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Physico-chemical Assessment of Rivers around Mineralized Marcasite Deposit

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ABSTRACT

The present investigation provides information on some ions; Fe^{2+}, Al^{3+}, Pb^{2+}, Cd^{2+}, Ca^{2+}. Cl^{-}, SO_4^{2-}, PO_4^{3-}, and NO_3^{-} on water sample of the three rivers around the mineralized area of Marcasite deposit. Results obtained from the analyses on four samples collected from each of the three rivers showed the mean range values of the following parameters; pH, 5.03 – 5.74, Temperature, 24.98 – 25.73^{o} C, electrical conductivity, 1.88 – 198 µs/cm. TDS, 3.5 – 5.0 mg/dm^3, Chloride, 6.11 – 9.83 mg/dm^3, Sulphate, 1.2 – 1.3 mg/dm^3, Phosphate, 0.10-0.14 mg/dm^3, Nitrate, 0.321 – 0.532 mg/dm^3. Total hardness, calcium hardness and magnesium hardness ranged between 0.56 – 0.78 mg/dm^3, 0.42 – 0.53 mg/dm^3 and 0.09 – 0.25 mg/dm^3 respectively. The metal ions of iron, lead, cadmium and calcium ranged between <0.0001 – 0.9749 mg/ dm^3, 0.8497 – 3.9647mg/dm^3, 0.2483 – 1.7900 mg/dm^3 and 1.38 – 2.61mg/dm^3 respectively. These results are within the WHO permissible limits, except for iron content of *Ikwu Akanu* river which was relatively high; the level of lead and cadmium at some points of the rivers were found well above the WHO recommended standard.

KEYWORDS: rivers, inorganic, iron aluminum, water quality

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INTRODUCTION

Adverse environmental and ecological changes as a result of ore deposits, mining and anthropogenic inputs has become more tangible and menacing [1]. There exist questions and concerns on the possible state of the soil, rivers and even food crops where mineral deposits occur and surfaces of the deposit tampered with as a result of human activities [2]. Traces of heavy metals can be found naturally in the environment but industrial activities increase their level. In mineralized areas such as Ishiagu, Nigeria, one of the major sources of lead and zinc to the environment arise from galena and sphalerite mining activities and these had serious risk on the residents' health [3,4]. Evidence has shown that people living around mining sites or deposits have increased metal content in their blood [5]. Metals such as lead can cause reduced intelligent quotient in children and renal failure in human. It has been suggested that small doses of soluble aluminum which can be found in drinking water are in a chemical form which makes them subject to metabolism in the body in such a way as to increase the incidence of Alzheimer's disease, a form of senile dementia [6]. The patients on kidney dialysis can be fatally affected if the supply to the machine contains soluble aluminium. Iron in domestic water supply systems stains laundry and cause brownish colouration in water and other unaesthetic effects [7]. Thus, the need for regular monitoring of water sources so as to record any alteration in the quality.

The mineralization of natural waters results from heavy atmospheric precipitation of natural waters. This is attributed to dissolved, suspended solids of inorganic minerals washed down by rain and wind. So water contamination results [8,9]. Therefore, the quality of river water depends on the feeding source which include surface run – off, water of glaciers, dust from mines, metals and their compounds washed from ore deposits. These release a lot of heavy metals such as iron, enormous amount of wastes and other related pollutants into the rivers [2]. Water quality is determined by the physical and chemical limnology of a reservoir and includes all physical, chemical and biological factors of water that influence the beneficial use o the water [9,10,11,12]. Marcasite is the chief source of iron and aluminum and around these deposit, there are agricultural activities alongside mining on the deposit. The principal objective of the present study is to examine the chemical status and pollution levels of the rivers of the study area with respect to aluminum, iron ions and other parameters and hence ascertain their quality.

MATERIALS AND METHODS

Sampling

A field survey and mineralogical analysis of the almandine deposit was carried out to ascertain the presence of iron and aluminum as chief components of the rock. Four water samples were collected from each of the three rivers – *Ikwu Akanu (IA)*, *Ikwu Umudike (IU)* and *Ikwu Okorobi (IO)* in *Ideato* –

South Local Government Area of Imo State, Nigeria. Qualitative analysis was carried out on the twelve samples. The water samples were put into plastic bottles which have been cleaned with 2M HNO_3 and rinsed with de-ionized water. This serves to minimize the possibility of contamination of the sample bottles. The pre-treatment required by samples shortly after sampling prior to storage depends largely on the analysis to be carried out subsequently. Samples for elemental analysis such as alkaline earth and trace metals, concentrated HNO_3 of high purity was added to the samples to make the pH less than 2. These stabilize the sample, maintain the oxidation state of the elements, discourage precipitation and prevent metals from adhering to the walls of the containers.

Analytical methods

The pH, electrical conductivity and temperature were determined at the sampling sites using potable meters. The Hanna HI 98140 meter was used to measure the pH. The electrical conductivity of the water samples was measured with LABTECH conductivity meter. The phosphate, nitrate, and ammonia concentration using a Technicon AA 11 autoanalyzer and the total dissolved solids, total hardness, total chloride were measured by the standard methods [10,13,14].

Metal Ions Analysis

The river water samples (500 ml) were acidified with concentrated HNO_3 acid and concentrated to 25 ml using evaporation method [11]. After chelation, extraction and mineralization, metal ions were determined with the inductively coupled plasma –optical emission spectrophotometer, Leeman model. For all analysis, the blank was used to zero the instrument. The reproducibility of the analytical procedures was conducted by carrying out a triplicate analysis. Triplicate analytical data did not vary by more than 5% of the mean.

RESULTS AND DISCUSSION

The results of the physico-chemical analysis of the selected surface water (*Ikwu Akanu*, *Ikwu Umudike*, *Ikwu Okorobi*) are shown in the Tables below. For the water to be portable, the concentration of the undesirable substances should not exceed the levels recommended by the World Health Organization [15].

Tables 1 – 3 show the physico-chemical data of the three rivers while Table 4 gives the mean concentration of the different parameters of water samples for the three rivers. The variation of metal concentrations with distance from the river banks for the three rivers is given in Tables 5 to 7.

Table 1: Physico-chemical Data of *Ikwu Akanu* River

Parameters	A_1	A_2	A_3	A_4	Range	Mean	WHO
Temperature (^oC)	24.60	25.0	25.2	25.1	24.6 – 26.2	24.98	30-32^oC
pH	5.68	5.74	5.53	5.57	5.53 – 5.74	5.63	6.5 – 8.5
Elect. Conductivity (µS/cm)	1.90	1.90	2.10	2.00	1.90 – 2.10	1.98	400□s/cm
Total Hardness (mg/dm^3)	0.50	0.62	0.44	0.66	0.44 – 0.66	0.56	500mg/ dm^3
Calcium Hardness (mg/ dm^3)	0.42	0.56	0.40	0.50	0.40 – 0.56	0.47	
Mg Hardness (mg/dm^3)	0.08	0.06	0.04	0.16	0.04 – 0.16	0.09	50mg/ dm^3
Phen. Acidity (mg/dm^3)	4.00	7.50	10.00	7.00	4.00– 10.00	7.13	
TDS (mg/dm^3)	3.00	4.00	4.00	3.00	3.00 – 4.00	3.50	500mg/ dm^3
Turbidity (NTU)	38.63	36.67	28.13	32.33	28.13-38.63	33.94	
Choride (mg/dm^3)	9.13	8.94	9.33	11.91	8.94– 11.91	9.83	600mg/ dm^3
Sulphate (mg/dm^3)	1.20	1.60	0.80	1.20	0.80 – 1.60	1.20	400mg/ dm^3
Phosphate (mg/dm^3)	0.12	0.09	0.15	0.05	0.05 – 1.5	0.10	0.1mg/ dm^3
Nitrate (mg/dm^3)	ND	0.28	0.40	0.33	0.28– 0.40	0.34	
Iron (mg/dm^3)	1.33	1.07	0.53	ND	<0.0001– 1.33	0.97	0.3mg/ dm^3
Aluminum (mg/dm^3)	ND	ND	ND	ND	<0.0001	<0.0001	
Lead (mg/dm^3)	4.49	3.43	ND	ND	<0.0001 – 4.50	3.96	0.01mg/ dm^3
Cadmium (mg/dm^3)	2.02	1.18	ND	ND	<0.0001 – 2.02	1.60	0.05mg/ dm^3
Calcium (mg/dm^3)	2.02	1.02	1.11	1.3556	1.02– 2.02	1.38	75mg/ dm^3

ND = Not Detected

Table 2: Physico-chemical Data of *Ikwu Umudike* River

Parameters	U_1	U_2	U_3	U_4	Range	Mean	WHO
Temperature (^oC)	26.00	26.10	25.60	25.20	25.20 – 26.10	25.73	30 – 32^oC
pH	5.75	5.69	5.80	5.71	5.69 – 580	5.74	65-8.5
Elect. Conductivity (μS/cm)	1.90	1.90	1.90	2.10	1.90 - 2.10	1.95	400□s/cm
Total Hardness (mg/ dm^3)	0.54	0.46	0.62	0.88	0.46 - 0.88	0.63	500mg/ dm^3
Calcium Hardness (mg/ dm^3)	0.46	0.38	0.34	0.50	0.34 – 0.50	0.42	
Mg Hardness (mg/dm^3)	0.08	0.08	0.28	0.38	0.08 – 0.38	0.21	50mg/ dm^3
Phen. Acidity (mg/dm^3)	7.00	7.00	10.50	7.00	7.00– 10.50	7.88	
TDS (mg/dm^3)	4.00	6.00	5.00	5.00	4.00 – 6.00	5.00	500mg/dm^3
Turbidity (NTU)	34.43	45.90	38.47	36.10	34.43-45.90	38.73	
Choride (mg/dm^3)	6.26	6.07	6.55	6.26	6.07 – 6.55	6.29	600mg/ dm^3
Sulphate (mg/dm^3)	1.50	1.50	1.20	1.00	1.00-1.50	1.30	400mg/ dm^3
Phosphate (mg/dm^3)	0.08	0.16	0.15	0.18	0.08 – 0.18	0.14	0.1mg/ dm^3
Nitrate (mg/dm^3)	0.84	0.44	0.31	ND	0.31 – 0.84	0.53	
Iron (mg/dm^3)	0.35	0.24	ND	ND	<0.0001– 1.35	0.29	0.3mg/ dm^3
Aluminum (mg/dm^3)	ND	ND	ND	ND	ND	ND	
Lead (mg/dm^3)	3.39	ND	ND	ND	<0.0001 – 3.39	0.85	0.01mg/ dm^3
Cadmium (mg/dm^3)	0.9927	<0.0001	<0.0001	<0.0001	<0.0001 – 0.9927	0.25	0.05mg/ dm^3
Calcium (mg/dm^3)	3.29	1.18	2.35	1.8201	1.82 – 3.29	2.16	75mg/ dm^3

ND = Not Detected

Table 3: Physico-chemical Data of *Ikwu Okorobi* River

Parameters	O_1	O_2	O_3	O_4	Range	Mean	WHO
Temperature (^oC)	25.20	26.00	24.80	24.50	24.50 – 26.00	25.13	30 – 32^oC
pH	5.11	4.95	4.97	5.09	4.95 – 5.11	5.03	65-8.5
Elect. Conductivity (μS/cm)	2.00	1.80	1.80	1.90	1.80 – 2.00	1.88	400□s/cm
Total Hardness (mg/ dm^3)	0.84	1.02	0.80	0.44	0.44 – 1.02	0.78	500mg/ dm^3
Calcium Hardness (mg/ dm^3)	0.44	0.70	0.54	0.42	0.42 – 0.70	0.53	
Mg Hardness (mg/dm^3)	0.40	0.32	0.26	0.02	0.02 – 0.40	0.25	50mg/ dm^3
Phen. Acidity (mg/dm^3)	10.50	9.50	6.00	7.00	6.00– 10.50	8.25	
TDS (mg/dm^3)	5.00	7.00	1.00	4.00	1.00 – 7.00	4.25	500mg/ dm^3
Turbidity (NTU)	58.43	48.00	45.37	59.43	45.37 – 59.43	52.81	
Choride (mg/dm^3)	6.45	6.16	5.96	5.86	5.86 – 6.45	6.11	600mg/ dm^3
Sulphate (mg/dm^3)	1.50	1.50	1.20	1.00	1.00 – 1.50	1.30	400mg/ dm^3
Phosphate (mg/dm^3)	0.12	0.07	0.14	0.18	0.07 – 0.18	0.13	0.1mg/ dm^3
Nitrate (mg/dm^3)	ND	ND	0.29	0.35	0.29 – 0.35	0.32	
Iron (mg/dm^3)	ND	ND	ND	ND	<0.0001– 1.35	0.29	0.3mg/ dm^3
Aluminum (mg/dm^3)	ND	ND	ND	ND	ND	ND	
Lead (mg/dm^3)	2.23	2.94	5.02	2.47	2.23 – 5.02	3.17	0.01mg/ dm^3
Cadmium (mg/dm^3)	1.53	2.12	2.84	0.67	0.67 – 2.85	1.79	0.05mg/ dm^3
Calcium (mg/dm^3)	3.17	3.05	1.99	2.21	1.99 – 3.17	2.61	75mg/ dm^3

ND = Not Detected

Table 4: Mean values of Physicochemical Analysis of the three Rivers (IA, IU and IO)

Parameters	MEAN VALUES			WHO
	IA	IU	IO	
Temperature (^oC)	24.98	25.73	25.13	30 – 32^oC
Ph	5.63	5.74	5.03	65-8.5
Elect. Conductivity (µS/cm)	1.98	1.95	1.88	400us/cm
Total Hardness (mg/ dm^3/)	0.56	0.63	0.78	500mg/dm
Calcium Hardness (mg/dm^3)	0.47	0.42	0.53	
Mg Hardness (mg/dm^3)	0.09	0.21	0.25	50mg/dm^3
Phen. Acidity (mg/dm^3)	7.13	7.88	8.25	
TDS (mg/dm^3)	3.50	5.00	4.25	500mg/dm^3
Turbidity (NTU)	33.94	38.73	52.81	
Choride (mg/dm^3)	9.83	6.29	sss6.11	600mg/dm^3
Sulphate (mg/dm^3)	1.20	1.30	1.30	400nmg/dm^3
Phosphate (mg/dm^3)	0.10	0.14	0.13	0.1mg/dm^3
Nitrate (mg/dm^3)	0.34	0.532	0.321	
Iron (mg/dm^3)	0.9749	0.292	<0.0001	0.3mg/dm^3
Aluminum (mg/dm^3)	<0.0001	<0.0001	<0.0001	
Lead (mg/dm^3)	3.9647	0.8497	3.17	0.01mg/dm^3
Cadmium (mg/dm^3)	1.5991	0.2483	1.79	0.05mg/dm^3
Calcium (mg/dm^3)	1.38	2.1600	2.61	75mg/dm^3

Where IA = *Ikwu Akanu* , IU = *Ikwu Umudike*, IO = *Ikwu Okorobi*

Table 5: Variation of metal concentrations in *Ikwu Akanu* River with Distance from the River bank

Distance from the River Bank (m)	Metal concentrations (mg/dm^3)				
	Fe	Al	Pb	Cd	Ca
4.00	1.3266	<0.0001	4.4970	2.0162	2.0172
8.00	1.0714	<0.0001	3.4323	1.1820	1.0233
12.00	0.5266	<0.0001	<0.0001	<0.0001	<0.0001
16.00	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001

Table 6: Variation of metal concentrations in *Ikwu Umudike* river with distance from the River bank

Distance from the River Bank (m)	Metal concentrations (mg/dm^3)				
	Fe	Al	Pb	Cd	Ca
4.00	0.3460	<0.0001	3.3983	0.9927	3.2881
8.00	0.2380	<0.0001	<0.0001	<0.0001	1.1820
12.00	<0.0001	<0.0001	<0.0001	<0.0001	2.3500
16.00	<0.0001	<0.0001	<0.0001	<0.0001	1.8201

Table 7: Variation of average metal concentrations in *Ikwu Okorobi* river with distance from the River bank

Distance from the River Bank (m)	Metal concentrations (mg/dm^3)				
	Fe	Al	Pb	Cd	Ca
4.00	<0.0001	<0.0001	2.2324	1.5301	3.1713
8.00	<0.0001	<0.0001	2.9440	2.1182	2.0501
12.00	<0.0001	<0.0001	5.0211	2.8471	1.9940
16.00	<0.0001	<0.0001	2.4676	0.6718	2.2096

Water Temperature

Water temperature of the rivers ranged between 24.6 – 25.2, 25.2 – 26.10 and 24.50 – 26.00 ^oC for *Ikwu Akanu*, *Ikwu Umudike* and *Ikwu Okorobi* respectively. Their mean temperatures are 24.98, 25.73 and 25.13^oC. The slight temperature changes observed in the sampled stations can be attributed to climatic condition of the area which is generally characterized by slightly lower temperature for the month of June. The dense growth of forest vegetation which characterizes the sample locations might

also shade the water body from the high intensity of solar radiation so that the temperature is low. The surface water in these sampled areas is portable. Ikwu Umudike had the highest mean temperature value as shown.

pH values

The pH valves ranged between 5.53 – 5.74 for *Ikwu Akanu*, 5.69 – 5.80 for *Ikwu Umudike* and 4.95 – 5.11 for *Ikwu Okorobi*. The mean pH values are 5.63, 5.74 and 5.03 for IA, IU and IO respectively. The Results of the pH revealed that the three rivers are slightly acidic since 100% of the samples had values not within the permissible level of 6.5 - 8.5 as recommended by W.H.O [15]. The slight acidity could be as a result of run-off from domestic and agrarian waste disposal activities, since the samples were collected in June, the month of peak rainfall.

Electrical Conductivity

Electrical conductivity (E.C) of the study area ranged between 1.88 – 1.98 μs/cm and having the mean values of 1.98, 1.95 and 1.88 μs/cm for IA, IU and IO respectively. Electrical conductivity of water is a measure of its ability to carry electric current as a result of dissolved salts in the water. As ionic concentration increases, conductance of the solution also increases; therefore, conductance measurement provides an indication of ion concentration. The acceptable limit of conductivity in drinking water is 400 μs /cm. The mean range of E.C in the study area is within the W.H.O standard for portable water. The low conductivity values obtained is indicative of the fact that since the study was carried during the wet season (June) coinciding with peak precipitation there could have been dilution of the run-off. Another factor is the inflow of dissolved ions from the underlying rock formations in the area. The highest conductance was obtained in *Ikwu Akanu* River.

Hardness

The mean hardness values for the surface water samples ranged between 0.56 – 0.78 mgL^{-1}. *Ikwu Akanu* river ranged between 0.46 – 0.88 mg/l, *Ikwu Umudike* ranged between 0.46 – 0.88 mg/L with a mean of 0.63 mg/l while *Ikwu Okorobi* river ranged between 0.44 – 1.02 mg/L with a mean of 0.78 mg/L. The hardness in the study areas are within the W.H.O limit of 500 mg L^{-1}. Water hardness level in this area is suitable for portable water source. It is attributable to the low level of divalent metallic ions, Ca^{2+} and Mg^{2+} found in the rivers.

Total Dissolved Solids (TDS)

The mean TDs values ranged between 3.50 – 5.00mg/L. The range and mean TDs valves are 3.0 – 4.0mg/L, 3.5mg/L for IA, 4.0 – 6.0mg/L and 5.0mg/L for IU and 1.0 – 7.0, 4.25mg/L for IO. The water values obtained are good for drinking and other domestic purposes with respect to WHO limit of 500mg/L. Total dissolved solids increases the hardness of water, which in natural water is made up of carbonates and calcium sulphate, magnesium sulphate, potassium sulphate and sodium sulphate. The higher the TDS value, the higher the electrical conductance of the water. About 1,200mg/L^{-1} of TDS is likely to cause taste problems [11].

Anions

The mean chloride value obtained in the three rivers ranged from 6.11 – 9.83mg/L. The chloride ion ranged between 8.94 – 11.91mg/L. The chloride ion ranged between 8.94 – 1.91mg/L, 6.07 – 6.55mg/L and 5.86 -6.45 mg/L for IA, IU and IO respectively. *Ikwu Akanu* River has the highest mean Cl^- of 9.83 mg/L. All the values were within the WHO permissible limit of 600 mg/L. Chloride in excess of 100 mg/l^{-1} imparts salty taste on drinking water and can cause physiological damage. High chloride content value 40 mgL^{-1} indicates salt water contamination. Chlorides availability in the samples has their origin from the atmosphere and from sewage. Sulphate mean values ranged between 1.20 – 1.30 mg/L. The mean values of SO_4^{2-} for IA, IU and IO are 1.20, 1.30 and 1.30 mg/L. Sulphate values obtained from the study area are below the WHO standard of 400 mg/L. Low sulphate values got were attributed to dilution effect by rainfall which characterizes the month of June. Mean phosphate value in the rivers ranged between 0.10- 0.14 mg/L. The mean values of PO_4^{3-} are
0.10, 0.14 and 0.13 for IA, IU and IO respectively. The WHO recommended level for phosphate is 0.1 mg/L, therefore, the *Ikwu Akanu* water samples were within WHO standard while the *Ikwu Umudike* and *Ikwu Okorobi* samples were above the WHO standard. The high level of phosphate in the two rivers is attributed to surface run-off from nearby farm lands onto which NPK fertilizer have been applied. The mean value of nitrate in the study area ranged between 0.32 – 0.53 mg/L. The values are within the 45mgL^{-1} for nitrate by W.H.O. Values above this can cause *methaemoglobimia* in infants. This disease is characterized by blood changes and cyanosis in which the hemoglobin apparently becomes incapable of transporting oxygen. The water in the area is not harmful in this respect in view of the low nitrate average of 0.32 – 0.53 mg/L and also suitable for industrial purposes.

Cations

The mean value of iron that was detected ranged from <0.0001 to 0.9749 mg/L. The mean values of iron are 0.9749 mg/L, 0.292 mg/L and <0.0001 mg/L for IA, IU and IO respectively. *Ikwu Akanu* has the highest value of Iron (0.9749 mg/L) which is above the W.H.O standard. This slightly high Iron content could be attributed to run-off from automobile mechanic repairs since *Ikwu Akanu* is situated close to the *Orie* market square. The mean iron content of *Ikwu Umudike* and I*kwu Okorobi* were found to be within the WHO permissible limit of 0.3 mg/L. This makes these two rivers (IU and IO) fit for drinking. Iron (Fe) has a lot of corrosive property which it imparts to surface water as iron (III) hydroxide. Iron values greater than 0.3 mgL^{-1} can damage fabric, paper and corrode the inner walls of high pressure boilers. Aluminium content was found to be less than 0.0001 mgL^{-1} in the three rivers. This of course is within the W.H.O permissible limit. The mean content of calcium (Ca^{2+}) ranged between 1.38 – 2.61 mg/L. The highest calcium content was found at *Ikwu Okorobi* river with a mean value of 2.61 mg/L. The calcium content in all three rivers were within the WHO permissible limit of 75 mg/L. The waters are portable with respect to aluminium and calcium contents. The mean lead content ranged between 3.1700 – 3.9647 mg/L exceeding the WHO permissible limit of 0.01 mg/L. This renders the waters unfit for drinking and other domestic purposes. The highest level of lead was found at *Ikwu Akanu* river with a mean value of 3.9647 mg/L. This high lead could be attributed to wastes from used batteries and run-offs of lead from refuse dumps. Lead get into the water through industrial wastes, mining, lead paints, plumbing and the burning of coal and leaded gasoline.

Another probable source of the lead in the rivers is the leaching from soils that are found next to busy highways into the water system. Once lead falls onto the soil, it usually attaches to the soil, from where small amounts may leach into rivers as the soil particles are moved by rainwater [16,17]. The mean content of cadmium ranged between 1.5991 – 1.7900 mg/L exceeding the W.H.O standard of 0.05 mg/L. This cadmium content in the water is quite worrisome. The metal concentrations do not show any particular trend and this indicates that the source of the high lead and high cadmium metals might be diffuse (non-point source). The probable source of cadmium is from natural sources due to the geological formation of the catchment soil and from run off from agricultural soils where phosphate fertilizers have been applied. cadmium is a common impurity in phosphate fertilizers **[18]**. Other probable sources include leachates from disused Ni-Cd based batteries and cadmium plated items [19].

CONCLUSION

The results showed that the temperature of the rivers within *Amaiyi-Umuobom* has an average of 25.28 ^{o}C and falls within the W.H.O recommended limit. The pH of the rivers ranged between 5.03 – 5.74 indicating acidity and does not fall within the acceptable value. The electrical conductivity values of the waters were generally low as it ranged from 1.58 – 198 μs/cm. As expected, the values of total dissolved solids were quite low, having a mean range valve of 3.50 – 5.00 mg/L. The total hardness in the area ranged from 0.56 – 0.78 mg/L, indicating soft water which requires no treatment. This range also provides excellent irrigation processes which imply that sensitive crops can conveniently be grown in the area. The surface waters in the area were found to be relatively diluted by rainwater, having little concentration of anions with mean range values of 6.11 – 9.83, 1.20 – 1.30, 0.32 – 0.53 mg/L for chloride sulphate and nitrate ions respectively. The order is CL^{-}> SO_4^{2-}> NO_3^{-}. The concentrations of metal ions generally decreased with increasing distance from the river banks with the exception of lead and cadmium whose concentrations increased to a certain level before decreasing. The result revealed that Fe ranged between <0.0001 to 0.9749 mg/L, aluminium content was less then 0.0001 while that of calcium ranged between 1.38 – 2.61mg/L. lead (Pb) and cadmium (Cd) were found well above the W.H.O permissible limit. This is attributed to anthropogenic activities like lead piping, lead paints and auto emissions from petrol as well as batteries. This poses a health risk to the *Amaiyi- Umobom* community and environs.

Since the metal concentrations do not show any particular trend, the source of the lead and cadmium metals in the water might be diffuse. The waters being slightly acidic might have dissolved the cadmium washed down into the rivers from nearby farms on which phosphate fertilizers have been applied. Run-offs of lead paints and lead solders might have possibly been deposited into the rivers. Source of lead in dust and soil include lead that falls to the ground from the air, and withering and chipping of lead – based paints from buildings and other structures; all the could be washed down into the rivers through rainfall[18,19]. The result also revealed that the marcasite deposit does not possess considerable adverse effect on the quality of the rivers owing to the low contents of its major constituent elements. Conclusively, the three rivers can be said to be portable with respect to all other physical and chemical parameters with the exception of pH, cadmium and lead.

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