## Research Article

# APPLICATION OF PRINCIPAL COMPONENT ANALYSIS FOR THE ASSESSMENT OF SURFACE WATER QUALITY OF VILLAGE STREAM1,IN ANAKPA URUAN LOCAL GOVERNMENT AREA OF AKWA IBOM STATE NIGERIA

## Anthony Okon Etim*

Department of Environmental Management and Toxicology, Michael Okpara
University of Agriculture, Umudike, Abia State Nigeria

| ARTICLE INFO | ABSTRACT |
|---|---|
| | An agglomerate multivariate study of the effect of crude oil exploration and exploitation on the surface water quality of Anakpa village stream 1 was conducted. This was done because Crude oil exploration and exploitation activities often introduce chemical substances which may contaminate the environment with trace metals. Therefore, to evaluate the extent of impact of such activities in the village stream of Anakpa principal component analysis method was utilized. The PCA was applied so as to investigate and identify sources of trace metals Fe, Zn, Pb, Cr, Cd, Vi and Ni in the surface water. The Study applied HACH Standard approved method procedure to determine the trace and nutrient contents of the domestic water. The study was conducted in village stream1 of Anakpa Uruan close to the area where crude oil exploration and exploitation is undertaken. Samples were collected randomly from upstream, downstream of the village stream 1. There were positive and insignificant relations between trace metals and nutrient content of the surface water samples as revealed in the multivariate analysis of the test sample results. Iron and $P^H$ correlated positively at $p<0.05$ with r value of 0. 689. Cd also exhibited positive correlation with phosphate at $p<0.05$ with r value of 0. 672.Pb also exhibited positive correlation with BOD at $p<0.05$ with r value of 0. 745. Other metals such as Nickel, Vanadium and chromium exhibited negative correlation with other nutrient content of the surface water tested. The result of agglomerate hierarchical analysis shows that the crude oil exploitation had serious effect on the enhancement of the trace metals load in the surface water of village stream1 in Anakpa, Uruan Local Government Area of Akwa Ibom State, Nigeria. |

## INTRODUCTION

Environmental pollution arising from industrial activities have contributed to the severe environmental degradation in crude oil bearing communities of Niger Delta, Nigeria (Akubugwo et al2016). Such degradation according to Akubugwo *et al*. (2016) is usually detrimental to the use of the part of the environment by man, fishes and plants. In many villages around crude oil exploration and exploitation chemical spillage is often recorded on land as well as surface water within and outside the operational areas where crude oil processing companies are located (Akubugwu and Duru, 2011).Therefore, in March, 2016 surface water samples from the village stream1 use for drinking and cooking in Anakpa Uruan Local Government Area of Akwa Ibom State, Nigeria were analysed.

In view of the study the level of some trace metals such as Pb, Fe and Zinc were noticed to be higher than the acceptable levels recommended by WHO (2004). But the inherent sources of these metals were difficult to ascertain since trace metals load could occur natural in environment. Therefore, application of principal component and multivariate analysis were used to investigate the source of pollution. As reported by Facchinelli *et al*. (2001).) principal component analysis is important modern scientific approach often used to evaluate the source of metals pollution load in environment. As mentioned by Kogbara *et al*. (2015) The method organizes parameters into groups based on the similarities inside of the group and dissimilarities outside of different groups. Principal component analysis according to utilized the percentages of the variance of the rotated correlation matrix to detect multivariate

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*Corresponding author:* **Anthony Okon Etim**
Department of Environmental Management and Toxicology, Michael Okpara University of Agriculture, Umudike, Abia State Nigeria

homogeneity and multivariate heterogeneity in respect to trace metals effect in water quality parameters (Kogbara *et al*. 2015) Accordingto Ekpeyong and Udofia (2015) the principal component analysis technique regarded as effective tools in water quality analysis in view of flexibility in data interpretation and handling. Nevertheless, in Uruan, the application of this technique for the identification, classification and characterization of surface water quality are scarce. Thus, this method was adopted for this study to uncover anthropogenic or natural grouping of physicochemical parameters in village stream1 surface water quality of the Anakpa, Uruan region of Akwa Ibom State, Nigeria

## MATERIALS AND METHODS

### The study Area

The specific study location is Anakpa fig (1). Anakpa is a village in Uruan Local Government Area. Anakpa situates between latitudes 5 $^0$10'N and longitudes 8$^0$3'E in the North and West. Uruan is one of the thirty-one (31) Local Government Areas in Akwa Ibom State, Nigeria. Uruan Local Government is made up of three major clans. They clans are divided into south, central and the North Central. Anakpa is within the central Uruan Clan. Uruan Local Government area was created from Uyo Local Government area in 1988. The headquarter is located in Idu. Uruan occupies a large land mass (422.352 Sq.km) in Akwa Ibom State, Nigeria. Uruan Local Government situates between latitudes 6 $^0$40$^0$ and longitudes 7$^0$20$^0$E in the North and West. It is bounded on the East by Odukpani Local Government Area in Cross River State, in the south by Okobo Local Government Area in the West by Nsit Atai and Asutan Local Government Areas and in the North by Itu Local Government Area.The soils in the area are formed on Tertiary Coastal Plain sands. The soils are deep with loamy sand to sandy loam surface over clay loam to sandy clay subsoil. Because of their sandy nature, they are fragile and highly susceptible to erosion. They are also acidic and are generally referred to 'Acid Sands' since they are both acidic and sandy. The vegetation in the area is Tropical Rain Forest. However, in most of the areas the original rain forest has virtually disappeared because of clearing the forest for farming. What we have now is farmland with crops or land under fallow. The most important tree now is oil palm which is generally not destroyed when the land is cleared for farming. It is the most important economic crop for the people. The Important, arable crops grown in the area include maize, cassava, yams, coco yam, Fluted pumpkin, plantain and banana. Crude oil exploration in Anakpa Uruan started 50 years ago onshore by Shell Petroleum development Company (SPDC). The crude oil locations in Anakpa are labelled Edik 1 and Edik 2 and Edik 3.Crude oil have been leaking from these three locations polluting the immediate environment. Apart from Anakpa, crude oil wells are also located in, other locations in Uruan Local Government Area. Alsoin the central clan of Uruan Local Government there are untapped crude oil wells located in Nung Oku, Mbiakong, Ikot Akpa Ekang, Use Uruan, Esuk Odu,Ikot Inyang, Esuk, Anakpa. Nung Oku, and Nwaniba. In the Southern part of Uraun Local Government Area Untapped crude oil wells are located in Ekpene Ukim, Ndon Ebom. Ituk-Mbang, Nung Ikono the Ufok, Ibiaku Ishiet, a Adadia and Ekim Nden.
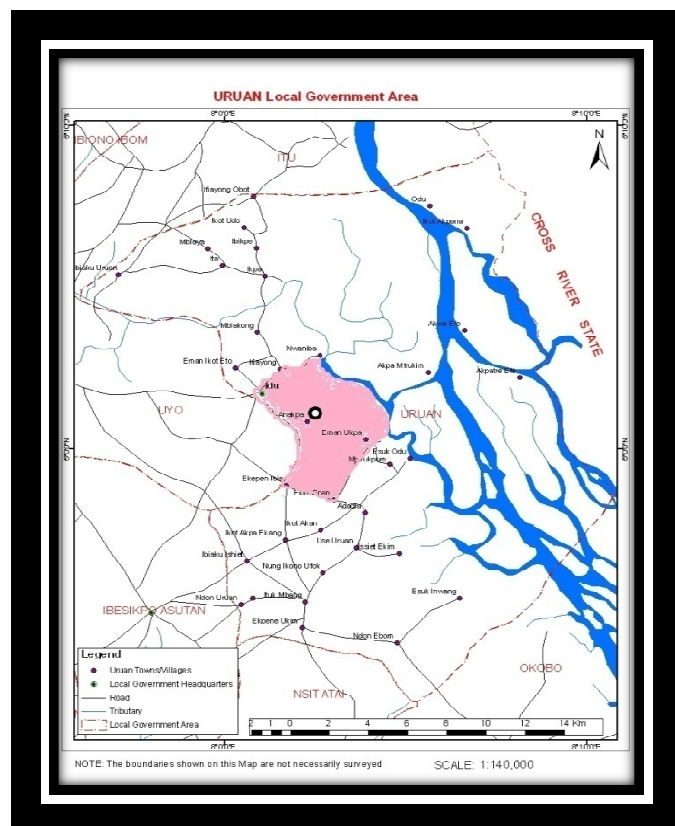


**Figure 1** Map of Uruan Showing Specific Study Locations

**Specific Study Locations**

### Sample Collection and Analysis

Surface water sample from the village stream 1 was collected in triplicate to allow for appropriate representative of the samples. Samples were collected in the plastic containers from the upstream, downstream of the surface water of the village stream 1 of the study location. The samples were properly inserted into the cooler and taken into the laboratory for analysis. Prior to sample collection the sample containers used were properly rinsed to remove any impurities from the container. Samples for BOD were taken into sealed black containers in order to prevent interferences. All samples taken into the laboratory for analysis were stored at temperature of 4 $^O$C. All, samples were labelled properly for traceability and easy identification prior to analysis. Temperature, dissolved oxygen, electrical conductivity, Total dissolve solid(TDS) were measured in-situ with the portable measuring device employed for the water sampling and collection.

### BOD

This was determine using HACH (2006) standard approved method procedure for domestic water. The standard BOD solution was diluted with the water sample incubated in BOD reactor apparatus for 24 hrs., at the temperature of 20 $^O$C. Then allowed to cool to room temperature. The reading then obtains directly using HACH DR3800 model spectrophotometer.

### Turbidity

Determine using HACH (2006) turbidity method through direct reading from HACH model 3800 spectrophotometer as defined in the test method.

### Nutrients and Trace Metal Analysis

Samples were treated accordingly base on HACH 3800 recommended test procedure for nutrient and trace metal content of domestic water. Designated powder pillows inserted to the 25mls of the sample and sample then allowed to remains within the stipulated time line as recommended in the HACH3800 model test method procedure for domestic water. And read directly with DR 3800 model of spectrophotometer to obtain nutrient or trace metal content accordingly expressed in milligram per litre (mg/l). In all blank reading were obtained without the powder pillows to ensure the stability and functionality of the test equipment prior to taking the actual reading of the test solutions.

### Statistical Analysis

Regression coefficient, principal component analysis and multivariate agglomerate hierarchal cluster analysis were employed to analyse the physicochemical properties of the surface water sample from village stream 1. The level of significant measured at p<0,05, p<0.01 and p<0.02 in order to determine the relationship between the trace

in oil contaminated communities of Ibeno. Consequently, this may result in high level of disease-causing microorganisms since a high turbidity level in water is frequently associated with higher level disease-causing microorganisms (Reza and Singh, 2009)

### Temperature

Temperature of surface water studied ranged between 25.20°C and 27.00 °C with mean value of 26.08 °C (Table 4.1). However, lower range of 25.00 – 26.10 °C and mean (25.23±0.41 °C) were obtained in the Control site. The range obtained in studied surface water is lower than that reported by Uyom *et al.* (2014) in oil contaminated surface water. The obtained mean is also higher than that reported in Control site. This shows that oil activities within studied area may have affected the temperature of studied surface water. The range reported in studied surface water is lower than 27 - 28°C recommended for potable water by WHO (1993). Hence, these water bodies may not be favourable for aquatic organisms since studies have shown that temperature has great influence on dissolved oxygen and bacterial activities in water (Ukpong and Peter, 2012).

## RESULTS AND DISCUSSIONS

**Table 1** Physicochemical properties Village Stream 1 Surface Water Samples in Anakpa

| Tests | Sampling in months in two years study period | | | | | | | | | | | | CONTROL | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 3 | 6 | 9 | 12 | 15 | 18 | 21 | 24 | Min | Max | Mean | SD | Min | Max | Mean | SD |
| Odour (Hu) | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Turbidity (NTU) | 79.22 | 79.22 | 79.92 | 79.18 | 78.56 | 79.38 | 79.66 | 79.33 | 77.40 | 81.30 | 79.31 | 1.05 | 0.87 | 2.03 | 1.48 | 0.43 |
| Temp. °C | 25.94 | 26.08 | 26.20 | 26.20 | 26.16 | 26.12 | 25.84 | 26.12 | 25.20 | 27.00 | 26.08 | 0.41 | 25.00 | 26.10 | 25.23 | 0.36 |
| pH | 6.51 | 6.43 | 6.39 | 6.20 | 6.10 | 6.21 | 6.47 | 6.64 | 5.75 | 6.84 | 6.37 | 0.33 | 6.76 | 7.21 | 7.04 | 0.13 |
| Calcium (mg/l) | 0.37 | 0.35 | 0.31 | 0.29 | 0.30 | 0.29 | 0.28 | 0.30 | 0.16 | 0.84 | 0.85 | 0.03 | 0.04 | 0.08 | 0.06 | 0.01 |
| Sodium(mg/l) | 0.66 | 0.58 | 0.54 | 0.53 | 0.54 | 0.53 | 0.55 | 0.56 | 0.26 | 1.46 | 0.56 | 0.44 | 0.02 | 0.08 | 0.04 | 0.02 |
| Magnesium(mg/l) | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.01 | 0.06 | 0.02 | 0.01 | 0.01 | 0.02 | 0.02 | 0.01 |
| Phosphatemg/l | 0.67 | 0.68 | 0.66 | 0.66 | 0.64 | 0.65 | 0.62 | 0.64 | 0.26 | 1.16 | 0.65 | 0.35 | 0.20 | 0.28 | 0.24 | 0.03 |
| COD (mg/l) | 0.04 | 0.03 | 0.03 | 0.02 | 0.03 | 0.04 | 0.04 | 0.03 | 0.02 | 0.06 | 0.03 | 0.01 | 0.01 | 0.02 | 0.02 | 0.01 |
| BOD (mg/l) | 0.01 | 0.01 | 0.01 | 0.01 | 0.02 | 0.01 | 0.02 | 0.01 | 0.01 | 0.02 | 0.01 | 0.01 | 0.01 | 0.02 | 0.01 | 0.04 |
| DO(mg/l | 3.27 | 3.25 | 3.17 | 3.25 | 3.24 | 3.22 | 3.24 | 3.25 | 2.24 | 4.36 | 3.24 | 0.68 | 1.65 | 2.16 | 1.97 | 0.17 |

Temp. = Temperature; COD = Chemical oxygen demand; BOD = Biochemical oxygen demand and DO = Dissolved Oxygen

### Physicochemical properties of village Stream Surface Water

#### Odour

Odour of both studied surface water and Control was below detectable limit indicating that this water property may not affect the water quality of the studied area (Table 4.1). Result obtained is below recommended limit of 15 Hu by WHO (1996) thus, odour of the studied surface water may not its potability. The study has also shown that the activities by Oil Company in the area under investigation may not have affected the odour of studied surface water. Turbidity levels of surface water and Control.

Results in Table 4.1 indicate that, turbidity of studied surface water varied from 77.40NTU to 81.30NTU with a mean value of 79.31±1.05NTU. The obtained mean value of turbidity in studied surface water is higher than 5.00 NTU recommended by WHO (2003). Results obtained could be indicative of impact of human activities on the quality of studied surface.

The obtained mean is also higher than 1.48NTU reported in Control site which also confirm the negative impact of oil activities on the water quality of studied surface water. The high turbidity level in studied surface water obtained is consistent with the findings by Ekpenyong and Udofia (2015)

#### pH

pH is one the most important chemical properties that determine most chemical reactions in water. The pH of studied surface water in Table 4.37 varies from 5.75 to 6.84 with mean value of 6.37±0.33. This mean is higher than that reported by Tanee and Albert (2015) in oil polluted water. The obtained range is lower than 6.80 – 7.30 recommended by WHO (2011) for potable water thus, these water bodies may constitute a serious environmental problem to the aquatic life (Wetzel, 2001). The Control site indicated a range of 6.76 – 7.21 with a mean value of 7.04±0.13 hence, human activities within studied area may have reduced the pH of surface water to acidic level.

#### Calcium (Ca)

Calcium ions in studied surface water ranged from 0.16mg/l to 0.84mg/l with mean value of 0.65±0.03mg/l (Table 4.1). This mean is lower than that obtained by Udoh and Chukwu (2014) in oil polluted surface water. A lower range of 0.04 – 0.08mg/l and mean value of 0.06±0.01mg/l were obtained in Control site. Consequently, crude oil activities within the study area may have impacted negatively on the quality of studied surface with regards to calcium contents. However, the mean calcium

level obtained is much less than 100mg/l recommended for water by WHO (2004) hence, it may not pose a serious problem to the consumers of studied water.

### Sodium (Na)

The distribution of sodium ions in studied surface water varied from 0.26mg/l to 1.46mg/l with a mean value of 0.56±0.44mg/l (Table 4.1). The obtained mean value of sodium is higher than that reported by Tanee and Albert (2015) in oil impacted water. The range and mean concentration of sodium ions in Control station are 0.02 – 0.08mg/l and 0.04±0.02mg/l respectively. Thus, the activities of Oil Company operating within the study area may have elevated the level of sodium in studied water bodies. Nevertheless, the obtained mean concentration of sodium in studied water bodies is much lower than 250mg/l recommended limit by WHO (1996) thus, the obtained level may not pose a serious threat to the consumers of water from the studied water bodies.

### Magnesium (Mg)

The distribution of magnesium ions in studied water bodies ranged from 0.01mg/l to 0.06mg/l with a mean value of 0.02±0.01mg/l. The obtained range of magnesium is much lower than that reported by Etesin *et al*. (2013) in oil impacted water. Magnesium concentrations in the Control site varied from 0.01mg/l to 0.02mg/l with a mean value of 0.02±0.01mg/l. The higher concentrations of magnesium ions in studied water bodies may be attributed to the activities of Oil Company operating within the area. However, the mean magnesium concentration reported is much lower than 100mg/l recommended for potable water by WHO (2004). Consequently, the level of magnesium obtained in studied water bodies may be considered as a pollutant rather it can support aquatic life favourably.

### Phosphate (Po$_4$)

Results in Table 4.37 indicate that concentrations of total phosphate in studied water bodies varied from 0.26mg/l to 1.16mg/l with a mean value of 0.65±0.35mg/l. The obtained mean is much lower than that reported by Tanee and Albert (2015) in oil polluted water bodies. Concentrations of total phosphate in the Control site ranged between 0.20mg/l and 0.28mg/l with mean value of 0.24±0.03mg/l. The elevated level of total phosphate in studied water bodies may be attributed to human activities in the area. However, the obtained mean of total phosphate in studied water bodies is lower than 0.50mg/l limit recommended by WHO (2008) for potable water. Thus, the level of total phosphate reported in studied water bodies may useful for aquatic life.

### Chemical Oxygen Demand (COD)

Chemical oxygen demand determines the quantity of organic chemicals that consume dissolved oxygen in a water body. Results in Table 4.1 indicate that COD varies between 0.02mg/l and 0.06mg/l with a mean value of 0.03±0.01mg/l. The mean COD level obtained in studied water bodies is lower than that reported by Akubugwo and Duru (2011) in oil impacted water bodies. However, a lower range of 0.01 – 0.02mg/l and mean value of 0.02±0.01mg/l were recorded for the Control site. Thus, the activities by Oil Company operating

within the study area may have elevated the COD levels in studied water bodies. The mean COD level obtained is much lower than 1000mg/l limit stipulated by WHO (2006) for potable water. Consequently, the level of COD reported in this study may not have damaging effects on the aquatic life.

### Biological Oxygen Demand (BOD)

Biochemical oxygen demand determines the amount of oxygen used by micro-organisms for the oxidation of organic matter. Water bodies with low BOD have low nutrient levels thus indicating high concentration of dissolved oxygen. Biochemical oxygen demand of studied water varied from 0.01mg/l to 0.02mg/l with a mean value of 0.01±0.01mg/l. This range is much lower than that obtained by Ewa *et al*. (2011) in crude oil impacted surface water. A range of 0.01 – 0.02mg/l and mean value of 0.010±004mg/l were obtained in the Control site. Thus, human activities in the studied surface water may not have affected the BOD of the aquatic environment. The mean BOD obtained is lower than 5.0mg/l recommended by WHO (2006) for a potable water hence, the obtained BOD level may not affect the potability of studied water.

### Dissolve Oxygen (DO)

Dissolved oxygen is a chemical property of water that is essential for the survival of aquatic organisms it also determines the freshness of a water body (Okorafor *et al*., 2013). Dissolved oxygen is studied water bodies varied from 2.24mg/l to 4.36mg/l with a mean value of 3.24±0.68mg/l (Table 4.1). This range is higher than that reported by Uyom *et al*. (2014) in a contaminated water body. A range and mean DO level obtained in the Control site are 1.65 – 2.16mg/l and 1.97±0.17mg/l respectively. The high DO levels in studied water bodies could be attributed to activities by Oil Company within the host community. Nevertheless, the mean DO value obtained in studied water bodies is lower than recommended limit of 15mg/l by WHO (1993). Consequently, the obtained DO levels may be suitable for life within these studied water bodies.

### Correlation Coefficient between Trace Metals and Physical Properties of Surface Water

The relationship between trace metals and other properties of water determined was assessed using correlation analysis as shown in Table 4.2 above

### Odour

The odour levels of studied water body did not show any relationship with trace metals examined as the odour levels were below detectable limit.

### Turbidity

Turbidity of water showed moderate negative association with Zn, Pb and Ni at $p < 0.05$ as indicated by their weak negative r values of -0.572, -0.599 and -0.475respectively (Table 4.2). Turbidity indicated a very weak negative relationship with Cr at $p < 0.05$ with r value of -0.087 ( Table 4.38). However, turbidity correlated positively though insignificantly with Fe, Cd and V at $p < 0.05$ with r values of 0.351, 0.201 and 0.653respectively (4.2). Thus, the relationship between

turbidity and trace metals in studied water was variable but insignificantly.

### Temperature

Temperature of the studied water bodies exhibited a negative and weak correlation with Fe, Zn, Pb, V and Cr at $p < 0.05$ with r values of -0.561, -0.417, -0.599, -0.180 and -0.087 respectively (Table 4.38). Hence, a higher temperature level of these water bodies may reduce the concentration of these metals but fairly. A very weak positive relationship was shown by temperature for Cd and Ni at $p < 0.05$ with r values of 0.030 and 0.072 respectively (Table 4.2). Thus, a change in temperature of studied water bodies may have little or no effect on the concentration of Cd and Ni.

### pH

The relationship between water pH and Fe in studied water bodies was a strong positive one at $p < 0.05$ with r value of 0.689. Thus, an increase in pH level of these water bodies may result in a corresponding increase in Fe concentration and vice versa. pH showed a weak negative association with Zn, Pb and Ni but a weak positive one with Cd, V and Cr at $p < 0.05$ with r values of 0.111, 0.350 and 0.305 respectively (Table 4.2)

### Calcium

Results in Table 4.2 indicate a strong positive relationship between calcium and Cd at $p < 0.02$ with r value of 0.762. Hence, the calcium contents of studied water bodies varied directly with concentration of Cd. Calcium showed a weak negative correlation with Fe and V at $p < 0.05$ with r values of -0.306 and -0.267 respectively (Table 4.38). However, calcium in studied water bodies correlated positively but insignificantly with Zn, Pb, Ni and Cr at $p < 0.05$ with r values of 0.376, 0.119, 0.226 and 0.069 respectively (Table 4.38). Hence, a change in calcium contents of these water bodies may not have significant influence on the concentration of Fe, V, Zn, Pb, Ni and Cr.

### Sodium

Sodium exhibited a positive but insignificant relationship with all the trace metals (Fe, Zn, Pb,Cd,V,Ni,Cr) determined in studied water bodies at $p < 0.05$ r values of 0.040, 0.496, 0.311, 0.561, 0.018, 0.244 and 0.487 respectively (Table 4.2). Thus, an increase in sodium contents of studied water bodies may result insignificant increase in concentration of these metals and vice versa.

### Magnesium

Magnesium contents in studied water bodies did not show any relationship with trace metals determined. Consequently, a change in magnesium contents of studied water bodies may not have any impact on the concentration of these metals and vice versa.

### Phosphate

Concentrations of total phosphate in studied water bodies showed strong negative and positive relationship with Fe and Cd at $p < 0.05$ with r values of -0.698 and 0.672 respectively. Accordingly, an increase in the concentration of total phosphate in studied water bodies may reduce the concentration of Fe but elevate that of Cd significantly. Total phosphate in studied water bodies correlated positively but insignificantly with Zn and Ni at $p < 0.05$ with r values of 0.217 and 0.211(in Table 73). However, total phosphate in studied water bodies exhibited weak negative association with Pb, V and Cr at $p < 0.05$ with r values of -0.398, -0.243 and -0.335 respectively (Table 4.2).

### COD

Chemical oxygen demand of studied water bodies showed a positive but insignificant relationship with all the metals Fe, Zn, Pb, Cd, V and Cr determined except Ni at $p < 0.05$ with r values of 0.259, 0.140, 0.488, 0.236, 0.218 and 0.619 respectively (Table 4.2). However, a weak negative association was established between COD and Ni at $p < 0.05$ with r value of -0.478(Table 4.2). Consequently, an increase in COD of studied water bodies may result in a fair increment in the concentration of all the trace metals except Ni.

### BOD

Biochemical oxygen demand of studied water bodies showed a strong positive relationship with Pb at $p < 0.02$ with r value of 0.745. Thus, BOD of studied water bodies was directly proportional to the concentration of Pb in studied water bodies. BOD showed weak positive correlation with Fe, Zn, Ni and Cr at $p < 0.05$ with r values of 0.360, 0.043, 0.183 and 0.073 ( Table 4.2). However, a weak negative relationship was exhibited by BOD with Cd and V at $p < 0.05$ with r values of-0.361 and -0.333 respectively (Table 4.2).

### DO

Results in Table 4.2 show a very strong positive relationship between dissolved oxygen and Zn at $p < 0.05$ with r value of 0.906. Thus, a decrease in DO level of studied water bodies may result in a corresponding decrease in the concentration of Zn and vice versa. Dissolved oxygen in studied water bodies correlated positively but insignificantly with Fe, Pb, Ni and Cr at $p < 0.05$ with r values of 0.141, 0.446, 0.378 and 0.541 respectively ( Table 4.2). Hence, an increase in DO level may result in a fair increase in the concentration of Fe, Pb, Ni and Cr. However, DO levels of studied water bodies exhibited a weak negative relationship with Cd and V at $p < 0.05$ with r values of -0.304 and -0.179 respectively (in Table 4.2). Thus, a decrease in DO of studied water bodies may result in a fair decrease in the concentration of Cd and V in studied water sample.

### Multivariate and Principal Component Analysis of Village Stream 1 Water Sample

**Table 3** Correlation coefficients between different trace metals studied village stream I.

|  |  | Fe | Zn | Pb | Cd | V | Ni | Cr |
|---|---|---|---|---|---|---|---|---|
|  | Fe | 1.000 |  |  |  |  |  |  |
|  | Zn | .318 | 1.000 |  |  |  |  |  |
|  | Pb | .303 | -.193 | 1.000 |  |  |  |  |
| Correlation | Cd | .437 | .386 | -.423 | 1.000 |  |  |  |
|  | V | -.048 | -.784** | .204 | .170 | 1.000 |  |  |
|  | Ni | .156 | .129 | -.028 | .195 | -.013 | 1.000 |  |
|  | Cr | -.061 | -.532 | .360 | .160 | .822* | -.421 | 1.000 |

* Correlation is significant at $p < 0 .01$ level.** significant at $p < 0.02$ (two – tailed).

**Table 4** Total Variance Explained Village Stream 1

| Component | Initial Eigenvalues | | | Extraction Sums of Squared Loadings | | | Rotation Sums of Squared Loadings | | |
|---|---|---|---|---|---|---|---|---|---|
| | Total | % of Variance | Cumulative % | Total | % of Variance | Cumulative % | Total | % of Variance | Cumulative % |
| 1 | 2.667 | 38.098 | 38.098 | 2.667 | 38.098 | 38.098 | 2.430 | 34.719 | 34.719 |
| 2 | 1.626 | 23.232 | 61.330 | 1.626 | 23.232 | 61.330 | 1.658 | 23.684 | 58.403 |
| 3 | 1.286 | 18.369 | 79.699 | 1.286 | 18.369 | 79.699 | 1.358 | 19.395 | 77.798 |
| 4 | 1.035 | 14.779 | 94.477 | 1.035 | 14.779 | 94.477 | 1.168 | 16.679 | 94.477 |
| 5 | .376 | 5.369 | 99.846 | | | | | | |
| 6 | .007 | .097 | 99.943 | | | | | | |
| 7 | .004 | .057 | 100.000 | | | | | | |

Extraction Method: Principal Component Analysis.

**Table 5** Matrix of major principal components Village Stream

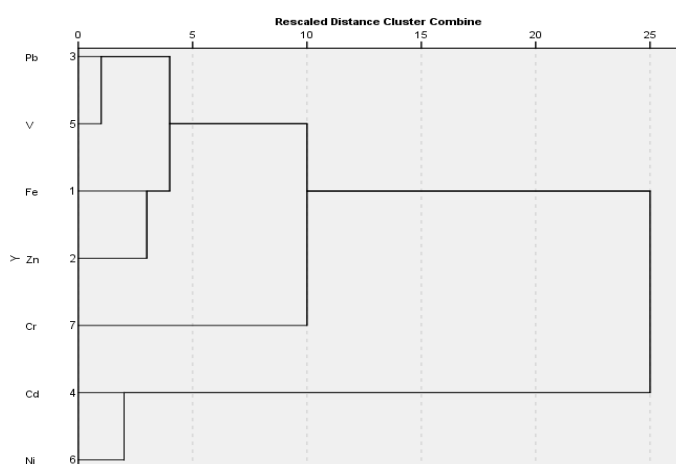| Component | | | |
|---|---|---|---|
| 1 | 2 | 3 | 4 |
| .871 | .386 | -.172 | .243 |
| .869 | .334 | -.059 | -.268 |
| -.863 | .184 | .110 | -.321 |
| -.237 | .876 | -.393 | -.103 |
| -.241 | .707 | .548 | -.113 |
| .416 | -.001 | .882 | .003 |
| -.350 | .255 | .091 | .882 |



**Figure 2** Hierarchical clusters formed among trace metals in studied village stream I.
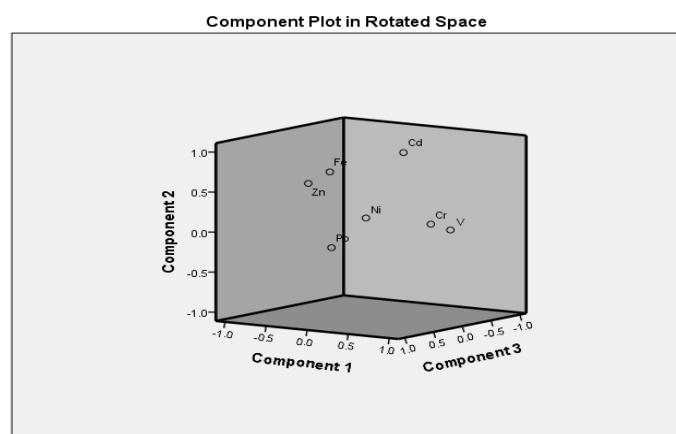


**Figure 3** Plots of Major components in PCA of trace metals in village stream I.

### Correlation Analysis

Correlation matrix in Table 4.45 shows that, most of the trace metals correlated with one another either positively or negatively but insignificantly at $P < 0.05$ as indicated by their r values in Table 4.3. However, strong negative relationship existed between V and Zn at $p < 0.02$ with $r = -0.784$. Vanadium also correlated significantly but positively with Cr at $p < 0.01$ with r value of 0.822. Consequently, the presence of V in studied stream may have hindered the accumulation of Zn and vice versa. Nevertheless, availability of V may have elevated the concentration of Cr. The presence of other metals in studied stream may have influence the availability of the other negatively or positively but insignificantly and their concentrations may be affected by variable factors (Romic and Romic, 2002).

### Principal Component Analysis

Results for the principal component analysis of trace metals in village stream I are shown in Table 4.5. Results obtained indicated four main components with Eigen value greater than one and a significant total variance of 94.48%. Factor one contributed 38.10% of the total variance with strong positive correlation with V and Cr but strong negative association with Zn (Table 4.3). This represents impacts of mineralogical processes and industrial effluents on the water quality. Factor two contributed 23.23% of the total variance with a strong positive loading on Cd and Fe (table 4.3). This is an indicative of impacts of agricultural runoff and natural oxidation-reduction processes (Edet *et al.*, 2014; Wu *et al.*, 2008). Factor three added 18.37% to the total variance and exhibited strong positive loading for Pb. This represents impact of industrial activities on the water quality. The fourth factor contributed 14.78% of the total variance and showed significant positive correlation with Ni. This represents impact industrial effluents on the studied water quality (Nriagu, 1989).

### Cluster Analysis

The association among trace metals in village stream I is illustrated as clusters in Figure 3 above. Figure 2 shows six major clusters namely: (i) between Pb and V (ii) Pb and Fe (iii) Zn (iv) Cr (v) Cd and (vi) Ni. These different clusters indicate their common relationship and source in the studied stream.

A plot of the major components of PCA resulted in four different clusters in Figure 3. Cluster 1 showed very strong positive loading for V and Cr and a strong negative correlation with Zn which is similar to factor one. Cluster 2 indicated strong positive loading for Cd and Fe which is consistent with factor 2. Cluster 3 exhibited very strong positive correlation with Pb similar to factor 3. The fourth cluster showed very significant positive loading for Ni representing factor 4.

## CONCLUSION

The pollution of the village stream1 surface water were multiple in perspective. The principal components analysis shows that four factors were obvious. The positive values recorded on trace metals principal component analysis shows that the trace pollution source was from the crude oil exploration effluent generated and disposed directly to the immediate environment. Nevertheless, mineralization contributes minimal effect of trace metal load to the environment as defined in factor 1 of the principal component analysis. Therefore, people within the community should be informed of the severe health impact caused by this polluted water source. Furthermore, an alternative source of drinking water should be provided for the affected community. The area should also by cordoned off and appropriate synergies posted at designated locations to prevent people from drinking the

polluted water. There is needs for further medical evaluation of the people within the affected community so as to determine the extent of associated health caused on the entire community who depends on this water for drinking and cooking.

# References

Akubugwo, E., Elebe,E.U. and Osuocha, K.U.(2016). Studies on the impact of crude oil exploration on soil quality and crops grown in Kpan community in Khara Local Governemnt Area of River State, Nigeria, *International Research Journal of Biotechnology and Biochemical Sciences 3*(1): 126

Akubugwu, E.I and Duru, M.K.C. (2011**).** Human activities and water quality: a case study of Otanuri River, Owerri, Imo State Nigeria, *Global Research Journal of Science 3*(1) :48-52.

Ekpeyong, N.S., and Udofia, U.S. (2015). Crude oil pollution and its impact on water quality in Ibeno community, *Journal of Studies in Sociology of Science* 6(2):9-13.

Edet, A., Ukpong, A., and Nganye, T. (2014). Baseline concentration and source of trace element in groundwater of Cross River State, *Nigeria, International Journal of Environmental Monitoring and Analysis* 2(1):2-11.

Etesin,U., Udoinyang,E., Harry,T.(2013).Seasonal variation of physico-chemical parameters of water and sediments from Iko River, Nigeria, *Journal of Environmental and Earth Science*3(8):120-126

Ewa, E.E., Iwara, A.I., A deyemi**.**A,.Eja,E.I., Ajake, A.O. and Otu, C.A.(2011). Impact of industrial activities on water quality of Omoku, Greek, *Sha Journal of Environmental Studie,*1(2):2-9

Facchinelli, A., Sacchi, E., Mallen,L.(2001). Multivariate statistical and GIS -based approach to identify heavy metal sources in soils, *Journal of Environmental Pollution*1(14):4-8

HACH (2006): Water Analysis. Handbook, DR/3800 spectrophotometer manual. HACH company. USA.

Kogbara, R.B., Ayotamuno, J.M., Worlu, D.C., Manuel-Fubara,I.(2015). A case study of petroleum soil texture classes, *Journal of Toxic and Hazardous Substances and Environmental Engineering* 9(2):6-9

Nriagu, J.O. (1989). A global assessment of natural sources of atmospheric trace metals, *Journal of Natural and Environmental Sciences* 338(62):47-49.

Reza.R., and Singh. (2009). impact of industrial development on surface water reservoirs in Angul, *International Journal of Environmental Science* 1(4):2-6

Romic, M and Romic, D. (2002). Heavy metal distribution in agricultural topsoil in urban areas, *Journal of Environmental Geology* 43(1):795-805

Tanee, F.B.G. and Albert, E .(2015).Reconnaissance assessment of long-term effects of crude oil spill on soil element properties and plant composition at Kwawa Ogoni, *Journal of Environmental Science and Technology*(8) 96:320-329.

Udoh,B.T. and Chukwu, E.D.(2014). Effect of crude oil and industrial waste pollution on some soil chemical properties in Ikot Abasi, Niger Delta State Area, Nigeria, *Proceedings of the38th Annual Conference of the Soil Science Society of Nigeria* 10th March,83-88.

Uyom,U.U., Ama, O.K., Ephraim.(2014).Some physical and chemical characteristics of Akpa Yafe River Bakassi Cross River State, Nigeria, *Journal of Academia and Industrial Research(JAIR)* 2 (11):231-234

Ukpong ,E.C. and Peter, B.U.(2010).Physico-chemical and bacteriological analysis of drinking water in Ibeno Local Government Area of Akwa Ibom State, Nigeria, *Journal of Technology* 31 (2):117-123.

Wu, S., Zhou, S., Li.Xi., Johnson.W.C., Zhang, H., Shi, J.(2008). Heavy metals accumulation trends in Yixing, China: an area of rapid economic development, *Journal of Environmental Science* 61(1):2-9

Wetzel.R.G. (2001). Limnology: Lake and Rive Ecosystems,3rd Edition. Academic Press, San Diego CA.985.

World Health organization: Geneva (2008) Trace elements in water quality and Health.

World Health organization: Geneva (2006) Trace elements in water quality and Health.

World Health Organization: Geneva (2004) Trace metals elements in Water quality and Health.

World Health Organization: Geneva (1996) Trace metals elements in water quality and Health.

World Health organization: Geneva (1993) Trace elements in water quality and Health.

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