Original research paper

Effect of oil Pollution on Soil Properties along Pipeline Right of way at Osisioma Ngwa, Abia State, Nigeria.

Abstract

The study examined the effects of oil pollution on soil properties along pipeline right of way at Osisioma Ngwa, Abia State, Nigeria.A transect of 50m x 500m was laid along the oil pipeline right of way and also in the control plot (natural forest) of 1.5km away from the oil pipeline. Soil samples were collected at 50m interval from 9 selected sample points within the laid transect along the oil pipeline right of way and control plot using a properly calibrated soil auger and core samplers. The soil samples were collected in the topsoil (0-20cm depth) and subsoil (20-40cm depth) into well labeled polythene bags. Thus, 36 soil samples were collected for laboratory analysis using standard methods. Descriptive and inferential statistics (pairwise t-test and Spearman Rank Statistics) were to analyze the data. Findings revealed that sand content was predominant in the study area. Clay was significantly higher in the control plot than polluted soil ($t=2.347$; $p=0.006$). The mean bulk density was significantly higher in the polluted plot than the control plot ($t=4.107$; $p=0.03$). The soil pH was significantly more acidic in the polluted soil than the non-polluted soil ($t=4.283$; $p=0.004$). The total organic C and total N were significantly lower in the polluted soil than the non-polluted soil while slight variation was observed in available P, exchangeable Ca and exchangeable Na between the polluted soil and non-polluted soil. However, exchangeable Mg and exchangeable K were significantly higher in the control soil than the polluted soil. The exchangeable acidity, Zn, Pb and Cu were significantly higher in the polluted soil than the non-polluted soil.Total hydrocarbon was significantly correlated with pH ($r=0.696$; $p<0.05$); available P. ($r= 0.660$; $p<0.05$) and EC ($r=-0.672$, $p<0.05$). The study recommended among others that liming should be employed to neutralize and reduce the acidity level in the polluted soil.

Key Words: Effects, Pollution, Soil, Properties, Pipe-line, Right of Way.

1: Introduction

Prior to the discovery of oil, the people of Osisioma Ngwa Local Government in Abia State made their living from exploration of the resources from the land, water and forest as farmers, fishermen, and hunters, conscious of the critical position of the environment to the sustenance and their future generations[1]. The discovery of oil in this area made all activities including agricultural pursuit to become peripheral and subservient to oil exploration. However, oil exploration came with its challenges and associated impacts on man and the environment. On the 3rd of September, 2012, oil spill occurred at Osisioma trunk line area of the local government in Abia State [2].The rupture of the pipeline released significant amounts of crude oil into the environment. Due to this incident, a vast array of agricultural farmlands and products were destroyed, premature death of various cash and food crops in the neighboring farmlands. In addition, various environmental resources were also affected and most importantly the health and general living conditions of the people living in the community and its environment[2]. According to SPDC Bulletin [3], oil spill which occurred on September 5th 2011 along the Port Harcourt Aba trunk line close to Aba (Abia, State) devastated six oil producing communities Osisioma NgwaLGA of Abia state. The affected communities were Umuebulungwu, Umuorie, Umuitiri, Umukala, Obohia, and Obahu. The spillage occurred as a result of the washing by officials of Shell Petroleum Development Company [SPDC] of the oil tank at IsimiriOil Field, Ukwa West Local Government, Abia State. The pressure exerted in order to get the tank properly clean was alleged to have burst the connecting oil pipe which conveyed products from the location to one of the shell's flow stations.Some of the burst pipes were reportedly put in place in the 1960's and since then, there has been no effort at upgrading them, this and alleged act of negligence got the pipeline to burst at the slightest pressure. Although the spillage occurred at the IsimiriOil location, the fast running river had spread the spilled oil to other communities destroying the swamp and the entire ecosystem along its route. Furthermore, other spillages that had occurred along the same trunk line have destroyed the farmlands and vegetation of these communities. This is the crux of the matter that necessitated this research to investigate the spillages along this trunk line and how it has damaged the soil making it impoverished with nutrients and rendering the people hopeless in terms of their farming activities. The discovery of oil in this area coincides with the boom years of this period [4]. As excessive oil exploration and seismic activities in the area have had negative reverberation for soil toxicity and quality, there is a general concern among environmentalist that the quality of crops in this area is rapidly deteriorating. Traditional food staples crops such as cassava, yam are adversely affected by the continuing forage for oil without requisite environmental impact assessment[5]. It is therefore imperative to ascertain the effect of this oil on soil properties. Statistics of fire outbreaks and explosion shows an alarming increase not only in number of incidents but in magnitude of damage to the environment, loss of valuable assets and on the national economy. Nigeria National Petroleum Corporation (NNPC) reported that 57 cases of pipeline explosion were recorded in 2008, 497 cases in 2009, 984 reported cases in 2010, 747 cases in 2011, 507 cases in 2012, 373 cases in 2013, 3700 cases in 2014[6].There were 15 reported cases of pipeline incident along system 2E between Oyigbo and Osisioma in January 2000 to February 2001 (Punch Newspaper, 2001).Several studies have been done on the impacts of oil spillage on soil physic-chemical properties both within and outside Nigeria and these included in the works of,[8]; [9]; [10]; [11]; [12], just to mention a few. It is realized that none of these studies had consideration for Osisioma Ngwa as a place facing with the problem of oil spillage. Moreover, these studies did not investigate the problem of oil spillage at the right of way of oil pipeline. Hence, the present study focused to examine the effects of oil spillage from the right of way of pipeline at Osisioma Ngwa LGA, Abia State.

2:Aim and Objectives of the Study

The aim of this study is to determine the effects of oil spillage on soil properties along the pipeline right of way at Osisioma NgwaLGA, Abia State, Nigeria.

To achieve this aim, the following objectives are stated to guide the study as follows to:

1. Determine the impact of oil spillage on soil physical and chemical properties in the study area.

2. Ascertain the differences between polluted and unpolluted soil along the pipeline right of way in the study area.

3. Determine the extent oil spillage has affected soil nutrients in the study area.

4. Determine the relationships between soil properties.

3: Research Hypotheses Statement

These hypotheses were tested in the study

1.There is no significant difference in the nutrients between polluted and unpolluted soil in the study area.

2. There is no significant difference in the concentration of heavy metals between polluted and unpolluted soil in the study area.

4:Method of Study

The research is experimental and the data used are primary sources of data.Thus, the study made use of both experimental plot (polluted soil) and the control plot (natural forest). The polluted plot along the oil pipeline right of way of pipeline network 2E belonging to the Petroleum Product Marketing Company (PPMC) a subsidiary of Nigeria National Petroleum Company (NNPC). The non-polluted area is a natural forest of 1.5km away from the oil pipeline right of way.

5:Soil Samples Collection and Laboratory Analyses

A transect of 50m x 500m was laid along the oil pipeline right of way and also in the control plot (natural forest). Soil samples were collected at 50m interval from 9 selected sample points along the oil pipeline right of way and control plot. At each sample point, soil sample was taken at the depth of 0-20cm (topsoil) and 20-40cm (subsoil) using a soil auger. Thus, 36 samples were collectedandproperlylabeledinpolythene bags. Core samplers were used to collect soil samples for bulk density analysis. Soil samples were thereafter transported to the laboratory and were air-dried under the room temperature, while core samples were oven dried at 105^{0}C for 36 hours. The air-dried samples were sieved prior to analysis. The samples were analyzed for the following parameters: particle size composition (sand, clay, silt), bulk density, soil pH, electrical conductivity (EC), total organic carbon (Total Organic C), exchangeable bases[Calcium (Ca), Potassium(K), Sodium(Na), Magnesium(Mg)), Total hydrocarbon, Exchangeable acidity, total nitrogen (Total N), available phosphorus (Available P) and heavy metals[Copper (Cu), Zinc (Zn), Lead (Pb), Nickel (Ni)].

6: Particle Size Composition

The particle size composition was conducted to determine the percentage content of sand, silt and clay in the soil. The analysis was performed using the Bouyoucos hydrometer method [13].

*Measure 50g of the sample

*Half fill the cup with 50ml of calgon (mixture of sodium hexametaphoshate and sodium carbonate) and shake vigorously to disperse the content.

*Transfer in 1000ml measuring cylinder

*Take the temperature reading.

3.4.2 pH determination

The pH of the soil was determined the pH meter in a soil liquid

*Weigh 20g of sample in a plastic beaker

*Add 20ml of distilled water and stir

*Obtain the reading using pH meter by dipping it inside the solution.

*Record the readings.

7: Electrical Conductivity

Electrical conductivity was determined using the same method with pH but with a different instrument which is called conductivity meter.

8: Exchangeable Bases (K,Na,Ca,Mg)

Exchangeable bases were extracted with neutral normal ammonium acetate.

*Measure 5g of sample into a cup

*Add into it 50ml 1N ammonium acetate

*Using a mechanical sample to shake them

*Then filter

*Using atomic absorbent spectrometer to take up the readings of Ca,Mg,K and Na.

9: Total organic carbon

Organic carbon was analyzed using the Walkey and Black(1934) wet oxidation method.

*Wash conical flask

*Polverize/mash the sample

*Weigh 1g on weighing balance and pour inside the conical flask

*Add 10ml of 1N $K_2Cr_2O_7$

*Add 20ml of conc.H_2SO_4

*Allow to stand for 30mins

*Add 100ml distilled water.

*Add 25ml of 0.5N$FeSO_4$-it turns blue

*Titrate with 0.5N $KMnO_4$-until the colour changes to purple.

*Take the readings.

10: Heavy metals

Heavy metals were analyzed using atomic spectrometer

*Wash round bottomed flask

*Weigh 1g of the sample and pour in each of the flask

*With pipette add 3ml concentrated nitric acid

*Then add 2ml concentratedHcl acid

*Add 3ml distilled water into it

*Put inside the heating mantle at about 70^{o}C,keep checking the sample till it changes colour.

*Bring out from the heating mantle and allow to cool.

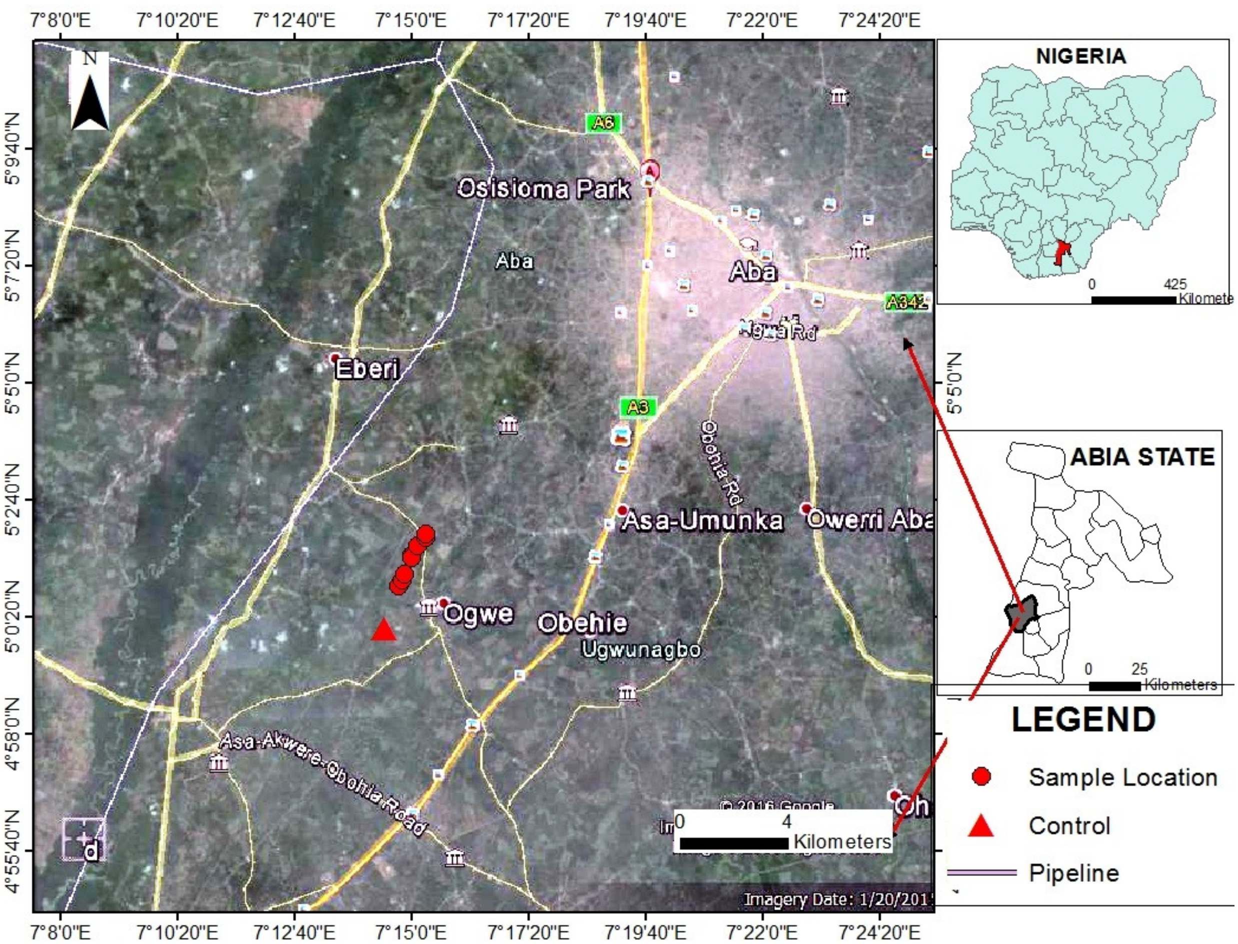
*Add 30ml of distilled water into the sample and filter into a 50ml volumetric flask with a filter paper

*Allow to stand for 24hrs

*Analyzed using an atomic spectrometer

11: Data Analysis

Both inferential and descriptive statistics were employed. Descriptive statistics was used to explain the mean values of soil parameters. Inferential statistics included pairwise t-test and Spearman rank correlation statistics. Pairwise t-test was used to test the significant variations of the soil parameters between the polluted and non-polluted soil at $p<0.05$ confidence level. Spearman rank correlation statistics were employed to determine the relationships among the soil parameters. Statistical Package for Social Scientists (SPSS) 20.0 version was used for the computations. Graphs, tables and charts were used to present the data.



Map1: Satellite Imagery Map of Nigeria Pipeline Distribution network showing communities in the study area and spill points (INSERT, Abia State Map showing Osisioma Ngwa LGA)

12: Results

Effects of crude oil pollution on physical properties of soil: The effect of crude oil pollution on physical properties of soil is shown in table 1 whereby the sand content was higher in both topsoil and subsoil in the polluted soil than non-polluted soil. Generally, the sand content in the topsoil was slightly higher than that of subsoil. The mean silt in the polluted soil was 5.36% and 5.42% in the topsoil and subsoil respectively while the mean silt on the non-polluted site was 5.53% and 5.93% in the topsoil and subsoil respectively. It was also observed that the clay content in the polluted site was lower than that of the non-polluted site, although the content was higher in the subsoil than the topsoil. The mean bulk density was 1.43 g/cm^3 and 1.49 g/cm^3 in the topsoil and subsoil respectively in the polluted site. The mean bulk density was very low in the control plot than the polluted site. Also,pH, clay and bulk density were significantly varied between the polluted and non-polluted sites.

Table1: Physical properties under polluted and non-polluted soils

Soil Properties	Polluted Site (Mean±SD)		Control Plot (Mean±SD)		t-value (p<0.05)
	Topsoil (0-15cm)	Subsoil (15-30cm)	Topsoil (0-15cm)	Subsoil (15-30cm)	
Sand (%)	90.67±0.76	90.18±0.57	88.68±0.83	87.00±0.61	1.066 (p=0.308)
Silt (%)	5.36±1.91	5.42±1.31	5.53±0.81	5.93±1.46	1.099 (p=0.325)
Clay (%)	3.98±0.27	4.40±0.47	5.60±1.11	7.07±1.84	2.347* (p=0.006)
Bulk Density	1.43±0.04	1.49±0.02	1.22±0.04	1.28±0.05	4.107*

(gcm^{-3})					(p=0.03)

Source: Researcher's analysis. N=9, *Significant at p<0.05.

13: Effects of crude oil pollution on nutrients and exchangeable bases properties of soil

The analysis on the effects of crude oil pollution on nutrients and exchangeable bases in both polluted and non-polluted soils is presented in table 2 and it shows that pH in the polluted soil of the topsoil was 4.56 and subsoil was 4.57. The mean pH was 6.03 and 5.90 in the topsoil and subsoil of the control site. This shows that the soil in the polluted site was very acidic while at the control site was weakly acidic, but the pH was more acidic in the subsoil at the control site. The analysis also reveals that in the polluted site, the mean EC was 34.06 uS/cm and 31.87 uS/cm in the topsoil and subsoil respectively while at the control plot, the mean EC in the topsoil and subsoil was 29.53 uS/cm and 30.10 uS/cm respectively. Themeantotalorganic C was 1.16% in the topsoil under pollution while the total organic C in the subsoil under pollution was 0.72%. In the control plot, the organic C was higher in both topsoil and subsoil than the polluted soil. Similarly, total N was in the polluted soil than the control plot soil. Furthermore, the mean available P was 27.60 mg/kg and 29.45 mg/kg in the polluted plot, while in the control plot, the available P was 30.01 mg/kg in the topsoil and 26.38 mg/kg in the subsoil. The mean Ca in the topsoil and subsoil in the polluted soil was slightly varied. Meanwhile the mean Ca in the control plot was higher than that of the polluted soil.The mean Mg, K, and Na in the topsoil and subsoil of the polluted soil were lower than that of the control plot.More so, the mean Mg, K and Na were higher in the topsoil than the subsoil. Finally, the exchangeable acidity was 1.83 mg/kg and 1.66 mg/kg in the topsoil and subsoil under the polluted soil while the mean exchange acidity was lower in the control plot than the polluted soil.

Table 2: Nutrients and Exchangeable Bases

Soil Properties	Polluted Site (Mean±SD)		Control Plot (Mean±SD)		t-value
	Topsoil (0-15cm)	Subsoil (15-30cm)	Topsoil (0-15cm)	Subsoil (15-30cm)	
pH (H_2O)	4.56±0.21	4.57±0.16	6.03±0.09	5.90±0.05	4.283* (p=0.004)
EC (us/cm)	34.06±2.43	31.87±2.41	29.53±7.89	30.10±7.33	1.112 (p=0.124)
Total Organic C (%)	1.16±0.22	0.72±0.08	2.16±0.31	1.77±0.48	3.254* (p=0.012)
Total N (%)	0.26±0.07	0.18±0.05	0.86±0.07	0.71±0.10	2.762* (p=0.045)
Available P (mg/kg)	27.60±1.86	29.45±2.61	30.01±3.67	26.38±2.07	1.125 (p=0.241)
Ca (mg/kg)	0.85±0.07	0.81±0.06	1.18±0.12	0.87±0.16	-1.272 (p=0.218)
Mg (mg/kg)	0.75±0.08	0.71±0.10	1.07±0.09	1.26±0.32	4.214* (p=0.007)
K (mg/kg)	0.87±0.06	0.86±0.06	1.39±0.07	1.31±0.06	3.587* (p=0.004)
Na (mg/kg)	0.62±0.04	0.56±0.04	0.72±0.09	0.68±0.17	1.127 (p=0.225)
Exchangeable Acidity (mg/kg)	1.83±0.13	1.66±0.16	0.76±0.04	0.78±0.06	3.472* (p=0.005)

Source: Researcher's analysis. N=9, *Significant at p<0.05.

14: Effects of crude oil pollution on physical properties of soil

The effect of crude oil pollution on total hydrocarbon and heavy metals is shown in table 3. The mean total hydrocarbon did not show significant variation except in the subsoil of the control plot with value of 0.04 mg/kg. There was no variation in the concentrations in Ni in both polluted and non-polluted. The mean concentration of Zn, Pb and Cu was significantly higher in the polluted soil than the control soil. The results also reveal that the mean concentrations of Zn, Pb and Cu were all higher in the topsoil than the subsoil.

Table 3: Total Hydrocarbon and Heavy Metals

Soil Properties	Polluted Site (Mean±SD)		Control Plot (Mean±SD)		t-value
	Topsoil (0-15cm)	Subsoil (15-30cm)	Topsoil (0-15cm)	Subsoil (15-30cm)	
Zn (mg/kg)	15.95±3.15	15.29±2.17	3.46±0.66	3.68±0.79	6.047* (p=0.001)
Pb (mg/kg)	6.00±0.86	5.14±0.70	0.09±0.01	0.09±0.02	5.356* (p=0.002)
Ni (mg/kg)	0.01±0.00	0.01±0.00	0.01±0.00	0.01±0.00	0
Cu (mg/kg)	10.39±1.72	9.35±1.42	1.44±0.34	1.47±0.47	4.249* (p=0.003)
Total Hydrocarbon (mg/kg)	0.34±0.02	0.33±0.02	0.07±0.31	0.04±0.02	2.142* (p=0.025)

Source: Researcher's analysis, 2016. N=9, *Significant at p<0.05.

14: Relationships existing between total hydrocarbon and other soil properties in the topsoil in the polluted site and the Relationships between total hydrocarbon and physical properties in the topsoil in the polluted site

The correlations between total hydrocarbon and physical properties of soil in the topsoil under polluted site are presented in table 4.The correlations between total hydrocarbon and physical properties of soil in the topsoil of the polluted soil were negative except sand with moderate correlation coefficient (r=0.515). None of the physical properties of soil was significantly correlated with total hydrocarbon. However, there was a strong and negative correlation existing between sand and silt (r=-0.954) while the correlations between clay and sand was moderate and negative (r=-0.574). The correlations between sand and bulk density was low and negative (r=-0.301); between silt and clay (r=0.445); between silt and bulk density (r=0.310) while between clay and bulk density was positive and low (r=0.241).

Table 4: Correlations between the physical properties of soil in topsoil inthe polluted site

	Sand	Silt	Clay	Bulk Density	Total Hydro Carbon
Sand	1.000				
Silt	-0.954*	1.000			
Clay	-0.574	0.445	1.000		
Bulk Density	-0.301	0.310	0.241	1.000	
Total Hydrocarbon	0.515	-0.521	-0.161	-0.388	1.000

*Correlation is significant at $p<0.05$

15: Relationships between pH, EC,nutrients, exchangeable basesand total hydrocarbon in the topsoil in the polluted site

The relationships between pH, EC, nutrients, exchangeable bases and total hydrocarbon in the topsoil in the polluted site are shown in table 5. It is revealed that pH had positive and relatively high correlation with total hydrocarbon (r=0.696). However, EC had significantly negative correlations with total hydrocarbon (r=-0.672). Also, available P had a positive and relatively high correlation with total hydrocarbon (r=0.660). Other nutrient and exchangeable bases had low correlations with total hydrocarbon. However, pH had negative and low correlations with most of the chemical properties except exchangeable acidity which had strong and significant correlation (r=0.860); and available P which had relatively moderate and positive correlation, though not significant (r=0.475). The correlations between EC and exchangeable bases (Ca, Mg, Na) were negative and low except K which had positive, though low correlation. The correlations between total N and organic C was very strong, positive and significant (r=0.937) while organic C had positive and moderate correlation with exchangeable acidity (r=0.502). Furthermore, the correlation between Ca and K was positive and relatively high (r=0.636) while the correlation between K and Na was also moderate and positive (r=0.564).

Table 5: Correlations betweenpH, EC, nutrients, exchangeable bases and total hydrocarbon in the topsoil in the polluted site

	pH	EC	Total Organic C	Total N	Av. P.	Ca	Mg	K	Na	Exchangeable Acidity	Total Hydrocarbon
pH	1.000										
EC	-0.402	1.000									
Total Organic C	-0.244	-0.251	1.000								
Total N	-0.307	-0.109	0.937*	1.000							
Av. P	0.475	-0.059	0.144	-0.047	1.000						
Ca	-0.285	-0.183	0.017	0.084	-0.211	1.000					
Mg	-0.025	-0.167	0.294	0.441	-0.110	-0.100	1.000				
K	-0.126	0.017	0.328	0.462	0.000	0.636	0.050	1.000			
Na	0.038	-0.009	0.090	0.043	0.392	0.494	0.132	0.564	1.000		
Exchangeable Acidity	-0.860*	0.119	0.502	0.409	-0.266	0.136	0.009	-0.017	0.052	1.000	
Total Hydrocarbon	0.696*	-0.672*	0.198	-0.051	0.660	-0.176	0.063	-0.181	0.309	-0.274	1.000

*Correlation is significant at $p<0.05$

16: Relationships between heavy metals and total hydrocarbon in the topsoil in the polluted site

The correlations between heavy metals and total hydrocarbon are shown in table 6. All the heavy metals investigated had low correlations with total hydrocarbon. However, positive and significant correlation existed between Pb and Cu (r=0.820). EC had negative and relatively high correlation with Zn (r=-0.667) and positive correlation with Pb (r=0.561).

Table 6: Correlations between heavy metals and total hydrocarbon in the topsoil in the polluted site

	pH	EC	Zn	Pb	Ni	Cu	THC
pH	1.000						
EC	-0.402	1.000					
Zn	0.293	-0.667*	1.000				
Pb	-0.004	0.561	-0.017	1.000	.		
Ni	0.000	0.000	0.000	0.000	1.000	.	.
Cu	0.142	0.283	-0.017	0.820*	0.000	1.000	
Total Hydrocarbon	0.696*	-0.672*	0.336	-0.211	0.000	0.008	1.000

*Correlation is significant at p<0.05

17: Discussion of Findings

Findings revealed that sand content was predominant in the study area. Also, the study area was texturally homogenous. Clay was significantly higher in the control plot than polluted soil (t=2.347; p=0.006). Similarly, the mean bulk density was significantly higher in the polluted plot than the control plot (t=4.107; p=0.03).The polluted soil was more acidic than the control site. The soil pH was significantly more acidic in the polluted soil than the non-polluted soil (t=4.283; p=0.004). There was a slight variation in the EC between the polluted and non-polluted soils. The total organic C and total N were significantly lower in the polluted soil than the non-polluted soil (t=3.254; p=0.012). Slight variation was observed in available P, exchangeable Ca and exchangeable Na between the polluted soil and non-polluted soil. However, exchangeable Mg and exchangeable K were significantly higher in the control soil than the polluted soil. The exchangeable acidity was also significantly higher in the polluted soil than the non-polluted soil (t=3.472; p=0.005).It was observed that the heavy metals such as Zn, Pb and Cu were higher in the polluted soil than the non-polluted soil. However, there was very little trace of Ni in the study sites. The total hydrocarbon was significantly higher in the polluted soil than the non-polluted soil (t=2.142; p=0.025). None of the physical properties of soil was significantly correlated with total hydrocarbon at $p<0.05$ in the topsoil of the polluted soil. Meanwhile, significant correlation was found between silt and sand in the topsoil of the polluted soil (r=0.954; $p<0.05$). Total hydrocarbon was significantly correlated with pH (r=0.696; $p<0.05$) and available P. (r= 0.660; $p<0.05$). EC had a negative but significant relationship with total hydrocarbon (r=-0.672, $p<0.05$). It was observed that pH had significant correlation with exchangeable acidity (r=0.860). Similarly, the relationship between total organic C and total N was positive and significant (r=0.937). However, EC was significantly and negatively correlated with Zn (r=-0.667, $p<0.05$) while positive and significant correlation also existed between Pb and Cu (r=0.820; $p<0.05$).

18: Conclusion and Recommendations

Based on the findings, the following recommendations were suggested.

1. Should check operational improvement of oil pipeline infrastructure and involvement of the people in decision making relating to the operation of oil pipeline operation in the area and possibly planned campaign to enlighten the populace on the effects of oil pipeline fire.
2. Government should effectively checkmate the activities of vandals and an automatic shut off should be installed and also restricted flow devices should be activated when unauthorized access is observed across the section.
3. Liming by adding carbonates of Ca and/or Mg ($CaCO_3$; $MgCO_3$) or hydroxides of Ca and/or Mg (Ca(OH); Mg(OH)) and oxides of Ca and/or Mg (CaO; MgO) is required to reduce and neutralize the acidity level of the polluted soil.
4. Laws should be promulgated and the laws should be enforced to punish offenders or the culprits vandalizing the pipelines. This would prevent the vandals from incessant breaking of the pipelines and thus the ecosystem will be preserved.
5. The host communities should take ownership of the environment and kick against any move for saboteur.
6. To avoid fast/rapid movement of the heavy metals either laterally or longitudinally, regular application of organic manures in the form of farm yard manure; compost; green manures; poultry dropping; palm oil mill effluent and so on is highly recommended.

18.1: Conclusion

The study has vividly revealed that crude oil pollution in the right of way of pipeline in Osisioma LGA, Abia State, Nigeria has really affected the soil physical and chemical (pH, EC, nutrient, exchangeable bases, total hydrocarbon and heavy metals) properties. The crude oil pollution has increased sand content but lowered silt and clay contents. Similarly, the pH, EC, total organic C, total N, exchangeable Ca, Mg, K, and Na were lower in the polluted soil. The heavy metals (Zn, Pb, Cu) and total hydrocarbon increased in the polluted soil.More so, pH and EC correlated significantly with total hydrocarbon in the topsoil in the polluted soil.

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Appendix I

The Study Area

The study was carried out around the System 2E from Port Harcourt to Makurdi oil pipeline in Osisioma Ngwa Local Government Area of Abia State (Figure 1.1). The study area is found in the latitudes between 05^{o} 12$^{'}$ 53$^{''}$ and 05^{o}12$^{'}$ 44$^{''}$ North; and longitudes between 007^{o}19$^{'}$ 53$^{''}$ and 007^{o} 19$^{'}$ 57$^{''}$ East. The land measured about four hundred squared meters (PPMC, 2010).

Osisioma Ngwa LGA is situated in the Aba Senatorial District, the commercial nerve centre of the eastern state of Nigeria. The LGA is bounded on the North by the present Umuahia Zone, on the West by Owerri and Mbaise, on the East by IkotEkpene and Abak and on the South by Ukwa. The town is traversed by pipeline through Port Harcourt-Enugu express road with an intersection at AroNgwa with Port Harcourt-Makurdi oil pipeline network. The Aba petroleum depot belonging to the Petroleum Product Marketing Company [PPMC] is also located at Osisioma with interlink of pipeline facilities. The plain topography of the area makes road access very easy.

Relief, Drainage and Population: Abia State has a variety of land forms, despite the fact that it is dominated by flat and low lying land generally less than 120m above sea level.

The important waterways are the Imo River to the South and to the West, The Aba or Aza River That rises at Abayi at a point near Okpontu (Okoro, 2001).

Osisioma Ngwa LGA has a population of about one million people and an area of a little over 2300km^2. The occupation of the people is largely farming which is a form of producing farm products. The major rural industries include garri and palm produce in addition to Akwete cloth weaving in which most of their women were engaged (Amadi and Nwankwoala, 2013).

Climate: The climate of the place falls under Koppen's classification with two seasons in the year namely: the rainy season and the dry season (Anyadike, 2002).The rainy season begins in March and ends in October with a break in August while the dry season begins in November and last till February. The temperature of the place is normal around 25^{o}C .The hottest months are January to March which records a mean temperature above 27^{o}C.

Vegetation and Soil: The study area is situated in the tropical rainforest of the southern Igbo plain, though with some patches of savanna plants. According to Maduabuchi (2004), the vegetation around the sampled location is a mixture of savannah and rainforest. The vegetation of Osisioma Ngwa area is a mixture of grass and self-regenerated low land rainforest. There is dominance of palm trees, isolated raffia palm trees and other trees of economic value (Maduabuchi, 2004). The plain landscape supports farming activities which in most cases are of subsistence nature. Shifting cultivation is of a general practice in the area, with fallowing periods ranging from 2-4years. The soil of the region is classified into fresh water alluvium and leached coastal plain sand (Oyegun, 1999). The soils are not particularly fertile and are prone to much leaching due to heavy rainfall. Fertilizer is made to improve the soil fertility for the enhancement of agricultural yield. Prominent arable crops cultivated in the area include cassava, yam, cocoyam, maize and vegetables. Harvesting and milling of palm fruits is a common occupation. The main ecological problems in the state are sheet and gully erosion.

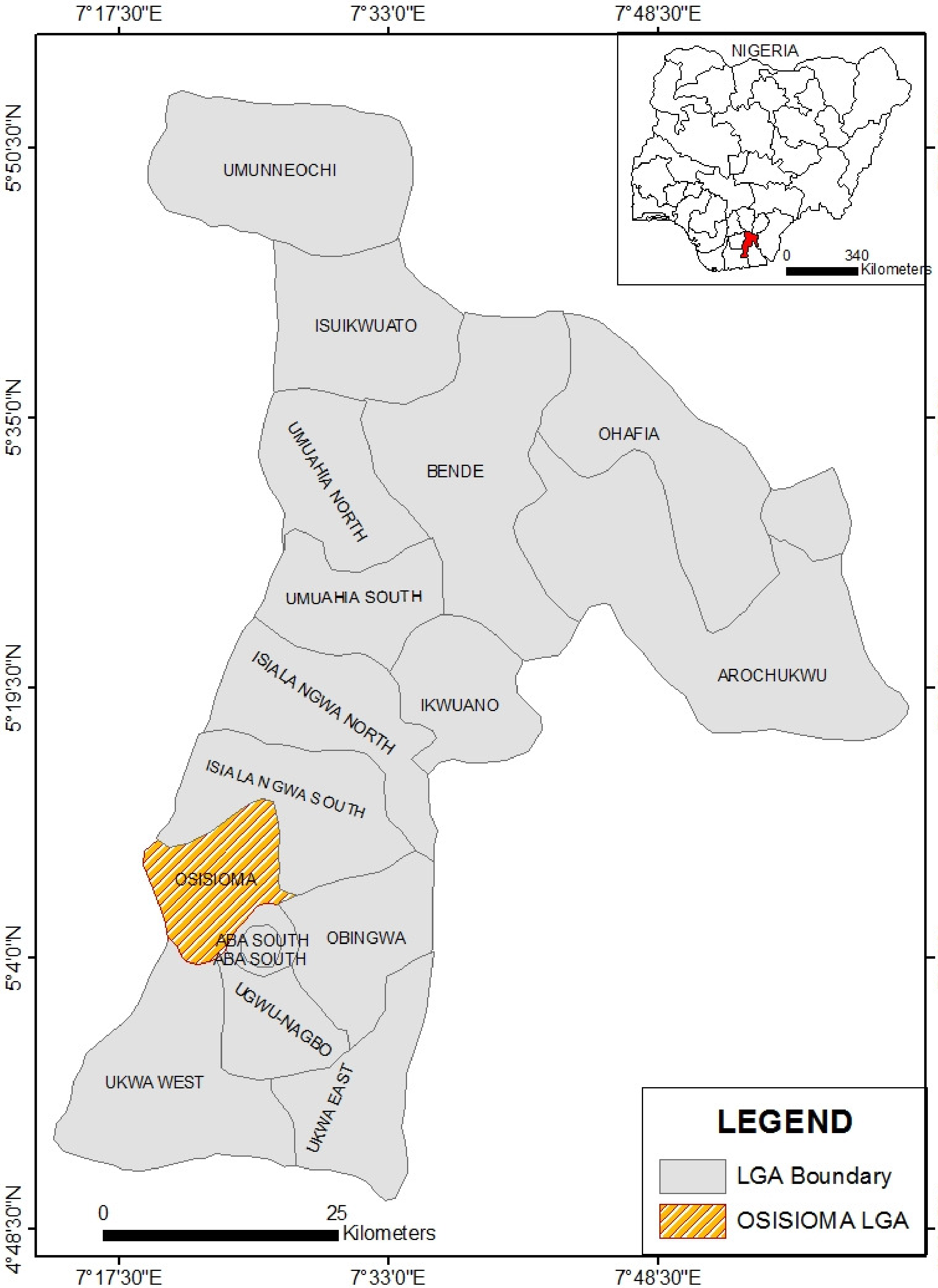

Figure 1.1 : Showing map of Abia State with the local governments, Osisioma study area shaded.