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Determination of physico-chemical soil quality around yorla oil field area in rivers state, Nigeria

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Abstract
Post-remediation status of soil around Yorla oilfield in Kpean community of Rivers State was assessed. A total of 4 soil samples were obtained from four different locations at a depth of 0-20cm using soil auger. Results showed the following levels: N, P, K (0.17 0.01)%, (22.83 1.23) mg/kg, and (32.03 1.82)mg/kg respectively; TPH (607.98 432.06) mg/kg, TOM (2.02 0.16)%, TOC (1.16 0.09)%, Temperature (25.60 0.17)^{0}C, Electrical Conductivity (47.93 1.57) µS/cm and pH (5.99 0.20). The mean concentrations of the heavy metals were Cd (0.03 0.01)mg/kg, Pb (0.40 0.16) mg/kg, Cr (6.18 1.43) mg/kg, Zn (2.91 0.01)mg/kg, V (0.90 0.04)mg/kg, Ni (0.07 0.01)mg/kg and As (0.11 0.03)mg/kg. The principal component analysis showed that principal components 1, 2, 3, were highly correlated with Pb, TPH and soil Temperature respectively. The levels of the quality parameters differed significantly between the control and sampling stations A (sig.F = 0.000), B (sig.F= 0.002) and C (sig.F=0.000) at P <0.05. The soil was moderately acidic and had lower TOC values in the oil impacted soil. Result obtained revealed that the concentration of heavy metals were within the recommended limits by Environmental Guidelines And Standards for the Petroleum Industry In Nigeria (EGASPIN). The observation of this study indicated that the remediation carried out at the oil-spill site was poorly executed and it is recommended that proper treatment of the soil should be carried out so that it could be used for the intended purpose by the community.

Keywords: physicochemical parameters, metal toxicity, bioaccumulation, biomagnifications, food chain

1. Introduction

The increasing exploration, exploitation, transportation and refining of crude oil in the Niger Delta region have led to accidental oil-spills that affect agricultural activities (Osuji *et al*, 2006 and Osam *et al*, 2011) [12,11].

Oil spills occur due to equipment failure, staff incompetence and sabotage (Sousa *et al*, 2008) [15]. Trace and heavy metals associated with crude oil pollution are persistent in the soil and can bioaccumulate and biomaginigy in the food chain, a trend dangerous to agriculture, human and wildlife (Akhionbare, 2009) [1].

Soil is not an inexhaustible resource and, if poorly managed, its characteristics can be lost in a short period of time, with limited opportunities for regeneration (Nortcliff, 2002) [7]. With the spate of crude oil facilities failure at abandoned wells caused by corrosion and sabotages, there is increased oil spillage in Yorla oilfield area. Crude oil has been known to contain heavy and trace metals and hydrocarbons (Osuji *et al.*, 2006) [12]. These pollutants heavy ultimately find their way into the soil (Yorla oilfield area) through the following processes.

Oil spill from Shell Petroleum Development Company (SPDC) facilities failure, incomplete remediation exercise, Lack of quantitative information on the post-remediation soil.

These pollutants especially heavy metals and hydrocarbons are non-biodegradable, toxic and can bioaccumulate and biomagnify in food chains. Hence, these pollutants might be found in food grown on such land.

The negative consequences on the health of consumers of foods grown on such lands can only be imagined.

This study will help in evaluation of Physico-chemical Soil Quality around Yorla Oilfield area in Rivers State. This will be achieve through the following objectives:

1. To determine the levels of some physicochemical parameters in post-remediation soil around the Yorla oilfield area.
2. To determine the levels of some heavy metal parameters in post remediation soil.
3. To determine the physico-chemical parameters that contributed the greatest impacts in the post remediation soil.

2. Methodology

2.1 Study Area

The study area is in Yorla oil field well 10, located in Kpean Community Farmlands, Ken-khana region of Khana Local Government Area of Rivers State. The area is in the Niger Delta region South East flank of Port Harcourt city.

The study area lies between lateitude 4^0, 35^{1}N, and longitude 7^0, 28^{1}E (Table 1).

Its topography is mainly characterized by lakes, creeks, lagoons and swamps of varying dimension.

Kpean community is in Ogoni Land, located in the coastal plain of the Eastern Niger Delta.

The people are predominantly farmers and fishermen. The region is divided administratively into four local government area: Eleme, Tai, Gokana and Khana.

It has a population of close to 832,000 according to the 2006 National Census, consisting mainly of Ogoni people (UNEP Report Ogoniland, 2011) [16].

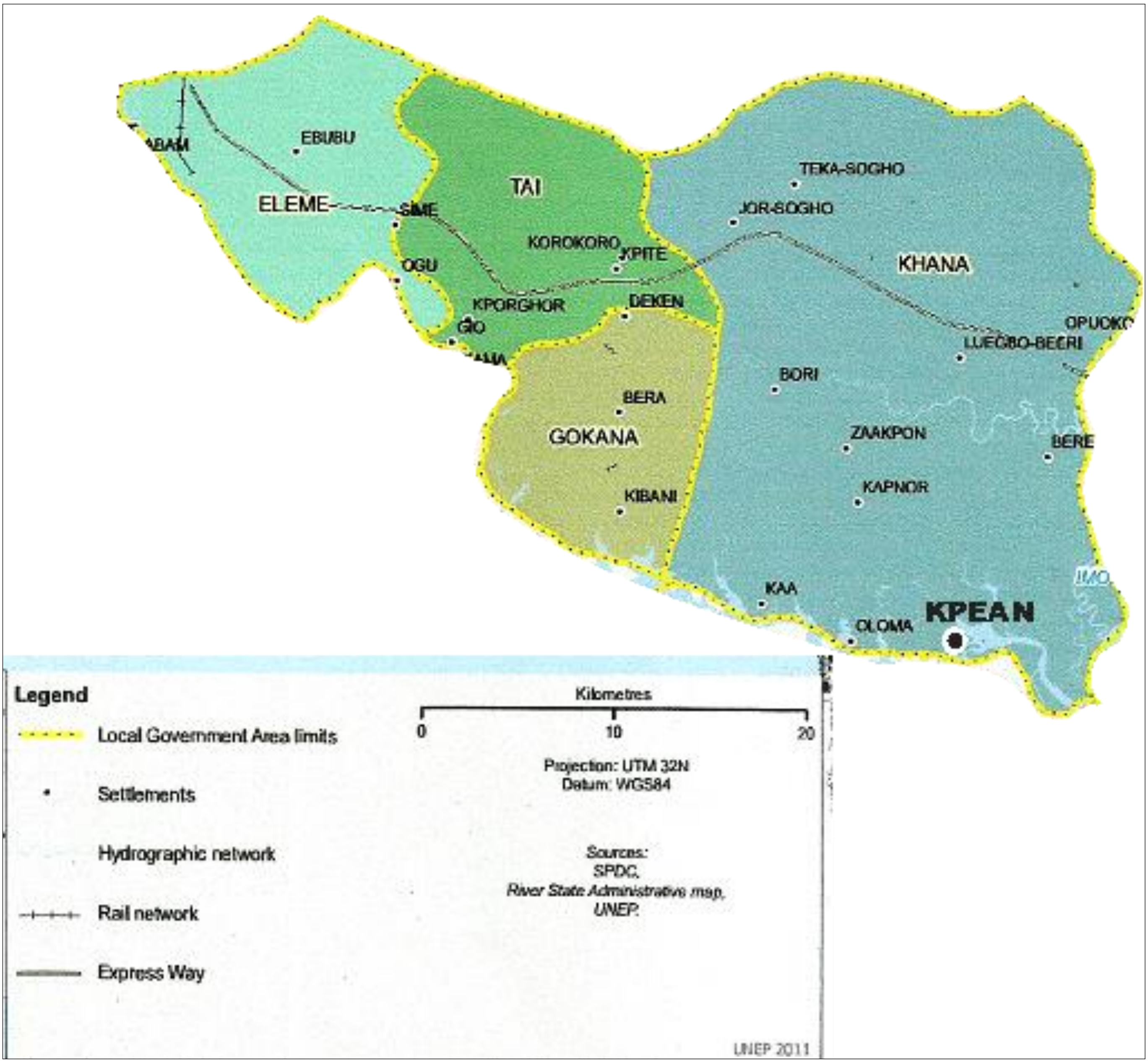

Fig 1: Map of Ogoniland showing study area (adapted from Ogoni UNEP Report, 2011).

Map 4. Oil industry infrastructure in Ogoniland

Fig 2

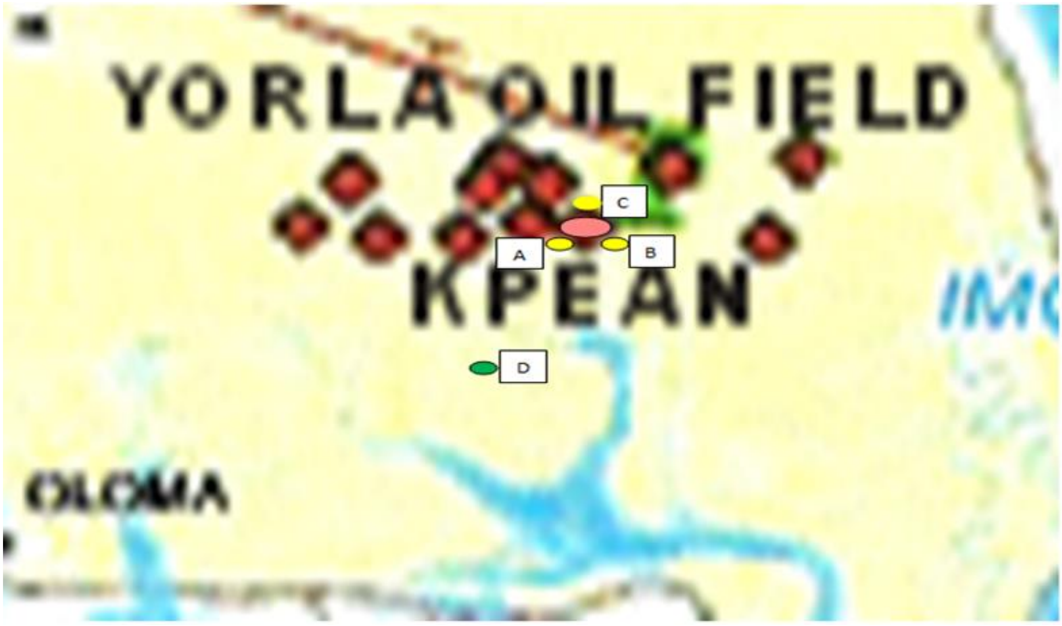

Fig 3 Map of the Study Area (Yorla Oil Field in Ogoniland) Showing Sampling points () Around Well 10 (

2.2 Methods

Experimental work was done in two distinct areas

Heavy metal analysis. The HMs analyzed were: Pb, Cd, V, As, Cr, Ni and Zinc Analysis of the physicochemical properties of the soil. This included Temperature, pH, N, P, K, Total Organic Matter, Total Organic Carbon, Electrical Conductivity and Total Petroleum Hydrocarbon.

Sample Collection

Soil samples were collected from three sampling points:
Location A (Lat.004^{0}, 35^{1}, 37.2^{11} North;
Long. 007^{0},28^{1}, 16.8^{11} East
Location B (Lat.004^{0}, 35^{1}, 97.2^{11} North; Long. 007^{0},28^{1}, 30^{11}East
Location C (Lat.004^{0}, 35.9^{1}, 97. 2^{11}North; Long. 007^{0}, 28^{1}, 30.5 East
Control, D (Lat.004^{0}, 37^{1}, 37.3^{11} North; Long. 007^{0}, 28^{1}, 24^{11}East
The control sample was collected from Location D at about 1km from the oil spilled site.

Sample Pretreatment

Samples for heavy metal analysis were air-dried and sieved using 2mm mesh. The dried soil samples were broken, pulverized with pestle and mortar and sieved. The samples were transferred to pre-cleaned Pyrex Petri dishes (APHA *et al*., 1998) [4].

Digestion

2 – 3g of soil sample was digested in about 15cm^3 of aqua-regia (HCl: HNO_3 = 3:1) for approximately 4 – 5hrs using hot bath and maintaining a heating temperature of 110^{0}C. The sample was placed in 100cm^3 pyrex glass beaker and diluted with distilled water up to 50cm^3. The solution was filtered and the filtrate analyzed using Atomic Absorption Spectrophotometer (AAS), APHA (1998) [4].

Analysis

The concentration of metals in the samples was determined using Atomic Absorption spectrophotometer. Prior to the analysis, calibration was done with standard of known concentrations. Dissolved metals were determined by aspirating a portion of the filtered sample directly into the AAS. The concentrations of heavy metals were ascertained from the data generated by AAS and expressed in mg/kg.

ph, Electrical Conductivity & Temperature

pH and conductivity were measured using a digital Oakton pH meter (model PCD 650) and HANNA conductivity/TDS meters (HI 9835) respectively. Temperature was measured using a thermometer. The pH, meter was standardized with buffer solutions (4 & 7). The tip of the probe was rinsed with deionised water and cleaned with tissue paper. The probe was then immersed in the sample and the corresponding steady reading was taken.

Total Petroleum Hydrocarbon (TPH), Potassium, Nitrogen and Phosphorus

The method is based on USEPA 8270. Sample extraction was carried out with dichloromethane followed by sample clean-up and separation. One µl of extract (after concentration) was injected into Agilent 7890 GCMS for analysis. The concentration of TPH was deduced from the calibrating graph (APHA *et al*., 2002) [5]. After acid digestion of the soil sample, the concentration of potassium (K) in the sample was determined using Atomic Absorption Spectrophotometer (ASTM D4192) method (APHA, 2002) [5]. The method for TOC was adopted from APHA 5310B (High temperature combustible method) which uses spectrometry. Total organic matter = TOC *1.75 (APHA, *et* *al.*, 2002) [5]. Nitrogen and phosphorus was measured using spectrophotometer.

Statistical Analysis

We performed statistical analysis by using the raw data. Relationship between heavy metal and other physico-chemical parameters were determined by bivariate correlation using the pearson coefficient in a two-tailed test (r < 0.01 and 0.05). Descriptive statistics was used in this study (SPSS version 22.0). Principal component analysis was used to determine which components were highly correlated and also to know the principal component that may constitute Major hazards.The level of significance of each parameter in the process was measured by using analysis of variance (ANOVA).

3. Results and discussion

3.1 Results

The result obtained from the field are presented below

Table 1: Level of Physico-Chemical Parameters in Soil Around Yorla Oilfield, Rivers State

S/N	Parameter	Analytical Method	Method Detection Limit	DPR Limit		SAMPLE ID			
				Target Value	Intervention Value	Station A	Station B	Station C	Control
1	pH	APHA4500H				6.05	6.45	5.97	5.47
2	Conductivity µS/cm	APHA2510B				43.7	48.2	48.5	51.3
3	Temperature ^{0}C	APHA 25508				25.2	26.0	25.5	2.57
4	Total Organic matter, %	Spectrometry				1.80	1.89	1.92	2.48
5	Total Organic Carbon %	Spectrometry				1.03	1.08	1.10	1.42
6	Phosphorus mg/kg	Spectrometry				20.1	23.4	21.9	25.9
7	Total Petroleum, mg/kg	USEPA8270 &EPA 8015	0.0001			312	111	1954	54.9
8	Potassium, mg/kg	ASTMD4192	0.05			30.0	31.1	29.6	37.4
9	Nitrogen, %	Spectrometry				0.14	0.16	0.17	0.19
10	As, mg/kg	ASTMD2972	0.10	29	55	0.07	0.07	0.09	0.19
11	Cd, mg/kg	ASTMD3557	0.01	0.50	12.0	0.01	0.03	0.04	ND
12	Cr, mg/kg	ASTMD1687	0.05	100	380	4.08	4.79	5.46	10.4
13	Ni, mg/kg	ASTMD1886	0.05	35	210	0.06	0.06	0.08	0.08
14	Pb, mg/kg	ASTMD3559	0.05	85	530	0.21	0.10	0.50	0.80
15	Zn, mg/kg	ASTMD1691	0.05	140	720	2.23	2.11	1.90	5.71
16	V, mg/kg	ASTMD3373	0.05			0.87	0.92	0.81	0.98
17	Latitude					04^0 35.372^1	04^0 35.97,2^1	04^0 35.99,9^1	04^0 37.31,3^1
18	Longitude					007^0 28.16',8"	007^0 28',30"	007^0 28'.30,5"	007^0 28'.02"
19	C/N Ratio					7.36	6.75	6.47	7.47

The levels of Total Petroleum Hydrocarbons (TPH) varied widely (range=1899.10 mg/kg), while other parameters have narrow variations. pH, Electrical Conductivity (EC), Temperature, and Total Organic Matter (TOM) varied between 5.47 – 6.45 (5.9 0.20), 43.70 – 51.30 (47.93 1.57)µS/cm, 25.20 – 26.00 (25.60 0.17)^{0}C, and 1.80 – 2.48 (2.02 0.16)% respectively (Table.1). Total Organic Carbon (TOC) level varied between 1.03 – 1.42 (1.16 0.09) %, phosphorus varied between 20.10 – 25.90 (22.33 1.23) mg/kg, Total Petroleum Hydrocarbon (TPH) varied between 54.90 – 1954.00 (607.98 452.06) mg/kg, Potassium varied between 29.60 – 37.40 (32.03 1.82) mg/kg and Nitrogen varied between 0.14 – 0.19 (0.17 0.01) % (Table 1 and 2)

Table 2: descriptive statistics of physico-chemical parameters in soil around yorla oilfied

Parameters	Minimum	Maximum	Range	Mean	Se
Ph	5.47	6.45	0.98	5.99	0.20
Conductivity µS/cm	43.70	52.30	7.60	47.93	1.57
Temperature (^{0}C)	25.20	26.00	0.80	25.60	0.17
TOM (%)	1.80	2.48	0.68	2.02	0.16
TOC (%)	1.03	1.42	0.39	1.16	0.09
Phosphorus (mg/kg)	20.1	25.9	5.8	22.83	1.23
Total Petroleum Hydrocarbon (mg/kg)	54.9	1954	1899.1	607.98	452.06
Potassium (mg/kg)	29.6	37.4	7.8	32.03	0.01
Nitrogen (%)	0.14	0.19	0.05	0.17	0.01
Arsenic (mg/kg)	0.07	0.19	0.12	0.11	0.03
Cadmium (mg/kg)	0.01	0.04	0.03	0.03	0.01
Chromium (mg/kg)	4.08	10.40	6.32	6.18	1.43
Niekel (mg/kg)	0.06	0.08	0.02	0.07	0.01

Lead (mg/kg)	0.10	0.80	0.70	0.40	0.16
Zinc (mg/kg)	1.90	5.71	3.81	2.99	0.91
Vanadium (mg/kg)	0.81	0.98	0.17	0.90	0.04

Variation of Heavy Metal Parameters

The levels of arsenic, cadmium, chromium and nickel varied between 0.07 – 0.19 (0.11 0.03) mg/kg, 0.01 – 0.04 (0.03 0.01) mg/kg, 4.08 – 10.4 (6.18 1.43) mg/kg and 0.06-0.08 (0.07 0.01) mg/kg respectively (Table.1).

Lead (Pb) level varied between 0.10-0.80 (0.040 0.16) mg/kg, Zinc varied between 1.90 – 5.71 (2.91 0.91) mg/kg, and vanadium varied between 0.81 – 0.98 (0.90 0.04)mg/kg as seen in Table 1 and 2.

Relationship between Physico-Chemical Parameters

There were some significant r correlations existing between the physicochemical parameters (Table 2).

Table 3: Correlation (R) Matrix between the Physico Chemical Parameters in Soil of Yorla Oilfield

	pH	EC	TEMP	TOM	TOC	P	TPH	K	N
AS	-0.895	0.769	0.172	0.992**	0.992**	0.829	-0.253	0.951*	0.864
Cd	0.635	-0.064	0.217	-0.608	-0.607	-0.350	0.726	-0.727	-0.175
Cr	-0.851	0.825	0.269	0.998**	0.999**	0.879	-0.256	0.957*	0.901
Ni	-0.760	0.725	0.000	0.663	0.667	0.506	0.506	0.468	0.832
Pb	-0.947	0.718	-0.044	0.874	0.877	0.641	0.139	0.749	0.854
Zn	-0.839	0.671	0.181	0.972*	0.972*	0.816	-0.468	0.987	0.756*
V	-0.372	0.514	0.506	0.743	0.739	0.793	-0.848	0.874	0.487

* = Significant at $P < 0.05$, ** = significant at $P < 0.01$

At P<0.05, TOM, correlated positively with zinc ions (r=0.972), TOC correlated with zinc ions (r = 0.972), K ions correlated with As (r – 0.951), Cr ions (r = 0.957) and zinc ions (r = 0.987), while N correlated with Zn ions (r = 0.756) Table 4.4) At P<0.01, TOM and TOC correlated positively with As ions (r 0.992) and Cr ions (r = 0.998 and 0.999 respectively). However, the other physicochemical Parameter did not show significant correlations.

Principal components analysis (PCA)

The physicochemical parameters that were subjected to the PCA procedures produced both initial and extraction communalities that were all high. The first three principal components (PCs) formed the extraction solution with a cumulative percentage variability of 100% in the original 16 variables (Table.3).

Table 4: Extraction sums of squared loadings of the physico-chemical properties.

Components	Total	% of Variance	Commulative (%)
1	11.129	69.557	69.557
2	2.795	17.468	87.025
3	2.076	12.975	100.000

The rotation maintained the cumulative percentage of variation explained by the extracted components. PC 1 alone contributed about 55.71% variability, PC 2 contributed about 25.69% variability, and PC 3 contributed about 18.601% variability (Table 4.).

Table 5: Rotation Sums of Squared Loadings of The Physico-Chemical Properties.

Components	Total	Variance	Commulative
1	8.913	55.706	55.706
2	4.111	25.694	81.399
3	2.976	18.601	100.000

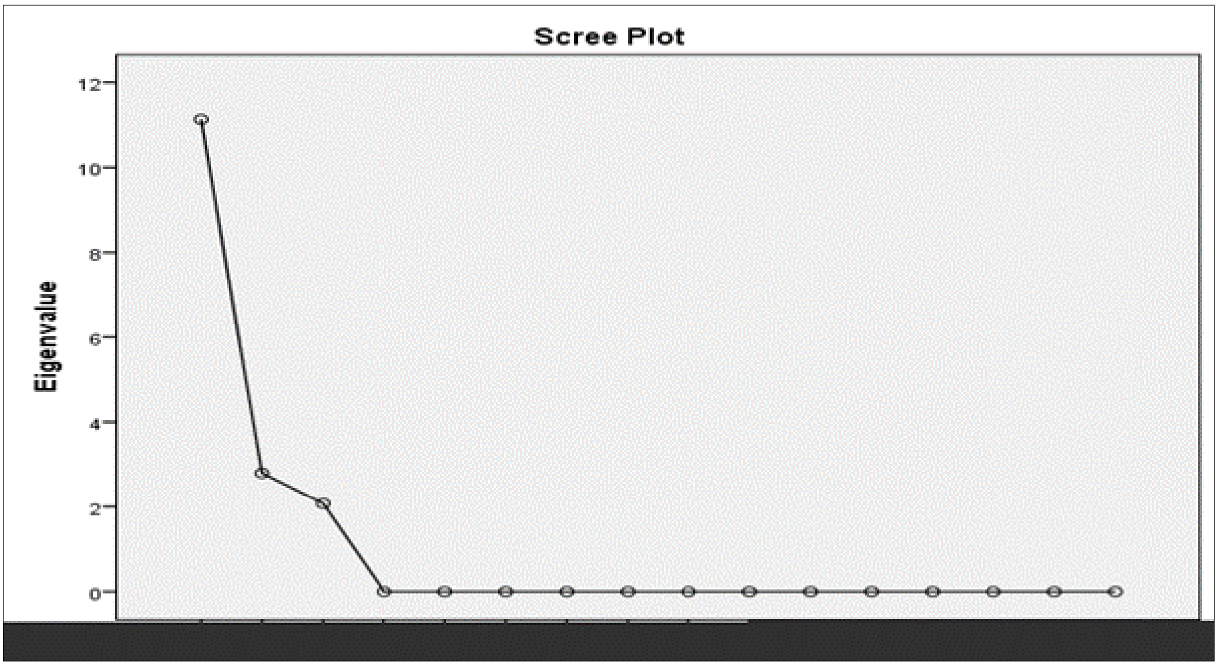

Fig 4: Scree plot of Eigen values by component numbers of the physico-chemical parameters

The extracted components are on the steep slope, while the components on the shallow slope contributed nothing to the solution. The first component (PC 1) was most highly correlated with the concentration of Pb (1.00), and also had high loadings for pH (-0.943), Electrical Conductivity (EC) 0.716, TOM (0.862), TOC (0.865), P (0.629), K (0.732), N (0.852), Arsenic ions (0.906), Cr ions (0.889), Ni ions (0.920), and Zn ions (0.792).

PC 2 was most highly correlated with TPH (-0.971), Cd ions (-0.869), Zn ions (0.591), and V ions (0.852). However, PC 3 was most highly correlated with soil temperature (0.991) and also had high loadings for EC (0.698), P ions (0.689), and N (0.524). The component plot in Rotated space reveals that the components were skewed in distribution (Fig 2); with soil temperature and pH appearing to be more closely related with each other than with the other parameters.

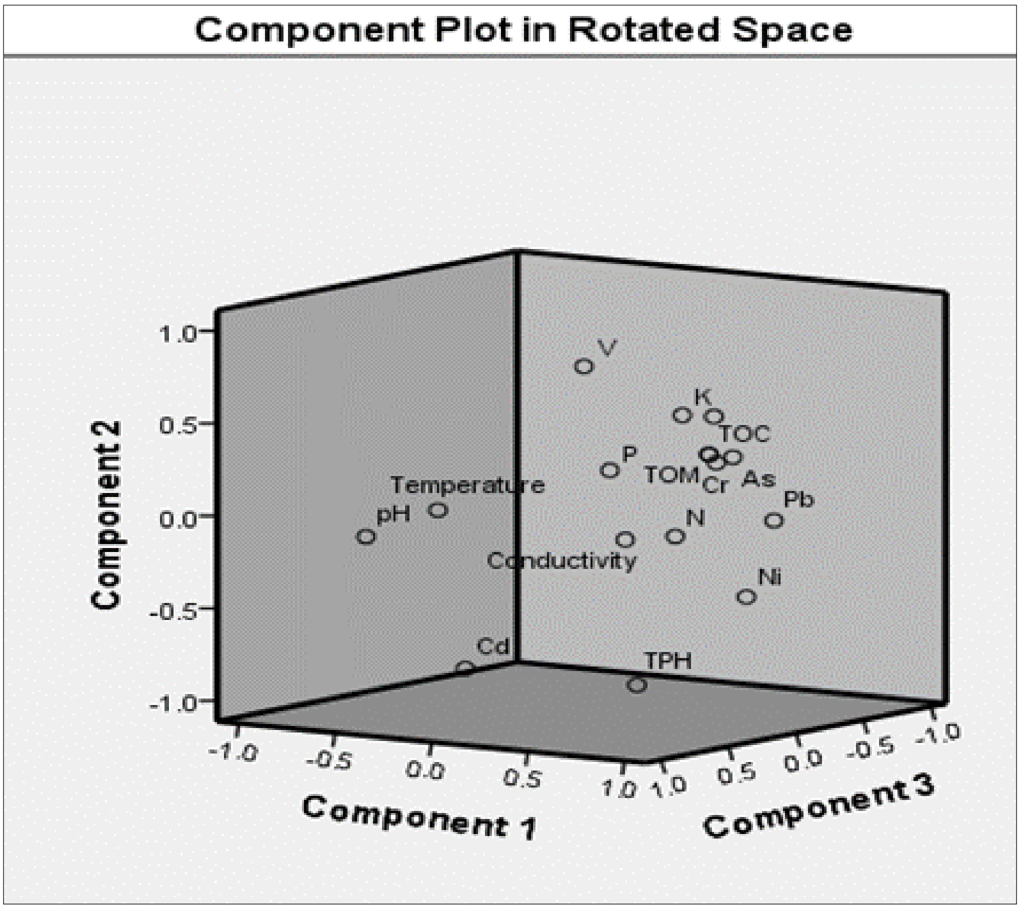

Fig 5: Component plot in rotated space of the physico-chemical parameters

3.2 Discussion

Variation in Physico Chemical Parameters

The mean level of pH in the soil from Yorla oilfield area was 5.99 0.20 showing that the soils were moderately acidic. The result obtained in this study was similar to the work by Onojake *et al* (2012) [9] which recorded pH of 6.50 0.21, 6.48 0.20 and 5.33 1.16.

The study was done at Ebocha – 8 oilfields in Obrikom, Ogba/Egbema-Ndoni Local Government Area of Rivers State. The pH values of the oil impacted soil lies within the acidic range and may not support the growth of most crops that thrive on alkaline soil (Onojake *et al* 2012) [9]. Studies by Kiran (2013) [6]. recommended the pH range of 6.8 to 8.0 as good for optimum plant growth. Acidification of soil depletes important nutrient elements such as potassium, calcium and magnesium (*Akhionbare et al., 2013*) [2]. pH also affects the solubility and availability of soil constituent which may affect biological activity in the soil. Liming is therefore necessary to deacidify the affected mat layer of soils for such soil to accommodate plant life (Onojake *et al*., 2012) [9]. Conductivity values in this study were higher in the control station (station D) than in other stations. This may be due to the spillage observed in stations A, B and C. This has caused decrease in the concentration of some soluble salts as reported by (Oviasogie *et al*., 2007) [14].

Temperature value at location B was the highest in this study. Result of Principal component analysis showed that component 3 was highly correlated with temperature (0.991) and had high loadings for Electrical conductivity (0.698) and phosphate ions (0.689) (Fig 4.2). This showed that temperature of the soil and conductivity come from same source. Temperature gradient affects the distribution of ionic soluble salts. Thus desorption and absorption of material depends on the temperature, conductivity and pH of the soil involved (Akhionbare *et al.*, 2013) [2].

The mean levels of TPH of soil from Yorla oilfield in the different stations sampled are given in Table 1 and 2. TPH value of station C (1954mg/kg) was the highest in this study. The toxicity of Petroleum hydrocarbon oil in soil has been established at concentration range greater than 1000mg/kg (DPR, 2002).

Studies by Onojake and Osuji, (2012) [9], on post-remediation status of Ebocha 8 field in Obrikom, Rivers State revealed that the total hydrocarbon content of the surface and subsurface soil were 19837.12 14565.05, 1672.37 113.67 and 50.0 10mg/kg respectively. The high values of the results of the subsurface and surface soils are not unconnected with pollution. The high concentration of TPH at station C in this study shows that the soil is contaminated and the crop planted in the soil may absorb these TPH compounds which would be transferred to animals that feed on the crop or vegetables (Onojake *et al*., 2012) [9].

TPH can cause headache, dizziness and nerve disorder (peripheral neuropathy) at high concentration. The nerve disorder consists of numbness of feet and legs. TPH can cause negative effects on blood immune system, lungs, skin and eyes (ATSDR, 1999) (Nwineenwii, 2011).

The control station (D) had the highest Total Organic Matter/Total Organic Carbon. The Organic Carbon content of a soil is the net result of the rates of the carbon inputs (the rate of net photosynthesis) and organic decay (Osakwe, 2014) [10]. He observed that acidity increased as the carbon/organic contents of the soil in station A, B, C and D increased. TOM/TOC is vital to plant life in the maintenance of soil fertility. The Total Organic Matter is suggestive of microbial activity leading to release of organic carbon and acidic substance (Osakwe, 2014) [10].

There were reductions in the values of N, P and K at stations A, B, C when compared with the control station D. This may not be unconnected with oil-impacted soil. The low level of Nitrogen in the soils studied can be attributed to the fact that at weakly acidic pH, the activities of nitrogen converting bacteria are inhibited (Osakwe, 2014) [10]. The availability of soil phosphorus depends on the soil pH (Osakwe, 2014) [10]. Deficiency of phosphorus in soil may cause stunted growth and delay in plant development. Phosphorus is essential in cell division, energy transformation and metabolic processes in plant (Osakwe, 2014) [10]. Plants utilize potassium for photosynthesis (formation of carbohydrate), plant metabolism, regulation of enzyme activity and for increase of sugar and starch (Kiran, 2013) [6]. Potassium in the soil may exist in exchangeable (slowly available form) as in cation exchange capacity (Osakwe, 2014) [10].

Variation in heavy metal levels

The heavy metals analyzed in this study were within the acceptable limits as specified by Environmental Guidelines and Standards for the Petroleum Industry in Nigeria (EGASPIN) (Table.1). The concentration(s) of Lead at the control site (D) was above the values obtained in the station A, B, C and was due to anthropogenic factor and high vehicular emissions which is evident from the fact that the soils were excavated alongside major ways connecting towns and villages having populations (Yaylali-Abanuz, 2011). The Principal Component 1 is highly correlated with Pb (1.00), had high loading for pH, TOM, TOC, P and N indicating that it came from same origin.

Relationship between Quality Parameters

Relationships between heavy metals and physico chemical factors are given in Table 3. The communalities of 1 for all the physicochemical parameters show possibilities of stronger existence. Principal Component Analysis was performed to establish possible factors that contribute towards the metal concentrations as shown in appendix II, Table 3 and 4. Analysis of variance was employed to show the confidence level of the analysis. At 95% confidence level (0.05), the results show that F (MSR) calculated for stations A, B and C are 2587092.618, 225220.440 and 79186820.281 respectively. The P – values are 0.000, 0.002 and 0.000 which are lesser than the 0.05 P value of 95% confidence level. Therefore, there is significant difference between station A, B and C at 0.05 P value. Hence $P < 0.05$

4. Conclusions

The result of all the variables investigated in this study indicated that despite the remediation adopted at Yorla oilfield spillage site, a substantial amount of petroleum hydrocarbon was still present in the soil. This finding shows that the containment or remediation measure at the time of leakage was incompletely done. Heavy metals analyzed in this study were within tolerable limit. However, they have potential to bioaccumulate if not properly monitored. To reduce the possible risk to the residents and poor agricultural yield, more mitigating measures should be employed on the site now.

Remediation Contracts should be awarded to only certified contractors who can execute the task effectively and efficiently.

The community (host of the facilities) should take a proactive and public stand against individuals or groups, who engage in illegal activities such as bunkering and artisanal refining.

Government should encourage effective monitoring and supervision of project on and after project completion. In essence, continuous post remediation monitoring should be made mandatory by stakeholders.

References

1. Agency for Toxic Substance and Disease Registry (ATSDR). Toxicological profile for total petroleum hydrocarbon, Atlantic, G. A.: U.S. department of health and human services, 1999.
2. Akhionbare SMO. Assessment of Heavy MetalPollution from a municipal mixed solid waste Dump. *Global Journal of Engineering and Technology*. 2009; 2(3):467- 474.
3. Akhionbare SMO, Akhionbare WN, Nwachukwu JI. Metal in Environmental pollution in: The Environment: Issues, Cases and Sustainability. Springfield publishers, Owerri, 2013, 250-273.
4. American Public Health Association (APHA); American Water Works Association (AWWA); Water Environment Federation (WEF). Standard Methods for examination of water and waste water, 20thed, publish by the America Public Health Association, Washington D.C, 1998.
5. American Public Health Association (APHA). Standard method for examination of water and waste water, 21st edition. American Publish health association, American Water works Association and Water Environmental Federation (APHA – AWWA – WEF), published by the American public health Association Washington D.C, 2002.
6. Kiran GC. Studies of the physico-chemical parameters of soil samples. *Advances in applied science research*. 2013; 4(6):246 -248.
7. Nortcliff S. Standard of Soil Quality Attributes Agriculture, Ecosystems and Environment. 2002; 88:161-168.
8. Nwineewii JD. The impact of Eleme petrochemicals Company on the levels of some heavy metals and hydrocarbons in water, sediments and biota from Eleme creeks, Rivers State. Ph.D Thesis, University of Calabar, 2011.
9. Onojake MC, Osuji LC. Assessment of the Physicochemical properties of hydrocarbon contaminated soil. *Archives of Applied Science Research*. 2012; 4(1):48-58.
10. Osakwe SA. Evaluation of Physicochemical Characteristics of Soils in the Flood Diaster Areas of Isoko Region of Delta State, Nigeria. *IOSR journal of Applied Chemistry*. 2014; 7(5):24-31.
11. Osam MU, Wegwu MO, Uwakwe AA. The Omoku old pipeline oil spill crop: Total hydrocarbon content of the affected soils and the impact on nutritive value of food crops. *Archives Applied Science Research*. 2011; 3(3):514 -521.
12. Osuji LC, Onojake CM. Field reconnaissance and estimation of petroleum hydrocarbon and heavy metals content of oils affected by Ebocha-8 oil spillage in Niger Delta, Nigeria. *Journal of Environmental Management*. 2006; 79:133-138.
13. Osuji LC, Achugasim O. Trace Metals and Volatile Aromatic Hydrocabon Content of Ukpeliede-Oil spillage-site, Niger Delta, Nigeria; *Journal of Applied sciences and environmental management*. 2010; 14(2):17-20.
14. Oviasogie PO, Omoruyi E. Levels of Heavy Metals and Physicochemical Properties of Soil in a foam Manufacturing industry. *J. Chem. Soc. Nig*. 2007; 32(1):102-106.
15. Sousa A, Pereira R, Antunes SC, Cachada A, Pereira E, Duarte AC, *et al*. Validation of avoidance assays for the screening assessment of soils under different antropogenic disturbances, Ecotoxicology and Environmental Safety. 2008; 71:661- 670.
16. United Nations Environmental Programme (UNEP). The UNEP Report: Environmental Assessment of Ogoniland, 2011.
17. Yaylali Abanuz G. Heavy Metal contamination of Surfaces oil around Gebze industrial area, Turkey. Microchem. J. 2011; 99:82-92.