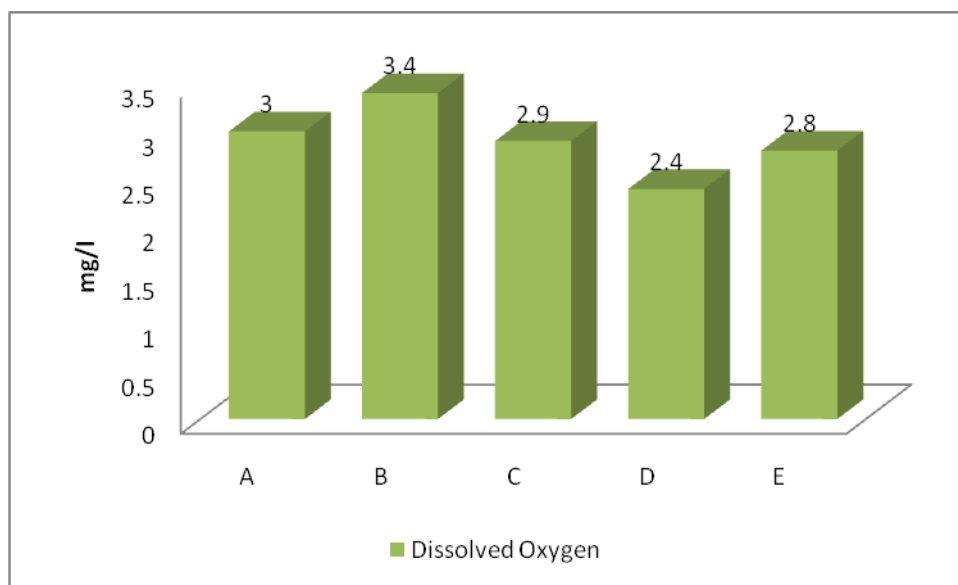

Figure 9: Chemical Analysis of Dissolved Oxygen Content in Water

3.2.4 Heavy Metals in Water

The concentration of lead in water samples A, B, C, D and E are 0.17, 0.15, 0.24, 0.16 and 0.21 respectively. These concentrations are above the WHO standard of 0.10mg/l most especially in A and E were the impact of oil spillage is frequent, this might be responsible for the recurrent report of toxic biochemical effect in the water of the study area, which includes poor development and intelligence quotient in children, renal dysfunction etc.
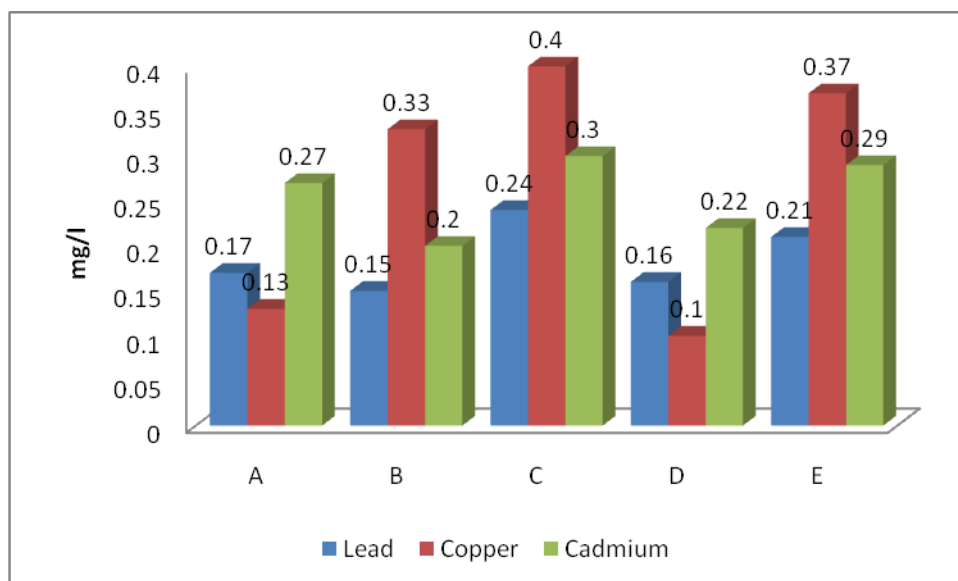

Figure 10: Chemical Analysis of Heavy Metal Content in Water

Figure 10 also shows the concentration of copper in the water samples are within WHO standard of 1.0mg/l; therefore copper poses no threat to the environment and human life in the study area. Concentration of cadmium is another parameter that was tested for in the water of the study area, which the result shows that the concentration is above WHO standard of 0.005mg/l as stated in Figure 10, it is believed that excess of cadmium in water is responsible for high blood pressure, renal dysfunction, pain in the bone and cancer of the lung etc.

4   Conclusion

This paper has clearly revealed that environmental components of the area have been seriously polluted by the oil spill. High contents of some heavy metals above the normal levels are detected in the soils and water bodies, and also in the tissues of fish and plant samples. This would clearly affect the qualities of crops and aquatic animals. Heavy metals are known to accumulate in the food-chain and could get into the drinking water. Staying in the polluted area would be harmful. The pollution must have created severe health risks to the people of Bomu community.

4   Recommendation

It is strongly recommended that best practices is adhered to in oil exploration, transportation and storage as this would minimise the occurrence of oil spillage in future.

Meanwhile, the cleaning up of the area should be carried out as soon as possible and some compensation should be paid to the people who have suffered for a long time from the damaging spill.

Establishment of regional spill response centres along our coastlines, and the use of data collected with an airborne system will help in managing oil spill problems in Nigeria. Since Ghana is planning to commence Oil exploitation, Ghanaian Government should borrow a leaf from the Nigerian experience.

5   Acknowledgement

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