

Environmental Implications of the Geochemical Dispersion of Heavy Metals in Soils and Water in Okpoma Area, Southeastern Nigeria

Ochelebe Ibu¹, Ekwere Azubuike S.², Ekwere Solomon J.³
^{1,2,3}Department of Geology, University of Calabar, Calabar, Nigeria
(²zerratta77@yahoo.com)

Abstract- An assessment of the distribution of selected heavy metals (Mn, Pb, Zn, Sr, Ni, Ba, Cd, As, Cu and Fe) in soils and waters in Okpoma area within the Lower Benue Trough was carried out to investigate their environmental implication. The soil and water samples were prepared and analyzed for their metal content using Atomic Absorption Spectrophotometer (AAS) model PG 990. Organic matter content (OM) and pH of the soil samples were also determined. The analytical result showed that, unlike most parts of the Benue Trough, all the elements studied were below the local threshold and regional background value in soils. The distribution pattern of the heavy metals shows that, Fe and Mn have higher concentration in the soils of the area. Fe was distributed more around areas that are frequently flooded, while Mn was distributed more around areas of high human activities. The same pattern was observed in water; however the distribution in water were more around flooded areas. The distribution of Fe was consistently high in Ugwaba and Ijama area, while Mn was distributed more in Akpakpa area. The enrichment factor value shows that the soil of the area has been minimally to moderately contaminate with the heavy metals studied. All the elements studied showed negative to weak correlation with each other. The concentration of the elements in water were lower when compared with that of the soil, some elements (Mn and As) had values above the World Health Organization guidelines value for drinking water quality. Others (Ba, Cd and Pb) were not detected in water. Result of R-mode factor analysis indicates that pH, organic content, agricultural activities and lithology are the factors controlling the distribution of metals in the area.

Keywords- Environmental Implication, Geochemical, Heavy Metals, Soil, Water

I. INTRODUCTION

Heavy metals such as zinc (Zn), manganese (Mn), nickel (Ni), copper (Cu), cadmium (Cd), and iron (Fe), are major constituents in the earth crust. Heavy metals are those elements with densities greater than 5g/cm^3 [1]. Heavy metals occur naturally in rocks and soils. However, their concentration in the ambient environment have increased dramatically since the industrial revolution when man started working the earth to

mine these metals for industrial purposes. Sediments and water contain information about the adjoining area and could be used for the geochemical characterization of large areas. These media give an indication of the input of heavy metals to the area, usually bound to the fine grained sediments or dissolve in water that drains through an enriched zone. The normal geogenic constituent usually reflects the elemental and mineralogical component of the source materials [2].

In recent time's heavy metals in soil and water, the whole world over, are more and more becoming an issue of concern at all levels, since these resources constitute a crucial component of our environment. More emphases are now shifted from exploration to their impact on the environment. All elements are critical for proper growth and development within permissible limits of human consumption. The important trace elements include Co, Cr, Cu, Mn, Ni, Se, and Zn while Ag, As, Ba, Cd, Hg, Pb, Sb and Th have no renowned function but are poisonous above certain tolerance levels[3]. The concentration of these elements in soil and water could come from many sources among which are weathering of naturally high background rocks, anthropogenic pollution, mineral deposits etc [4].

The shales, sandstone and limestone similar to those associated with the brines of Okpoma area are known to contain variable levels of mineralization in other parts of the Benue Trough [5]. This could imply that the area may probably contain lead- zinc mineralization similar to those found in Abakiliki area. Geochemical studies by [6], of some of the intrusive rocks in Oyioba-Uganga area revealed enrichment in some trace elements (Sr-919ppm, Ba-1,198ppm). Also there is an increase in the use of fertilizers and agro chemicals by farmers in the area to increase their yield to carter for the increasing population. These can impact negatively on the soil and water resources of the area. The information on the distribution of heavy metals in the area will guide in the sustainable management of the soil and water resources of the area.

The present study attempts to examine the environmental implication of some heavy metals in soil and water in the area, by determining their concentrations and distribution in the soil and water of the area.

II. METHODOLOGY

A. Description of study area

The study area lies within Yala and Ogoja Area of Southeastern Nigeria (Fig.1). The area is part of the geologic unit known as the Lower Benue Trough and the major rock types are shales and sandstones of the Asu River group and EzeAku formation (Fig. 2). There are two major drainage systems in the area (Onwu and Aya Rivers) with a network of other tributaries that are seasonal in nature. The rivers, according to [7], are structurally controlled. The drainage pattern is dendritic with the minor rivers and streams emptying into the major rivers. The area is characterized by a distinct rainy and dry season. The rainy season normally starts from April to September while the dry season is from October to March. The annual rainfall is between 200 and 250 cm [5]. In between the rainy and dry seasons is a short period of *harmattan* which is characterized by hot dry and dust laden wind. The average temperatures range from 25° to 28°C (77° to 82°F) which are high throughout the year [8]. The vegetation is typically of Guinea savannah belt which is characterized by the presence of tall grasses and scattered trees and bushes.

Sampling: A total of 21 soil and 11 water samples were collected and the sample locations are presented in Fig. 1. For soils about 2 kg representative samples were collected from each sampling point. The samples were air dried, disaggregated and sieved. The <63 µm fraction was collected for analysis. Water samples were collected from rivers, open wells and boreholes. Physical measurements were carried out in the field and these parameters included; The hydrogen ion concentration (pH), electrical conductivity, Eh, and TDS (total dissolve solid) with the use of PHT-027 Multi-parameter probe. The prepared soil samples were analyzed for heavy metals at the National fertilizer Development Institute Kaduna, Nigeria.

Sample analysis: About 1 g of the homogenized portion was weighed into 100 ml glass beakers. The samples were then moistened with few drops of de-ionized water. 10 ml of 4 M HNO₃ acid was added to each beaker the beakers were then covered with a glass disc and placed in a fume chamber, on a sand bath over a hot plate. The mixtures were refluxed at moderate temperature for about one hour, and then evaporated at a temperature range of 180° to 190 °C to dryness leaving behind a white residue. The white residue was leached with 5 ml of HCl acid into already calibrated test tubes with labels. The mixtures were then made up to 10 ml by adding de-ionized water. The test tubes were sealed with plastic stoppers and taken for analysis for Mn, Zn, Ni, Cd, Cu, Fe, As, Ba and Sr using Atomic Absorption Spectrophotometer model PG 990.100 ml of the water sample was filtered and concentrated to about 60 ml in 100 ml standard flask to which 5.0 ml HNO₃ was added. This was made up to 100 ml mark with de-ionized water followed by elemental analysis for Mn, Zn, Ni, Cd, Cu, Fe, As, Ba and Sr.

III. RESULTS AND DISCUSSION

Results of analysis of heavy metals soils are presented in table 1. Statistical analysis of data from analysis was conducted and the results are presented in table 2.

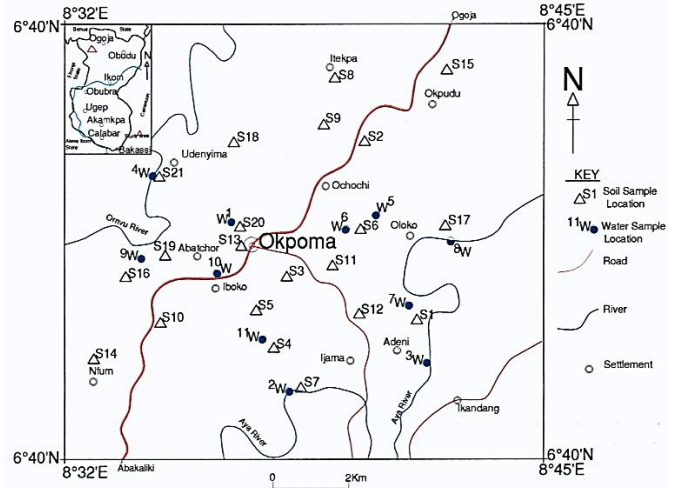


Figure 1. Map of the study area showing sample locations

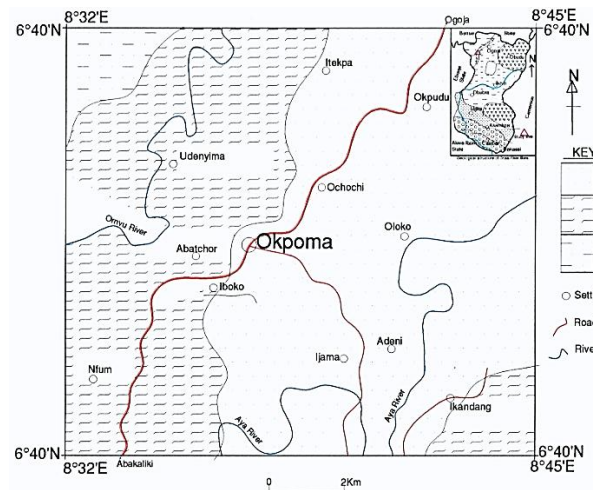


Figure 2. Geologic map of the study area

Observation of results in table 1 and 2 shows that the concentration of manganese in the soils is 10.47 ppm. The values range from 5.72 – 16.48 ppm. Mn has a threshold value of 16ppm which is lower than the minimum background value of 20 ppm reported in [9]. The Mn concentration is far below the average shale value of 900 ppm [10] and that of uncultivated soil of 320 ppm [11]. The distribution pattern of Mn in the study area is presented in Fig.3. It was observed that the concentrations of Mn were higher in areas with higher human activities compared to remote areas, suggesting some form of anthropogenic input.

Zinc: The mean concentration of zinc in the soils is 0.49 ppm, the concentration ranged from 0.11 -0.97 ppm with threshold value of 1 ppm, which is the same as the minimum value as reported by [9]. There was no enhanced concentration of zinc in the area. All the samples recorded values below the 70 ppm reported as crustal average by [12] and average shale composition of 95ppm [10]. Fig. 4 shows the distribution

pattern of zinc in the area. The low concentration of Zn could be due to its mobility and susceptibility to leaching [13].

Nickel: The mean concentration of Ni is 0.54 ppm and ranged from 0 – 1.5 ppm with median value of 0.374 ppm, the local threshold value is 1ppm. These values are very low when compared to those reported in literature; [12] reported crustal average of 68 ppm while [11] reported a median value of 17 ppm. The distribution pattern of nickel in soils around the area is presented in Fig. 5.

Cadmium: The mean concentration of cadmium recorded is 0.14 ppm with the values ranging from 0 to 0.28ppm with a local threshold value of 0.3 ppm. This is more than the crustal mean value of 0.15 ppm [12] and the average shale value of 0.03 ppm [10]. Higher values were recorded in flood plains and areas of agricultural activities such as Mfom, Okpudu and Udenyima. Cadmium occurs naturally in phosphate rocks and is introduced into soils through the application of fertilizers rich in Cd. Cadmium at elevated concentration is not beneficial to man and other animals as regular consumption of plants with high concentration of Cd can cause adverse health effects, by accumulating in the kidney, spleen and liver [14]. Distribution pattern of Cd in the study area is presented in Fig. 6. The high concentration of cadmium in some area is could be linked to fertilizer application in farms.

Arsenic: The concentrations of arsenic ranged between 0 – 1.66 ppm with an average value of 0.44 ppm. This is more than the minimum global value of 0.1 ppm reported by [9]. It has a threshold value of 1.5 ppm that is slightly lower compare to the crustal mean value of 1.8 ppm reported by [12]. It is however lower than the average shale value of 10 ppm reported by[10]. The spatial distribution of arsenic in the area is presented in Fig. 7.

Copper: The mean concentration of Cu is 0.45 ppm and values range from 0 to 1.1 ppm. The threshold value is 1 ppm that is lower compared to crustal average of 50 ppm [12]. Fig. 8 presents the distribution of copper in the area.

Iron: The mean concentration of iron in the area is 5.96 ppm and the values ranged between 2.4–10.29 ppm, with a threshold value of 10 ppm. The distribution pattern of iron is given in Fig. 9. The concentration of iron in Okpoma is generally low compared to minimum value of 2000ppm [9], average shale value of 46700ppm [10] and crustal average of 21000ppm [12]. Iron is immobile in both oxidizing and reducing environments [13]. This could account for its low value; Since Fe is one of the most abundant metals in the earth crust.

Strontium: Strontium, though not a heavy metal, was studied because of its association with barium. The concentration of strontium in the area ranged between 0 - 0.24

ppm with the mean value of 0.08 ppm. The threshold value of Sr is 0.2 ppm which is far below the average shale composition of 300 ppm [10]. Figure10 shows the spatial distribution of strontium in the area.

Barium: Barium was studied because of its geochemical application as guide to barite deposit [15]. The barium content of all the soil samples ranged between 0 – 0.65 ppm with a mean value of 0.31. The threshold value is 0.7ppm and is far below the background values documented in literature (Table 2). The low concentration of Ba in Okpoma shows that, unlike the other parts of the Benue Trough, the area has no barite mineralization. Distribution pattern of barium is presented in Fig. 11.

A. *Enrichment Factor (EF):*

Enrichment factor (EF) was used to identify anomalous metal concentration by employing geochemical normalization of the heavy metal data to a conservative element of either Al or Fe [16]. Fe was selected as reference element in this study, because it is mainly supplied from sediments and is one of the widely used reference elements [17]. EF was computed for each location relative to the abundances of species in source materials to the computed background value. The equation proposed by [17], was used to assess degree of contamination and to understand the distribution of the heavy metals of anthropogenic origin from sites by individual elements in sediments. EF is a good tool to differentiate metal concentration derived from anthropogenic or naturally occurring sources [18] and [19]. Table 3 shows the EF of the heavy metals in each location with respect to the calculated local background value, and classification scheme proposed by [20].

Computation shows that the EF value ranged from 0 to 6.74 with over 70% having EF of less than 1.5. Only As recorded significant enrichment in location 18 (Udenyima) all the other location had EF value ranging from background concentration to moderate enrichment. Elements with EF values less than 1 indicate that leaching and consumption of such element took precedence over its accumulation in the area [21]. Elements which are naturally derived have EF value of nearly unity while elements of anthropogenic origin have EF values of several orders of magnitude [17]. For EF values greater than 1.5 shows that such heavy metals were derived from other sources, suggesting environmental contamination by those particular heavy metals. On the basis of EF values, the area is believed to be minimally to moderately contaminated with some heavy metals, while location S18 have been significantly contaminated with arsenic. The EF values indicates that Mn, Zn, Ni, Cd, As and Cu concentrations in the area need to be monitored to prevent potential pollution risk in the future.

TABLE I. HEAVY METAL CONCENTRATION (PPM) FOR SOIL SAMPLES

Sample Code	LOI(%)	pH	Mn	Zn	Sr	Ni	Ba	Cd	As	Cu	Fe
S1	1.2	6.65	8.349	0.971	0.03	0.460	0.642	0.194	0.177	0.348	4.594
S2	4.6	7	15.439	0.436	0.101	0.634	0.351	0.139	0.166	0.226	6.303
S3	4.4	6.99	9.705	0.727	0.169	1.500	0.313	0.043	0.446	0.340	7.047
S4	3.4	7.2	13.755	0.944	0.006	0.312	0.343	0.029	0.056	0.334	10.29
S5	4.4	6.35	13.587	0.111	0.015	0.460	0.413	0.224	0.231	0.335	4.677
S6	10	6.77	5.722	0.802	0.151	0.112	0.103	0.025	0.804	0.402	8.068
S7	5.6	6.97	14.165	0.431	0.239	0.284	0.477	0.139	1.660	ND	10.095
S8	5.6	6.61	11.416	0.571	0.048	0.507	0.653	0.175	0.236	0.666	3.981
S9	8.2	6.82	10.467	0.312	0.103	0.268	0.445	0.180	0.448	0.433	6.861
S10	5	6.57	8.962	0.388	0.053	0.312	0.216	0.205	0.275	0.329	5.846
S11	2.4	6.66	13.146	0.085	0.147	ND	ND	0.286	1.174	0.159	5.617
S12	2	6.67	7.892	0.436	0.088	0.129	0.102	ND	ND	0.889	9.788
S13	10.6	7.17	5.986	0.244	0.140	0.458	0.510	0.087	ND	0.329	5.187
S14	3.8	6.55	8.197	0.557	0.059	1.016	ND	0.267	0.155	0.440	3.284
S15	1.2	6.94	10.498	0.941	0.072	0.536	0.342	0.229	0.101	0.625	6.613
S16	3	6.12	9.695	0.802	0.065	0.283	0.112	0.054	0.182	0.382	4.285
S17	7.8	7	12.377	0.169	0.083	0.278	0.296	0.019	0.694	0.692	2.400
S18	6.2	5.59	8.312	0.241	0.049	0.211	ND	0.257	1.604	0.438	3.392
S19	3.6	7.03	16.487	0.215	ND	0.702	0.430	0.200	0.839	1.091	6.303
S20	9.2	6.06	9.705	0.388	0.001	0.374	0.590	0.150	ND	0.118	3.392
S21	8.2	6.53	5.722	0.601	0.082	0.879	0.236	0.117	0.026	0.889	7.047

ND – Not detected LOI – Loss on ignition

TABLE II. STATISTICAL DESCRIPTION OF HEAVY METALS IN SOIL (PPM)

Heavy metal	Statistical values n=21 (this study)					Background from different sources					
						Bowen 1979			Average shale ¹	Crustal average ²	Uncultivated soils ³
	Mean	Min	Max	Median	Threshold	Median	Min	Max	Mean	Mean	Median
As	0.44	0	1.66	0.231	1.5	6.0	0.1	40	10	1.8	7.5
Ba	0.31	0	0.65	0.342	0.7	500	100	3000	580		300
Cd	0.14	0	0.28	0.150	0.3	0.35	0.01	2	0.03	0.15	
Cu	0.48	0	1.1	0.382	1	30	2	250	45	50	15
Fe	5.96	2.4	10.29	5.846	10	40000	2000	550000	46700	21000	
Mn	10.45	5.72	16.45	9.705	16	1000	20	10000	900		320
Ni	0.54	0	1.5	0.374	1	50	2	750	68		17
Sr	0.08	0	0.24	0.072	0.2	250	4	2000	300		
Zn	0.49	0.11	0.97	0.436	1	90	1	900	95	70	

1-Turekian and wedepohl (1961), 2-Taylor (1964), 3-Connor and Shacklette (1975)

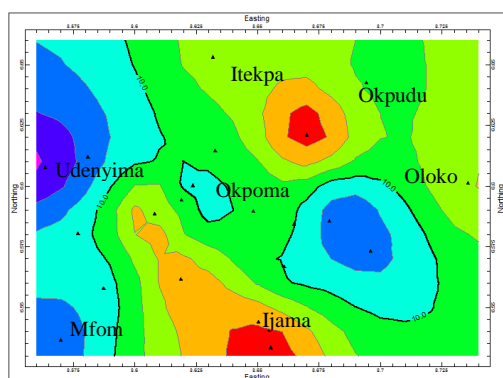


Figure 3. Distribution Pattern of manganese in the study area

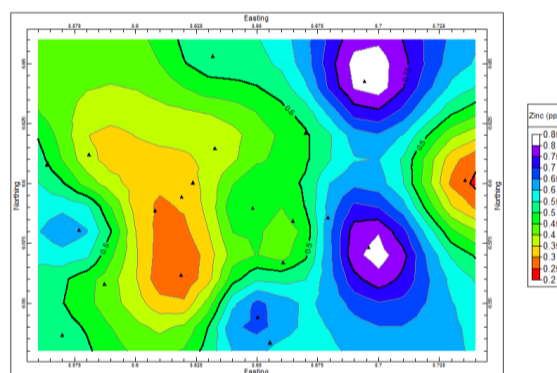


Figure 4. Distribution pattern of zinc in the study area

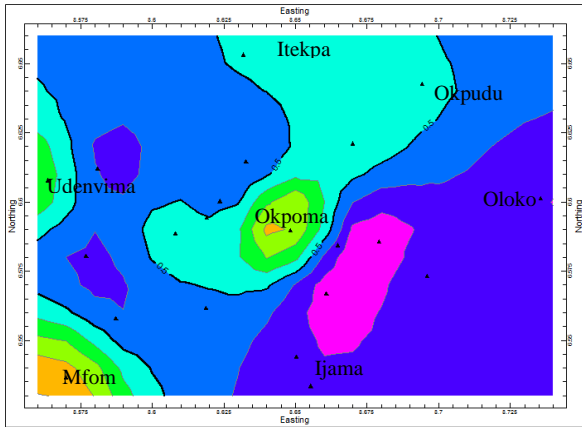


Figure 5. Distribution pattern of nickel in the study area

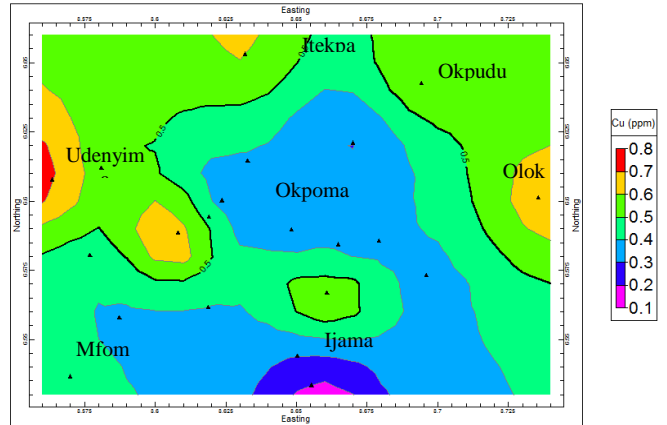


Figure 8. Distribution pattern of copper in the area

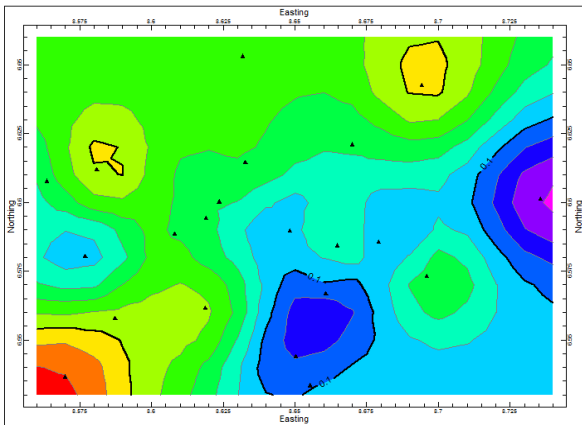


Figure 6. Distribution pattern of cadmium in the study area

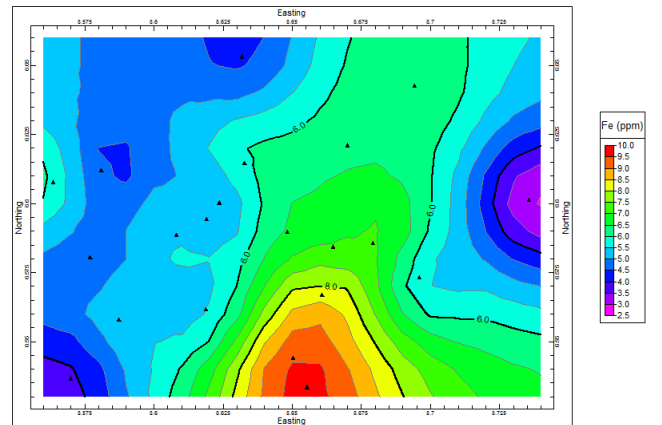


Figure 9. Distribution Pattern of iron in the study area

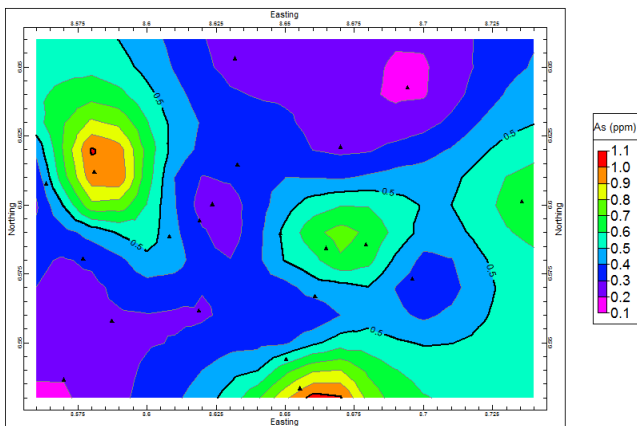


Figure 7. Distribution pattern of arsenic in the study Area

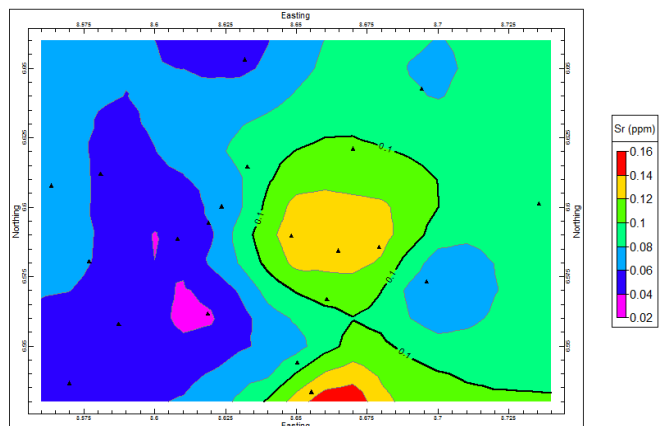


Figure 10. Distribution pattern of strontium in the study area

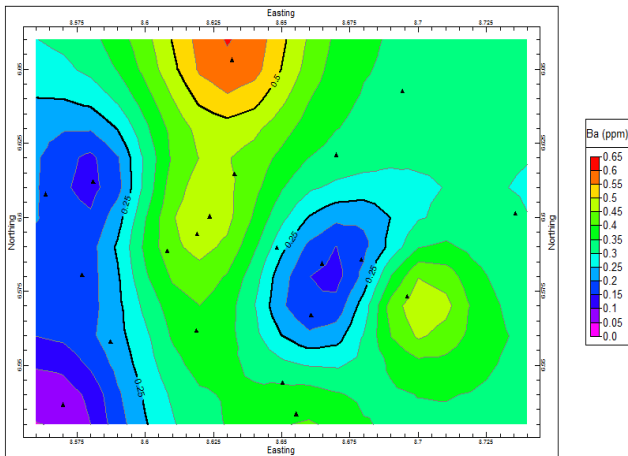


Figure 11. Distribution Pattern of barium in the study area

Heavy metals in water: Table 4 shows the heavy metal concentration in water along with some statistical parameters. From the deductions, the mean concentration of Mn in the water is 1.49 ppm and ranged from 0 to 4.41 ppm. This value is comparable to that reported in the saline water of the area by [5]. The concentration of Mn in the water samples are generally higher than the World Health Organization guideline value for drinking water of 0.4 ppm [22], implying that the water in most parts are polluted. High intake of Mn could lead to neurological disorder [23]. The major source of Mn in water is through erosion of natural deposits. The highest value was recorded in the sample from Akpakpa River at Itega Okpudu.

Zinc: The mean concentration of Zn in the water samples was 0.048 ppm. The values ranged from 0 to 0.11 ppm, the concentration of zinc is low, but higher when compared with average value of 0.02 ppm for fresh water reported by [24]. However the concentration of Zn in water has no health implication [22].

Strontium: The concentration of Sr in the water ranged from 0 to 0.05 ppm with average concentration of 0.01 ppm. The values are lower than the average value of 0.4 ppm reported in [13].

Nickel: The mean concentration of Ni in the water was 0.076 ppm; and the values ranged from 0 – 0.19 ppm, which is within the WHO (2004) guideline value of 0.2 ppm.

Arsenic: The mean concentration of As in the water was 0.032 ppm, the values ranged from 0 to 0.11 ppm, which is higher than the WHO (2004) guideline value for drinking water quality of 0.01 ppm, in some areas. The highest concentration is recorded in the sample from the public hand dug well in location W10 (Woleche). Arsenic is a naturally occurring element, often found in rocks that contain other valuable metals, such as copper and lead. Arsenic has long been recognized as a poison, and is the most common cause of acute mental poisoning in adults [25]. Large oral dose of arsenic can cause death. Lower doses can cause decreased production of white blood cells [26].

Copper: The concentration of Cu in the water is low. The values ranged from 0.03 to 0.44 ppm with mean concentration of 0.173 ppm which is lower than the WHO (2004) guideline value for drinking water quality of 2 ppm.

Iron: The concentration of iron in the water ranged from 0 to 3.2 ppm with mean value of 1.439 ppm. The concentration of Fe in the water is higher than the water supply ceiling of the U.S. Environmental protection agency of 0.3 ppm [27].

R-mode Factor Analysis. The data of the heavy metals obtained in this study were subjected to R-mode factor analysis as an effort to determine the sources of metal concentration, as well as the factors controlling them. The analysis groups' related variables into principal associations called factors on the basis of their mutual correlation coefficient [28] and [29]. These associations may be interpreted in terms of mineralization, lithology and environmental processes [30]. The results of the factor analysis are summarized in a factor matrix (table 5). A four-factor model that accounted for 63.8% of data variance was considered, in view of known geology, environmental evidence and land use pattern in the area. Only variables with loading greater than 0.4, were considered significant members of a particular factor.

Factor 1: pH, Zn, Cd, As and Fe: This factor accounts for 19.55% of the total data variance of the four-factor model and associated Zn, Cd, As and Fe with pH. The factor reflects the influence of pH on the mobility of Zn, Cd, As and Fe. Most metals are mobile at low pH due to dissolution and decomposition in the soil [31]. The moderate to low pH values reported in this study indicate some interaction with carbonate host rock. The reported occurrence of sphalerite (ZnS) in the Abakaliki area probably can be implicated for the presence of Zn in this loading. The presence of As in this factor is indicative of the occurrence of arsenopyrite in the source material. Also the presence of Cd suggests influence of human activities (fertilizer application) in this loading.

Factor 2: Sr, Cd, As, pH and Fe: This factor accounts for 18.5% of the total data variance. The presence of Sr, which substitutes readily for Ca [32], in this loading is an indication of weathering and composition of sediments of Carbonate origin. The presence of pH in this factor also reflect the mild influence of pH on the mobility of Sr, Cd, As and Fe.

Factor 3: Mn and LOI: This factor accounts for 14.13% of the total data variance. The factor reflects the influence of organic matter in the absorption of Mn in the area. Organic content has been shown to influence natural metal concentration [33].

Factor 4: Cu and Zn: This factor accounts for 11.63% of the total data variance. This factor suggests the influence of tectonic activity in the distribution of Cu in the area, as the metal is concentrated around Udenyima area where some relics of tectonic activities were recorded. Also the negative value of Zn in this factor is an indication of reverse relationship between Cu and Zn suggesting ion exchange reaction where the Cu was being exchanged for Zn.

TABLE III. ENRICHMENT FACTOR FOR THE HEAVY METALS IN SOILS AND THEIR CLASSIFICATION (AFTER SUTHERLAND, 2000)

Sample code	Mn	Zn	Sr	Ni	Ba	Cd	As	Cu
S1	1.03	2.64	0.65	1.11	2.79	2.07	0.56	0.95
S2	1.39	0.87	1.59	1.11	1.11	1.11	0.39	0.46
S3	0.78	1.29	2.41	2.36	0.88	0.28	0.91	0.60
S4	0.76	1.14	0.10	0.33	0.66	0.15	0.08	0.40
S5	1.65	0.29	0.43	1.09	1.75	2.35	0.70	0.91
S6	0.43	1.23	1.86	0.15	0.25	0.19	1.40	0.62
S7	0.80	0.53	2.38	0.31	0.95	0.69	2.35	0
S8	1.63	1.79	1.26	0.93	3.27	2.26	0.86	2.10
S9	0.87	0.56	1.46	0.44	1.31	1.31	0.94	0.78
S10	0.87	0.83	0.85	0.59	0.75	1.79	0.68	0.71
S11	1.33	0.20	2.67	0	0	2.58	2.97	0.36
S12	0.46	0.56	1.02	0.15	0.20	0	0	1.14
S13	0.66	0.58	2.70	0.98	1.97	0.87	0	0.71
S14	1.42	2.13	1.83	3.46	0	4.12	0.70	1.68
S15	0.90	1.78	1.06	0.91	1.03	1.74	0.22	1.19
S16	1.28	2.33	1.63	0.73	0.51	0.58	0.60	1.11
S17	2.93	0.89	3.33	1.30	2.50	0.42	4.11	3.89
S18	1.39	0.88	1.47	0.69	0	3.83	6.74	1.62
S19	1.49	0.44	0	1.23	1.37	1.59	1.9	2.18
S20	1.63	1.44	0.03	1.21	3.48	2.21	0	0.44
S21	0.46	1.06	1.13	1.39	0.68	0.85	0.06	1.59
Mean	1.15	1.12	1.42	0.97	1.21	1.48	1.25	1.12

EF Indices

EF ≤ 1

EF 1 - 2

EF 2 - 5

EF 5 - 20

EF 20 - 40

EF > 40

Degree of Enrichment

background concentration

depletion to minimal enrichment

moderate enrichment

significant enrichment

very high enrichment

extremely high enrichment

Heavy metal

Mn, Zn, Sr, Ni, Ba, Cd, As, Cu

Mn, Zn, Sr, Ni, Ba, Cd, As, Cu

Mn, Zn, Sr, Ni, Ba, Cd, As, Cu

As

TABLE IV. HEAVY METAL CONCENTRATION IN WATER SAMPLES (PPM)

CODE	pH	Eh	Mn	Zn	Sr	Ni	Ba	Cd	As	Cu	Fe
W1	6.25	189	1.117	0.099	0	0	0	0	0	0.094	1.817
W2	-	-	0.77	0.042	0.015	0.014	0	0	0	0.144	0.586
W3	6.73	146	1.022	0.032	0	0.032	0	0	0.06	0.073	1.168
W4	6.94	99	0	0.04	0	0	0	0	0	0.12	0.633
W5	6.3	575	4.405	0.046	0.006	0	0	0	0	0.159	1.357
W6	6.44	122	2.788	0.027	0.049	0	0	0	0.05	0.03	2.171
W7	6.13	230	0.587	0	0.012	0.129	0	0	0.101	0.192	0
W8	6.57	184	2.319	0.058	0.032	0.143	0	0	0	0.142	2.4
W9	6.36	127	0.945	0.072	0	0.143	0	0	0.015	0.357	0
W10	7.21	89	0.044	0.102	0	0.193	0	0	0.111	0.438	2.502
W11	6.25	167	2.43	0.011	0	0.129	0	0	0.018	0.155	3.197
MEAN	6.518	192.8	1.493	0.048	0.010	0.076	0	0	0.032	0.173	1.439
SD	0.346	141.2	1.344	0.033	0.016	0.083	0	0	0.042	0.120	1.069
RANGE	6.13-7.21	89-575	0-4.41	0-0.11	0-0.05	0-0.19	0	0	0-0.111	0.03-0.44	0-3.2
WHO ^b	-	-	0.4	N/A	-	0.2	0.7	0.03	0.01	2	N/A

b- World Health Organization (2004) N/A- Not Applicable

IV. CONCLUSIONS

From the study, indication from the Enrichment Factor values shows that, the soil of the area has been minimally to moderately contaminated with the heavy metals studied, while Udenyima area have been significantly contaminated with arsenic. The concentration of Mn and Fe were more in the soil compared to other metals. Also concentration of Mn and As had values above the world health organization (2004) guidelines values for drinking water quality. So the populace stands the risk of health hazards posed by these elements. It is recommended that, based on the EF values of Mn, Zn, Ni, Cd, As and Cu in the soils and the concentration of Mn and As in water, the concentrations of these elements in the area need to be monitored to prevent potential pollution risk in the future. Also the water should be treated before being used for domestic purposes.

TABLE V. FACTOR ANALYSIS IN SAMPLE CONCENTRATION

	Factor 1	Factor 2	Factor 3	Factor 4
LOI	-0.175725	-0.339400	-0.627163	0.248537
pH	0.631762	-0.449133	0.344098	0.280984
Mn	-0.120266	-0.115144	0.848978	0.377060
Zn	0.723402	0.195296	-0.068064	-0.482552
Sr	0.023923	-0.820248	-0.027187	-0.298727
Ni	0.391566	0.199673	-0.035904	0.265242
Ba	0.369308	0.211334	0.300484	0.202251
Cd	-0.583411	0.419185	0.392126	-0.090245
As	-0.603537	-0.474087	0.291430	-0.227193
Cu	0.221233	0.242807	-0.176087	0.551667
Fe	0.502654	-0.613629	0.207926	-0.132113
Eigenvalue	2.346244	2.220026	1.696484	1.395638
%total Var.	19.55203	18.50021	14.13736	11.63032
Cum. %	19.55203	38.05225	52.18961	63.81993

REFERENCES

[1] Dubbin, W.E., 2005. Environmental Geochemistry, in Richard et al (Ed.), Encyclopedia of Geology(pp.21-25), London: Elsevier Academic press.

[2] Anikeyev, V.V., Perepelitsa, S.A. & Shumilin, Y.N., 1994. Effects of man-made and Natural sources on the Heavy-Metal Patterns in Bottom Sediments in the Gulf of Peter the Great, Sea of Japan. *Geochemistry International*, 31(4),73-85.

[3] Alloway, B. J., 1995. Soil Pollution and Land Contamination: in R. M. Harrison (Ed), *Pollution: Causes, Effects and Control* (pp318). Cambridge: The Royal Society of Chemistry.

[4] Asaah, V.A., Abimbola, A.F. & Suh, C.E., 2006. Heavy metal concentration and distribution in surface soils of the Bassa industrial Zone I, Duala Cameroun. *Arabian Journal of Science & Engineering*, 31 (2A), 147- 158.

[5] Ekwere, S.J. & Ukpogon, E.E., 1994. Geochemistry of saline ground water in Ogoja, Cross River State of Nigeria. *Journal of Mining & Geology*, 29, 277-282.

[6] Ekwueme, B.N., 1995. The Nature of Magmatism and Tectonic Setting of the Oyioba-Uganga Area, Southern Benue Trough, Nigeria: Evidence from Major and Trace Element Geochemistry. In Srivastava and

Chandra (Ed.), *Magmatism in relation to Diverse tectonic settings*, (pp.67-77). New Delhi: Oxford & IBH Publishing CO. PVT. LTD.

[7] Olade, M.A., 1975. Evolution of Nigeria's Benue Trough (aulacogen): a reinterpretation, *Nigerian journal of Mining & Geology*, 13, 20-27.

[8] Encarta, 2009. 1993-2008microsoftcorporation.

[9] Bowen, H. J. M., 1979. *Environmental chemistry of the elements*. London: Academy Press.

[10] Turekian, K.K. & Wedepohl, K.H., 1961. Distribution of the elements in some major units of the earth crust. *Geological Society of America Bulletin*, 72, 175-192.

[11] Connor, J. J. & Shacklette, H. T., 1975. Background geochemistry of some rocks, soils, plants and vegetables in the contaminous United State. United State Geological Survey professional paper, Paper 547F.

[12] Taylor, S.R., 1964. Abundance of chemical elements in the continental crust; a new table. *Geochim Cosmochim Acta*, 28, 1273-1285.

[13] Rose, A.W., Hawke, H.E. & Web, J.S., 1981. *Geochemistry in mineral Exploration*. London: Academic Press.

[14] Eisler, R., 1985. Cadmium hazards to fish, wildlife and invertebrates: contaminated hazards review biological report 85. U.S Fish and Wildlife services, USA.

[15] Friedrich, G.H. & Pluger, W.L., 1971. Geochemical prospecting for barite and fluorite deposits. Toronto symposium, 151-156.

[16] Yuan, C., Shi, J. B., He, J., Liu, L. L. & Jiang, G., 2004. Speciation of Heavy Metals in Marine Sediments from the East China Sea by ICP-MS with Sequential Extraction. *Environment International*, 30, 769-783.

[17] Ameh, E.G., Kolawole, M.S. & Imeokparia, E.G., 2011. Using Factor-Cluster Analysis and Enrichment methods to evaluate impact of cement production on stream sediments around Obajana cement factory in Kogi State, North central Nigeria. *Advances in Applied Science Research*, 2(1), 76-89.

[18] Morillo, J., Usero, J. & Gracia, I., 2004. Heavy metal distribution in marine sediments from the south west coast of Spain. *Chemosphere*, 55, pp.431-442.

[19] Adamo, P., Arienzo, M., Imperato, M., Naimo, D., Nardi, G. & Stanzione, D., 2005. Distribution and partition of heavy metals in surface and subsurface sediments of Naples city port. *Chemosphere*, 61, pp.800-808.

[20] Sutherland, R. A., 2000. Bed sediment-associated trace metal in an urban stream. *Environmental Geology*, 39, 611-37.

[21] Loska, K., Wiechula, D. & Pelczar, J., 2005. Application of enrichment factor to assessment of zinc enrichment/depletion in farming soils. *Community Soil Science & Plant Anal*, 36, 1117-1128.

[22] World Health Organization., 2004. *Guidelines for drinking water quality*. Geneva.

[23] Standard Organization of Nigeria., 2007. *Nigerian standard for drinking water quality*. Abuja.

[24] Turekian, K.K., 1977. Geochemical distribution of elements. In *Encyclopaedia of science & technology*, 4th ed. New York: McGraw-Hill,

[25] Adegoke, J.A., Agbaje, W.B. & Isaac, O.O., 2009. Evaluation of heavy metal status of water and soil at Ikogosi warm spring, Ondo State, Nigeria. *Ethiopian Journal of Environmental Study & Management*. 2(3),88-93.

[26] Richard, F., 2010. Goldsmith institute 2010 Annual report. Goldsmith institute, New York.

[27] United States Environmental Protection Agency., 1977. *Quality criteria for water*. US EPA, Washinton.

[28] Nichol, I., Garret, R. G. & Webb, J. S., 1969. The Role of Some Statistical and Mathematical Methods in the Interpretation of Regional Geochemical Data. *Economic Geology*, 64, pp.204.

[29] Davis, J. C., 1973. *Statistics and data analysis in Geology*. New York: John Wiley & sons Inc.

[30] Elueze, A. A., Ekwere, A. S. & Nton, M. E., 2009. Geoenvironmental assessment of the environs of the Aluminium Smelting Company in Ikot Abasi, southeastern Nigeria. *Journal of Mining & Geology*, 45(2),115-129.

[31] Cox, P.A., 1995. *The elements on earth; Inorganic chemistry in the environment*, New York: Oxford Uni. Press Inc.

[32] Eide, E. A., 2005. Geochronological Techniques: in Encyclopedia of Geology. In Selley, R. C., Robin, L. & Plimer, I. R. (Ed.), Amsterdam: Elsevier Academic press.

[33] Azmatullah, M. & Ekwere, S.J., 1985. Heavy metal distribution in sediments from Cross River Estuary, SE Nigeria, Nigerian Journal of Mining & Geology. 21(1&2), 165–169.